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"LET KNOWLEDGE GROW FROM MORE TO MORE
AND THUS BE HUMAN LIFE ENRICHED."

A New Survey of Universal Knowledge

ENCYCLOPÆDIA BRITANNICA

Volume 17

P *to* PLASTERING

ENCYCLOPÆDIA BRITANNICA, INC.

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P TO PLASTERING

P This letter throughout its known history has represented the unvoiced labial stop. It corresponds to Semitic 𐤐 (*pe*), perhaps deriving from an earlier sign for "mouth," Greek Γ, Γ, ꓶ (*pi*). The rounded form occurs in the early Greek inscriptions from the island of Thera. In the Italic alphabets the form varied strangely. Etruscan had ꓶ and Ρ. The standard form in the Latin alphabet was evidently borrowed from the Etruscan Ρ, but the colonial Latin alphabet of the 3rd century B.C. also shows a form ꓶ resembling the Chalcidic. The Umbrian alphabet had ꓶ, a form resembling the ancient Semitic. Faliscan had the rounded form ꓶ, Γ. Oscan lengthened the second small vertical stroke and developed the form Π.

NAME OF FORM	APPROXIMATE DATE	FORM OF LETTER
PHOENICIAN	1200 B.C.	𐤐
CRETAN	1100-900	ꓶ
THERAEAN	700-600	ꓶ
ARCHAIC LATIN	700-500	Ρ
ATTIC	600	ꓶ
CORINTHIAN	600	ꓶ
CHALCIDIAN	600	Ρ
IONIC	403	ꓶ
ROMAN COLONIAL	PRECLASSICAL AND CLASSICAL TIMES	ᴧ Γ Ρ
URBAN ROMAN		ᴧ Ρ
FALISCAN		ꓶ
OSCAN		Π Π
UMBRIAN		𐤐
CLASSICAL LATIN AND ONWARD		P

DEVELOPMENT OF LETTER "P" FROM EARLIEST TIMES TO THE PRESENT

The minuscule letter resembles the majuscule, the chief difference being that the loop is brought down to the level of the line of writing and the vertical stroke extended below the line. Thus a cursive form of the 6th century was ꝑ, the uncial form was ꝓ, the Carolingian ꝑ.

The English initial *p* is slightly aspirated, that is, it is accompanied by a slight puff of breath, in contrast to the unaspirated *p* of French for example. In English, as in French and German, the letter is used in combination with *h* in words of Greek origin to denote the unvoiced labiodental spirant expressed in other words by the letter *f*; *e.g.*, "philosophy," "phonetics" and "graphic." Initial *p* is silent in the combinations *ps* and *pt* in such Greek-derived words as "psychology" and "pterodactyl."

For the history of sound changes affecting the letter *p*, *see* GERMANIC LANGUAGES. *See* also ALPHABET.

(B. F. C. A.; J. W. P.)

PAARL, a town of Cape Province, S.Af., is situated on the Great Berg River, between the Drakenstein Range and Paarl Mountain, 36 mi. ENE of Cape Town by rail. Pop. (1960) 38,059; (1962 est.) 44,000. Discovered in 1657 by Abraham Gabbema and founded by Huguenot settlers in 1688, Paarl extends about eight miles along the river. It is the centre of the South African wine and grape industry, and also produces citrus fruits and olives. Industries also include textile and flour mills, and cigarette and jam factories. The town has six high schools, a commercial training college, and two teachers' training colleges.

(C. H. BL.)

PAASIKIVI, JUHO KUSTI (1870–1956), Finnish statesman, for ten years president of Finland, was born at Tampere on

Nov. 27, 1870. He studied law and history at Uppsala and Leipzig universities, and from 1902 to 1903 was a lecturer in law at Helsinki University; but subsequently he turned to financial administration and banking business. Believing that small nations cannot afford to stand on their rights against the power policies of big ones, he ranged himself in the campaign for Finnish constitution (*see* FINLAND: *History*) with the "compliers" of the Old Finnish Party, while the leading jurists of the day took the Constitutional standpoint. He was a senator (minister) from 1908 to 1909, but resigned from the government to show the Russians that even the Old Finns could not approve illegal actions. As prime minister of the first government after the War of Independence in 1918, he favoured a pro-German policy and a monarchy for Finland. He headed the Finnish delegation at the peace talks with Soviet Russia in 1920 and warned the government against trying to take advantage of Russia's temporary weakness.

Paasikivi's policy toward Russia during and after World War II was a logical continuation of his activity as a politician of the Old Finnish Party. In Oct. 1939 he led the Finnish delegation which unsuccessfully attempted to reach a peaceful settlement with the U.S.S.R. As minister during the Russo-Finnish Winter War of 1939–40 he did much to speed up the conclusion of peace; as ambassador to Moscow in 1940–41 he skilfully represented his country's interests and at the same time counseled his government to make concessions. In the Russo-Finnish Continuation War of 1941–44 he made contact with the Russians to explore the possibility of a peace. As prime minister from Nov. 1944 to March 1946 he made sure that the peace conditions were faithfully carried out, though the punishment of the wartime political leaders caused him personal difficulties. As president of the republic from March 1946 to Feb. 1956 he stood farther aloof from party life than any of his predecessors. His aim, which he pursued with considerable success, was to remain absolutely uncompromising over Finnish independence while so handling Finland's foreign relations as to avoid all conflict with Soviet interests and to inspire the U.S.S.R. with confidence in Finnish sincerity. He died in Helsinki on Dec. 14, 1956. His memoirs, *Paasikiven linja* (two volumes) appeared in 1956.

See K. Kare, *Juho Kusti Paasikivi* (1956). (E. K. I. J.)

PABIANICE, a town of central Poland in Lodz *wojewodztwo* (province), lies in the Lodz Highlands on the Dobrzynka River, a secondary tributary of the Warta, 10 mi. (16 km.) SSW of Lodz by road. Pop. (1960) 56,000. It is the second most important town in the Lodz industrial region and is on the railway from Lodz to Poznan and Wroclaw. Its Renaissance castle houses the museum. The town is a textile centre and also has chemical, metal, and papermaking industries. Settled as early as the 11th century, Pabianice acquired town rights in 1297. (T. K. W.)

PABNA (PUBNA), a town and district in the Rajshahi division of East Pakistan. The town, headquarters of the district, lies on the Ichamati River (a tributary of the Padma) 75 mi. WNW of Dacca. Pop. (1961) 40,792. It is a well laid out industrial town with many old buildings and is noted for its Hindu Temple of Jor Bangla, the walls of which are decorated with images of gods and goddesses. In the town are the Pabna Jubilee tank (excavated in 1887), Jinnah Park, a public library, a mental hospital, and a degree college affiliated to Rajshahi University. It is noted for its hosiery and handloom products.

PABNA DISTRICT (area 1,877 sq.mi.; pop. [1961] 1,959,060) lies in the angle between the Jamuna River in the east and the Padma in the southwest. It is intersected by countless water channels, so that during the rainy season most of the villages are accessible by boat, and many by boat only. The district is a wide alluvial plain, the southwestern portion being of a higher level. Fields of rice and jute, the two staple crops, are almost encircled by clumps of trees and bamboos which conceal the village sites. Enriched by annual floods, the soil is extremely fertile; two-thirds of the district yields two crops and many parts three crops annually. Sirajganj, northeast of Pabna, is a trade centre. (K. S. AD.)

PACA, any of several large, tailless, rabbitlike rodents of the family Dasyproctidae, known also as spotted cavies. The lowland

LLOYD G. INGLES

LOWLAND PACA (CUNICULUS PACA), SOMETIMES ATTAINING THE SIZE OF A LARGE RABBIT

pacas (*Cuniculus,* or *Agouti*) occur from Brazil to Mexico, chiefly in swampy areas; the mountain pacas (*Stictomys*) live in forests in the Andes of Ecuador and Venezuela. They are closely related to the agoutis and acushis (*Dasyprocta* and *Myoprocta*), but stouter. Pacas have hooflike feet and thick long brownish hair, attractively spotted. They possess large internal cheek pouches and peculiar bony cheek plates that are particularly enlarged in males.

Nocturnal in habits, pacas live in bank burrows and feed on leaves, roots, and fruits. They provide leather and are a favourite food locally. The rare pacarana, or false paca (*Dinomys*), of the northern Andes, has a well-developed tail and belongs to a separate family (Dinomyidae). (R. H. MA.)

PACARAIMA, SERRA (Sp. SIERRA PACARAIMA; Eng. PAKARAIMA MTS.), is the tabular upland that surmounts the Guiana Highlands along the border between Brazil and Venezuela, and between Brazil and British Guiana. It reaches its highest elevation in Mt. Roraima (9,094 ft.), located where the boundaries of the three countries come together. The Serra Pacaraima extends for about 250 mi. in an east-west direction. None of these surface features, including Mt. Roraima, is properly called a mountain, for the summits are flat or gently rolling; but the steeply cliffed sides make these tabular forms look like mountains as one approaches them on the ground. They are developed on the very thick, flat-lying sandstones of the Cretaceous Age that lie over the top of the ancient crystalline rocks of the Guiana Highlands. The rivers that rise on the plateau tops pour over the cliffed edges in spectacular waterfalls, such as Kaieteur Falls in British Guiana. It was these massive tablelike features, their tops often obscured by clouds, that inspired A. Conan Doyle to write *The Lost World,* an imaginative account of an exploring expedition that found the almost inaccessible heights populated by dinosaurs and other extinct animals.

Although the Serra Pacaraima has not been carefully explored, its essential character is known and the border between Venezuela and Brazil has been surveyed. The region is almost uninhabited except by a few tribes of Indians. Although the crystalline rocks of the Guiana Highlands contain gold and diamonds, iron ore, and other industrial minerals, the cover of sandstones contains no minerals of value. (P. E. J.)

PACATUS DREPANIUS, LATINIUS (LATINUS) (fl. *c.* A.D. 390), Gallo-Roman orator and poet, was the author of an extant panegyric addressed to Theodosius I at Rome in A.D. 389 after the defeat of the usurper Maximus. He was a friend of Symmachus, the champion of paganism, and of the Christian poet Ausonius. It is uncertain whether Pacatus was pagan or Christian; in his speech he denounced Maximus' persecution of the Priscillianist heretics. In A.D. 390 Pacatus received the proconsulship of Africa and later held other high office.

For text *see* W. Baehrens (eds.), *XII Panegyrici Latini* (1911). *See* also E. Galletier, *Panégyriques latins,* vol. iii (1955). (W. S. MS.)

PACHECO, FRANCISCO (1564–1654), Spanish painter and author, whose pictures and writings are representative of the Spanish baroque, was born at Sanlúcar, where he was baptized on Nov. 3, 1564. He went early to Seville, where he lived with his

cousin, F. Pacheco, a canon whose house was a meeting place of the learned and artistic world of the town. Pacheco studied art under Luis Fernandez. It is not known whether he went abroad, but he greatly admired Italian art and formed a collection of Italian Renaissance drawings. Later he opened an academy, which was largely attended. Of his pupils the most distinguished were Alonso Cano and Velázquez, who became his son-in-law. His early work is hard and cut out. After a visit in 1611 to Madrid and Toledo, where he met El Greco, he became interested in chiaroscuro. Specimens of his work are in the gallery, the university and the cathedral at Seville. The church of St. Sebastian at Alcalá de Guadaira, near Seville, contains one of his most important works. He was a successful portraitist and is said to have executed 150 portraits. Pacheco visited Madrid again in 1623 with Velázquez and stayed until 1625. In his later life he devoted himself to writing. His treatise on the art of painting (*Arte de la pintura,* 1649) is of considerable value for the study of Spanish art.

PACHELBEL, JOHANN (1653–1706), German composer, one of the great organ masters of the generation before J. S. Bach, was born in Nürnberg in August 1653. He studied in Altdorf and Regensburg, and later held posts as organist in Vienna, Stuttgart, and other cities. In 1695 he was appointed organist at the St. Sebalduskirche in Nürnberg, where he remained until his death on March 6 or 7, 1706.

All Pachelbel's work is in a clear and contrapuntally simple style. His organ compositions show a knowledge of the Italian forms such as the toccata, derived through J. J. Froberger from G. Frescobaldi. Of special importance are his chorale-preludes, which did much to establish the chorale melodies of Protestant north Germany in the more lyrical musical atmosphere of the Catholic south. Pachelbel also wrote harpsichord music, but without much feeling for that instrument's individuality, and other instrumental music, including six suites for two violins.

(C. P. Co.)

PACHER, MICHAEL (fl. 1465–1498), German painter and wood-carver, executed his chief work, the great altarpiece in the parish church of St. Wolfgang, in Upper Austria, between 1478 and 1481. It is one of the greatest monuments of the late German Gothic period. The centrepiece is an elaborate wood carving representing Christ and Mary with St. Wolfgang and St. Benedict. The wings, two on each side, are painted with scenes from the life of Christ and St. Wolfgang. While the carving is of the Late Gothic style prevalent in Germany at the time, the paintings are influenced by the Italian Renaissance, which penetrated into the Tirol from Verona; they especially show the influence of Mantegna. The figures are plastic, the composition clear and monumental. Other works by Pacher are: the altarpiece (wood carving) in the church of Gries, near Bozen (mod. Bolzano, Italy) (1471); the high altar for the church of St. Francis, in Salzburg, begun in 1484 and left uncompleted; and the altarpiece of the cathedral at Brixen (mod. Bressanone, Italy), representing the fathers of the church, panels of which are in the Munich and Augsburg galleries.

PACHMANN, VLADIMIR VON (1848–1933), Russian pianist known for his performances of Chopin, was born at Odessa on July 27, 1848. In 1866 he went to Vienna where he studied under Joseph Dachs. He first appeared as a pianist at Odessa in 1869 and later played in Germany, Austria, and France. Though his early concerts were successful he was severely self-critical and withdrew for long periods of study. He first appeared in London in 1882, married his Australian pupil Marguerite Oakey in 1884, and made his first visit to the United States in 1891. Until about 1925 he toured Europe and America as a performer almost exclusively of the works of Chopin which he played in an intimate, miniature style. The informal commentaries he provided on the music in the course of performance were a peculiarity of his concerts. He died in Rome on Jan. 7, 1933.

PACHOMIUS, SAINT (292?–346?), Egyptian monk, founder of Christian cenobitical life, was born about 292 at Esna (Isna) in Upper Egypt, of pagan parents. The facts concerning his life and work are much entangled with legend. He apparently served as a conscript in the Roman army and on his return became a Christian (314). He at once went to live an eremitical life near Dandarah by the Nile, putting himself under the guidance of an aged hermit. After three or four years he was called (by an angel, according to legend) to establish a monastery of cenobites, or monks living in common. Pachomius spent his life in organizing and directing the great order he created, which at his death included nine monasteries with about 3,000 monks, and a nunnery. The order was called Tabennesiot, from Tabennisi, near Dandarah, the site of the first monastery. Athanasius was his firm friend and visited his monastery *c.* 330 and later. The date of his death was probably 346 or 348. His feast is celebrated on May 9 (Coptic Church) or May 14. (*See* also MONASTICISM.)

St. Pachomius' rule has not survived in its original form. The *Lausiac History* (*c.* 419) of Palladius quotes it, and St. Jerome made a Latin translation of a text written in the Coptic Sahidic dialect. St. Benedict's rule made considerable use of it.

See H. Thurston and D. Attwater (eds.), *Butler's Lives of the Saints,* vol. ii, pp. 259–262 (1956), with bibliography. (X.; E. R. Hy.)

PACHUCA, a city of Mexico and capital of the state of Hidalgo. Pop. (1960) 64,571. Situated in a valley of an inland range of the Sierra Madre Oriental at an elevation of 8,150 ft., Pachuca stands in the midst of the rich mining districts of Atotonilco el Chico, Capula, Potosí, Real del Monte, Santa Rosa, and Tepenené. Pachuca was one of the first settlements in New Spain, and its first mine was discovered in 1534. It is said that some of these silver mines were known to the Indians before the discovery of America. The nearby Real del Monte mine is considered to be one of the most extensive mining properties in the world. Begun in 1739, the mine is still in operation. Demonstrating the silver wealth of the region, the old Trinidad mine alone produced 40,000,000 pesos worth of silver in ten years. It was possibly in Pachuca in 1557 that Bartolomé de Medina discovered the "patio" process of reducing silver ores with quicksilver, which was widely used until the 20th century. A sharp decline in mineral production in recent years in Pachuca has posed a serious employment problem, which the government is seeking to resolve by greater industrialization. The city's industries include smelting works and a large number of metallic ore reduction plants. Pachuca has a university, a school of mines and metallurgy founded in 1877, a meteorological observatory, and a public library. (H. R. Hy.)

PACHYSANDRA, a small genus of the box family (Buxaceae), comprising several species of herbs or subshrubs of value as ground cover in shade because of their more or less evergreen leaves. The Allegheny pachysandra (*P. procumbens*), native to eastern North America from the mountains of Kentucky to western Florida and Louisiana, is of little value as an ornamental because of the dingy colour and deciduous character of its leaves. The Japanese pachysandra (*P. terminalis*), a true evergreen with thick glossy foliage, is a very desirable low-growing cover plant, succeeding admirably in full sun or partial shade; the variety *variegata* is a choice cover plant for ornamental effects. These plants are sometimes called spurge, a name more correctly restricted to many euphorbias (*q.v.*). (J. M. Bl.)

PACIFIC, WAR OF THE (1879–1884), grew out of a dispute between Chile and Bolivia over control of a part of the Atacama Desert lying between the 23rd and 26th parallels on the Pacific coast of South America. The territory contained valuable mineral resources, particularly sodium nitrate.

Negotiations for a boundary settlement began in the early 1840s. In 1863 the Bolivian Congress authorized the President to declare war on Chile if that nation refused to settle the question peacefully. Open conflict was averted when Bolivia became the ally of Chile, Peru, and Ecuador in a war against Spain in 1866. Chile and Bolivia then negotiated a treaty recognizing the 24th parallel as their boundary, but giving Chile the right to share the export taxes on the mineral resources of Bolivia's territory between the 23rd and 24th parallels.

When the war with Spain ended, relations between Chile and Bolivia deteriorated. Bolivians resented sharing taxes from their territory with Chile, and feared that Chile might seize Bolivia's coastal region because the mining industry there was controlled by Chilean interests, aggressively supported by the Chilean govern-

ment. Peru's interest in relations between Chile and Bolivia complicated the situation. Not only were Peru and Chile traditional rivals for hegemony on the Pacific coast but the prosperity of the Peruvian government's guano monopoly and the thriving nitrate industry in Peru's province of Tarapacá were related to mining activities on the Bolivian coast. In 1873 Peru approved a "secret" alliance with Bolivia under which the two nations mutually guaranteed their territories and independence.

In 1874 satisfactory relations between Chile and Bolivia were restored by approval of a revised treaty under which Chile gave up its share of the export taxes on minerals shipped from Bolivia. In return, Bolivia agreed not to increase existing taxes on Chilean enterprises in Bolivia for 25 years. Harmony prevailed until 1878 when a new Bolivian government sought to impose an additional tax upon a Chilean corporation—the Antofagasta Nitrate Company. After Bolivia failed to heed Chilean protests that the tax violated the treaty of 1874 and threatened to confiscate the property of the company for failure to pay the tax, Chilean forces occupied the port city of Antofagasta (Feb. 14, 1879). Bolivia then declared war on Chile and called upon Peru for help. Peru, unprepared for war and in serious financial difficulties, sought to end the Chilean-Bolivian conflict through mediation. However, when the Peruvian mediator admitted the existence of the Peruvian-Bolivian treaty of alliance, Chile declared war on both Peru and Bolivia (April 5, 1879).

Chile occupied the Bolivian coastal region with ease and proceeded to take the offensive against more powerful Peru. Naval victories at Iquique (May 21, 1879) and Angamos (Oct. 8, 1879) placed Chile in control of the sea approaches to Peru. A Chilean land force then conquered the Peruvian province of Tarapacá late in 1879 and occupied the provinces of Tacna and Arica in June 1880. A United States effort at mediation in Oct. 1880 failed when Chile demanded territorial concessions from both of its enemies as a price for peace. A few months later Chilean forces captured the Peruvian capital of Lima (January 1881).

For nearly three years Chile refused to negotiate a peace treaty with Peru because of Peruvian resistance, encouraged in part by U.S. sympathy for the Peruvian cause, to making territorial cessions. Finally, on Oct. 20, 1883, Chile and Peru approved the Treaty of Ancón under which Tarapacá was ceded to Chile. The treaty also provided that Chile would occupy the Peruvian provinces of Tacna and Arica for ten years, at the end of which time a plebiscite would be held to determine their definitive nationality.

In 1884 a truce was arranged with Bolivia which gave Chile control of the entire Bolivian coast. A definitive treaty (1904) ceded this region to Chile, making Bolivia a landlocked nation. In return, Chile agreed to build a railroad connecting La Paz (the seat of the Bolivian government) with the port of Arica and guaranteed freedom of transit for Bolivian commerce through Chilean ports and territory. (R. N. Bu.)

PACIFIC COAST. The Pacific coast of North America possesses two unifying geologic and geographic properties—the Pacific Ocean, which constitutes a natural western border, and the coastal mountain ranges that form the western shoreline of the United States. The physiographic interior consists of a diverse assortment of valleys, plateaus, river systems, and mountains, each of which possesses a distinctive geologic history. For this reason, as well as for historical and sociological reasons, it is difficult to establish firm inland boundaries for the region. The most commonly accepted definition of the Pacific coast is largely a political one; it defines the region as comprising the states of California, Oregon, Washington, Idaho, Alaska, western Montana, and the province of British Columbia, which was formerly a part of the old Oregon country. (For a geographic description of this area *see* United States [of America]: *Physiography.*)

Before white men reached North America, the Pacific coast was inhabited by native peoples belonging to several culture areas and language families. The California Indians possessed a very simple culture pattern and spoke a great variety of languages, whereas the dominantly Salishan- and Nadene-speaking Indians of the Pacific Northwest, as well as the Eskimo-Aleut groups of the Bering Sea area, had distinctive and relatively highly developed cultures. Intruding upon both of these major segments were the Indians of the Columbia Plateau whose culture was profoundly influenced by the northern desert and northwest coastal tribes. (*See* Indian, North American.)

The Spaniards were the first to explore the Pacific coast. Following Balboa's discovery of the Pacific Ocean in 1513, the Spaniards intensified their search for a sea passage to the East Indies; their voyages along the Pacific coast led to the discovery of California by Juan Rodríguez Cabrillo in 1542. During the ensuing century and a quarter Mexican-based voyages carried these seafaring Spaniards steadily northward. By the time of the American Revolution the Spaniards had already gained familiarity with the California coast, cruised in Alaskan waters, established a base of sorts in Nootka Sound on Vancouver Island, and used the coastal waters for part of the famed Manila-Acapulco galleon trade. Except for the unplanned "visit" of Francis Drake to the vicinity of San Francisco Bay in 1579 and his assertion of an English claim to New Albion (the name given the region by this English navigator), the Spanish hold on California remained unchallenged for three centuries.

California.—This enviable position was in large measure due to Spain's role as a colonizer. During the period 1769–1823, Spain established many missions and ranchos in California's fertile and semihumid south-coastal valleys. Under Spain's (after 1822, Mexico's) suzerainty Alta (Upper) California became a somewhat self-sustained pastoral community. A sunny climate, a generally inviting countryside, trade possibilities, and an appealingly simple life offered irresistible attractions to foreigners.

During the first half of the 19th century a Spanish and Christianized Indian population of about 16,000 inhabitants became hosts to more than 3,000 foreign settlers, mostly Americans. The presence of Americans in California, and U.S. official desire to acquire West Coast ports were among the significant factors bringing on the war with Mexico in 1846–48. By the terms of the Treaty of Guadalupe Hidalgo, Feb. 2, 1848, at the end of the war, California was included in the Mexican territory ceded to the United States.

The discovery of gold in California on Jan. 24, 1848, led the next year to the famous gold rush of the "Forty-niners." In 1850 California was admitted to the Union as the 31st state, and the decades that followed witnessed a rapid population growth, far-reaching agricultural developments (involving reclamation of arid areas), the discovery and exploitation of rich petroleum resources, and industrial and commercial expansion. At the time of the 1960 census California had a population of 15,717,204, making it the second most populous state. In 1964 it became the most populous state according to official U.S. Census Bureau estimates.

Pacific Northwest.—The northern portion of the Pacific coast, called the Pacific Northwest, has had a somewhat different history from that of California. It was Vitus Bering, the Russian-sponsored explorer, who in 1728 became the first to navigate the strait named in his honour. This initial Muscovite interest led to the formation in 1799 of the Russian-American Company, which established trading posts in parts of Alaska. In 1867 Russia sold Alaska to the United States, and in 1958 Alaska became the 49th state in the Union.

North of California lay the Oregon country, a region roughly as large as Alaska and possessing strikingly varied physical features, soil, and climate. The humid Willamette-Puget Sound trough dominates the region west of the Cascade Mountains; an elevated arid plateau spreads over the region east of the Cascades; and binding together the major portions of the Oregon country is the mighty Columbia River.

During the last quarter of the 18th century ships of British and American registry carried on extensive maritime explorations along the Oregon coast and concurrently developed there a thriving sea otter fur trade. The discovery of Oregon's rich fur resources led, after the turn of the century, to an accelerated British and American competition in the establishment of inland trading operations. British companies—first the Northwest Company and then the Hudson's Bay Company—gained control of the region north of the Columbia River; American traders, missionaries, and pioneer set-

tlers dominated the region south of the river. Following the relinquishment of territorial claims by Russia and Spain, it remained for Great Britain and the United States to resolve their overlapping claims to the Oregon country. After a period of agreed upon "joint occupation," the 49th parallel was established in 1846 as a permanent boundary line to Puget Sound (but not including Vancouver Island). The territory north of this line went to Great Britain; the territory south of it to the United States.

American public interest in this Pacific coast region during the mid-1840s has been referred to as "Oregon fever." What had begun as a small American overland migration to Oregon in 1841 (by way of the Oregon Trail) gained momentum, and after the boundary settlement the tide of migration grew steadily. In 1848 Oregon was made a U.S. territory; and as settlement spread, new states were formed from it. Oregon was admitted to the Union in 1859, Washington in 1889, and Idaho in 1890.

Regional Characteristics.—Situations peculiar to the Pacific coast have given this geographically and historically diversified region at least some measure of cohesiveness. Until the admission of Hawaii as a state in 1959, the Pacific coast represented the western borderland area of the United States. As such the people and the press of this region displayed over the years a degree of regional self-consciousness. For example, the Pacific coast population felt that it was relatively isolated from the rest of the nation. This feeling was early manifested by Pacific coast efforts to bring about a union of eastern and western lines of transportation and communication, an enhancement of maritime trade, and adequate Pacific coast military defenses. Because of this feeling of isolation, innumerable regional business and professional groups have emerged on the Pacific coast over the years and are still active. Some of these organizations, however, exist simply as branches of nationally organized bodies. Quite apart from this feeling of isolation, which is being diminished by high-speed means of communication and travel, the Pacific coast has been obliged to cope with many problems of a peculiarly western nature. For example, Oriental immigration has been largely a Pacific coast problem. Another problem peculiar to this region has been the heavy dependence of West Coast business enterprises upon eastern capital investment. For reasons traditionally associated with the most westerly segments of U.S. settlements, the people of the Pacific coast are generally credited with being youthful, exuberant, and optimistic in spirit; casual or "western" in dress; progressive in business management; eager to promote population growth and business booms; and, by virtue of location, more conscious than their fellow citizens in the East and Middle West of America's destiny in the Pacific Ocean area.

See also ALASKA; CALIFORNIA; OREGON; WASHINGTON.

(O. O. W.)

PACIFIC ISLANDS, a term used to denote all the islands in the Pacific Ocean. However, not all of the islands in the Pacific are discussed in this article. The Indonesian archipelago, the Philippines, and Japan clearly belong to Asia, while the Bonin and Volcano islands as far south as Iwo Jima, like the Kuril Islands, are essentially Asian island arcs; the Aleutian Islands between Kamchatka and Alaska form a similar continental arc. Moreover, the Revilla Gigedo, Galapagos, and Juan Fernández groups to the east are usually counted as part of America, while New Zealand can be considered apart.

By far the greater number, both of groups and individual islands, normally thought of as "the Pacific Islands" (and so treated here) lie in a relatively restricted part of the ocean, between latitudes 10° N and 25° S and between Australia and longitude 130° W. The main exceptions are the Marianas, or Ladrones (12°–20° N, about 145° E), which really prolong the Bonin line; the great chain of the Hawaiian Islands across the Tropic of Cancer; and the isolated Easter Island (*q.v.*). New Guinea, a vast continental island, is in some respects anomalous, but because of its strong racial and cultural affinities with the groups east of it, it is treated with the other Pacific Islands here.

The Pacific Islands are usually divided into three major groupings: Micronesia in the northwest (Mariana, Caroline, Marshall, and Gilbert islands); Melanesia, from New Guinea to Fiji (including the Solomon Islands, New Hebrides, and New Caledonia); and Polynesia to the east and northeast of Fiji (including the Hawaiian, Samoan, Tonga, Tuamotu, and Marquesas islands, and other groups). To some extent these divisions correspond to racial and cultural distinctions.

This article is divided into the following sections and subsections:

I. Physical Geography
  1. The High Islands
  2. Coral Islands
  3. Climate
  4. Soils
  5. Vegetation
  6. Animal Life
  7. Mineral Resources
II. Anthropology
III. History
  1. Exploration and Exploitation
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  6. Western Pacific High Commission
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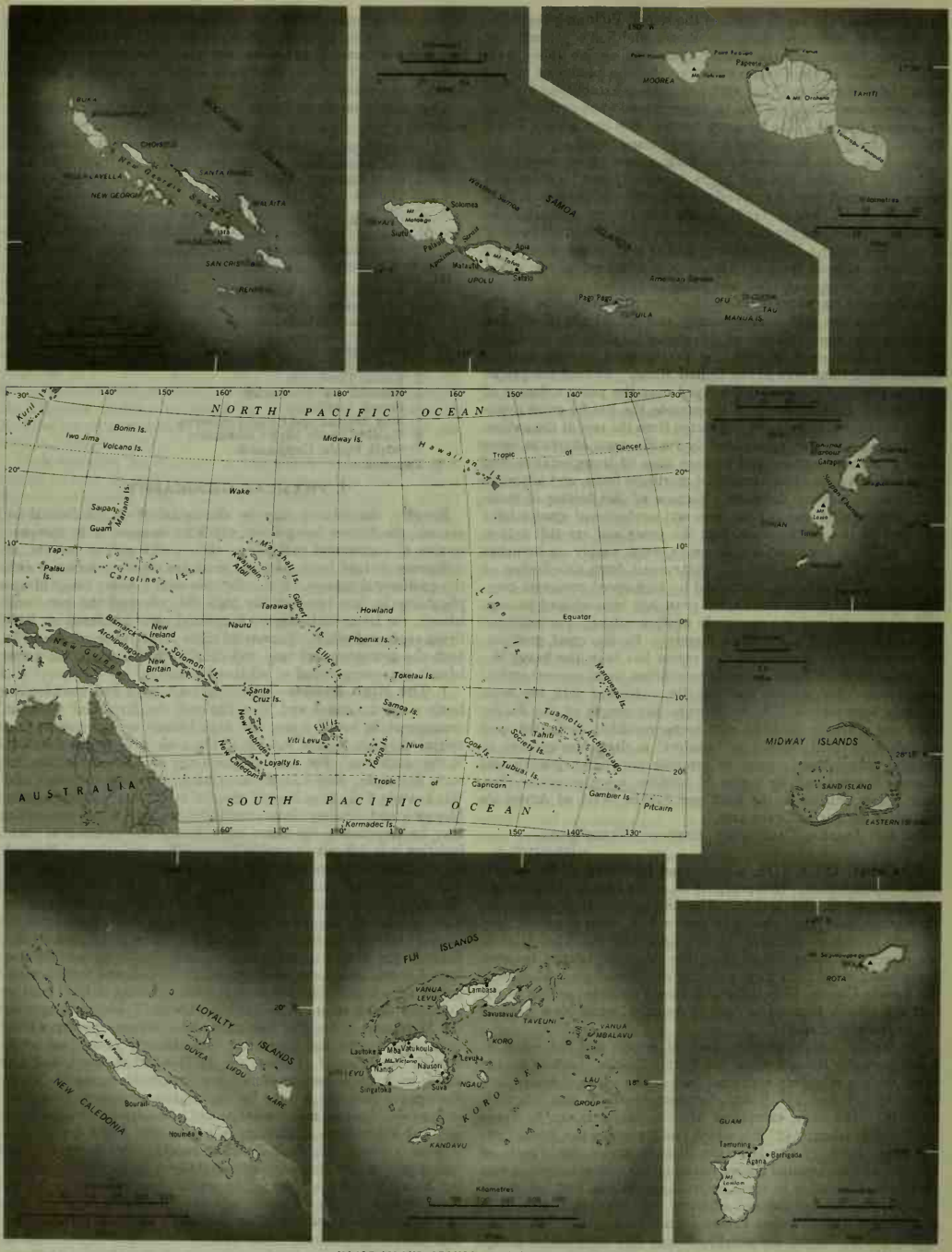
I. PHYSICAL GEOGRAPHY

Broadly, the islands may be distinguished as continental or oceanic, the former being those which by location or by the possession of continental rocks (*e.g.*, sialic rocks such as granite, or sediments derived from marginal seas) are clearly associated with the continental masses. But a division with a wider range of applicability is that between the high volcanic and the low coral islands, the latter including both uplifted coral platforms or still-living reefs and atolls. Islands of these three types are found in both the epicontinental seas and the Pacific basin proper; some islands are compounded of all three elements.

1. The High Islands.—Omitting such large and complex islands as New Guinea and New Zealand, the former of which is continental in every sense, the high islands are all volcanic in origin; they are mainly basaltic in the basin proper and andesitic in the southwest. But some of the larger ones (New Britain, the main Solomons, New Caledonia, some of the New Hebrides, and Viti Levu in Fiji) have limited areas of sedimentary rocks, mainly Mesozoic and Tertiary; local crustal deformation due to volcanism may be responsible for these occurrences, and because of their isolation it is difficult to establish any wide correlations. Most of the high islands do not reach any great altitude; apart from the 16,000-ft. ranges of central New Guinea, and the great volcanoes of Hawaii (Mauna Kea, 13,796 ft.), they rarely exceed 4,000 to 6,000 ft., though Tahiti reaches 7,352. But as altitudes of 2,500 ft. or more may be reached on an island only a few miles round (*e.g.*, Kao, in the Tonga Islands, attains 3,380 ft. in an area of less than 5 sq.mi.), they are often extremely rugged, and human occupation may be possible only on a few tiny pockets of level land or a narrow beach strip. Especially in Hawaii, Tahiti, and some of the Marquesas, a peculiar feature is the existence of steep-walled deep valleys with flat floors that end abruptly in a blind semicircular head; some of these are 2,000–3,000 ft. deep, and the valley walls are sometimes fluted in a remarkable manner. These flutings are probably formed by the headward erosion of canyons under conditions of heavy rainfall and alternating layers of hard and soft volcanic rock; faulting may also play a part.

Some volcanic islands, *e.g.*, in the northern Marianas, are too young and/or too small to have developed much soil; this does not hold for those which run to several hundred square miles: New Britain and New Ireland together are nearly 18,000 sq.mi., and other large islands are New Caledonia (6,470), Viti Levu in Fiji (4,011), and Hawaii Island (4,030). On such islands, there is a considerable stream development and often well-marked diversity of climate and vegetation (often resulting from differing rain-



MAJOR ISLAND GROUPS IN THE PACIFIC OCEAN

fall on windward and leeward aspects), so that there may be some diversified landscapes and economic activity—a contrast to the smaller high islands and nearly all the low coral isles.

2. Coral Islands.—*General.*—The Pacific is the great domain of reef-building corals, and the great majority of the many thousands of Pacific isles and islets are formed of coral, at least in those portions that emerge above sea level. Reef-building corals cannot live where the sea temperature falls below 20° C (68° F), or at depths more than about 150 ft. below the surface. Since many coral islands rise steeply from great depths, their origin poses a difficult problem (*see* also CORAL REEF).

Most of the high islands are bordered along the shore by fringing reefs which may be a few hundred yards wide. Many also have offshore barrier reefs, which may be continuous for miles and are separated from the shore or the inner fringing reefs by some miles of open water. The south coast of New Caledonia, for example, is bordered by such a reef about 400 mi. long. Gaps in fringing and barrier reefs are usually opposite river mouths, as the silt smothers the coral organisms. In the extreme case of the atoll, the reef encloses a lagoon with no central island at all.

The most generally accepted theories of the origin of barrier reefs and atolls are based on Charles Darwin's view, according to which they begin as fringing reefs on a high island; subsidence of the island, accompanied by the building-up of the reef, leads to the formation of the encircling lagoon, and finally the central island disappears completely, leaving only the more or less circular reef. Much evidence favours this view, notably the presence on many high islands of embayments presumably caused by the drowning of the valleys by submergence, and the fact that borings on Funafuti (Ellice Islands) and Bikini (Marshalls) reached depths of over 1,000 ft. and 2,556 ft. respectively without finding any but coralline material.

But there are some difficulties with this explanation, the most important being that the interior lagoons of atolls are normally flat-floored and fairly shallow, with remarkably accordant depths. There is little growth of coral on the inner edge of the reef, where the food supply is scanty, and Sir John Murray maintained that the lagoons were formed by the solution of the dead coral in the centre of coral platforms formed on submarine banks. There seems little to support this theory, however. R. A. Daly's "glacial control" theory holds that with the lowering of sea level and temperature when much of the hydrosphere was locked up in the great Pleistocene ice caps, the reefs over large areas of the Pacific died and were destroyed by marine planation, which also cut into the high islands or even bevelled off many of them into submarine platforms. According to this view, the present coral would be only a thin layer, which does not square with the evidence of borings; on the other hand, the theory does seem a plausible explanation of the flat accordant lagoon floors. Quaternary changes in relative sea levels have, however, been complex; while no one simple theory can cover all cases, some form of the subsidence theory seems likely to hold the field. There has certainly also been uplift, perhaps local, to form the flat islands of raised coral and such features as the coral limestone terraces of the Huon Peninsula in New Guinea.

Raised Coral Islands.—These are few compared either with volcanic islands or atolls, but they are quite important. Typically more or less circular or elliptical in form, they betray their origin by a raised edge. They do not reach any great height or size—most of them are under 10 sq.mi.—but Niue, between the Tonga and Cook islands, has 100 sq.mi., and Makatea in the Tuamotu archipelago reaches 230 ft. As they are virtually flat slabs of limestone, recently uplifted, their soils are thin, with the surface broken by little crags and solution hollows; surface water is usually absent; vegetation is usually a dry scrub and there is little agriculture. On the other hand, they may be important suppliers of guano phosphate; *e.g.*, Ocean Island and Nauru.

Atolls.—There are literally thousands of Pacific atolls, and many groups, extending over sea areas of thousands of square miles, consist almost entirely of atolls; among such are the Marshalls and Gilberts in Micronesia, and the Line Islands and the Tuamotus in Polynesia. In Melanesia they are not as a rule so conspicuous, though a number of the Lau Islands in Fiji are atolls.

Atolls may be only a mile or two in diameter, but some may be 50 mi. or more wide: Kwajalein in the Marshalls is about 90 by 20 mi. They are rarely circular and often are highly irregular; rarely also is the lagoon completely enclosed, gaps in the reef being more often on the leeward side. The land area of an atoll is difficult to determine; the dry land consists of elongated patches of coral debris and sand thrown up by the waves (most often, of course, on the windward side) on top of the reef. The reef itself may be broken into several separate islands at high tide, although the tidal range in the Pacific is usually very small, sometimes only one or two feet. These little scraps of land are often measurable in acres rather than square miles, and rarely exceed 20–25 ft. above mean sea level.

The smaller and the more recent atoll islets offer little inducement for human occupancy. They have little soil or fresh water, and their economic importance is mostly as sources of guano or sites for airfields (*e.g.* Canton and Howland islands). Many islands, however, have somewhat more soil and some fresh water and, with the foods from sea and shore, they can support limited populations. Relatively few, such as those in the Gilberts, have sufficient soil (in part formed artificially, by a sort of composting in trenches cut in the limestone rock) to grow crops such as taro and bananas. (*See* also ATOLL.)

3. Climate.—The vast majority of the Pacific Islands lie within the tropics; in the northern hemisphere only the string of reefs extending northwest of Hawaii from French Frigate Shoals to Midway Islands, and in the southern only the Kermadecs, some of the Tubuai group, Pitcairn with its adjacent islands, and Norfolk Island and Easter Island, are outside these limits. North, east, and southeast is unbroken ocean—it is about 3,500 mi. from the Marquesas to South America—and there is no land mass within the Pacific large enough to create more than local land and sea breezes. Except in the west and southwest, where the proximity of Asia and Australia produces some monsoonal effect, no other part of the world approximates so nearly to the ideal planetary circulation of winds and currents on a rotating globe.

The major pressure elements are the doldrums low-pressure belt along the thermal equator and the subtropical highs of the eastern Pacific. The highs are normally centred between Hawaii and California and between Easter Island and Chile; from them the trade winds (*q.v.*) flow toward the equatorial low pressure, being deflected by the earth's rotation so that they blow from the northeast in the northern and the southeast in the southern hemisphere. The doldrums rarely form a definite belt of calms, but are marked by light variable winds; in the eastern Pacific they are never south of the geographical equator, but they do shift to the south of it in Melanesia during the southern winter. From about longitude 140° W to 180° W, and sometimes a few degrees beyond, the doldrums belt of calms is narrow or virtually absent. Indeed, the two trade winds actually meet along the intertropical front, which varies from about latitude 2° N to 10° N, reaching higher latitudes in the northern summer. Then the trades may be almost easterly, and since their air masses naturally vary in temperature, density, and water content, fronts are formed in which warmer and moister air is undercut by the denser air mass; considerable turbulence and heavy rain may result.

In the west and southwest this pattern is somewhat distorted by the seasonal reversals of temperature and pressure over the land masses which create the Asian and the weaker Australian monsoons. In the northern summer there is a strong indraft into eastern Asia, and over all the island groups west of about longitude 160° E (the Carolines, Marianas, etc.) southeasterly or southerly winds prevail. The Australian land mass has a similar effect in the southern summer, but it is much weaker and has little influence east of the Solomons.

Tropical Cyclones.—In general, the trades are not really strong winds, but rather moderate breezes (13–18 mph), and indeed in subequatorial latitudes not that strong. Most of the area, however, except within 3–4° on either side of the equator, is subject to occasional violent cyclonic storms, generally termed hurricanes or (in the western area) typhoons. The major areas of origin ap-

pear to be in the general region of the Carolines in the northern summer, and along the parallel of latitude 10° S between longitudes 160° E and W, in the southern. Their tracks are generally roughly westward at first, and then curve around to the north and northeast in the northern and to the south and southeast in the southern hemisphere. There is a subsidiary area of origin off the Mexican coast.

The centres of hurricanes do not move rapidly (10–30 mph), but the spiral winds around them reach destructive force, often up to 60–75 mph; winds of 150 mph have been recorded. As practically all buildings in the Pacific Islands (except in Honolulu) are of light construction, and bush and tree crops are staples in most islands, the devastation can be extremely severe, especially on low atolls. Very heavy rain (up to 20–25 in. in 24 hr.) also occurs; and so-called tidal waves associated with hurricane disturbances can reach up to 40 ft. or more. Against the destruction caused must be placed the facts that the belt of really high intensity is narrow, and that a much wider belt receives good rain. The Pacific Island groups rarely receive more than two or three severe storms a year, as against nine or ten in the Philippines and Japan. (*See* TROPICAL STORM.)

E. AUBERT DE LA RUE

GRASSLANDS ON EROMANGA ISLAND, NEW HEBRIDES

Temperature and Rainfall.—Sea and air temperatures are fairly uniform in the tropical Pacific. Along the equator (except in the extreme east under the influence of the cold Humboldt current) sea temperatures are 27.8–28.3° C (82–83° F) all the year, decreasing to about 21.1° C (70° F) toward the tropics. As a rule, the islands have mean temperatures between 21.1° C (70° F) and 26.7–29.4° C (80–85° F); annual range is negligible at the equator and not more than about 5.6° C (10° F) anywhere. Daily ranges, usually between 5.6° and 11.1° C (10° and 20° F), are more important, and on the larger islands are influenced by local land and sea breezes. In these islands, moreover, altitude can make an appreciable difference to temperature.

Rainfall is much more variable, both seasonally and in geographical distribution. In the high islands the direction of exposure is extremely important, and the slight shifts of the trade winds with the movement of the thermal equator are sufficient to produce distinct seasonal changes. Thus Suva, on the southeast (windward) side of Viti Levu in Fiji, has about 120 in. annually, with a maximum of 15 in. in March and a minimum of 5 in. in June; while Lambasa, on the leeward side of the next largest Fijian island (Vanua Levu), has only 80 in., with four months (June through September) having 2–3 in. each. In the Hawaiian Islands the contrasts are even more striking; there the windward slopes are on the northeast, where at high levels annual totals of 200 to 400 in. are common; but on low ground on the leeward side the annual rainfall is under 20 in. Generally speaking, north of the equator most rain falls in June through October, south of it from November to April; but there is much variation. Low islands may receive only a few inches a year except in hurricane years; as these islands are usually composed either of coral limestone or sand, there is not likely to be any surface water.

The tropical Pacific usually has fairly clear skies. However, thunderstorm frequency is high, particularly in Melanesia and western Polynesia, and much of the rainfall is associated with convectional thunderstorms.

4. Soils.—The soils of the high islands are much more varied than those of the coral islands, not only because of the greater range of minerals in the volcanic parent rock, but because such islands generally have a less uniform environment. Many steep slopes and recently formed lava fields have little or no soil. Usually, the greatest fertility is found in some areas of recent volcanic ash deposition, and (in larger islands) in small alluvial flood plains and deltas, where a great variety of soil constituents may be mingled. In hot, humid environments leaching is active; and although fully developed laterite is not common, semilateritic soils are; *e.g.*, in New Caledonia.

Coral islands, raised or atoll, are deficient in mature soils. There may be a few inches of plant debris and humus, of low fertility, but the permeability of the underlying coral rock reduces soil moisture, while on low islands both ground water and subsoil are likely to be saline. In a sense, the only important plant nutrient is phosphatic guano, and as that depends on the droppings of birds on practically uninhabited and arid islands, it is of value only when transported elsewhere.

5. Vegetation.—There is no particular difficulty in accounting for biological distributions in the continental islands of the southwest Pacific, since they have at times been linked to the Asian land mass. As late as the Pleistocene, when the abstraction of sea water into the ice caps resulted in a general lowering of sea level of the order of 300 ft., water barriers in this area were narrow. The spread of plants and animals to New Zealand and the remoter islands, however, presents more problems. Biologists have been wont to postulate a series of land bridges to an extent which geologists find bewildering, if not indeed altogether inconsistent with isostasy. Winds and currents have certainly played a large part in the dispersal of the vegetation and animal life, but their precise role is still disputed.

In general, the vegetation is distinctly Indo-Malayan. New Guinea seems to have been a centre of distribution, and some of the oceanic islands have maintained or evolved endemic species and even genera; for example, about 80% of the 2,500 species of flowering plants in New Caledonia, not strictly an oceanic island, are endemic. The vegetation is richest in the west and on larger high islands; the American component is slight. All this has also some bearing on the vexed question of human origins and movements within the Pacific, and tends to confirm the generally accepted view that the distant affinities of the Polynesians are to be found in the Malaysian region.

Strand Vegetation.—This is probably the most widespread type,

being the only vegetation on nearly all the low islands and an important element on the high ones. It is, naturally, halophytic (salt-tolerant) and consists of plants whose seeds can survive long periods of flotation in seawater, or can be transported by winds or birds. The coconut is an example of the former group, though its ubiquity is mainly attributable to artificial planting; other widespread plants are screw pines (*Pandanus*), casuarinas, cycads, hibiscus, and various creeping vines. The number of species is small. This strand vegetation is generally rather open bush or on low dry islands even a coarse heath; but in islands with high rainfall it may form jungly thickets with heavy undergrowth.

Tidal Vegetation.—In the west, nipa palms form a dense border to tidal creeks in the brackish zone; mangroves are more important and have a wider range. They cover very large areas in New Guinea and are still conspicuous in Fiji, but are not found east of Samoa except where artificially introduced, as in Hawaii.

Rain Forest.—The original vegetation of the wetter windward sides of most of the high islands is a dense tropical evergreen forest, with a large number of species. The larger trees have typically buttressed trunks, and the margins of the forest, accessible to sunlight, have a dense undergrowth of palms, bamboos, rattans, tree ferns, and shrubs. In the west, orchids and other epiphytes, including the well-known staghorn fern, are common. In New Guinea large, swampy lowland areas are occupied dominantly by sago palms.

Secondary and Other Forests.—On drier slopes, rain forest is replaced by a more open tropical forest; where this (or even rain forest) has been destroyed, it is succeeded by a dense scrub with a few taller trees. In the curious dry zone around Port Moresby in Papua, there is a very open grove of the woodland eucalypt-like *Melaleuca*, a clear expression of Australian affinities; but in the higher ranges New Guinea also has commercially exploitable forests of araucaria pines. Another species of *Araucaria*, the Norfolk Island pine, is now dispersed in other subtropical countries as an ornamental tree. At moderately high levels there may be cloud or elfin forest of dwarf trees with much epiphytic growth and long, dangling tree mosses.

Grasslands.—There are relatively considerable areas of grassland in some of the larger high islands. Their origin is doubtful, though repeated clearing and burning (for gardening, to drive game, and to facilitate the search for edible wild roots) has at least expanded these areas, as in the *talasiga* ("burnt land") of Fiji. The same is probably true of the really extensive tall-grass savanna of the central highlands of New Guinea.

In a few cases, as in New Guinea and Hawaii, the mountains extend above the zone of maximum relief rainfall and carry only a dry scrub or heath. There are also, in damper areas, limited peaty bogs.

6. Animal Life.—The nonintroduced vertebrate fauna of the Pacific Islands is very small: bats, rats (probably accompanying human migrations), a few small lizards, and amphibians fill up the list for the more oceanic islands; a few snakes are found in Fiji and Samoa and are more numerous in the Solomons and New Guinea. The latter island has crocodiles and many small marsupials, including wallabies.

Introduced mammals are much more important. Since the 18th century the pig has achieved a central position in the cultural life of many tribes; *e.g.*, in the New Hebrides and New Guinea. Cattle are important in some islands, and the mongoose is common in the cane fields of Fiji.

The bird life of the islands is much more rich and varied, and endemic species are common in the central Pacific. Farther west in Melanesia the birds resemble those of southeast Asia. Among the notable varieties are birds of paradise, frigate birds, and parrots.

Among land invertebrates most interest attaches to the mollusks; in the high islands there are many endemic forms of land snails. Introductions include the extremely destructive giant snail, brought by the Japanese for food to New Britain during World War II and still, despite energetic repressive measures, a menace to bush crops.

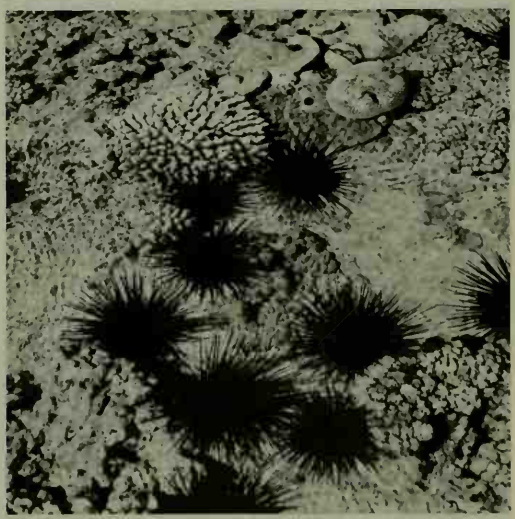
The insects are numerous. The most important are perhaps the mosquitoes. Of these, *Aedes aegypti* is fairly common, although yellow fever, of which it is a carrier, has never reached the islands; but malaria and its carrier *Anopheles* are found in most of Melanesia, though not in Fiji or Polynesia. The imported rhinoceros beetle is a serious pest of coconut palms.

The fish population of tropical Pacific waters is large in numbers of species, but (as in tropical forests) commercial exploitation is limited by the scattering of species. Even so, much more could be done to develop Pacific fishing, both for export and for local consumption, especially in some of the high islands. But the exploitation of marine invertebrate fauna is probably more important than in any other part of the world except Japan. Among its products may be mentioned pearls, pearl and trochus shell, various crustacea, and the sea slug, dried and exported as trepang, or bêche-de-mer (*q.v.*), to Chinese communities. Pearling and the bêche-de-mer trade were of considerable historical importance, as was whaling, in the 19th century; the tortoiseshell industry is still of some significance in the tourist trade.

7. Mineral Resources.—The geological setting of the Pacific Islands is not favourable to mineralization. Only the larger continental or semicontinental islands have metal ores of any significance, and not then on a world scale, except perhaps for the nickel of New Caledonia.

New Guinea has rich alluvial goldfields in the Wau-Bulolo area, so rich that soon after their discovery in the late 1930s it was profitable to bring in heavy dredging equipment by air. Though still productive, the goldfields are a wasting asset, and the gold companies are insuring their future by investing in timber exploitation of the adjacent araucaria forests. There are small deposits of copper and other base metals, and at the western end of the island in the Vogelkop Peninsula, a small oil field; but prolonged prospecting has not yet struck payable oil in Australian New Guinea. Fiji has one large gold mine and some intermittent small-scale manganese mining. Bauxite deposits are found in the high islands of the Carolines (Babelthuap, Yap, Ponape); those on Babelthuap are the most important, and were mined by the Japanese.

New Caledonia is the only really important mineralized area. The production of nickel (locally refined into matte) and chromium from its metamorphic rocks is substantial, and there are deposits, hitherto little exploited, of cobalt, silver-lead-zinc, manganese, antimony, and copper. There is also some coal, but this



E. AUBERT DE LA RUE

HATPIN URCHINS AND COLONIES OF CORAL ON RAROIA ATOLL IN THE TUAMOTU ARCHIPELAGO, FRENCH POLYNESIA

is too poor for smelting; and low-grade iron ore, at present not commercially exploitable.

In the low islands the one important mineral is phosphate rock, which is extracted from several islands, most notably Ocean Island, Nauru, Angaur in the Carolines, and Makatea.

II. ANTHROPOLOGY

Despite the theory of an American origin for much of the culture of the Pacific Islands, popularized by Thor Heyerdahl after his remarkable voyage (1947) from Peru to the Tuamotus on the raft "Kon Tiki," practically all authoritative students of Pacific anthropology hold that there can be little doubt of a southeast Asian origin for the peoples of the Pacific and their cultures. Nevertheless, much or most of the earlier history remains speculative, and reconstructions of oral tradition and interpretations of myth may often have been at once too liberal and too literal.

Of the three great zones into which the Pacific is divided, Melanesia seems to present the most problems from an ethnic point of view. Its languages, although (with a few exceptions) ultimately belonging to the Austronesian family, as do those of Polynesia and Micronesia, are more archaic and much more differentiated among themselves, while racially there seem to be at least three distinct and ancient stocks (Negrito, Australoid, and Negroid). Melanesians are usually much darker in skin colour and with much curlier hair than Polynesians and Micronesians, and perhaps have a somewhat wider range of social structures but an even greater degree of political fragmentation and tribal particularism (*see* MELANESIA). Melanesia includes New Guinea and the larger semi-continental islands of the southwest Pacific as far as Fiji; in the eastern part of Fiji (the Lau group), Polynesian—specifically Tongan—influence is strong, though much of this dates only from the 19th century.

Micronesia (*q.v.*), as the name suggests, consists almost entirely of very small islands, from the Marianas and the Palau group to the Gilberts, inclusive. Ethnically, the people are practically pure Polynesians in the east but part Malaysian and part Melanesian in the west. Their material culture is usually severely restricted by the scanty resource base of their islands, but social structures are complex and hierarchical.

The Polynesians were the latest pre-European entrants into the Pacific, which was indeed the last major area of the world to be occupied by man. It seems likely that their final dispersal, as far as New Zealand, took place in the 9th–13th centuries A.D. (*see* POLYNESIA). The eastern Polynesians show linguistic differences from those of the more western groups (Ellice Islands, Samoa, Tonga), and both New Zealand and Hawaii seem to have been settled from the Marquesas and Tahiti. The Polynesians are often light-skinned and strikingly handsome by Western standards, and show a remarkable degree of linguistic and cultural similarity, attributable in part to the shorter duration of their occupation.

Although social custom, family and kin structure, governmental systems, and all the intangibles of life (except perhaps the Polynesian myths) were extremely diversified, the material basis and organization of life in the islands showed a striking uniformity. Basically, all the peoples were subsistence gardeners, with roots such as yams and taros, and tree products such as coconuts and breadfruits as the main vegetable staples. Fishing was of great importance to all within reach of the sea, which included nearly all tribes except those of the interior of New Guinea and a few of the larger Melanesian islands. The rapid spread of the pig, introduced by 18th-century explorers, to a central cult position may have derived from the fact that it appeared to be a heaven-sent source of much-needed protein. The arts of basketry and weaving, but not of pottery, reached a high level of development among many peoples. Tools were of wood and stone; where good stone was not available, sharks' teeth and shell were used for cutting tools. Many of the Pacific peoples were admirable boatbuilders and skilled navigators. *See* OCEANIA.

III. HISTORY

The European phase of Pacific history (for the protohistory, *see* OCEANIA; POLYNESIA) begins with Ferdinand Magellan's crossing in 1520–21; but this, and the search for Terra Australis by Alvaro de Mendaña and Pedro de Quiros (between 1567 and 1607), were less practically important than the development of the islandless "silver galleon" route between Mexico and the Philippines. The Dutch discovered little, except from the voyage of Abel Tasman (*q.v.*) to Fiji and New Zealand (1642–43), and at the end of the 17th century Oceania was almost as unknown as Australia.

1. Exploration and Exploitation.—The 18th century was the great age of scientific exploration in the Pacific, and after the voyages of John Byron, Samuel Wallis, Philip Carteret, L. A. de Bougainville, and above all, James Cook, the major features of most of the island groups were known, though much detail remained to be filled in. The immediate effect of these explorations was intellectual rather than economic. Reports and reflections on the manners and customs of the islanders, seemingly so free, natural, and noble, contributed powerfully to the half-romantic, half-rationalist ideology of the Encyclopaedists and the school of Jean Jacques Rousseau.

By the last quarter of the 18th century, British whalers, and in its last decade Yankee traders sailing to Canton, were becoming increasingly familiar with the islands. Sandalwood and bêche-de-mer were in much demand in China, and large quantities were exacted from islanders by force and fraud until the sandalwood was worked out. Continuing for a longer time and probably even more violent in its impact was U.S. and British whaling. The foundation of Sydney in 1788 and Hobart in 1804 gave the British good bases for both whaling and sealing in subantarctic waters; but New Englanders were always in the lead (even in Australia their camps preceded British settlement in places). Early bases were in the Marquesas and Society islands, later ones in Hawaii and New Zealand; the general lawlessness of the whaling and trading posts in New Zealand forced a reluctant British government to establish political control by 1840. Tribal warfare became far more savage as the more adroit chiefs cooperated with traders to obtain guns;

E. AUBERT DE LA RÜE

SUGARCANE FIELD ON A FIJIAN ISLAND

in New Zealand even a curio industry in smoke-dried tattooed heads grew up. But syphilis, other diseases, and rum probably killed more than did direct violence.

2. The Christian Missions.—Early Spanish missionary work in the western Pacific was scarcely influential beyond the Marianas, and for Oceania in general Christian effort began with the London Missionary Society's expedition to Tahiti in 1797. The next half century saw the heyday of the Evangelical movement in England, and by 1845 the gospel in Protestant versions had been brought, with more or less success, to most major island groups. Most of the missions were English, but in Hawaii U.S. missionaries were dominant from the start. The first French Roman Catholic mission, to Hawaii in 1827, found the ground preempted by the Boston mission; but in the 1840s the Catholics, backed by French naval power, secured hitherto Protestant Tahiti; mission influence played a strong part in the French annexation of New Caledonia in 1853. Mission rivalries in the Pacific were a distinct, though minor, factor in Anglo-French tensions in the 1840s; the frigate's flag followed the creed to an extent embarrassing to later and more tolerant mission chroniclers.

Mission influence has been extravagantly praised and decried. Lack of support from home sometimes almost compelled missionaries to give more energy to such mundane enterprises as planting and trading than to the gospel. They sought to convert chiefs who would then coerce their followers to convert, and it cannot be questioned that some acted as agents for their home countries and that others were corrupted by power. Their ruthless attacks on all aspects of heathenism (which gave the islanders most of their cultural and psychological satisfactions) may have been essential to success but must have contributed to the apathetic fatalism and the loss of interest in life so widely noted later in the century. Yet, though self-seeking was not absent, the missions did in the last resort destroy evil as well as harmless customs; with some success they fought against the subversion of native life by alcohol and firearms, and they were tireless in publicizing and protesting against the evils of the labour trade. Except in New Guinea, almost all the Pacific peoples are now Christians, and despite definite cultural losses it is fair to say that their life has been reintegrated on different terms. That the new integration is not entirely complete or balanced, however, is shown by the frequency—especially after the traumatic experiences of World War II—of messianic and millenarian outbursts and Cargo cults (*q.v.*).

3. Copra and Colonialism.—The period of the American Civil War saw the rise of the Pennsylvania oil industry and the concomitant decline of whaling, which was also hard-hit by the activities of Confederate cruisers. But it also saw a short-lived cotton boom in some islands such as Fiji and the development of dried coconut (copra) as one of the world's main sources of vegetable oil. Later, other plantation products (especially sugarcane in Fiji and Hawaii) became important, but for a century copra has dominated Pacific economics. Even when copra was grown by the islanders themselves the white trader had a key role as middleman; and after about 1860–65, large areas of the best land in the islands passed into European hands, often by very dubious means.

The islands then began to have an intrinsic economic value. The European and American population was increasing, and problems of law and order were too complex and pressing to be left to consular officials backed up by naval officers when the latter happened to be about. Moreover, blackbirding (the traffic in indentured labour for Queensland sugar plantations and Peruvian guano mines) was accompanied by scandalous abuses. Pacific guano islands themselves were so valuable that the United States and other countries legally recognized a sort of private-enterprise annexation (they were mostly uninhabited), and the general increase in commerce made cable and coaling stations desirable.

Some attempts were made to establish indigenous kingdoms, which often represented the interests of a particular mission or trader group. Of these, Fiji lasted only a few years until 1874; Hawaii, the best-founded kingdom, survived till American planting and trading interests overthrew it in 1893; Tonga alone remains. By the 1880s, the rivalry between Britain, the United States,

E. AUBERT DE LA RÜE

TARO PLANTATION ON AN IRRIGATED ALLUVIAL PLAIN, AT THE FOOT OF A HIGH CORAL CLIFF, RURUTU ISLAND, FRENCH POLYNESIA

France, and Germany was acute. To some extent, however, the Pacific Islands were the small change of colonialism, claims there being good barter for more serious demands in Africa, the main focus of imperial interest; hence the political fragmentation of the Pacific. By 1900, after the Spanish-American War, all the Pacific had been parceled out between these four powers.

4. The 20th Century.—In the last quarter of the 19th century, however, a new factor entered the situation, in the rise of minor powers—Australia and New Zealand—in the Pacific itself. Both entertained notions of a manifest destiny to the north which at times embarrassed the U.K. government with its wider interests; both were extremely suspicious first of French and later of German expansions in the Pacific. In 1914, Australia seized German New Guinea, and New Zealand occupied German Samoa. At the same time Japan took the groups north of the equator (Marianas, Carolines, Marshalls) which had been bought by Germany from Spain in 1899. These countries retained their seizures, as League of Nations mandates, after 1919. The final and most dramatic act in Pacific history opened with the Japanese attack on the U.S. at Pearl Harbor in 1941; at the end of this war of the Pacific—the first truly oceanic war in history—the entire ocean became virtually a U.S. sphere of influence.

In the postwar world, the very limited resource basis of most of the island groups makes their economies precarious; even the possession or lack of an airport suitable for jet airplanes can shift the balance of the increasingly important tourist trade. Normal economic development must face the heavy costs involved in long transport hauls for relatively small consignments.

Nevertheless, the islands are not altogether exempt from the growing pains of nationalism. Although Australian and Dutch policies in New Guinea tended toward self-determination, and perhaps federation or union, for the whole island, Netherlands New Guinea (Irian Barat) was in 1962 transferred to United Nations jurisdiction in preparation for handing over to Indonesia in the following year. In French Oceania there is at least an incipient nationalism and anticolonialism, complicated in New Caledonia by the presence of a long-settled French minority numbering one-third of the total population. While Western Samoa made orderly progress from New Zealand trusteeship to independence in 1962,

political development in Fiji was inhibited by the conservatism of Fijian leadership, with its fears of domination by the economically more active Indian majority.

IV. ADMINISTRATIVE GROUPINGS

Considering that the total land area and population of the Pacific Islands (excluding New Guinea) are less than 65,000 sq.mi. and 2,000,000 people, their political geography is somewhat complex. This arises from the piecemeal acquisitions and conflicting claims of the colonial powers. Few groups have ever had an adequate census; populations of these small units may suffer drastic and sudden changes as a result, for example, of military movements; and it is difficult indeed to compute the land areas of thousands of scraps of land, many of them uninhabited and crudely (if at all) surveyed. These considerations must be borne in mind in referring to the table.

1. New Guinea.—This great island, in many ways a physical and cultural unit, is under three administrations. The portion west of 141° E began to come under effective Dutch control by about 1900, but the Dutch title was challenged by Indonesia, which claimed it as an integral part of the former Netherlands Indies, despite its strong ethnic differences from the rest of Indonesia. It passed to Indonesian sovereignty in 1963. Papua was annexed by Queensland in 1883, to forestall suspected German designs, but the annexation was disavowed by the British government until its hand was forced by the German annexation of northeast New Guinea and the Bismarck Archipelago in the next year. Papua was transferred to Australian control in 1906, and German New Guinea was seized by Australian forces in 1914. After World War I it became an Australian mandate, and after World War II a United Nations trust territory. Australia presents separate reports on its development to the UN, but for practical purposes it is united with Papua and controlled by the Department of Territories in Canberra. It includes Bougainville (*q.v.*), Buka, and Green Islands in the northern Solomons. (*See* NEW GUINEA.)

Nauru has a similar history of German and Australian occupation. An important source of phosphates, it is administered by Australia although the UN trusteeship is vested jointly in Australia, the United Kingdom, and New Zealand.

2. British Territories.—Control of the Solomons was divided between Germany and Great Britain in 1886, and British control was established by 1893; the protectorate includes the Santa Cruz group north of the New Hebrides and also the isolated island of Tikopia, classic ground to anthropologists but so rarely visited that it might as well be independent. (*See* BRITISH SOLOMON ISLANDS PROTECTORATE; SOLOMON ISLANDS.) Fiji (*q.v.*) was annexed in 1874; it includes the Polynesian island of Rotuma about 400 mi. N.

Administratively, some of the Phoenix and Line islands are attached to the Gilbert and Ellice islands (*q.v.*) colony, including Fanning Island, Washington Island, and Christmas Island (*q.v.*), the largest Pacific atoll, covering about 234 sq.mi. of which 94 are dry land. Of the Line Islands not contained in the colony, the minor and usually uninhabited guano islands of Caroline, Flint, Malden, Starbuck, and Vostok are administered by the Western Pacific High Commission. In the Phoenix Islands, Canton Island is of some importance as a way station on transpacific air routes.

3. United States Territories.—Areas controlled by the United States, except for Hawaii (*q.v.*), are of primarily strategic interest. Hawaii was an independent kingdom, but increasingly strong U.S. interests set up a caretaker republic in 1893–94 pending annexation in 1898, an indirect result of the Spanish American War. In 1959 Hawaii became the 50th U.S. state. U.S. control of the Philippines after the Spanish-American War necessitated the acquisition of Wake Island and Guam (*qq.v.*), the latter ceded by Spain in 1898, as bases on the route to Manila. In 1899 the Caroline Islands (*q.v.*), the Marianas, and the Marshall Islands (*q.v.*) were purchased from Spain by Germany (which already claimed Yap in the Palau group of the Carolines and the Marshalls). These three groups were seized by Japan in 1914 and in 1919 became a Japanese mandate under the League of Nations; after World War II the U.S. took over their trusteeship under the UN. American Samoa was acquired by treaty in 1899 after the whole group had been under joint U.S., British, and German control since 1889. (*See* SAMOA ISLANDS.)

In the central Pacific, the United States occupies, solely or jointly, several minute islands which were of negligible interest, except for guano, until the 1930s, when they became of considerable value as way stations for aircraft flying between Hawaii and the southwest Pacific. Of these, Baker, Howland, Jarvis (*qq.v.*), and Johnston (this last acquired as a guano island in 1858), with Kingman Reef and Palmyra Island at the northern end of the Line group, are indisputably American; the rest of this group, from Malden to Flint islands, are

Administrative Groupings of Pacific Islands

Territory	Area (in sq. mi.)	Population (in 1960 unless stated)	Capital	Political status and remarks
New Guinea				
West Irian (Irian Barat)	160,000 (approx.)	735,000	Kota Baru	Ceded to Indonesia (1963)
UN Trust Territory of New Guinea	93,000	1,402,000	Port Moresby	Administered with Papua by Australia.
Papua	90,540	503,000	Port Moresby	Australian external territory
Nauru	8	4,539 (1961)	—	UN trust territory, administered from Canberra for Australia, New Zealand, and U.K.
United Kingdom territories				
British Solomon Islands Protectorate	11,500	123,956 (1959)	Honiara	Protectorate
Gilbert and Ellice islands	369	45,600	Tarawa	Crown colony; includes Christmas and Ocean islands, Phoenix Islands and some of Line Islands
Fiji	7,055	401,018	Suva	Crown colony; includes Rotuma
Pitcairn Island	2	148	Adamstown	Colony by settlement
United States territories and administrations				
Hawaii	6,415	632,772	Honolulu	Became 50th state of U.S. in 1959
Wake Island	3	1,097	—	U.S. naval and air base
Guam	212	67,044	Agana	Unincorporated territory
Mariana Islands	184	9,300 (1961)	Saipan	Forming UN trust territory of the Pacific Islands. Divided into administrative districts of Marshall Islands, Palau, Ponape, Rota, Saipan, Truk, and Yap. Central administration from Guam
Caroline Islands	461	53,214 (1961)	—	
Marshall Islands	70	15,399 (1961)	Majuro	
American Samoa	76	20,051	Pago Pago	Unincorporated territory
Anglo-American condominium				
Canton and Enderbury islands	27	320	—	
French territories				
New Caledonia	7,298	77,000	Nouméa	Includes Wallis and Futuna islands, Loyalty Islands and other dependencies
French Polynesia	1,448	76,000	Papeete	Oversea territory. Includes Society, Tuamotu, Gambier, Tubuai (Austral) and Marquesas islands, and Clipperton Island
Anglo-French condominium				
New Hebrides	5,700	60,400	Vila	
New Zealand territories				
Cook Islands	93	18,369 (1961)	Avarua	
Niue	100	4,868 (1961)	Alofi	
Tokelau (Union) Islands	4	1,870 (1961)	—	
Kermadec Islands	13	10 (1961)	—	Part of New Zealand; meteorological and air-radio station
Other territories				
Western Samoa	1,137	107,000	Apia	Former UN trust territory; independent in 1962
Tonga Islands	270	63,000	Nukualofa	Independent kingdom under British protection
Easter Island	46	600 (1955)	—	Part of Valparaíso province, Chile

SCENES IN THE PACIFIC ISLANDS

Ancient rice terraces in northern Luzon in the Philippines

An islander weaving paroli into strips to be used for roof of home on Maupiti

Fish are herded with nets woven of palm fronds in a lagoon on Palmerston in the Cook Islands

A long curving beach on Buna, New Guinea

St. Paul's rocks on Pitcairn Island

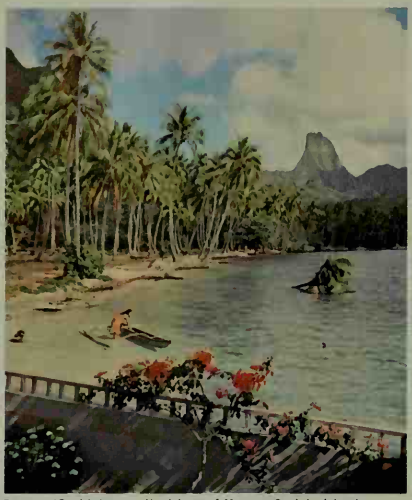
Detail of roof construction for a Polynesian house in Samoa

PHOTOGRAPHS, (TOP LEFT) ED OREWS—PHOTO RESEARCHERS, INC., (TOP RIGHT) SHOSTAL, (CENTRE RIGHT) STEVE CROUCH FROM SHOSTAL, (CENTRE LEFT, BOTTOM LEFT) R. C. KREINER—PHOTO RESEARCHERS, INC., (BOTTOM RIGHT) GEORGE HOLTON—PHOTO RESEARCHERS, INC.

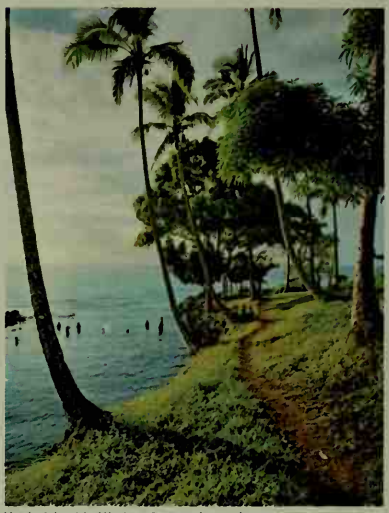
PACIFIC ISLANDS

SCENES IN THE PACIFIC ISLANDS

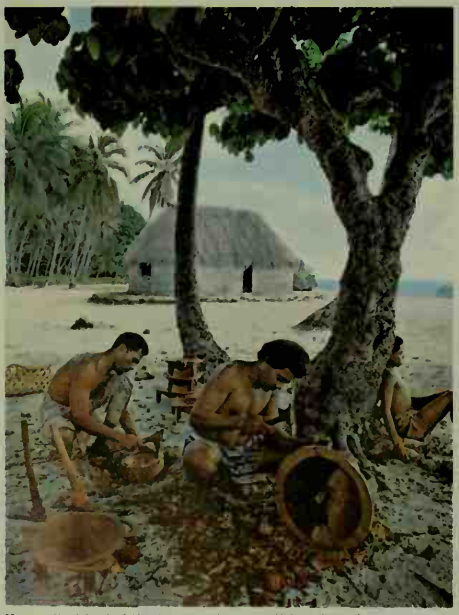
A beach in American Samoa



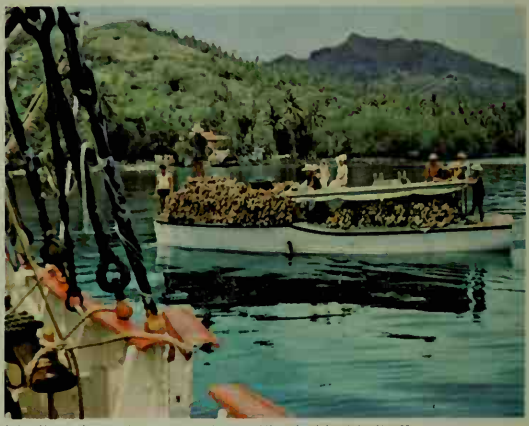
Paopao (Cook) bay on the island of Moorea, Society Islands



Upolu Island in Western Samoa at sunset



Men on the island of Kambara, or Kabara, Fiji Islands, making ceremonial drinking bowls



A boatload of wood in Taa Huku bay on Hiva Oa Island in the Marquesas

PHOTOGRAPHS: (TOP LEFT) GEORGE HOLTON—PHOTO RESEARCHERS, INC.; (TOP RIGHT) FREDA CLOSS FROM SHOSTAL; (BOTTOM LEFT, CENTRE) JOHN LEWIS STAGE—PHOTO RESEARCHERS, INC.; (BOTTOM RIGHT) R. C. KREIMER—PHOTO RESEARCHERS, INC.

claimed both by Britain and the United States. More important are Canton Island (*q.v.*) and Enderbury in the Phoenix group; by agreement, these were to be under joint Anglo-American control for 50 years from 1939. There are also American installations on Funafuti in the Ellices.

Farther north the United States also holds Midway at the extreme northwest of the Hawaiian chain (annexed 1867) and Marcus (1,000 mi. NW of Wake), originally annexed by the Japanese in 1899 as a cable base.

4. French Territories.—These comprise the large island of New Caledonia (*q.v.*), annexed in 1853 and from 1864 to 1894 used largely as a penal colony; and farther east French Polynesia (*q.v.*) acquired piecemeal after 1842. The Marquesas and the Society islands, of which Tahiti (*q.v.*) is the largest, are the chief units. French influence also predominates in the Anglo-French condominium of the New Hebrides (*q.v.*), which after 20 years of ineffective control by a joint naval commission acquired its present status in 1906.

5. New Zealand and Other Territories.—New Zealand took possession of the Cook Islands (*q.v.*) and Niue in 1901. Western Samoa, German since 1899, became a mandate and later a UN trust territory under New Zealand administration, obtaining independence in 1962. The modern kingdom of Tonga (*q.v.*) was formed under missionary influence in 1845 and accepted British protection in 1900; it is the only survivor of the three attempts at consolidating an indigenous monarchy in the Pacific, the others being Fiji and Hawaii.

6. Western Pacific High Commission.—In the early days, governmental responsibilities in the Pacific Islands were formally undertaken by European traders and planters. Between them and the indigenous people stood only consular agents, backed up by naval officers with roving commissions. Special commissions were granted to high colonial officials; for instance Sir Hercules Robinson, 1st baron Rosmead, governor of New South Wales in 1872–79, negotiated the cession of Fiji to the British crown (1874). To overcome the obvious shortcomings of the old system insofar as British subjects were concerned, a high commissionership for the western Pacific was set up in 1877. Its jurisdiction excluded the self-governing colonies of Australia and New Zealand (and, later, territories controlled by them such as Papua, New Guinea, and Western Samoa) and—significantly in view of its origins—any territories "being within the jurisdiction of any other civilized power." Until 1952 this post was always held by the governors of Fiji, but it was then made a separate office and its headquarters transferred from Suva to Honiara in the Solomons.

The commission exercises a general supervision over administration in the Gilbert and Ellice islands and the Solomons, and the British side of the Anglo-French condominium in the New Hebrides. Relations with British-protected Tonga and the affairs, such as they are, of Pitcairn are, however, still supervised from Suva. The high commissioner's court was in 1962 replaced by a high court of the western Pacific, which has the functions of a superior court of record. The funds of the commission are provided jointly from the revenues of the Gilbert and Ellice islands colony and the British Solomon Islands Protectorate, with a U.K. contribution in respect to the New Hebrides.

7. South Pacific Commission.—The patent impossibility for the small, poor, and fragmented island administrations to provide adequate research and welfare for problems which are often common to most groups, led the Australian government to propose a South Pacific Commission, which was formed at Canberra in 1947. The governments of Australia, France, New Zealand, the U.K., and the U.S. are members on behalf of their various holdings. The seat of the commission is in Nouméa, New Caledonia. The commission undertakes research on economic, biological, medical, educational, and social problems affecting the Pacific peoples, and to some extent acts on behalf of UN agencies (Food and Agriculture Organization; World Health Organization; United Nations Educational, Scientific, and Cultural Organization). It cannot undertake executive action, but disseminates the results of research both on a technical and a popular level. Each member country appoints two delegates to the commission, whose Research Council meets twice a year in Nouméa. The commission also holds a triennial conference of delegates (mostly indigenous) from all the Pacific territories and at various centres to discuss common problems of economic and social development.

V. POPULATION

The material scarcely exists for a general review of population trends in the Pacific Islands. Even where census figures exist, they are usually simply by-products of administration, taken by unskilled officials (Fiji and Hawaii are the chief exceptions). Many figures depend on enumeration by district officers when on tour, and even if the gross numbers are approximately correct, such vital information as age distribution is lacking or vague.

Early observers in all probability grossly exaggerated the numbers of the people. The points at which they made extended stays were often, naturally, important centres of population, and people must have gathered from some distance to see the wonderful strangers. But there can be little doubt that the indigenous populations were much more numerous than they are today; some writers think they may have numbered 3,500,000, or nearly twice the present population, which itself includes many immigrants from Asia. Definite examples of depopulation can be cited; pure Hawaiians probably numbered about 150,000 in 1820 and still exceeded 100,000 in 1836, but by 1853 they had decreased to just over 49,000 and at the 1953 census there were only about 12,000. Within a year after the cession of Fiji (1874) there was a devastating measles epidemic, and the Fijian population fell from 114,748 in 1881 to 84,475 in 1921, after which it rallied to reach 148,134 in 1956. The Marquesas provide one of the most drastic examples: discounting early guesses of 100,000 or even 200,000, a figure for 1813 of 50,000 is thought probably correct; a low point of about 2,000 was reached as late as 1921. By the 1960s there were about 4,000 Marquesans, a decline of more than 90% in a century and a half. Earlier, the Chamorro people of the Marianas had almost vanished, being reduced from about 40,000 to 1,654 in 1964.

Introduced diseases such as smallpox, measles, influenza, and syphilis, to which the islanders had no immunity, were probably the major factor in depopulation; alcoholism was also prevalent in some societies. Losses in battle against the European intruders, while not negligible, were less important than those in intertribal warfare, made far more deadly by the use of guns. The labour trade drew off a large proportion of young adult males, particularly in the smaller Melanesian islands. This disruption of family life was doubtless one factor in the loss of a will to survive and in the abnormally low birthrate (accentuated by a high infant mortality) noted in the later 19th century; another factor was the subversion of highly integrated social codes by the alien ideology and mores of the missions. In the 1880s and 1890s, indeed, many sympathetic observers held that the island peoples, by and large, were on the road to extinction. After being a source of labour for Queensland sugar plantations and Peruvian guano deposits, the islands then became importers of plantation and other labour on a large scale: Japanese, Filipinos, and Portuguese to Hawaii, Tonkinese to New Caledonia and the New Hebrides, Indians to Fiji, and Chinese traders to nearly everywhere.

In the 20th century the decline has been decisively checked. The revival of the Fijians has been noted; on Guam the population increased by 149% between 1901 and 1947 (from 9,676 to 24,139). The most immediately obvious factor in this change is the introduction, under settled administrations, of at least a minimum of medical services. More important, perhaps, has been an increasing self-confidence in coming to terms with the modern world and an increasing participation in modern economic activity. These attitudes are far from complete, and perhaps owe much to administrators more intelligently aware than their predecessors not only of their responsibilities for welfare as well as for economic development, but of the importance of societal factors. The upshot is that whereas at the beginning of the 20th century the demographic problems of the Pacific were seen as problems of depopulation and even race extinction, there is now an increasing concern with overpopulation.

Overpopulation is as yet a pressing problem only in small atolls, such as those of the Gilberts, where the tiny scraps of coral sand cannot support increasing numbers; even before World War II some of the Gilbertese were being relocated in the Phoenix Islands. Other shifts have been necessitated by military needs, as in the evacuation of Bikini, or by economic development, as in the removal of the Banabans of Ocean Island to Rambi Island in Fiji, to make room for the quarrying away of the island for phosphate. The need to make a similar removal of the Nauruans was engaging the Australian government in the 1960s.

Most of the high islands could probably support larger populations than they do now: three of the smaller islands of Fiji, for example, have fewer than 12,000 people on 252 sq.mi., while three West Indian islands, of the same volcanic type in similar latitudes, carry 175,000 people on 251 sq.mi. However, distance from markets and a quite different socioeconomic history render it very difficult for the small and scattered Pacific communities to establish any large-scale modern economies. Thus, without heavy subsidies from outside (which are not likely to be forthcoming), it is difficult to exploit the limited resources to the extent possible with modern technology. It is therefore likely that, with the rapid increase of population that seems inevitable, there will be an increasing pressure on the land; and with the decay of the plantation system, the imported populations may give rise to serious racial complications. This is already the case in Fiji, where Indians outnumber Fijians and are increasing more rapidly. In some cases, also, increasing numbers may face a decreasing water supply; the maintenance of the growing population of Honolulu is already posing severe problems of this type.

See also references under "Pacific Islands" in the Index.

(O. H. K. S.)

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PACIFICO, DAVID (1784–1854), known as DON PACIFICO, gave his name to a celebrated diplomatic interlude in which Viscount Palmerston, then British foreign secretary, acted with characteristic high-handedness. Pacifico was a Portuguese Jew who, having been born in Gibraltar, was a British subject. After serving as Portuguese consul in Morocco (1835–37) and then as consul-general in Greece, he settled in Athens as a merchant. In 1847 his house was burned down in an anti-Semitic riot, the police standing quietly by. Pacifico claimed £4,000 from the Greek government as compensation for the loss of goods and £26,000 for the loss of alleged records of debts owed to him.

Palmerston vigorously supported Pacifico's demands and in January 1850 sent to the scene a British naval squadron which blockaded the Piraeus and seized Greek ships to the value of these and other claims. This action provoked indignation in Britain and elsewhere. Pacifico's reputation was bad and many people suspected that his estimate of damage was grossly exaggerated. Moreover, Britain shared a protectorate of Greece with France and Russia, and should not have acted alone. Palmerston further antagonized the French by allowing the blockade to be resumed after they had negotiated a settlement. The Greeks had to pay the full £4,000, but for the loss of the papers a commission awarded Pacifico only £150. He moved to London, where he died on April 12, 1854.

The incident had its greatest effect in British internal politics. Palmerston's policy was censured by the House of Lords (June 18, 1850) but in the great debate (June 24–28) in the House of Commons, he successfully vindicated his policy and won a majority of 46. His speech concluded with the famous peroration; ". . . as the Roman, in the days of old, held himself free from indignity, when he could say *Civis Romanus sum*" (I am a Roman citizen); "so also a British subject, in whatever land he may be, shall feel confident that the watchful eye and the strong arm of England will protect him against injustice and wrong."

(D. E. D. B.)

PACIFIC OCEAN, the largest division of the hydrosphere, lying between Asia and Australia and North and South America. It is nearly landlocked to the north, communicating with the Polar sea only by Bering strait, the open passage of which is 40 mi. wide and less than 180 ft. deep. The southern boundary was sometimes regarded as the parallel of 66½° S., but this limit is artificial, and it is now considered that the Pacific extends to the borders of the Antarctic continent, exactly as the Atlantic and Indian oceans do. As east and west boundaries in the higher southern latitudes one may take the meridians passing through South cape in Tasmania and Cape Horn. The north to south distance from Bering strait to Antarctica, near Cape Colbeck, is 9,900 mi., and the Pacific attains its greatest breadth between Panama and Mindanao (Philippine Islands), where it measures 10,700 mi. The distance between Yokohama, Jap., and San Francisco, Calif., is about half as great again as that from New York city to Southampton, Eng.; similarly, the distance between Sydney, Austr., and Cape Horn is greater than that from Buenos Aires, Arg., to Cape Town, Republic of S. Af., by fully a half. The coasts of the Pacific are of varied contour. The American coasts are for the most part mountainous and unbroken, the chief indentation being the Gulf of California; but the general type is departed from in the extreme north and south, the southern coast of South America consisting of bays and fjords with scattered islands, while the coast of Alaska is similarly broken in the south and becomes low and swampy toward the north. The coast of Australia is high and unbroken; there are no inlets of considerable size, although the small openings include some of the finest harbours in the world, as Moreton bay and Port Jackson.

The Asiatic coasts are for the most part low and irregular and a number of seas are more or less completely enclosed and cut off from communication with the open ocean. Bering sea is bounded by the Alaskan peninsula and the chain of the Aleutian Islands; the Sea of Okhotsk is enclosed by the peninsula of Kamchatka and the Kuril islands; the Sea of Japan is shut off by Sakhalin Island, the Japanese islands and the peninsula of Korea; the Yellow sea is an opening between the coast of China and Korea; the China sea lies between the Asiatic continent and the island of Formosa, the Philippine group, Palawan and Borneo. Among the islands of the Malay archipelago are a number of enclosed areas—the Sulu, Celebes, Java, Banda and Arafura seas.

The Pacific was first scientifically explored by the great English deep-sea expedition of H.M.S. "Challenger" (1872–76), by the German expedition of S.M.S. "Gazelle" (1874–76) and then by the two United States ships "Tuscarora" (1874–79) and "Albatross" (1888–1905), by the Russian warship "Vityaz" (1887), by S.M.S. "Planet" (1906–14) and others. Many important soundings in the southwest Pacific were made by H.M.S. "Penguin" and a number of British cable ships; in high southern latitudes the "Discovery" (1901–04) carried out many observations. Extensive investigations were made by the Danish vessel "Dana II" (1928–29) in the South Pacific and by the Netherlands H.M.S. "Willebrord Snellius" in the East Indies (1929–30). The non-magnetic vessel "Carnegie" had only partially completed a program of oceanographic exploration when it was destroyed by explosion and fire at Apia, Samoa, in 1929. U.S. naval vessels have accumulated data from Bering strait to Antarctica. Intensive studies have been conducted off the west coast of the United States and Canada by oceanographic, naval and fisheries groups and in the waters surrounding Japan by Japanese naval and fisheries organizations. Under the direction of the British Discovery committee, "Discovery II" investigated the high southern latitudes and "William Scoresby" the waters off the west coast of South America.

Extent.—The area of the Pacific ocean, excluding adjacent seas, is about 64,000,000 sq.mi. and its volume 170,000,000 cu.mi. The Pacific ocean has double the area of the Atlantic—the next

largest division of the hydrosphere—and has more than double its volume of water. Its area is greater by as much as the area of Africa than the whole land surface of the globe, Antarctica included. The total land area draining to the Pacific was estimated by Sir John Murray at 7,500,000 sq.mi., or little more than one-fourth of the area draining to the Atlantic. The few large American rivers draining to the Pacific include the Yukon, Columbia, Fraser and Colorado. The chief Asiatic rivers are the Amur, Yellow river and Yangtze, none of which enters the open Pacific directly. Hence the proportion of purely oceanic area to the total area is greater in the Pacific than in the Atlantic.

Relief of the Ocean Floor.—The more or less symmetrical basin and ridge topography characteristic of the Atlantic is not found in the Pacific. The central Pacific trough, extending from the Aleutian Islands in the north to latitude 60° S. and from Japan to the North American coast, has free communication at depths exceeding 13,000 ft., although numerous elevations and ridges are present. Particularly west of 150° W. many of these elevations extend above the surface as single islands, groups or chains of islands. The West Pacific ridge, which actually consists of several shorter ridges, extends from Japan to Antarctica and is continuous at 13,000 ft. except for small breaks at 11° N. and 10° S. That portion of the andesite line which separates the igneous rock province of the continental blocks of Asia and Australia from that of the central Pacific basin follows this ridge system rather closely.

A broad elevation extends from Central America to the south and west, joining Antarctica in the longitude of New Zealand. This elevation is actually branched so that a series of deep basins are isolated along the Central and South American coasts. These branches also form the northern and western boundaries of the Pacific antarctic basin. The Tuamotu archipelago rises from a western extension of the ridge.

Depths in the great basins are commonly greater than 16,000 ft. but, even in their deepest parts, rarely exceed 23,000 ft. On the other hand, depths in many of the smaller elongated trenches and troughs located near and parallel to continental coasts, island arcs and submarine ridges often exceed 26,000 ft. Some examples of such structure are found along the Central and South American coasts, of which the deepest is Atacama trench (25,050 ft.). Island arcs with deep trenches on their convex sides in the central Pacific trough are the Aleutians, Kurils, Japan, Bonins, Marianas and Tonga-Kermadec. In the western trough are the deep trenches associated with the Ryūkyus, Philippines and Bougainville-New Britain.

Most of these trenches have depths exceeding 26,000 ft., and in at least four of them soundings greater than 33,000 ft. have been obtained. These have been found in the Japan trench by the U.S.S. "Ramapo," in the Philippine trench by the German vessel "Emden," in the Marianas trench by the H.M.S. "Challenger" (the greatest accepted depth of the Pacific is at a point midway between Guam and Yap called Challenger Depth, which has been descended to 35,800 ft.) and in the Tonga-Kermadec trench by the U.S. ship "Horizon." In 1957 the Russian ship "Vityaz" reported a sounding of 35,958 ft. in the Marianas trench and 35,567 in the Tonga depression. The trenches are associated with vulcanism, large gravity anomalies and high seismic activity.

Emphasis on depths exceeding 13,000 ft. excludes many features of interest and importance. Isolated basins cut off from the open ocean but with depths exceeding 13,000 ft. are found in the Sea of Japan, South China sea, Sulu sea, Celebes sea, Banda sea, Coral sea and Fiji basin. Partially isolated basins occur in the Bering sea, Caroline basin, New Hebrides basin and east Australia basin.

MAJOR TRENCHES, BASINS, RIDGES, AND PLATEAUS OF PACIFIC OCEAN FLOOR

Islands are numerous to the west of 150° W., and most of these have volcanic cores, although in low latitudes they are surrounded with coral reefs or surmounted with coral islands or atolls. Detailed soundings made after 1940 revealed hundreds of guyots, flat-topped sea mounts rising from the ocean bed to minimum depths mostly between 3,000 and 7,000 ft. The flat top is attributed to wave erosion at a lower relative stand of sea level. Fossils collected from sea mounts and from bore holes in the Marshall Islands indicate extensive subsidence relative to the sea surface has occurred within the last 100,000,000 years. Despite the numerous oceanic islands the depths between them are great; and the average depth of the Pacific (including adjacent seas) is 13,215 ft., exceeding that of the Atlantic by about 2,300 ft. The mean depth of the Pacific ocean (excluding adjacent seas) is 14,050 ft.

Bottom Deposits.—The characteristics of sea-bottom sediments are described in OCEAN AND OCEANOGRAPHY: *Marine Sediments* because they are common to all oceans.

Red clay rather than calcareous globigerina ooze is the most abundant deep-sea sediment, primarily because of the virtual

absence of calcareous deposits in the North Pacific. In the southern hemisphere the sediments are similar to those in the Atlantic and Indian oceans, with globigerina ooze giving place to red clay in the deeper basins, with small patches of radiolarian ooze. The diatomaceous ooze characteristic of high southern latitudes extends across the Pacific except for a break south of Cape Horn. On the other hand, in the North Pacific there are virtually no calcareous open-ocean sediments; diatomaceous ooze is present in the northern portion (unlike the Atlantic), and radiolarian ooze is abundant in a band between about 5° N. and 15° N. in the eastern Pacific. The absence of calcareous sediments in the North Pacific is believed to be related to the relatively slow circulation of the deep water.

Pelagic sediments cover 86.7% (55,000,000 sq.mi.) of the open Pacific (excluding adjacent seas), red clay covering 42.6%, globigerina ooze 31.4%, diatom ooze 8.7% and radiolarian ooze 4.0%. The remaining 13.3% and all adjacent seas (5,560,000 sq.mi.) are covered with terrigenous sediments containing coarse-grained debris of land origin or calcareous sediments produced by shallow-water bottom-living plants and animals.

The red clay of the Pacific differs from that of the Atlantic in having a higher content of manganese dioxide which colours the sediments a dark chocolate brown. Manganese concretions, often containing sharks' teeth and earbones of whales, are rather common.

Meteorology.—Partly because of its great extent, and partly because there is no wide opening to the arctic regions, the normal wind circulation is on the whole less modified in the North Pacific than in the Atlantic, except in the west where the southwest monsoon of southern Asia controls the prevailing winds, its influence extending eastward to 145° E., near the Marianas, and southward to the equator. In the South Pacific, during the winter months of the northern hemisphere, the northwest monsoon of Australia affects a belt running east of New Guinea to the Solomon Islands. In the east the northeast trade belt extends between 5° and 25° N., the southeast trade crosses the equator, and its mean southern limit is 25° S.

The trade winds are generally weaker and less persistent in the Pacific than in the Atlantic, and the intervening belt of equatorial calms is broader. Except in the east of the Pacific, the southeast trade is only fully developed during the southern winter; at other seasons the regular trade belt is cut across from northwest to southeast by a band 20°–30° wide, in which the trades alternate with winds from the northeast and north, and with calms, the calms prevailing chiefly at the boundary of the monsoon region (5° N.–15° S., 160° E.–185° E.). This area, in which the southeast trade is interrupted, includes the Fiji, Samoa and Society groups and the Tuamotus. In the Marquesas group the trade wind is fairly constant.

The great warming and abundant rainfall of the island regions of the western South Pacific and the low temperature of the surface water in the east cause a displacement of the southern tropical maximum of pressure to the east; hence we have a permanent South Pacific anticyclone close to the coast of South America. The characteristic feature of the southwestern Pacific is therefore the relatively low pressure and the existence of a true monsoon region in the middle of the trade-wind belt. It is to be noted that the climate of the islands of the Pacific becomes more and more healthful the farther the islands are from the monsoon region. The island regions of the Pacific are everywhere characterized by uniform high air temperatures; the mean annual range varies from 1° to 9° F., and the diurnal range from 9° to 16° F. In the monsoon region relative humidity is high, viz., 80% to 90%. The rainfall is abundant; in the western island groups there is no well-marked rainy season, but over the whole region the greater part of the rainfall takes place during the southern summer, even as far north as Hawaii.

The whole North Pacific from the tropic to the Bering sea has on its Asiatic side a monsoonal reversal of its prevailing winds, winter and summer. In winter exceedingly dry and cold northwesterly winds, dependent on an air-pressure maximum over Siberia and an air-pressure minimum near the Aleutians, blow over the whole area. Flowing over the ocean, this air is heated and its moisture content is greatly increased by evaporation from the sea surface. In summer, with low pressure over the Asiatic continent, warm and rainy south and southeasterly winds (in connection with the southwest monsoon of the China sea) prevail over the whole area of the Yellow sea, Japan sea, Sea of Okhotsk and Bering sea. On the American side of the Pacific from southern Alaska to northern California marine air moves toward land or follows the mountainous coast throughout the year except for temporary changes associated with passing atmospheric depressions or with an especially well-developed continental high-pressure cell. In winter, winds are predominantly southerly, varying locally from southwest to southeast, but in summer shift clockwise to give northerly winds increasing in persistence going southward from Vancouver Island. These circumstances explain the great differences shown in the following table between the average air temperatures on the Australo-Asiatic side of the Pacific and on the American.

Air Temperature (° F.) and Rainfall (in.) in the Pacific

Place	Lat.	Feb.	May	Aug.	Nov.	Year	Amplitude	Rain
Ajan, Sea of Okhotsk	56° N.	0.0	35.4	55.0	14.4	27.0	57.2	44
Sitka, Alsk.		32.5	44.1	54.9	36.7	42.5	22.4	81
Yokohama, Jap.	36° N.	40.8	63.3	78.1	51.3	57.7	38.2	58
San Francisco, Calif.		52.5	54.1	58.6	56.1	55.2	10.8	23
Sydney, Austr.	34° S.	70.5	58.5	54.5	66.4	62.8	19.1	50
Valparaíso, Chile		63.1	55.6	52.5	59.0	57.7	10.6	14

Surface Currents.—In the North Pacific, approximately between latitudes 10° N. and 25° N., the trade winds maintain a permanent current from east to west. As this current reaches the Philippine Islands one part turns south along the coast of Mindanao and bends back toward the east as the beginning of the equatorial countercurrent. The greater part bends north, flows past the northern Philippines and along the eastern coast of Formosa, continues on the western side of the Ryūkyū Islands and then follows the eastern side of the main islands of Japan as far as latitude 35° N. North of Formosa the current is known as the Kuroshio or the Japan current. During summer one branch of the Kuroshio enters the Sea of Japan through Tsushima strait and flows north along the western coasts of the Japanese Islands.

The Kuroshio is a counterpart of the Gulf stream, and according to theory advanced since 1950, the intensity of each is associated with the oceanic wind systems, the presence of a western oceanic boundary, and the variation with latitude of the deflecting force of the earth's rotation. When departing from the coast of Japan, the current continues toward the east as the Kuroshio extension, but branches are sent to the south and to the north. The greater bulk of the warm water turns south before reaching the Hawaiian Islands and forms part of a large clockwise eddy in the western Pacific. A minor part passes to the north of the Hawaiian Islands and approaches the American mainland to within 500–600 mi., where it turns south and contributes to a smaller, clockwise eddy between the Hawaiian Islands and the mainland.

The branches of the Kuroshio which turn northeast off Japan mix with the waters of the Oyashio, the cold current which flows toward the southeast along the Kuril Islands. The Oyashio represents an outflow of surface water from the Bering sea and is a counterpart of the Labrador current. The mixing of the warm Kuroshio water with the Oyashio water, chilling in winter, and dilution by rain lead to the formation of the cold water of low salinity which flows east to the south of the Aleutian Islands. On nearing the American coast part of this water turns north and forms an eddy in the Gulf of Alaska, whereas part turns south as the cold California current, which can be traced to about lat. 25° N., where it is deflected to the west. In spring and summer, upwelling (*see* OCEAN AND OCEANOGRAPHY: *Movement of Sea Water: Vertical Water Movements*) takes place along the coast of California and lowers the temperature near shore.

In the Bering sea the circulation is counterclockwise, with a sluggish inflow between the westernmost of the Aleutian Islands and a surface outflow along Kamchatka. In the Sea of Japan the

circulation is also counterclockwise, with warm water flowing north along the west coasts of the islands of Japan and very cold water flowing south along the Siberian coast (the Liman current). In the Yellow sea and the East China and the South China seas, the currents change with the monsoon and are directed to the south in winter and to the north in summer.

The equatorial countercurrent sets eastward primarily between the latitudes of 5° N. and 10° N. In the region between Mindanao and the Marshalls it is broken up into eddies, but farther east it is better developed and velocities frequently exceed two knots. Observations since 1950 show that the countercurrent may double in velocity within a five-week period, and that it fluctuates greatly within shorter periods. At times it apparently breaks down into two or more branches. The countercurrent shifts its location with season, and in August is found farther north than in February. An equatorial undercurrent beneath the westward flowing water of the south equatorial current has been observed to set eastward to the vicinity of the Galapagos. For an explanation of the countercurrent *see* OCEAN AND OCEANOGRAPHY: *Movement of Sea Water: Permanent Currents.*

In the South Pacific trade winds maintain a steady flow to the west from the South American coast to about long. 180°. This current, the south equatorial current, flows approximately between lat. 5° N. and lat. 15° S.–20° S. To the south of 40° S. the antarctic circumpolar current, which is maintained by the permanent west winds, flows from west to east. The greater part of this current continues to the South Atlantic ocean through Drake passage, between South America and Antarctica, but part turns north along the west coast of South America as the Peru (Humboldt) current. Within the Peru current low temperatures are found along the coast to within 5° of the equator because of the intense upwelling. The Peru current is one of the most productive areas of the oceans, as is evident from the enormous schools of fish upon which the guano birds feed.

A warm current flows southwest from the Gulf of Panama and converges with the Peru current. Occasionally this warm current continues much farther to the south past the latitude of Callao (12° S.) and is then known as El Niño ("The Child"). The development of El Niño has disastrous consequences to the life in the sea and to the guano birds which live off the fish. It is also associated with excessive rainfall which leads to catastrophic floods and tremendous erosion. It is probable that the extreme developments of El Niño are caused by a slight change in the atmospheric circulation and that the disastrous rainfalls are related to such change and are not an effect of the southward extension of the warm current.

Deep-Sea Circulation and Character of Deep Water.—No deep and bottom water forms anywhere in the Pacific by sinking of surface water. The great basins of that ocean are filled by water which enters the Pacific from the west between Australia and the antarctic continent. This deep water has been formed mainly by sinking near the shelf of the antarctic continent in the Weddell sea region and contains admixture of deep water from the North Atlantic and the Mediterranean.

The deep and bottom water of the Pacific is characterized by a very uniform salinity and temperature. To the north of 55° S. the salinity at a depth of 6,600 ft. is 34.6‰ (per mille) and increases toward the bottom, reaching values of about 34.68‰ in the North Pacific and about 34.72‰ in the South Pacific. In the North Pacific the temperature decreases from about 2° C. (36° F.) at 6,600 ft. to about 1.5° C. (35° F.) at 13,000 ft., and in the South Pacific from about 2° C. (36° F.) to about 1° C. (34° F.) at 16,000 ft. At greater depths the temperature increases about as would be expected from heating associated with compression (adiabatic heating) and reaches 2.45° C. at 31,200 ft. depth in the Philippine trench and 1.74° C. at 30,500 ft. in the Tonga trench.

In the South Pacific there is evidence of a northward flow of the coldest water along the bottom and of a northward flow of low-salinity antarctic intermediate water (*see* ATLANTIC OCEAN) at a depth of about 3,000 ft. Between depths of 6,000 ft. and 13,000 ft. the deep water probably moves to the south and rises toward the surface near the antarctic continent. In the North Pacific there is no evidence of such a circulation except that intermediate water of low salinity is encountered at depths of 1,300–2,600 ft. and participates in the large-scale clockwise circulation of the surface layers. A slight clockwise movement appears also to be present at very great depths with an occasional renewal of the deep water in the western part of the ocean. In agreement with the sluggish deepwater circulation it is found that the oxygen content of the deep water is low, particularly in the North Pacific, where the values range from 2 to 3½ cc. per litre.

Temperature.—The distribution of the sea-surface temperature is closely related to the character of the currents. In the tropics only a narrow belt of high temperatures is found on the eastern side of the ocean, but on the western side where the equatorial currents branch north and south, warm tropical waters are found over a wide range in latitude.

The effect of the currents, including the effects of upwelling off the coasts of North and South America, is particularly evident in

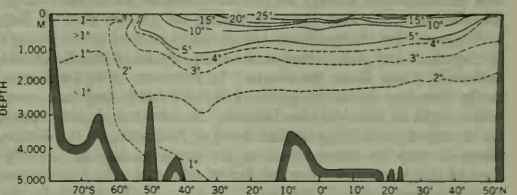

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FIG. 1.—VERTICAL SECTION SHOWING DISTRIBUTION OF TEMPERATURE IN THE PACIFIC OCEAN, APPROXIMATELY ALONG THE MERIDIAN OF 170° W

the great contrast between temperatures in the western and the eastern parts of the ocean in latitudes 20°–35° N. and S. Thus, in lat. 35° N. the average temperature in August is about 25° C. (77° F.) on the coast of Japan and about 15° C. (50° F.) in the same latitude on the coast of California. In February the temperature in 20° S. is 27° C. (81° F.) on the coast of Australia and 19° C. (66° F.) off the coast of Peru. In high southerly latitudes the sea-surface isotherms run nearly east-west, but in the northern part of the North Pacific the highest temperatures are found in the east, and the lowest in the west where the cold Oyashio flows south.

In the tropics a belt of low temperatures stretches across the ocean at depths between 500 ft. and about 2,000 ft. The presence of this cold water at shallow depths does not show that deep water rises to the surface, but the temperature distribution is directly related to the existence of the equatorial currents which flow toward the west and within which the warm water must be to the right in the northern hemisphere and to the left in the southern. For the distribution of temperature at great depths, *see* the section *Deep-Sea Circulation and Character of Deep Water*, above. For annual and diurnal variation in temperature, *see* OCEAN AND OCEANOGRAPHY: *Physical Properties of Sea Water: Temperature, Freezing Point and Heat Capacity.*

Salinity.—The salinity of the surface water of the South Pacific is nearly the same as that of the South Atlantic and the Indian oceans, but the surface salinities of the North Pacific are lower than those of any other ocean. The maximum values are about 35.5‰ (per mille) as contrasted with values exceeding 37‰ in the North Atlantic.

The general distribution of salinity follows the same pattern as in the other oceans. It is related to the currents and is greatly influenced by precipitation and evaporation. In 5°–10° N. where precipitation dominates, the surface salinities are less than 34.5‰, whereas in about 25° N. and 20° S. where evaporation exceeds precipitation, maximum values of 35.5‰ and 36.5‰ are encountered. To the north of 40° N. and along the American west coast to the equator the salinity is less than 34‰, except in the Gulf of California. To the south of 55° S. the salinity is also less than 34‰. Large seasonal variations in salinity are found

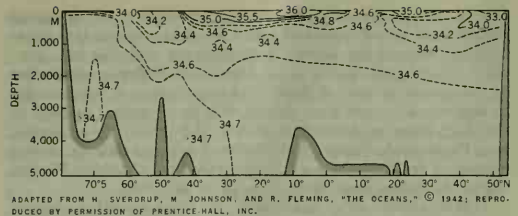

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FIG. 2.—VERTICAL SECTION SHOWING DISTRIBUTION OF SALINITY IN THE PACIFIC OCEAN. APPROXIMATELY ALONG THE MERIDIAN OF 170° W

along the coasts, particularly along the Asiatic coast where large rivers empty into the sea. For the salinity of the deep water, *see* the section *Deep-Sea Circulation and Character of Deep Water*.

Ice.—The Polar sea is considered part of the Atlantic ocean, and ice conditions in that sea are described in ATLANTIC OCEAN. The Bering sea is free from ice during the greater part of July and August; but, from September on, ice is carried south through Bering strait and also freezes in the bays. Some of this ice breaks and drifts away from the coasts. In February drift ice is generally found as far south as the Pribilof Islands and may come within sight of the Aleutian Islands. In winter and early spring ice is carried south along the east coast of Asia and past the Kurils, where it may be encountered as far south as lat. 40°–42° N. Part of this ice comes from the Sea of Okhotsk. Ice also freezes in the northern part of the Sea of Japan. In the North Pacific icebergs are found only in some of the sounds on the coast of Alaska between latitudes 55°–60° N. No icebergs are encountered in the Bering sea.

In the South Pacific the pack ice around the antarctic continent reaches its greatest extension in October, when the northern limit is found in about lat. 62° S. In March the entrance to and the western coast of Ross sea are generally ice free, but all other parts of the antarctic continent are blocked by ice. The northern limit of icebergs from the antarctic follows approximately the parallel of 50° S., except near South America, where no icebergs have been reported to the north of 56° S.

See also references under "Pacific Ocean" in the Index.

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PACIFISM is a word that is first found at the beginning of the 20th century in connection with the movements which attempted to establish peace between nations and advocated the settlement of disputes by means of arbitration, the setting up of international courts and the reduction of armaments. The pacifists of this period did not necessarily claim that no war under any conceivable circumstances could be justifiable, but they maintained that there were practicable methods of avoiding war and tried to arouse the opinion of the peoples of the world in favour of adopting these methods. Their critics, on the whole, attacked them for an undue optimism, which might lead a country to depend on unreliable methods to the extent of weakening the nation's defenses and sacrificing its essential interests.

During World War I the word pacifism became especially associated with the conscientious objectors who refused military service when conscription was introduced. And it gradually came to bear the more specific and now accepted meaning of a belief that the waging of war by a state and the participation in war by an individual are absolutely wrong, under any circumstances.

HISTORY

Ideas of the Ancient World.—In the ancient world, on the whole, war was taken for granted as a necessary evil by some people, while in some parts of the world it was not even regarded as an evil. Military service, therefore, was regarded as a natural obligation, either for a special military caste or for the whole body of citizens or tribesmen or subjects. Individual voices in various lands cried out against the evils of war, but the first genuinely pacifist movement known came from Buddhism, whose founder demanded from his followers absolute abstention from any act of violence against their fellow creatures. It may have seemed at one time as if this might become a practical policy when in India the great king Asoka, in the 3rd century B.C., definitely renounced war. It must, however, be remembered that he was thinking primarily of wars of conquest. He ruled over a secure and well-established empire, and what he would have done if he had been faced, as his successors were, with attacks from barbarians beyond his frontiers, we do not know. At any rate, in succeeding ages Buddhism does not seem to have been very successful in restraining the rulers of the countries in which it was adopted from making war. This may to some degree have been due to the fact that the Buddhist rule of life, as generally understood, was by way of being a counsel of perfection which comparatively few could be expected to follow in its completeness.

In the western world there is little trace of any pacifist teaching until the rise of Christianity. The only notable exception is to be found in the sect of the Essenes, a small religious fraternity which arose among the Jewish population of Palestine. Knowledge of them is extremely scanty, but it seems certain that they were established some time before the beginning of the Christian era and that throughout the greater part of their history they renounced war and indeed any use of violence.

Early and Medieval Church.—It was, however, with the rise of the Christian church that the question of participation in war really became a significant problem. It seems that from an early date there were differences of opinion on the point within the Christian body. The exact meaning of the teaching contained in the Gospels will be considered later. But it is clear that for the earliest Christian community the question hardly arose as a practical problem at all. No doubt few of its members were either liable or eligible for service in the Roman armies. Quite apart from that, however, they thought of themselves as a small body of the elect, living in constant expectation of the Second Coming, walking the path of separation and taking no responsibility for the affairs of the world, either in civil administration or military service. It is evident from St. Paul's writings that they expected the civil powers, who "bear not the sword in vain for the punishment of evil doers," to use force when necessary, and it is natural to suppose, with St. Augustine, that this would have applied to defense against attack from outside as much as to the suppression of lawbreaking within. The Christian did not necessarily disapprove of this, but it was clear to him that it was not his function. Christian writers were particularly concerned to stress, both at this time and later, that Christianity in itself was a religion of

peace that used only spiritual weapons, that there could be no question of its adherents attempting to advance their views by force and, above all, that there was no thought of a rising against the Roman government.

As Christianity spread and drew in people from every class and every part of the Roman world, the problem became more urgent. Christians might be faced with the possibility of joining the army and soldiers already in the army might be converted to Christianity. What was their position? In the 2nd and 3rd centuries there were definite statements by some Christian writers, Justin, Tatian, Tertullian in his latest writings, and others, to the effect that Christianity was incompatible with the soldier's profession. But that was certainly not a unanimous view, and it is doubtful whether it was even a majority one.

Clement of Alexandria maintained that a convert to Christianity should remain in the profession in which he already was, and mentions the soldier's profession among others in that connection. There is good evidence that by the end of the 2nd century there were considerable numbers of Christians in the army. Tertullian in his *Apology* says that they fill the camps and puts forward as part of their claim to consideration that they go to war alongside the other Romans. The situation was complicated, particularly in the 3rd century, by the fact that the soldier might be called upon to take part in pagan religious ceremonies and that he might be called upon to help in the enforcement of the penal decrees against his fellow Christians. It is probable that these things provided a stumbling block to the Christian soldier much more serious than the duty of fighting.

When the empire became officially Christian and Christian rulers had to take the responsibility for keeping law and order within and dealing with barbarian attacks from without, the pacifist view seems to have disappeared. St. Augustine held that a war to resist aggression or to enforce justice might be a Christian duty and that there was nothing incompatible with Christianity in the profession of a soldier. He must only fight in obedience to lawful authority and he must always remember that wars are fought for the sake of the peace that will follow them. Of course, a life devoted to the service of religion was the highest and those who had the vocation for this would eschew military service. But the majority of men did not have this vocation, and for them service in the army was as proper as any other secular calling. This became the accepted doctrine throughout the middle ages, and is restated and developed by St. Thomas Aquinas, who bases his view largely on the teaching of Augustine. This doctrine, which distinguishes "just" from "unjust" war, is still the doctrine of the Roman Catholic Church; it has some resemblance to the doctrine of the United Nations which forbids the use of force in international relations except in individual or collective self-defense, and then only under authority of the United Nations or on invitation of the state in whose territory force is used.

A thin stream of pacifist doctrine can be detected during the middle ages in connection with certain heresies that arose from time to time. The Waldenses, for instance, in the original form of their doctrine, maintained that not only war but any kind of taking of human life was contrary to true Christianity. Eventually they did take up arms to resist violent persecution, and it is likely that if they had not put up such a vigorous resistance in their Alpine valleys their sect would not have survived at all. In any case, their pacifism was only a small element in their whole doctrine and it was probably other elements that particularly aroused the hostility of the church.

The Reformation and After.—It is not surprising that pacifist ideas made their reappearance during the religious ferment at the time of the Reformation. In the 16th century their most prominent advocates were the Anabaptists, a sect which for a time, until it was checked by the most savage and bloodthirsty persecution from both Catholics and Protestants, seemed to be making considerable headway in Europe. The pacifist beliefs of the Anabaptists were again, of course, only one part of a much wider creed. There was, indeed, an extreme wing which advocated the use of force for the spread of the true religion and eventually went down fighting in its theocratic republic at Münster. But the great majority remained true to their pacifist beliefs throughout. This did not, however, save them from persecution as cruel as any that befell their more militant brethren.

A somewhat kindred movement, that of the Mennonites, also abjured all participation in war. So did the early Socinians, though the view seems to have been soon abandoned by their successors. Though persecution of all of these movements was largely directed against their other theological and social doctrines, their refusal to bear arms is sometimes specifically mentioned in the indictments against them. The persecutions were so effective that only scattered remnants managed to survive. Some of the Anabaptists went to England, but by the 17th century they had dropped the pacifist element in their beliefs and there were numerous Anabaptists in Oliver Cromwell's army.

In the 17th century, on the whole, especially in England, religious enthusiasm tended to take more militant forms. But there was one striking exception to this. For that century saw the origin of the sect which has been most consistently associated with pacifist doctrine, the Quakers or Society of Friends. At different periods there have been Quakers who, in one cause or another, have taken up arms. As a general rule, however, the witness against war and the refusal to bear arms have been among the outstanding characteristics of the society. The society, which never spread to any extent outside the English-speaking countries, met with some persecution at first, though nothing remotely comparable to the systematic campaigns of extermination waged against the Anabaptists. It does not appear that the repudiation of war was ever one of the major counts in the indictments against its members, and, after they had abandoned the extravagances of behaviour which marked some of the earlier enthusiasts, their manifest virtues secured them a considerable degree of tolerance. Their greatest triumph came when William Penn founded the colony of Pennsylvania as a predominantly Quaker settlement. There they showed that an unarmed society, practising strict justice and benevolence to the native population, could live in safety among the Indian tribes which were a constant threat to the other colonies.

As hitherto surveyed, pacifism appears as a part of the creed of some dissident Christian bodies and is invariably combined with a complex of other beliefs, some of which have a fairly close logical connection with it. Thus, a frequent source of inspiration is found in the idea of a return to the way of life of the primitive church, and the refusal to bear arms is sometimes associated with a call to apostolic poverty or a communion of goods or a renunciation of all earthly power over others. There is a general denial of the right of the secular power to enforce religious conformity, and there is frequently a reliance on individual religious inspiration, such as the "inner light" of the Quakers. Alongside of this we can observe a tendency for these bodies to abandon their hopes of a general acceptance as the one true form of Christianity and to think of themselves rather as a small body of the faithful in a world which, as a whole, can never be expected to receive their message. In modern times some of these bodies have expressly renounced all idea of proselytization. Their position, in fact, begins to approach that of the religious orders in Catholic Christianity, which are only open to those with a special vocation for that way of life.

These characteristics also mark some of the other religious bodies adopting pacifist views which sprang up in the 19th century. The Plymouth Brethren and the Christadelphians, with occasional individual exceptions, not only refuse to bear arms but also refuse to take any part in public affairs, to enter the service of the government or even to join trade unions. Their pacifism is, therefore, incidental to a much wider renunciation of privileges and responsibilities for a world that, as a whole, has rejected Christ. Fundamentally the same attitude, though modified in different degrees, is characteristic of many smaller religious bodies and communities. The Quakers, of course, have never cut themselves off from public service. They remain, nevertheless, to some degree a dedicated community with a way of life which would be unlikely ever to appeal to more than a small minority.

The 20th Century.—A phenomenon of more recent times, beginning roughly from the time of World War I, is the rise of a paci-

fist movement within existing Christian bodies which, as a whole, are not pacifist. There have been for a number of years strong pacifist movements in the Anglican and Methodist churches, though in neither do they represent more than a small minority of the whole. The movement has penetrated into almost all religious bodies including, to a slight extent, the Roman Catholic Church. There is also a small number of persons who, without any particular religious background, base their pacifism on a moral revulsion from the horrors of war. Also, and not always to be distinguished from these, there was, particularly at the time of World War I, a group whose members could most accurately be described as rationalist pacifists. Their attitude might be fairly described as the view that war is such an irrational folly that the intelligent man will have nothing to do with it. This group contained some distinguished names, but was on the whole restricted to a small number of intellectuals. Some of these, such as Bertrand Russell and C. E. M. Joad, abandoned their pacifism during World War II, but following the development of atomic weapons, many became convinced of the mutually suicidal character of war, and this type of pacifism increased.

The upshot of these developments was that, for the first time to any serious extent, pacifism became in itself a proselytizing creed, aiming at winning adherents from all religious bodies and indeed from every section of the community. A typical expression of this was the foundation of the Peace Pledge union in 1936 by an Anglican clergyman, H. R. L. Sheppard. It aimed at getting as many persons as possible to sign a solemn pledge to refuse to take part in any war; it was argued that if a sufficient number of persons would subscribe to this pledge war would become impossible. It would be wrong to say that the beliefs of the leaders of this movement depended entirely on this hope being fulfilled, but it was undoubtedly the prospect of that result that appealed to a large number of its adherents.

It is probably correct to say that the pacifist movement became strongest in Great Britain and the U.S., less strong in the British dominions and weaker still on the continent of Europe. In none of those parts of the world, however, did it attain a level at which it could seriously affect the policies of governments. In India, on the other hand, the figure of Mohandas Gandhi, with his creed of nonviolence, was in the centre of the scene for many years up to the time of his death. Though it is difficult to say how deep and permanent his influence has been in his own country, he nevertheless remains an object of universal reverence and an inspiration to pacifist movements all over the world.

PRINCIPLES

It will be apparent from this survey that there is no one set of principles at the back of all pacifist movements. It is possible to distinguish two general lines of approach, which are different and, in some of the forms they take, really incompatible, though in other forms they can be combined and are not infrequently confused. The one rests on the advocacy of pacifism and the complete renunciation of any form of war as a possible policy to be adopted by a nation. The other depends rather on the conviction of an individual that his personal conscience forbids him to participate in any act of war and perhaps in any act of violence of any kind. Such an individual may, no doubt, also advocate pacifism as a policy for the nation. But it is by no means necessary that he should and some of the religious sects mentioned would expressly renounce any responsibility for suggesting a policy for the nation at all.

Conversely, the advocate of pacifism as a policy may also feel it a personal duty to refuse any participation in warlike activities if war does break out. On the other hand, he might logically hold that, though a decision to go to war at all was a disastrous mistake, once the decision has been taken a war ending in the defeat of his country would be even more disastrous than a war ending in its victory. In such a case he would regard it as a duty to work for his country's victory in every way possible.

Pacifism as National Policy.—The arguments for pacifism as a possible national policy run on familiar lines. The obvious and admitted evils of war are stressed, the human suffering and loss of life, the economic damage and, perhaps above all, the moral and spiritual degradation that it brings. In recent years particular emphasis has been laid on the increasing power of destruction of the latest weapons. This argument sharply distinguishes the use of force in war, to promote conflicting policies of independent groups, from its use in police operations, to enforce the law of an organized community against dissident members. Its advocates often assume that the abandonment of war as an instrument of national policy will not be possible until the community of nations has become so organized that it can enforce justice among its members.

The nonpacifist of the present day would, in general, accept what the pacifist says about the evils of war and the need for international organization. But he would claim that the pacifist had not fairly faced the possible evils that would result from the alternative policy of nonresistance, the possible mass deportations and even mass extermination, or the subjection of conquered peoples to totalitarian regimes which claim to control their whole lives and, in particular, suppress just those values for which the pacifist stands.

The reply of thoughtful pacifists to this is to admit the seriousness of these evils but to claim that there are ways of meeting them which have already proved successful in some cases. They fix their faith on the process of collective security and pacific settlement or on the methods of nonviolence and nonviolent resistance. The two latter methods are often confused, but they put the emphasis in very different places and should be distinguished. The idea of nonviolence lays stress on the general attitude of benevolence and friendliness which, it is claimed, may often disarm the most savage aggressors. Nonviolent resistance, on the other hand, relies on the difficulties and inconvenience that can be caused to the conqueror or oppressor by a general refusal to co-operate. One of the classic instances of nonviolence is the success of the Quakers in Pennsylvania. There are numerous instances in which nonviolent resistance has been attempted with varying degrees of success. In many of these, it was merely a matter of tactics and did not proceed from any pacifist principles.

There are a striking number of occasions on which nonviolence and nonviolent resistance alike entirely failed to disarm the enemy or even to preserve the communities practising them. Pacifist sects were often the objects of the most ruthless persecution from the middle ages to the days of Adolf Hitler and were, in some cases, practically exterminated. The story of the persecution of the Jews over many centuries is only too familiar, though for generations they practised nonviolence toward their persecutors. As for nonviolent resistance, in the U.S.S.R. tribes or communities suspected of imperfect co-operation disappeared in whole or in part into the depths of Siberia.

It seems that these methods can only be effective against a power which has no very strong motives for going to extremes of suppression. It therefore seems clear to most or all nonpacifists that complete nonresistance would inevitably open the door to the domination of the most fanatical and ruthless elements. And it may well be asked what chance there would be for the eventual survival of pacifist creeds under such a domination.

A great part, if not the whole, of the argument in this connection turns on the probability or improbability of certain future results following a certain course of action. Difference of opinion about that is always possible but is hardly, in itself, a moral difference. If the authorities responsible for the policy of the state arrive at a different estimate of future probabilities from our own, we may disagree with them but we cannot say that they are morally in the wrong, and there is no warrant for our refusing to accept their decision, any more than there would be for our refusing to obey every law with which we disagreed.

Personal Pacifism.—The situation, however, is quite different when we come to the more fundamental pacifism of those who hold that their conscience tells them that it would be absolutely wrong to participate in warlike activities, whatever the consequences. As has already been seen, some of those who hold such a view may expressly renounce all responsibility for the decisions of the national community. But others may equally well regard it as a

duty to try to persuade others of the truth of their views, with the eventual hope that pacifism may be adopted as the policy of the whole nation. Their conviction of their own personal duty, however, would not be affected by their success or failure in this.

It has been a frequent subject of dispute among moral philosophers whether any action can be regarded as absolutely good or evil in itself regardless of any consequences that may follow from it. The ordinary man, it must be confessed, generally seems to want to have it both ways and to believe at the same time that we ought to do right regardless of the consequences and that we are morally responsible for the natural consequences of our action. Yet these two propositions taken strictly might easily lead to contradictory conclusions. Obviously, further analysis is needed, but that can hardly be attempted here. What can be done is to consider briefly the kind of arguments that have led people to believe in the absolute and unconditional wrongness of war and warlike activities and then, if necessary, consider the question of the possible relevance of the consequences as it arises.

A few pacifists would base their views on the claim to an immediate moral intuition which admits of no argument. But, though no doubt some kind of direct experience is an ingredient in every moral conviction, most pacifists would find the chief validation of their belief in the teaching of Christ in the Gospels, as they understand it and as they believe that His immediate followers understood it. There are, however, the widest differences of opinion among professed Christians about the true interpretation of this teaching and about its application.

It is common ground that Christ rejected war as a means of spreading His message. It is also clear that in individual relations He taught the greatest degree of forbearance and nonviolence in the face of personal injuries. But it is not at all clear what the bearing of this is on the problem of war and the position of the soldier. It is to be noted that on several occasions soldiers appear in the New Testament narrative—when the soldiers came to John the Baptist, when Christ healed the centurion's servant and when Peter baptized Cornelius—and on none of these occasions is there even a hint that their profession was necessarily incompatible with the reception of the new message. As for the renunciation of war, it is part of the essential nature of Christ's message that it was an appeal to the hearts of men which could not be imposed on them by force. It must be remembered that, if He renounced war, He renounced even more definitely any thought of political power and authority: "My Kingdom is not of this world. . . ." It is difficult to see how any clear conclusion can be drawn from this about the duty of Christians when, in very different circumstances, they find themselves in a position where they are forced to take some responsibility for the affairs of this world.

It has already been noted that the small pacifist sects who try to follow literally the precepts laid down in the Gospels attempt, as far as possible, to hold themselves aloof from the world and renounce all responsibility for the ordering of its affairs. Other Christian pacifists would not go as far as that. They agree that the precepts laid down by Christ for His immediate disciples are not likely to have been meant to apply literally in detail to everyone in the very different circumstances of today. But they hold that it should be possible to extract certain general principles which express the spirit in which the Christian can approach all the main problems of today or any other time. In particular, they stress the central position given in Christ's teaching to love as the supreme good. And they claim that this is quite incompatible with war against other human beings.

Against this it is sometimes argued that the teaching of Christ as recorded contains reference to justice and punishment as well as to love. A more weighty contention is that, when one is dealing not with the relations between individuals but with public behaviour, it is by no means obvious in all cases what course of action love of humanity would lead us to pursue.

We might consider, for instance, a situation in which warlike action would be necessary to suppress slave raiding and the slave trade. In such a case, if an authority which had the power refrained from taking such action, it might be displaying love toward the slave traders but, it might well be argued, it would not be at all an obvious expression of love toward their potential victims. This is a comparatively simple point but, more generally, when we are dealing with public affairs the meaning of love and the kind of actions in which it would express itself is a highly complicated problem.

Conscientious Objection.—This, then, is a brief statement of some of the main issues that are involved in the debate about pacifism. There is also a practical problem of great importance for nonpacifists when they ask themselves what attitude they would wish their country to take toward conscientious objectors to military service. Of course not all conscientious objectors are pacifists. There may be conscientious objections to participation in a particular war, not to war in general. But the great majority of conscientious objectors base their refusal to serve on their pacifist convictions. The authorities in different states have taken very different attitudes toward this. Some states do not recognize conscientious objection at all and a refusal to undertake military service is treated like any other breach of law. In some, the adherents of certain religious sects which include pacifism as part of their creed have been exempted but no recognition has been accorded to the individual objector. In only one or two countries has an attempt been made to recognize all types of conscientious objector (*q.v.*).

But the practical problem of the attitude of a nonpacifist community to the pacifist, particularly in wartime, still presents many difficulties. There are, moreover, wide differences of opinion among pacifists themselves about their attitude toward a community at war, ranging from the very small minority who would refuse to do anything that could help the national effort to those prepared to offer any kind of service short of actual fighting.

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PACK, OTTO VON (*c.* 1480–1537), the central personage of the "Pack affair," which in 1528 nearly caused a general war between Protestants and Catholics in Germany. A member of the Saxon nobility, he graduated as doctor of law at Leipzig, and by 1519 was in the service of George, duke of Saxony. He became the duke's trusted councilor and vice-chancellor, but constant lack of money soon drove him to more or less fraudulent practices. In Jan. 1528 he informed Philip, landgrave of Hesse, that an aggressive alliance against the Protestants had been concluded between the German king Ferdinand I, the electors Joachim I of Brandenburg and Albert of Mainz, Duke George and other Catholic princes at their meeting at Breslau in May 1527. Thereupon Philip and the elector of Saxony, John I the Steadfast, made a defensive alliance. While John wavered under the pacific influence of Luther and Melanchthon, Philip urged prompt military action to anticipate attack. When Pack, resorting to one subterfuge after another, failed to produce the original of the Breslau treaty, Philip published the alleged copy which Pack had furnished; but Duke George exposed this as a forgery.

Pack, whom Philip had taken under his protection, would not retract his story and was finally expelled from Hesse in 1529. Thereafter he lived as a fugitive till in 1536 he was arrested in the Habsburg Netherlands on the demand of Duke George. Under torture he tried to accuse Philip of complicity in the forgery. Sentenced to death (Feb. 8, 1537), he was executed on the same day, in Brussels.

See K. Dulfer, *Die Packschen Händel* (1958). (WA. HE.)

PACKAGING. In a society that produces foodstuffs and manufactured articles in one locality and uses them in another, a wrapping or container is necessary during storage, transport, and sale. The functions of a package are: (1) to contain a convenient-sized unit or amount of a product; (2) to protect it in transit; (3) to aid its safe delivery to the consumer; and (4) in some cases to display the product and promote its sale or to act as a dispenser of it. Originally instituted to produce simple containers, the packaging industry has expanded to meet the demands for processed and preserved foods, rather than seasonal crops, and to distribute increased varieties of manufactured items. Packaging reflects developments in other industries, especially petrochemicals and plastics, whereby new materials and methods of construction have been provided for containers.

DEVELOPMENT OF PACKAGING MATERIALS

Transport Containers.—Early containers for water, wines, and oils consisted of natural products such as gourds, hollow tree stems, and animal skins. Later, glass and pottery jars provided stronger containers.

Bottles.—Glass had been made into bottles as early as 1500 B.C. by winding and fusing glass rods around silica cores. About 200 B.C. glass was made by blowpipe in China, Persia, and Egypt. The carboy, a large globular glass bottle in a wicker frame, was introduced soon after for transporting larger volumes of liquid. It is still used as a container for corrosive substances. (*See* also COOPERAGE; GLASS; POTTERY AND PORCELAIN.)

Barrels and Drums.—The pottery jar was superseded by the wooden barrel, which was more sturdy and could be made in larger sizes. Although wood, in the form of plywood and veneer kegs, has retained a place in cylindrical drum manufacture, wooden barrels are now used mainly in the whisky trade. Their former function as containers for oils and chemicals has been largely taken over by the steel drum, first produced in the United States and Germany about 1903 with capacities ranging from 5 to 45 gal. Treated drums can now be used for most solid and liquid chemicals.

For transporting some types of dry goods, the fibreboard drum, a lighter, cheaper alternative to the wooden or steel barrel, was developed as a result of John Dickinson's invention in 1809 of the cylinder-mold process for making paperboard (*q.v.*). Prior to that, boards for boxes had been made by pasting individual sheets of paper together. Spiral winding techniques for making paperboard tubes evolved in the United States in the late 1800s, and early in the 20th century fibreboard drums were produced in barrel sizes. Progress was hastened in the 1920s by development of a method of winding drums from reels of paperboard. Modern fibreboard drums, with paperboard or steel ends, can carry weights up to 560 lb.

Boxes and Crates.—Wooden boxes were used from early times, and techniques of mass production developed as demand grew. The wooden box and slatted crate remain unsurpassed for packing heavy engineering items.

In the 1870s in the United States R. H. Thompson and H. D. Norris produced corrugated paper with a liner and from this corrugated containers were made. Paperboard also was being laminated into solid fibreboard and formed into cases with wooden frame ends. By the early 1900s this material was competing strongly with wood, and wooden box suppliers sought to have carriers in the United States discriminate against the new corrugated and fibreboard boxes. In fact, the Pacific Coast railroads charged higher rates for goods packed in fibreboard than for those in wooden boxes, because, it was said, of the railroad's interest in the lumber industry. This discrimination in rates was appealed to the Interstate Commerce Commission, and in April 1914 the commission ruled that equal rates should apply to eastbound goods in both fibreboard and wood. Strangely, no such discrimination had applied in westbound traffic.

Through care in design and choice of materials, fibreboard cases have become one of the most important types of transport containers. Produced in a variety of styles, they are cheaper than wood, lighter in weight, and collapsible. They can be waterproofed and, with double-walled construction, can carry weights up to 200 lb.

Sacks.—For many agricultural products (*e.g.*, wool, cereals, and refined sugar) the traditional transport container has been the jute sack, which in the 19th century began to displace earlier sacks of wool and cotton. The centres of the developing jute-sack industry were the United States, India, and Scotland. By 1860 sack-making machinery was in use, but in 1870 the multi-ply paper sack was developed by German paper manufacturers. World War I and a shortage of cloth in Europe hastened its development. The multi-ply paper sack received further impetus in the United States from 1915 to 1920 from improved methods of sack filling and closure. Up to 1939 these sacks were made mostly of kraft paper, which was waxed if a moisture barrier was needed. Since then bitumen-laminated kraft and plastic-coated papers have become available for special protective constructions. Typical sacks now contain two to six plies and hold weights of 14 to 112 lb.

Advances in plastic technology made the all-plastic sack possible. By the mid-1960s single-ply sacks made of polyethylene and polyvinyl chloride were in use for fertilizers.

Unit Containers.—*Bottles.*—The glass bottle as a container for liquids was handmade until 1880, when in the United States a machine was invented for making wide-mouthed glass jars. In 1895 Michael J. Owens invented a machine for making bottles (commercially introduced in 1903).

The first stoppers, wooden plugs, were superseded by corks. Higher internal pressures from carbonated drinks led to the invention in 1879 of the screw stopper, and in 1891 W. Painter patented the crown cork closure. Other closures followed—the external screw-thread tinplate cap and, after 1904, the Bakelite cap.

By the 1960s the lightweight bottle, achieved by redesign of the shape and more economical distribution of glass in the walls, was helping to offset rising costs and to preserve the place of glass in competition with liquid containers made of newer products.

In the soft drink and milk trade, the need for low-cost, non-returnable vending-machine containers was met by wax-impregnated and polyethylene-lined paperboard cartons. Thin-walled, deep-drawn polystyrene cartons are also used.

Bottles made of polyethylene and polyvinyl chloride provide containers whose contents can be ejected by squeezing. Numerous detergent and toilet preparations now appear in such containers.

Cans.—The need to furnish the French Army and Navy with portable food supplies led to the beginning of food canning in the early 19th century. Tin containers had been known in Bohemia since the 13th century. It was not until the late 18th century that sheet steel coated with tin was first used, in Wales, to make hand-soldered and riveted containers. Imported tin plate was used for the first known canning of food in the United States (1819). By 1890 tin plate was being manufactured there, and by 1912 United States output equaled that of the United Kingdom. Two important developments in canning were the introduction (in 1868) of internal lacquers for cans to prevent corrosion, and (in 1874) the application of autoclaves to boilers. Through the use of higher temperatures and pressures than those used in the old waterbath process, production times were shortened and the food was better sterilized. By the 1960s, continuous electrolytic tin coating of strip steel was replacing the former process of dipping the strip in molten tin. (*See* TIN PLATE AND TERNEPLATE.)

Cans, both tin plate and aluminum, are now used for ready-cooked products, brewery products, soft drinks, and many oils and semisolids. Where a reclosable pack is needed, lever-lid or slip-lid cans are used instead of sealed cans.

A package that can be used as a dispenser for its contents is attractive to purchasers, as seen in the growth of pressure packages and aerosol containers. The latter are made usually of tin plate, although some glass and plastic are used. Aerosol cans are fitted with a finger-operated valve at the top through which the contents are ejected as a spray, foam, or powder by pressure of either gas or liquefied vapour. The first aerosols, in the early 1900s, used gas pressure, but by 1930 liquid propellants were in use. The contents of aerosol containers range from insecticides to toilet preparations and paints.

Cartons.—Among the commonest containers are folding cartons made from paperboard that ranges between 0.012 and 0.045 in. in thickness. The discovery of a method of creasing paperboard to fold into a container is attributed to Robert Gair in the United States in 1879. The folding carton is well adapted for mechanized mass production. It has transformed a number of retail industries, aiding greatly in the introduction of new products, such as breakfast cereals. The carton has many desirable qualities, being lightweight, collapsible for storage, cheap, and disposable, and having suitable surfaces for printing. By itself it is not moisture resistant, nor does it protect its contents from loss or gain of moisture or flavour. Its simplest uses are for dry goods requiring only protection from crushing. When combined with waxed paper or plastic inner bags, liners, and overwraps, it can be used for moisture-sensitive foodstuffs, pastes, and even such liquids as motor oils. Waxed cartons, widely used for packaging frozen foods, provide an easily handled retail unit.

Cellophane.—Packages had long been decorated with printed representations of their contents; the development of cellophane (regenerated cellulose) by J. E. Brandenberger in Switzerland (1911) offered another possibility, that of displaying the product itself. Transparent sheets of cellophane were made into bags and used as overwraps, sealed by adhesives or gummed labels. In the 1920s in the United States nitrocellulose coatings on cellophane were found to provide better barrier properties to moisture and gases; they also made the cellophane sealable by heating. These coatings extended the use of cellophane as a protective package for foodstuffs. Subsequently, vinylidene chloride copolymer coatings further reduced permeability, thereby increasing storage life.

Plastics.—The first of the true plastic films used in quantity for packaging was polyethylene, introduced after World War II. This was joined by many others, among them polyvinyl chloride, polystyrene, saran, and polypropylene. These polymers are used in sheet form or coatings on cellophane, paper, or aluminum foil. The laminates have good protective and display properties for packaging a wide range of fresh and preserved food products.

Aluminum Foil.—Aluminum foil, which gives some laminates their extremely low permeabilities to gases and vapours, was developed in Germany and Italy in the early 19th century. First used in packaging for decorative effects, aluminum foil, now treated with thermoplastic coatings, provides corrosion resistance and heat-sealing qualities that have increased its usefulness.

The use of aluminum in can manufacture has already been noted; it has also largely replaced tin and lead in the manufacture of collapsible tubes. Lead tubes were introduced in 1840 to replace the small skin bags that were used to hold artists' colours; tubes of tin and of tin and lead were developed later to provide better corrosion resistance at reduced cost. When aluminum was introduced into the impact-extrusion process of tube manufacture, there were initial difficulties because of fracture and corrosion in the tubes when they were used. These were solved by annealing treatments and resin lacquers. The collapsible tube is extensively used for dispensing paints, adhesives, toilet preparations, etc., in small quantities. After 1960 polyvinyl chloride tubes were developed in Germany for corrosive products.

DESIGN

Packaging materials may be used either singly or in combinations. Choice of design is based on functional efficiency and aesthetic appeal. The designer must also consider convenient size for marketing, product content and protection, and cost. The sensitivity of package contents to impact, vibration, compressive loading, humidity, temperature, and light must also be considered. Protection against mechanical shock and vibration is often afforded by incorporating cushioning materials in the package design. These may be natural materials, such as felts and wood-wool, or expanded plastics, rubber, or metal springs. The package itself must have sufficient strength to withstand weight and compression in stacking.

The effects of climatic environment are felt by both package and contents. With metal containers there is, for example, the hazard of rusting; fibreboard cases may lose their strength in dampness. Food spoilage caused by excessive temperatures and humidities can be prevented by using a package with suitable barrier properties. Measures to prevent corrosion of metallic goods include surface treatments, vapour-phase corrosion inhibitors within the package, and hermetically sealed desiccated containers.

In some parts of the world packages may be attacked by insects or contaminated by molds and bacteria. Insecticides and fungicides can be incorporated into the package components, but these must be certified nontoxic when used in food packages. Sterilization against bacteria can be performed chemically, but its lasting effect depends on efficient sealing of the container.

In commercial packaging a balance is usually struck between package cost and permissible losses of the product in transit. Only very expensive items or vital military stores require 100% protection.

With the growth of self-service retail stores, product identification and sales appeal became of increasing importance. In both the United States and Europe studies are made to discover why customers choose one package rather than another (*see* PSYCHOLOGY, APPLIED: *Motivational Research*). The package designer must also be aware of packaging standards and regulations issued by governments and trade organizations. Some of these are applied throughout the world, by the International Standards Organization and similar bodies. Regulations concerning food packaging, for example, limit the lead content of printing inks used on the package, or the types of plastic used in wrappers. All additives and packaging materials must be nontoxic to satisfy food laws in the United States and some other countries. Other regulations protect the consumer by requiring that a declaration of contents, weight, and composition be printed on the package.

Numerous other regulations protect the carrier and assist the transport of goods: for example, those that govern the packaging of dangerous chemicals and radioactive substances; the transport of livestock by air; and the strength of containers for carriage by the railways at their risk. Standards that assist distribution specify the sizes of containers for horticultural produce and of the pallets on which goods are stacked. Other standards that specify materials, styles, and sizes for cans, bottles, cartons, and paper sacks reduce the amount of detailed specification in ordering.

Packaging for the armed forces is governed by special regulations which set more rigorous tests and higher standards than those of commercial practices.

THE PACKAGE MANUFACTURING INDUSTRY

Modern packaging demands mechanized production of basic materials and containers, and machines for filling, closing, and handling them. New materials and methods are constantly being sought, to reduce costs.

It has been calculated that 8% of the steel and 10% of the wood produced in the world is used in packaging. The proportion rises to more than 50% for tin plate, paper, and paperboard and to more than 70% for glass, excluding sheet glass. In plastics about one-quarter of polyethylene produced is used for packaging.

Manufacturing Processes.—Package manufacture is almost wholly mechanized; even wooden cases are machine-made, when sizes are standardized and sufficient quantities are needed. Open-topped food cans are produced on automatic equipment at rates of 600 per minute, and folding cartons from multiple dies are made at rates of more than 1,500 per minute. High speeds are achieved by continuous motion, the replacement of sheet feeding by reel feeding, and the combination of printing and manufacture in one machine. Even sheet feeding is speeded up if done automatically; this can treble the output of a machine making such items as fibreboard cases. Rapid adjustment of machines to produce different sizes and styles of package must be possible so that production-line flexibility is maintained and diverse requirements can be met.

Package Filling and Sealing.—Machines for filling or sealing can be as simple as heat sealers for polyethylene bags or as complex as fully integrated production lines, where the goods are inserted into a carton, sealed, collated, ejected into an outer con-

tainer, glued, and conveyed to a warehouse with the minimum of hand labour. Bottling machines, carton fillers, collapsible-tube fillers, vacuum-packaging machines, and film overwrappers can produce from 20 to 600 units per minute. Machines will also carry out the check weighing required by weights and measures regulations.

For labeling and sealing packages, emulsion, solvent, thermoplastic, pressure-sensitive, and moistening adhesives have been produced. Where thermoplastic films form part of the package body, no extra adhesive is used, and closure is accomplished by fusion with heat supplied by electricity or by infrared, ultrasonic, or radio-frequency sources. Adhesives may also be coated on paper, plastic, or fabric tape to secure the package contents or to seal such items as fibreboard cases. Heavier packages may be secured by tensioned strapping with steel or fibre-based tapes.

Package Handling.—Quantity production requires the mechanization and simplification of the movement of the product to be packaged, the packaging materials, and the final package. Mechanical handling reduces packaging costs by increasing speed, cutting labour, and reducing the risks of dropping that exist when goods are transferred by hand. The principal means of mechanical handling are belt, roller, and other types of conveyor-linking processes, pallets on which containers are stacked, and trucks for moving them.

Through the use of pallets, or skids, for stacking containers and lift trucks to handle them, warehouse space is conserved and loads are built up quickly for transport. Mechanical handling equipment makes possible the use of large container sizes. Free-standing bulk containers are now in use for the transport of cement, chemicals, sugar, liquid fats, and other free-flowing products. International standardization of pallet sizes to fit into vehicles also facilitates the shipment of goods.

Certain types of packaging need special equipment and technical knowledge. For example, there are contract packers who will handle the filling of aerosol containers or the packaging of mechanical or electrical equipment for export.

See also Bottles; Canning, Commercial; Cellophane; Foil; Food Processing Industry; Health and Safety Laws: *Enforcement of Legislation: Food and Drug Laws;* Paper Manufacture; Paper Products; Plastics.

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PACKING HOUSE: *see* Slaughterhouse.

PACORUS (Parthian *pkwr*), the name of several Parthian princes.

Pacorus, sometimes accounted Pacorus I, though it does not appear that he ever ascended the throne, was the son of Orodes II (reigned *c.* 57–*c.* 37 B.C.). He appears in history in 53 B.C. when the celebration of his marriage to the sister of Artavasdes, king of Armenia, coincided with the news of the Parthian victory over the Romans at Carrhae. In the summer of 51 B.C. he was sent to invade Syria with an army commanded by Osaces, an older warrior. Osaces, however, was killed in a battle with C. Cassius. Early next year Orodes, learning that one of his satraps was conspiring to make Pacorus king, recalled his son. In 45 B.C., however, Pacorus led a Parthian force to help the Pompeian general Q. Caecilius Bassus who was besieged in Apamea by the Caesarian forces. Pacorus forced the latter to raise the siege but then retired. When Orodes decided to support the refugee republican general Q. Labienus against the triumvirs in the spring of 40, Pacorus led an army into Syria and Palestine while Labienus occupied Cilicia and overran southern Anatolia. Jerusalem was pillaged and Herod (*q.v.*) the Great fled. In 39 B.C. M. Antonius (Mark Antony) sent Publius Ventidius against Lahienus, and the latter was defeated and killed. Pacorus returned to Syria, was lured into battle by Ventidius, and was also defeated and killed (38 B.C.). The head of Pacorus was displayed in the cities of Syria to convince them of the futility of hoping for Parthian support against the Romans.

Pacorus, brother of Vologaeses I (reigned *c.* A.D. 51–*c.* 80), was made king of Atropatene on his brother's accession to the Parthian throne. His kingdom was overrun by the Alani (Alans) from north of the Caucasus in 72.

Pacorus, sometimes accounted Pacorus II (*see* above), was king of Parthia from *c.* A.D. 78 to *c.* 115. Little is known of him, but he struck coins at Seleucia on the Tigris in April 78. His reign must have been filled with rebellions and the rule of counterkings (Artabanus IV, Osroes, and Vologaeses II). In 110 Pacorus sold the kingdom of Osroene to Abgarus VII, son of Izates. It is uncertain whether Pacorus was alive when Trajan invaded Mesopotamia (114–115). The date of his death is unknown. *See* also Persian History: *Parthian Empire, 2nd Century B.C.–3rd Century A.D.* (R. N. F.)

PACUVIUS, MARCUS (220–*c.*130 B.C.), the greatest Roman tragic dramatist before Accius. Bearer of an Oscan name, born in the Roman colony of Brundisium, and educated probably at Tarentum, he must (like his mother's brother, the poet Ennius) have been equally at home in Oscan, Latin and Greek. As a young man he followed Ennius to Rome and after a time joined the circle of the younger Scipio, as his uncle had joined that of the elder. He died at Tarentum, but was still at Rome at the age of 80, when he competed against Accius, his junior by half a century.

Unlike his uncle and teacher Ennius, Pacuvius, who was also known as a painter, confined himself as a writer almost entirely to tragedy, although he is said also to have composed some satires in the manner of Ennius. Apart from one Roman play entitled *Paullus* (celebrating the victory of Aemilius Paullus over Perseus of Macedon at Pydna in 168 B.C.), the titles of 12 plays translated from Greek originals are known, and it seems possible that Pacuvius wrote no more than these. The titles show that he did not share his uncle's preference for Euripides: one is from Aeschylus, four from Sophocles, only one from Euripides and six from post-Euripidean tragedy. Ingenious plots and those that gave ample scope for argument seem to have especially appealed to him. He did not follow his originals slavishly: Cicero praises him for having reduced the moanings of the wounded Odysseus, excessive in Sophocles, and in another Sophoclean play he has inserted, from a play of Euripides, a passage of invective against augury, which is altogether alien to the spirit of Sophocles. Particularly well known among the 400 or so surviving lines are a description of a storm at sea, and the pathetic appeal for burial of the murdered Polydorus.

Varro considers Pacuvius the model of the elevated style, and he and Cicero see in him the greatest Roman writer of tragedy; later Accius is placed beside or above him. Cicero, however, criticizes his Latin and the fragments show a number of peculiarities in the use and formation of words.

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PADANG, the chief port on the west coast of Sumatra in the province of West Sumatra (Sumatera Barat), Indon., lies at the foot of the steep Padang Highlands. Pop. (1961) 143,699. Padang was one of the oldest Dutch settlements in Sumatra. As early as 1606 an official of the Dutch East India Company (*q.v.*) was sent from Batavia (now Djakarta [Jakarta]) with orders to appoint residents on the west coast of Sumatra and to found factories there, and Padang seems to have been one of the earliest of these, for in 1664 it was styled the capital of Sumatra's west coast. Three years later a small fort and some warehouses were erected on the banks of the Padang River to support the resident and his small staff. The fortress was demolished by the British in 1793, and in 1795 Padang and the west coast of Sumatra were captured by a British force. A British garrison was maintained at Padang and the district remained under British control until 1819 when it was returned to the Netherlands government. The town prospered after the opening up of the highlands with their great mineral wealth and tourist traffic, and the general extension of cultivation in the Sumatra west coast residency, aided by the con-

struction of a railway along the coast to Sungailimau and inland to Fort de Kock (now Bukittinggi) and Pajakumbuh, and branching off from Padangpandjang to Sawahlunto.

The town is well laid out, with government offices and the headquarters and workshops of the railway. Mountain roads in the vicinity offer superb views of the islet-strewn bays and the Indian Ocean. Padang has a cooler climate than most coastal towns near the Equator (monthly mean of 79–80° F); rainfall averages 177 in. a year. The port, formerly called Emmahaven, lies five miles to the south on the northwestern side of Teluk Bajur (Bajur Bay, formerly called Koninginne—that is, Queen's—Bay). From it are exported rubber, copra, tea, coffee, cinnamon, hides, rattans, and also cement from a plant 11 mi. east of Padang. It was originally built as a bunker port for the coal from the great Umbilin coalfields near Sawahlunto, but after World War II production (reduced to about one-tenth of prewar production) was hardly enough for local needs, mainly those of the railway. The port was also affected by the diversion of part of the Padang Highlands' trade along the highway leading to Pakanbaru on the eastern plain. The port, constructed between 1880 and 1890, has two breakwaters, enclosing a harbour surface of one square kilometre. There are four wharves for general cargo, and also coal, salt, petroleum, and dynamite wharves. Shipping services run frequently to Javanese and Malayan ports. There is also an airport. (J. O. M. B.)

PADANG HIGHLANDS, a region on the west side of central Sumatra, Indonesia, which forms part of the Barisan Mountains (Pegunungan Barisan). Highest among several volcanoes are Mt. Merapi (9,480 ft.) and Mt. Singalang (9,440 ft.). Large rivers (Kampar, Inderagiri, and Batanghari) rise in these highlands and flow to the east coast through intramontane depressions. One of these contains Danau (Lake) Singkarak, and along its outlet, the Umbilin River, lies a coalfield. Waterfalls, canyons, and caves add to the superb scenery which, together with the salubrious climate, make it a favourite resort area. There are good road connections to Padang and to Medan (*qq.v.*), as well as Pakanbaru near the east coast. The region is the homeland of the Menangkabau, a skilful and enterprising people. Rice, coffee, and tea are the main products. Bukittinggi (*q.v.*) is the main town of the region at 2,700 ft.; it is connected by rail to Padang.

(J. O. M. B.)

PADDINGTON, a metropolitan borough of London, Eng., which under the London Government Act 1963 was to be amalgamated on April 1, 1965, with the City of Westminster and St. Marylebone to form the new London borough of the City of Westminster (*see* LONDON). The metropolitan borough of Paddington is bounded by St. Marylebone, Westminster, Kensington, Willesden. Area 2.1 sq.mi. Pop. (1961) 116,923. The land early belonged to the abbey of Westminster and was granted to the see of London by Edward VI. It remained rural until the 19th century when the Paddington Canal was cut (1801) and the railway built (1838). Development took place through the 19th century and some of London's earliest flats were built there. Hallfield, planned by the borough council, is an example since World War II of the application of high building to residential purposes. Paddington Station, the terminus of the Western region of British railways, was built originally for the Great Western Railway by I. K. Brunel with the help of M. D. Wyatt and Owen Jones. At St. Mary's Hospital, the drug penicillin was discovered by Sir Alexander Fleming in 1928. The district of Bayswater probably takes its name from "Bayard's watering place"—the stream where horses were watered. Paddington returns two members to Parliament.

PADDLEFISH, the name for two species of large archaic freshwater fishes that have, among other remarkable features, bizarre flattened snouts that overreach wide gaping mouths. They comprise the family Polyodontidae, related to the sturgeons. The American *Polyodon spathula,* of the Mississippi Basin, is dark green, smooth-skinned and may attain a length of 6 ft. or more and a weight in excess of 150 lb. The Chinese paddlefish (*Psephurus gladius*), of the Yangtse River Valley, is much larger. Both species are edible but not particularly prized; the flesh is usually smoked and the roe can be made into a caviar. *See* FISH; *Survey of the Bony Fishes: Sturgeons and Paddlefishes.*

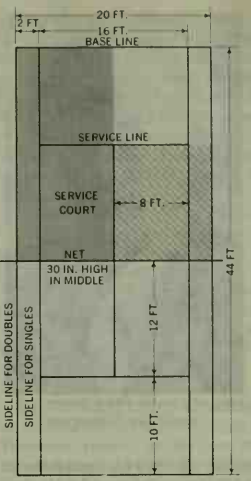


DIAGRAM OF A PADDLE TENNIS COURT

Shading (left) indicates area of adult service court; (right) children's service court

PADDLE TENNIS, a small-scale form of tennis which had its beginnings in a shipboard game originated by the British about 1890. In 1924 Frank P. Beal, then secretary of the Community Council of New York City, introduced a game similar to the British one to the city's playgrounds, calling it paddle tennis. The miniature character of the play area necessary for the game meant that many more children could be simultaneously accommodated on a small playground. Instead of racquets, short-handled rectangular wooden bats, called paddles, were used with a slow bouncing ball of sponge rubber. Courts at first were 39 × 18 ft., one-quarter the size of a regulation tennis court, and many remained that size. Official measurements appear in the accompanying diagram. The net is 31 in. high at the side posts and is pulled taut to not less than 30 in.

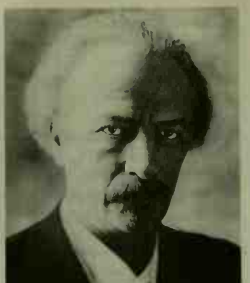
Rules and scoring are similar to tennis (*q.v.*) except that adults are required to serve underhand and are allowed only one serve. Children aged 13 and under may take two serves overhand and have a smaller service court. (F. S. BD.)

PADERBORN, a town of West Germany in the *Land* (state) of North Rhine-Westphalia, Federal Republic of Germany, lies 77 km. (48 mi.) NW of Kassel by road. It is the seat of an archbishop. Pop. (1961) 53,984. The town's appearance was much altered by severe bombing in World War II, but some old buildings survived. The three-gabled town hall (1613–16) is Renaissance; nearby is the Baroque Franciscan church with a fine façade by Antonio Petrini. The cathedral (11th–13th centuries), in the heart of the city, has a tower typical of Westphalian art and a monumental carved portal. The 12th-century district church, the Abdinghof Church (*c.* 1030), and the abbey church (now Evangelical) are all nearby. Of the town's many chapels, the Bartholomew Chapel is the oldest hall church in Germany. Other buildings include the classical gymnasium (1612), the philosophy and theology academy, rebuilt after World War II, and the Jesuit church (1682–86), restored after war damage. The diocesan museum contains the Madonna of Bishop Imad, an important 11th-century sculpture.

The Pader, a small affluent of the Lippe, rises below the cathedral in about 200 springs. Paderborn is an important rail and road junction. Cement, iron, and timber provide the town's chief industries. Paderborn was the birthplace of the Holy Roman Empire in 799 when Charlemagne (Charles the Great) met Pope Leo III there. Excavation of Charlemagne's palace began in 1964. Its prince bishop ruled it from about 1100 until 1802, when it passed to Prussia under an agreement with France. (RU. K.)

PADEREWSKI, IGNACY JAN (1860–1941), Polish pianist, composer, and statesman, who persuaded Pres. Woodrow Wilson to include a paragraph on Polish independence in his famous Fourteen Points (*q.v.*) and who was prime minister of Poland in 1919. Born on Nov. 18, 1860, at Kurylowka, in the Russian Podolia, the son of a steward of the property of a Polish landowner, he studied music from 1872 at the Warsaw Conservatory and from 1876 taught the piano there. In 1880 he married one of his pupils, Antonina Korsak, who died in childbirth the following year. Encouraged by the actress Helena Modrzejewska (Modjeska), he studied in Vienna from 1884 to 1887 under Theodor Leschetizky (Leszetycki), of whose method he became the principal exponent. During this period he also taught at the

Strasbourg Conservatory. Between 1887 and 1891 he made his first public appearances as a pianist in Vienna, Paris, London, and New York. Thereafter he impressed most critics, notably George Bernard Shaw, as the leading pianist of his time, remarkable for both his musical culture and his mind. His personality on the concert platform, like that of Liszt, his predecessor among piano virtuosos, generated a mystical devotion. Chopin, whose works he edited, Bach, Beethoven, and Schumann were the chief composers of his repertory. In 1898 he settled at Riond Bosson near Morges in Switzerland and the following year married Helena Gorska, *née* Baroness von Rosen. In 1901 his opera *Manru*, dealing with life in the Tatra Mountains, was given at Dresden. In 1909 his Symphony in B Minor was given at Boston, and in the same year he became director of the Warsaw Conservatory.



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IGNACY JAN PADEREWSKI

Throughout his life Paderewski was a staunch patriot. In 1910, on the 500th anniversary of the Battle of Grunwald, he had presented the city of Cracow with a monument commemorating the victory of the Poles over the Teutonic Order. During World War I he became a member of the Polish National Committee, presided over by Roman Dmowski, and was appointed its representative to the United States. During 1916 and 1917 he frequently urged Pres. Woodrow Wilson to use his influence to restore an independent and united Poland, with the result that Wilson included the independence of Poland in his tentative peace message of Jan. 22, 1917, and his Thirteenth Point of Jan. 8, 1918.

In December 1918 Paderewski visited Paris and London, where A. J. Balfour encouraged him "to go to Poland to unite the Polish hearts." By agreement with Dmowski in Paris, he left for Danzig and later visited Poznan and Warsaw, where Jozef Pilsudski was provisional head of state with a left-wing government. In Paris, however, the Polish National Committee was recognized by the Allies as representing the Polish nation. Persuaded by Paderewski on the necessity of forming a broad national government, Pilsudski asked him to form in Warsaw a government of experts free from party tendencies. This was formed on Jan. 17, 1919. Paderewski reserved the portfolio of foreign affairs for himself and appointed Dmowski first Polish delegate at the Paris Peace Conference.

His premiership was not a success. As a virtuoso Paderewski was accustomed to flattery and he resented criticism. His ambition was to be elected president of the Polish Republic, but he was supported by no political party. On Nov. 27, 1919, he resigned the premiership and returned to Riond Bosson. He never revisited Poland. In 1921 he resumed his musical career, giving concerts in Europe and the United States mainly for war victims. At the beginning of World War II, in October 1939, a Polish government in exile, formed in Paris with Gen. Wladyslaw Sikorski as prime minister, offered Paderewski the chairmanship of the Polish National Council. After the French capitulation in 1940 he went to the United States. He died in New York City on June 29, 1941.

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PADILLA, JUAN (d. 1542), Spanish Franciscan, the first Christian missionary to be martyred within the present territory of the United States, was born in Andalusia and joined the Franciscans there after service as a soldier. Confusion about the facts of his life has arisen from the presence in Mexico of another friar of the same name. The future martyr went to Mexico in 1528. In 1529 he accompanied an expedition to Nueva Galicia (northwestern Mexico). There he spent most of his remaining years except for a trip to Tehuantepec with Hernán Cortés in 1533. He laboured at Tepic, Tuchpán, Ponzitlán, Tulantizingo, and Zapotlán, and established the first Franciscan residences at Tulantizingo and at Zapotlán. During those years Padilla revealed a strong and resourceful character, somewhat impetuous and endowed with a marked gift of leadership. Perhaps these qualities caused his selection as one of the five Franciscans to accompany the Coronado expedition in 1540. Certainly they won him an honoured place with the captains of the expedition and even with Francisco Coronado, whom he accompanied on the journey to Quivira, probably in modern Kansas. When Coronado returned to Mexico, Padilla decided to go back to Quivira with a Portuguese, André do Campo, and several companions. After working for several months among the Wichitas, he decided to visit the Guas. In 1542 the Indians ambushed him on the road in sight of his companions, who escaped to Mexico. The probable site is near Lyons, Kan.

See Antonio Tello, *Historia general de Jalisco* (1894); H. E. Bolton, *Coronado on the Turquoise Trail* (1949). (A. S. TR.)

PADILLA, JUAN DE (1490?–1521), military leader of the Castilian *comuneros* in their revolt against the administration imposed by Charles I of Spain (the Holy Roman emperor Charles V). He was a member of an ancient noble family of Toledo. The choice of foreigners for high posts in Spain was especially resented at Toledo; and Padilla, who also had personal grievances, was involved in dissidence there early in 1520. Summoned in April to appear before the king at Santiago, he took up arms instead. When the *comunidades* (municipalities) of Castile, supported by nobles and clergy, set up their "Holy junta" at Ávila in July–August 1520 to oppose the cardinal of Utrecht (regent for the absent king since May; later Pope Adrian VI), Padilla was made captain general of its forces; and on Aug. 29 he took Tordesillas, thus assuring the junta's control over the hereditary queen of Castile, Joan the Mad, who had been living there since her abdication. There was rivalry, however, between the junta's commanders; the captaincy general was transferred in the autumn to Pedro Girón, pretender to the duchy of Medina Sidonia; and Padilla withdrew to Toledo. When the regency's troops had recovered Tordesillas (Dec. 5) and Girón had defected, the junta, now at Valladolid, recalled Padilla to be captain general again in January 1521. He occupied Torrelobatón for the *comuneros* on February 28. Seven weeks later, on the advance of the regency's forces, he tried to retreat to Toro but was attacked, defeated, and captured at Villalar on April 23, 1521, and executed next day.

PADISHAH, the Turkish form of the Persian *padshah*, a title—equivalent to "lord king"—of the reigning sovereign. In Europe it was applied to the sultan of Turkey. The Persian *padshah* is from *pati*, "lord," "master," and *shah*, "king."

PADSTOW, a seaport, market town, and urban district of Cornwall, Eng., is 15 mi. NW of Bodmin by road. Pop. (1961) 2,675. It lies on the north coast, two miles from the estuary of the Camel River, and owes its selection for early settlement to its tolerably safe anchorage. St. Petroc, called the patron saint of Cornwall, is said to have landed at Padstow and to have died there in the 6th century. The ancient name of the place was Petrocstow (Petroc's Church). A document owned by the Royal Institution of Cornwall provides proof that a corporation of Padstow was in existence in 1592. In the reign of Elizabeth I, Padstow was of major importance as a seaport, and Sir Walter Ralegh (Raleigh), who was once the warden of Cornwall, lived at Raleigh's Court House on the South Quay. Abbey House, on the North Quay, is a 15th-century building, and Avon Cottage, Treator, is the birthplace of Sir Goldsworthy Gurney, the inventor of the steam jet welding plant and the lighthouse revolving beam. Prideaux Place (1598), a fine Elizabethan manor house, is still occupied by descendants of the original family. The Church of St. Petroc is mainly Perpendicular with an Early English tower. At Harlyn Bay, 2½ mi. W of Padstow, is an Iron Age cemetery and a Celtic museum. Fish curing and shipbuilding were formerly carried on at Padstow; now there is only one shipyard and two other boatyards, all turning out small craft. Fishing, however, is still an industry. Padstow attracts many tourists, and sailing is much in vogue. Sand dredged commercially from the harbour is in demand

as a land fertilizer. A lifeboat is maintained by the Royal National Lifeboat Institution. On May Day everyone joins in the unique "Padstow 'Obby 'Oss" (hobby horse) festivities which are believed to have originated in an ancient fertility rite. (C. P. Bu.)

PADUA (Padova), a city of northeast Italy, capital of the province of Padua in the region of the Veneto (Venetia), and an episcopal see, lies 43 km. (27 mi.) W of Venice by road. Pop. (1961) 206,223, commune. The city is on the Bacchiglione River, navigable branches of which flow through it. In Roman times these channels, enclosing a kind of quadrilateral area, were a substitute for walls and, after the first medieval walls were built, served as a moat. Some parts of Padua are still of medieval aspect, with narrow, irregular streets flanked by colonnades. The modern main thoroughfare (with different names for its various sections) runs from north to south, starting at the railway station. On the east of that portion of it, called the Corso Garibaldi, stands the church of Sta. Maria dell'Arena with the Cappella Scrovegni, the oratory which Enrico degli Scrovegni built between 1303 and 1305 and which is frescoed throughout by Giotto. Close by is the Romanesque-Gothic church of the Eremitani (1276–1306), where the two Da Carrara lords of Padua, Jacopo or Iacopo (1350) and Ubertino (1345), are buried; its frescoes by Andrea Mantegna were almost destroyed in World War II. Farther south, on the Via 8 Febbraio, is the university, whose nucleus is the Palazzo "Il Bo" (16th–17th centuries); this includes the "Liviano" Building, where the faculty of letters is housed. Founded in 1222, the university is the oldest in Italy after Bologna; among its teachers have been famous philosophers, humanists, and scientists including Galileo, relics of whom are in a museum connected with it.

Opposite the university is the *municipio* (partly old) and beyond this is the Palazzo della Ragione (Il Salone), built 1218–19, reconstructed in the 14th century, with an 18th-century roof. North of these is the Caffé Pedrocchi, designed in neoclassic style by Giuseppe Zappelli (1831). It has links with the Risorgimento in Padua through the meetings held in its ornate rooms by patriots, artists, and men of letters and is mentioned in the preface of Stendhal's *La Chartreuse de Parme*. Farther west lies the Piazza dei Signori, with the Palazzo del Capitanio (now the university library) by Falconetto da Verona (1532) and the Loggia del Consiglio (1498). South of these rises the 13th-century Duomo (cathedral), which has a Romanesque baptistery frescoed by Giusto Menabuoi and rebuilt in the 16th century. Farther south, and east of the main thoroughfare on the Piazza del Santo, is St. Anthony's Basilica, where the saint is buried. It is Romanesque-Gothic (1223–1307) with Oriental touches such as the minaret-like appearance of the cupolas and bell tower. It has three naves; statues and reliefs by Donatello (1447) on the high altar; and works by P. and T. Lombardi, Jacopo Sansovino, and Mantegna. In the piazza also is Donatello's magnificent bronze monument to the condottiere in the service of the Venetian Republic, Erasmo da Narni ("il Gattamelata," 1453). Nearby is the Scuola del Santo, where there are frescoes by the young Titian; and adjoining it the civic museum with art gallery attached. This contains works by Guariento, Bellini, Giorgione, Tintoretto, Veronese, Longhi, Tiepolo, and Piazzetta. To the south is the botanical garden, whose date of foundation (1545) makes it the oldest in Europe, and, on its west side, an open space, the Prato della Valle, containing memorials to noteworthy citizens and university members.

Libraries, rich in incunabula, include the Biblioteca del Seminario with autographs of Petrarch and Galileo and the Biblioteca Antoniana with manuscripts of St. Anthony.

Padua is an important junction for electrified railways running east, west, and south, as well as a centre of the dense road network of the Veneto. There is a radio and television station on the highest peak of the Euganean Hills a few miles southwest. The nearest airport is that of Venice. The city is a lively agricultural, commercial, and industrial centre. Manufactures include electrical and agricultural machinery, drawn wire, motorcycles, artificial and synthetic fibres, liqueurs, soap, and ink.

According to legend, Padua, or Patavium, was founded in 1184 B.C. by the Trojan hero Antenor, but the first historical mention of it, reported by the Roman historian Livy (Titus Livius), who was born there (59 B.C.), dates from 302 B.C. It prospered greatly as a Roman city and, from the 12th to 14th centuries, as a leading Italian commune. Dante lived there, and St. Anthony died there in 1231. From 1318 to 1405 it was governed by the Carraras and by Venice from then until 1797, when Napoleon overthrew the Venetian Republic. Padua's part in the Risorgimento is marked by the rising of Feb. 8, 1848. The city was heavily bombed in World War II.

Padua Province.—The Paduan countryside is intensively cultivated, the chief crops being sugar beet, wheat, maize (corn), vines, and fruit. Cattle, especially dairy cows, are also raised. There is hydroelectric power production and extraction of methane gas. Among the many interesting small towns are Este (*q.v.*), noted for its ceramics; Abano Terme, Montegrotto Terme, and Battaglia Terme, with their well-known spas. At the foot of the Euganean Hills is the little town of Arquà Petrarca, where the poet Petrarch died in 1374 and where his tomb and house are shown.

(M. T. A. N.)

PADUCAH, a city of southwestern Kentucky, U.S., and seat of McCracken county, is located at the confluence of the Ohio and Tennessee rivers. It has been an important market for tobacco, strawberries, corn and livestock, with well diversified industry. The city is located in one of the world's greatest power-generating areas. The Tennessee Valley authority and the Atomic Energy commission added greatly to the city's industrial growth, while recreational facilities provided by Kentucky Lake and Kentucky Dam Village State park made the area a tourist attraction. The town is the seat of Paducah Junior college (1932). The council-manager form of government was adopted in 1934. The site, known as Pekin, was part of a grant to George Rogers Clark, American Revolutionary hero. At his death his brother William, coleader of the Lewis and Clark expedition, received the land, laid out the town in 1827, and named it for Paduke, a Chickasaw Indian chief who lived in the vicinity. It was chartered as a city in 1856. During the American Civil War, because of its strategic river facilities, the city was occupied by Union forces under Gen. Ulysses S. Grant, and was raided by Gen. Nathan B. Forrest, Confederate cavalry leader. Paducah was the home of Irvin Shrewsbury Cobb (*q.v.*), who is buried there.

For comparative population figures *see* table in Kentucky: *Population*. (J. C. Cr.)

PAEAN, in Homer's *Iliad*, is the physician of the gods. It is not known whether he was originally a separate deity or merely an aspect of Apollo. Homer leaves the question unanswered; Hesiod definitely separates the two, and in later poetry Paean is invoked independently as a health god. It is equally difficult to discover the relation between Paean or Paeon in the sense of "healer" and paean in the sense of song. L. R. Farnell referred to the ancient association between the healing craft and the singing of spells, and said that it is impossible to decide which is the original sense. Such songs were originally addressed to Apollo, and afterward to other gods, Dionysus, Helios, Asclepius. It was the custom for a paean to be sung by an army on the march and before entering into battle, when a fleet left the harbour and also after a victory.

Paeans were sung at the festivals of Apollo (especially the Hyacinthia), at banquets and later at public funerals. Later, especially in Hellenistic times (first by the Samians to Lysander) they are addressed to more or less deified men. The word paean is used of any song of joy or triumph.

PAELIGNI, an ancient people of central Italy, whose territory lay inland on the eastward slopes of the Apennines, their chief towns being Corfinium and Sulmo (Sulmona). Though akin to the Samnites (*q.v.*) to the south, they were not members of the Samnite confederation but formed a separate league with their neighbours the Marsi, Marrucini, and Vestini (*qq.v.*). This league appears to have broken up after the end of the Second Samnite War (304 B.C.), when each tribe came into alliance with the Romans. The Paeligni remained loyal to Rome, distinguishing themselves at the Battle of Pydna (168), until the Social War (the

war of the *socii*, or allies; 91 onward), when the mountain fortress of Corfinium was chosen as the capital of the rebellious allies and renamed Italia (Oscan *Vitelliu*). As a result of the war the Paeligni received Roman citizenship, together with the other allies; thereafter they became thoroughly romanized.

The oldest Latin inscriptions of the district probably date from shortly after the Social War; but as several of the dialect inscriptions, which are all in the Latin alphabet, show the normal letters of the Ciceronian period, there is little doubt that the Paelignian dialect lasted down to the middle of the 1st century B.C. Similar dialects were spoken by the Marrucini and Vestini; together they form a group known as Northern Oscan (*see* OSCAN).

See R. S. Conway, *The Italic Dialects*, vol. i, pp. 233 ff. (1897); M. Hofmann and E. Vetter in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, xviii, 2227–2275 (1942).

PAEONIA, the land of the Paeonians, originally included the whole Axius (Vardar) Valley, and the areas eastward to the Strymon River and Mt. Pangaeum, westward to Pelagonia, and southward to Pieria, an area now covering parts of northern Greece, southern Yugoslavia, and western Bulgaria. The Paeonians were a people probably of mixed Thraco-Illyrian origin, whom Homer makes allies of the Trojans. The Persian king Darius I (reigned 522–486 B.C.) deported two tribes to Phrygia and, weakened by the Persian invasion, those along the Strymon fell under Thracian control. The growth of Macedonia forced the independent Paeonians northward and they were henceforth restricted to an area between Illyria and the upper Strymon, centring on the Vardar around Stobi (near modern Gradsko) and Bylazora (Titov Veles, Yugos.). Philip II checked their frequent invasions of Macedonia, and defeated them. Paeonian cavalry served with Alexander the Great, and one tribe, the Agrianians, furnished valuable infantry. The native dynasty was held in high honour. About 289 King Audoleon received Athenian citizenship, and his daughter married Pyrrhus, king of Epirus. Shortly after the invasion by the Gauls under Brennus (280/279) a Paeonian confederacy (*koinon*) appears under King Dropion; but the Macedonian king Antigonus II Gonatas reunited Paeonia with Macedonia, of which it henceforth formed part. Under the Romans it fell under the second and third districts of Macedonia. Toward A.D. 400 Paeonia and Pelagonia became a separate province of Macedonia *salutaris* or *secunda* in the prefecture of Illyricum, but by then the people had lost their identity, and Paeonia was merely a geographical term. Modern Paeonia forms an *eparchia* in the *nomos* of Kilkis, Greece, with its capital at Goumenissa.

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(F. W. WA.)

PAEONIUS, of Mende in Thrace, a Greek sculptor of the latter part of the 5th century, B.C., is known for his statue of the goddess of victory at Olympia. The statement of Pausanias that he executed one of the pediments of the temple of Zeus at Olympia is doubtful.

There does exist an important original work of Paeonius in the Nike ("Floating Victory"), found at Olympia. Probably set up in memory of the battle of Sphacteria, 424 B.C., it bears the inscription "Dedicated to Olympian Zeus by the Messenians and Naupactians as a tithe of the spoil of their enemies. Paeonius of Mende made the statue, and was a successful competitor in the construction of the acroteria for the temple." It was on a triangular base, 30 ft. high, which still stands in front of the temple of Zeus. The statue itself is in the museum. Copies of the head are in the Hertz collection in Rome and in the Vatican.

See G. M. A. Richter, *The Sculpture and Sculptors of the Greeks*, new ed. (1950, 1951). (D. M. R.)

PAËR, FERDINANDO (1771–1839), Italian opera composer, was born at Parma on June 1, 1771. He was much influenced by the French opera of the period, his first opera, *Orphée et Euridice*, produced at Parma in 1791, being a setting of a French version of the Orpheus legend. In the same year he went to Venice as *maestro di cappella* and from there he moved to Vienna where he produced his most successful opera, *Camilla*, in 1799. In 1803 he was appointed *Kapellmeister* at Dresden and there produced his *Leonora*, a setting in Italian of J. N. Bouilly's libretto, which also formed the basis of Beethoven's *Fidelio*. In 1806 he accompanied Napoleon to Poland and in 1807 was appointed his *maître de chapelle* in Paris. In 1812 he succeeded Gasparo Spontini as director of Italian Opera at the Odéon, where he remained until 1827. He died in Paris on May 3, 1839. (DY. H.)

PAESTUM (Greek POSEIDONIA), an ancient Greek city in Lucania, Italy, near the west coast, 22 mi. SE of modern Salerno and 5 mi. S of the Silarus (modern Sele) River. It was founded by Troezenian and Achaean colonists from Sybaris, probably *c.* 600 B.C., for it was flourishing *c.* 540 B.C. when the neighbouring city of Elea (Velia) was founded. After many years' resistance it fell to the Lucanians (before 400 B.C.), changing its name to Paestum (though its Greek patron god Poseidon still appeared on some of its coins). Alexander, king of Epirus, defeated the Lucanians at Paestum *c.* 332, but the city remained Lucanian until 273, when it came under Roman rule and a colony was founded there. It remained loyal to Rome during the Second Punic War. Under Augustus and Tiberius the area was highly cultivated and celebrated for its flowers—the "twice-blooming roses of Paestum" are mentioned by several Latin poets; but the silting up of the mouth of the Silarus was already making the neighbourhood unhealthy. In 871 Paestum was sacked by Saracen invaders; its population then moved to Capaccio nearby. In the 11th century it was further dismantled by Robert Guiscard, and it was not until the 18th century that the ruins were rediscovered.

These include a large sacred area, divided in two by the forum (probably earlier the Greek agora), and containing three Doric temples in a remarkable state of preservation. The northern sanctuary contains the so-called Temple of Ceres, in fact a late 6th-century temple of Athena (the conventional names of the temples date from the 18th century). The exterior columns, 6 at the ends and 13 at the sides, and parts of the pediments survive, though the Ionic inner porch has vanished. In front stood a sacrificial altar as long as the temple is broad. The earlier temple in the southern sanctuary is the so-called Basilica, probably built *c.* 540 B.C. and dedicated to Hera. Its plan is unique: it has 9 columns at the ends and 18 at the sides, while a single inner line of columns runs down the middle. All the exterior columns and the architraves upon them are standing. The ornamented capitals of both Basilica and Temple of Ceres are without parallel in Doric architecture elsewhere. The temple known as the Temple of Neptune is another temple of Hera, probably built *c.* 460 B.C. and the best preserved of the three. There are 6 columns at the ends and 14 at the sides; the cella has two inner rows of 7 columns, each supporting a second smaller column. Excavations of this sanctuary revealed traces of 11 smaller shrines, all apparently dedicated to Hera.

The Temple of Peace in the forum, a Corinthian-Doric building,

J. ALLAN CASH—RAPHO GUILLUMETTE

THE SO-CALLED TEMPLE OF CERES AT PAESTUM, 6TH CENTURY B.C.

begun perhaps in the 2nd century B.C., was excavated in 1830. Traces of a Roman amphitheatre and other buildings, as well as of the main street, have also been found. The circuit of the town walls, well built of squared blocks of travertine and 15–20 ft. thick, is almost entire; they are about three miles in circumference enclosing a roughly rectangular area. There were four gates, the eastern gate (Porta Sirena), with a single arched opening, being well preserved. Outside the north gate is an extensive sepulchral area with burials of all periods. Near the mouth of the Sele is another sanctuary of Hera, which has produced several interesting archaic sculptured panels. A museum contains the rich and varied yield of several years of excavation at these sites.

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PÁEZ, JOSÉ ANTONIO (1790–1873), Venezuelan patriot and politician, a leader in the independence movement, and first president of the country, was born in Aricagua near New Barcelona on June 13, 1790, of part-Indian parents. As a youth he worked as a peon. In 1810 he joined the revolutionary movement against Spain as the leader of a band of mounted plainsmen. He became a valued lieutenant of Simon Bolívar (*q.v.*) and was instrumental in the victories of Carabobo (1821) and Puerto Cabello (1823). In 1826 he rebelled against the central authorities of Gran Colombia, of which Venezuela was a province; Bolívar personally negotiated the settlement which left Páez as military and civilian head of Venezuela. In 1829 Páez led the separatist movement which resulted in Venezuela's becoming a sovereign nation.

Elected president in 1831, he gathered about himself members of the old elite and those enriched by the war. As leader of the new nation Páez showed considerable political ability in balancing the antagonisms existing between the articulate elements. As a moderate dictator fulfilling the dual role of chief of government and a moral power above and beyond the law, he ruled directly or through lieutenants until 1846, when one of his personal choices for the presidency turned against him and he was imprisoned. He was sent into exile in 1850. In 1858 and again in 1861 he heeded the call to return and give direction to the oligarchy; each time he was forced after a few months to seek asylum abroad, the last time in 1863. He spent the remainder of his life in exile, mostly in New York City, but he also visited Argentina, Uruguay, Bolivia, Peru, and Colombia. He died in New York on May 7, 1873. His autobiography was published while he was living in New York (1867–69). (J. J. J.)

PÁEZ, PEDRO (1564–1622), Spanish Jesuit missionary, called the second apostle of Ethiopia, was born at Olmedo in 1564. He entered the Society of Jesus in 1582, and sailed for Goa in 1588. On his way to Ethiopia in 1589 he was captured by Turkish pirates and enslaved until 1596, when he returned to Goa, but set out again for Ethiopia in 1603. He learned the two chief dialects of the country, translated a catechism and wrote a treatise on the theological errors of the Ethiopian Church. He also wrote (in Portuguese) a history of Ethiopia (published in *Biblioteca historica de Portugal e Brasil*, serie ultramarina, vol. v, 1945–46). Páez succeeded in converting the emperor, and for a time the whole country was in large part Roman Catholic. Páez was the first European to visit the source of the Blue Nile. He died of fever at Gorgorà on May 20, 1622.

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PÁEZ, a South American Indian tribe belonging to the Chibchan (*q.v.*) linguistic stock. The Páez (pop. 16,000 in the 1960s) are, with the Goajiro (Guajiro), the most important Indian group of Colombia (*q.v.*). They live in the region of Tierradentro, on both sides of the upper Páez River, up to the Nevado del Huila volcanic peak. Discovered by Sebastián de Belalcâzar (*q.v.*) in 1534, the warlike Páez resisted Spanish colonial domination, and assisted by the rugged nature of their country they maintained their cultural identity and language. Their culture has undergone severe changes since pre-Columbian days. Spanish influence is felt in their dress, architecture, and layout of villages, which are built around a plaza and a church. They live in reserves in small, scattered family groups. Each village is administered by a *cabildo*, an elected municipal body. Officially Roman Catholic, they retain a belief in spirits from whom highly respected shamans (*see* SHAMANISM) are held to draw their supernatural power. The Páez are good weavers and make rope and various articles of sisal, as well as excellent waterproof hats and capes. They no longer cast gold ornaments and figures, as in prehistoric times. Although they rely mainly on maize and potatoes for subsistence, they raise sugar cane, from which they ferment their favourite drink.

See H. Nachtigall, *Tierradentro, Archäologie und Ethnographie . . .* (1955); M. Layrisse *et al.*, "Blood Group Antigen Studies of Four Chibchan Tribes," *American Anthropologist*, vol. 65 (1963).
(A. MX.)

PAGAN, a village in the Myingyan district, Burma, lies on the Irrawaddy River, 92 mi. SW of Mandalay. Pop. (1953) 2,825. It was the capital of the Pagan kingdom (*see* BURMA: *History*) from *c.* 1050 to 1300. The Mon people called the area around it Tattadesa, "the Parched Land." The walled city was quite small though the city in a wider sense stretched from Nyaungu in the north to Thiripyissaya in the south and to the foot of Mt. Taywin in the east. This area, still covered with hundreds of pagodas in various stages of decay, is a place of pilgrimage for the Burmese. The main gate Tabala (Tharaba) still survives. Many famous pagodas, Shwezigon (1090), Ananda, Thatbyinnyu, Shwegugyi, Gawdawpalin, Mahabodhi, Bu, and the beautiful Nanpaya (decorated with relief carvings in stone and built by Makuta the captive Mon king) are still well preserved. The Pagan Burmese were Buddhists before they conquered Lower Burma, and their Buddhism was a modified Hinayanism to suit their national genius. There were two religious sects, the Sinhalese order, which was orthodox, and the order of the "forest dwellers," which was more popular in the latter part of the Pagan period. A small museum of the archaeology department near the Ananda pagoda houses some inscription stones found at Pagan including the famous Rajakumar inscription, mistakenly called the Myazedi inscription, with Pyu, Mon, Pali, and Burmese faces (called the Rosetta Stone of Burma); the Disapramuk inscription describing the 1285 peace mission to Peking; a Chinese inscription mentioning the Mongol invasion; a Siamese inscription alluding to a pilgrimage made to Pagan; and a Tamil inscription referring to the building of a Hindu temple at Pagan. *See* also BURMA: *Archaeology.*
(T. TU.)

PAGANINI, NICCOLÒ (1782–1840), Italian violinist and composer, the principal violin virtuoso of the 19th century, and one of the creators of the aesthetic of extravaganza in musical romanticism, was born Oct. 27, 1782, at Genoa. He studied there with Giacomo Costa. Following his first appearance in 1793, he studied with Alessandro Rolla and Gasparo Ghiretti at Parma, and in 1797 toured Lombardy with his father. Gaining his independence soon after, he indulged in gambling and romantic love affairs.

Between 1801 and 1807 he wrote the 24 *Capricci* for unaccompanied violin, displaying the novel features of his technique, and the two sets of six sonatas for violin and guitar. He reappeared in Italy as a violinist in 1805, and was appointed director of music at Piombino by Napoleon's sister, Élisa Bonaparte Baciocchi. He later gave concerts of his own compositions in many towns in Italy, and in 1815 formed an attachment with the dancer Antonia Bianchi.

In 1828 Paganini's success in Vienna resulted in his becoming a popular idol, and his appearances in Paris and London in 1831 were equally sensational. In 1833 he settled in Paris where he inspired Berlioz to write his symphony *Harold en Italie*. Following the failure of the Casino Paganini, with which he was connected, he went to Marseilles in 1839. He died at Nice on May 27, 1840.

Paganini's romantic personality and adventures created in his

own day the legend of a Mephistophelean figure, though his inner nature was devoured by melancholy and depression. His violin technique, based on that of his works, principally the *Capricci,* the violin concertos and the sets of variations, demanded a wide use of harmonics and pizzicato effects, new methods of fingering and even of tuning.

Paganini's innovations revolutionized violin playing and became the basis for later virtuosi, notably Pablo de Sarasate y Navascues and Eugène Ysaÿe. Though the musical value of his work was limited, the influence of his virtuosity extended to piano and orchestral music, and themes from the *Capricci* inspired works in a brilliant style by Liszt, Rachmaninoff, and others.

See A. Codignola, *Paganini intimo* (1935); G. I. C. de Courcy, *Paganini, the Genoese,* 2 vol. (1957). (E. Lr.)

PAGE, SIR EARLE CHRISTMAS GRAFTON (1880–1961), Australian politician, leader of the Country Party (1920–39), was born at Grafton, New South Wales, on Aug. 8, 1880. Educated at Sydney University, he studied medicine and practised in northern New South Wales, where at that time a strong movement was developing in favour of the establishment of a new state, free from the allegedly overbearing effect of Sydney urban interests. This agitation, which attracted Page into politics, also gave great impetus to the growth of a primary producers' party, the Australian Country Party, which derived strong support from men who had settled on the land after returning from World War I. Hence it was pertinent that Page himself had served overseas (1916–17). As member for Cowper he was among the first Country Party representatives elected to the federal parliament in 1919, and he became the party's leader in 1920.

The Country Party's influence forced the withdrawal of W. M. Hughes from the leadership of the Nationalist Party and the premiership in February 1923. In the Nationalist and Country coalition, which replaced Hughes' government, Page led 5 Country Party members in a cabinet of 11. He had the portfolio of treasurer and was scarcely less influential than the prime minister, S. M. Bruce. Their governments, which continued until 1929, gave exclusive priority to the development of the national economy (*see* Australia: *History*). Page was created a privy councilor in 1929. Never again did he or the party exercise so much influence as in the 1920s. Nevertheless he was minister of commerce (1934–39 and 1940–41) and in 1934 established and was first president of the Australian Agricultural Council, which endeavoured to develop a national policy of primary production. Knighted in 1938, he was "caretaker" prime minister following the death of J. A. Lyons in April 1939, but his deposition from the party leadership shortly afterward marked the deepening of a very long political twilight. While minister of health (1949–January 1956) he put into practice the national health scheme for Australia and in 1955 became the first chancellor of the University of New England, Australia's only rural university. Page remained an M. P. until immediately before his death at Sydney on Dec. 20, 1961.

In the peculiar Australian situation where primary producers, although of crucial importance to the national economy, were heavily outnumbered by urban dwellers, Page played out an important historic part. Lacking, perhaps, great distinction, he nevertheless represented the Country Party with fidelity and helped to elevate it above the level of a pressure group. His autobiography, *Truant Surgeon,* was published in 1963. (O. M. R.)

PAGE, SIR FREDERICK HANDLEY (1885–1962), British aircraft designer and pioneer in civil air transport, was born at Cheltenham, Gloucestershire, Nov. 15, 1885. After studying electrical engineering at City and Guilds of London Engineering college, he became interested in the problem of flight and founded Handley Page, Ltd., in 1909. This was the first British company devoted solely to aircraft construction, and the first successful aircraft designed by Page flew in 1910. During World War I he produced the world's first twin-engined heavy bomber, which was shortly followed by the four-engined V-1500, designed for the bombing of Berlin, a project stopped by the Armistice. In 1919 he formed Handley Page Transport, Ltd., which pioneered airline services to France, Belgium, the Netherlands and Switzerland, and later merged to form Imperial Airways.

After World War I Handley Page, Ltd., continued to design successful bombers and transport aircraft, including the Victor crescent-wing, a four-jet bomber.

Handley Page died in London on April 21, 1962. (D. Cr.)

PAGE, THOMAS NELSON (1853–1922), U.S. author who did much to build up the romantic legends of the Southern plantation, was born on Oakland plantation, Hanover County, Va., April 23, 1853. He attended Washington College (now Washington and Lee University), taught for a year, and in 1874 graduated in law at the University of Virginia. He practised until 1893, when he moved to Washington, D.C., and devoted himself to writing and lecturing. He began by writing dialect verse, but first won notice with the story "Marse Chan" in the *Century Magazine.* This and similar stories were collected in what is probably Page's most characteristic book, *In Ole Virginia* (1887), reflecting his formative years amid the glamourous life of the old regime and the tumults of the Civil War. His essays and social studies have the same tone as his fiction. From 1913 to 1918 Page was ambassador to Italy. He died on Nov. 1, 1922, at Oakland, Va.

Page's works include *Two Little Confederates* (1888); *The Burial of Guns* (1894); *The Old Gentleman of the Black Stock* (1897); and *Red Rock* (1898). The Plantation edition of his works (12 vol.) was published in 1906.

See Rosewell Page, *Thomas N. Page* (1923); J. Hubbell, *The South in American Literature, 1607–1900* (1954).

PAGE, WALTER HINES (1855–1918), U.S. writer and diplomatist, who played an important part in British-U.S. relations during World War I, was born at Cary, N.C., Aug. 15, 1855. At 16, after a preparatory course at the Bingham Military School at Mebane, N.C., and a year at Trinity College (now Duke University), at Durham, N.C., Page entered Randolph-Macon College at Ashland, Va. The greatest and most lasting influence in his life there, Thomas Randolph Price, became deeply attached to Page, and obtained his appointment as one of the first 20 fellows of the new Johns Hopkins University at Baltimore. There under America's great classical scholar, Basil L. Gildersleeve, Page acquired a knowledge of antiquity and a feeling for Greek literature that influenced all his subsequent habits of thought as well as his own literary style. Page's health, always frail, caused him to leave Johns Hopkins without a degree. A winter (1878–79) spent in teaching English at the high school at Louisville, Ky., convinced him that he wanted an active life among men, and in 1880 he became editor of the *St. Joseph* (Mo.) *Gazette.* St. Joseph did not hold his interest long. He left in the summer of 1881 to make a tour of the Southern states, writing a series of brilliant articles that were simultaneously printed in several leading U.S. newspapers. The next two years Page spent as literary editor of the *New York World,* but in 1883 he resigned and returned to Raleigh, N.C. For two years he edited the *State Chronicle,* a weekly newspaper, as distinguished for the vivacity of its editorial style as for the unconventionality of its opinions. Page ridiculed the tendency to regard a Confederate war record as almost the exclusive qualification for public office; he advocated primary education for both whites and Negroes, the development of scientific agriculture, the building of modern highways, and the creation of local industries. All these changes North Carolina has since introduced; the youthful Page, however, was ahead of his time, and after two rather tempestuous years, in which he found himself denounced as a "Southern Yankee," he had to confess failure, dispose of his paper and resume his life in New York.

His Literary Career.—Page's opportunity came in 1887, when he joined the staff of the *Forum.* In four years he transformed a bankrupt property into a profitable one and made it an influential organ of public discussion. He resigned his editorship in 1895 and entered the Boston publishing house of Houghton, Mifflin & Co. For two years he was literary adviser and associate editor of the *Atlantic Monthly,* and in 1898 became editor in chief. In 1900 he joined Frank N. Doubleday in establishing the publishing house of Doubleday, Page & Co. and founding the *World's Work* magazine, on which he served as editor from 1900 to 1913. Both in his writing and in his lectures, he continued to advocate his favourite causes. *The Rebuilding of Old*

Commonwealths (1902) gives in eloquent language Page's aspirations for the revitalization of the Southern states. *A Publisher's Confession* (1905) gives his creed for his trade. In 1909 Page also published under the name of "Nicholas Worth" *The Southerner,* a semi-autobiographical novel interpreting his ideas on the South. Of these the leading one was popular education, especially in the backward South. As a member first of the Southern Education Board and afterward of the General Education Board, he aided in distributing the Rockefeller millions for this purpose. By initiating the movement for the eradication of the hookworm, he started the work that later took shape under the International Health Board. He served on Pres. Theodore Roosevelt's Country Life Commission, and was a leader in introducing the demonstration work of Seaman A. Knapp (*q.v.*) in agricultural areas. All these years he closely followed political affairs, and in 1911 he was one of the first to proclaim the presidential qualifications of Woodrow Wilson. One of Wilson's first acts, after his inauguration, was to appoint Page ambassador to Great Britain.

Ambassador in London.—For his five years in London Page's life had been a preparation. His passion for democracy, his belief that British institutions and literature formed the most solid basis of civilization, his long advocacy of British-U.S. cooperation as the most satisfactory method of solving world problems—all were put to the severest test in the arduous years of his ambassadorship. He had established familiar and congenial relations with the British public and British officialdom when World War I began. Up to that time Page had also worked in complete harmony with President Wilson. It was due mainly to Page's prompting that President Wilson persuaded congress to repeal the discriminating Panama tolls.

In the war Page, unlike Wilson at first, saw above all an attempt of Germany to grasp the hegemony of Europe and to substitute the Prussian conception of autocracy for the democratic ideal which he regarded as the true path of human progress. It was mainly this difference that caused the historic divergence between Page and Wilson. To the outside world Page maintained an attitude of strict neutrality; in his private communications to the president, however, he made no secret of his complete sympathy with the cause of the Allies and his general disagreement with the policy of the administration. When the "Lusitania" was sunk, Page in his letters and cablegrams to Wilson strongly advocated a U.S. declaration of war against Germany. He insisted then, as he did afterward, that U.S. intervention at that time would have brought the war to an early end with an Allied triumph. Page's great moment came on April 2, 1917, when President Wilson asked Congress to declare the existence of a state of war with Germany, and used arguments that Page had been forcing on his attention for two and a half years.

Page had never been in robust health; and the anxieties and labours of a terrible period gradually exhausted him. He had meditated resignation many times, and consented to remain only at the earnest request of President Wilson. In August 1918, however, he became so ill that the president acquiesced in his retirement. In early October he sailed on the "Olympic" and reached New York so weak that it was necessary to carry him from the ship. His one wish was to return to "the sand hills" of his early home in North Carolina. There he died on Dec. 21, 1918.

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PAGE, WILLIAM (1811–1885), U.S. portrait painter, was born at Albany, N.Y., on Jan. 3, 1811. He studied for the ministry and in later life became a Swedenborgian. He received his training in art from Samuel Morse and in the schools of the National Academy of Design, and in 1836 became a National Academician. From 1849 to 1860 he lived in Rome, where he painted portraits of his friends Robert and Elizabeth Barrett Browning. He died at Tottenville, Staten Island, N.Y., on Oct. 1, 1885.

Page's portraits of Charles W. Eliot and John Quincy Adams are at Harvard university.

PAGE, originally a youth of noble birth who left his home at an early age to serve an apprenticeship in the duties of chivalry in the family of some prince or man of rank. Pages first acted as assistants to squires, who were in attendance upon knights and their ladies. They were trained in arms and in the art of heraldry and received instruction in the chase, music, dancing, and such other accomplishments as befitted their social status. From being pages they were promoted to be squires and from that status were frequently advanced to knighthood. (*See* KNIGHTHOOD, CHIVALRY AND ORDERS.)

In Great Britain the duties of the sovereign's pages used to include attendance at royal functions or receptions such as "drawing rooms" and court levees, till these fell into desuetude. Pages still appear, clad in scarlet coats edged with gold lace and with bars of lace across the front, long white waistcoats, white breeches, and white silk hose, and wearing three-cornered hats, on occasions such as the opening of Parliament, at which the sovereign's train is carried by two pages; and at coronations, when the earl marshal and all the peers in the procession are attended by pages of honour bearing their coronets. Pages of honour to the sovereign are usually appointed at the age of 12 or 13 and give up their positions at 17. Many of them are later granted commissions in the Household Cavalry or in a regiment of the Guards. (C. F. J. H.)

PAGEANT, an entertainment, frequently in the open air, illustrating a theme by means of spectacle rather than by consecutive narrative and dramatic characterization. Three early usages of the word in English are recorded: (1) to denote the individual episodes of a miracle play cycle (*see* DRAMA: *Medieval Drama*); (2) to describe the wagons upon which miracle plays were presented in the streets of certain English towns; (3) to describe any piece of stage scenery or machinery, such as those used in the indoor court masques (*see* MASQUE). It is, therefore, difficult to distinguish the origins of the pageant from those of other dramatic forms, but by the 17th century the word had acquired the more definite, if pejorative, meaning of a raree-show.

Although the name pageant is comparatively recent, men have used spectacle as a means of entertainment, teaching, and propaganda from early times; and the Roman triumph, in which a procession of soldiers and prisoners was used to illustrate the theme of victory, may be regarded as an early form of pageant. The cribs set up in churches at Christmas (which made their appearance at least as early as the 8th century A.D. and were popularized by St. Francis of Assisi in the 13th century) are a particularly interesting later example of the form. They differ, of course, from other pageants in that they do not use human actors, but their defiance of chronological realism, which permits the shepherds and the kings to appear together in the same scene, is noteworthy in that it requires the spectator to use his previous knowledge to establish the true historical and narrative connection between the figures represented—a requirement characteristic of pageants throughout the ages. The growth of drama with human actors in churches led to many developments of the pageant form. Early in the 11th century, for example, at Limoges, the three kings entered the church in procession as part of the Mass of the Epiphany and followed a moving star across the choir to the high altar, where they presented their offerings of gold, frankincense, and myrrh. At Beauvais, in the 13th century, a young girl carrying a baby rode into church on an ass during the Mass of the Feast of Fools on Jan. 14 (*see* FOOLS, FEAST OF)—a dramatic representation of the flight into Egypt, which had not yet developed into a play. When such religious pageants became plays, with complete plots and full characterization, they ceased, in the modern sense of the word, to be pageants at all. They then merely supplied the contributory element of "pageantry" or "spectacle" to drama, which Aristotle noted as one of its essential ingredients.

The development of some religious pageants into drama did not mean, however, the end of the pageant as a separate form, and it also flourished as a secular manifestation. In the Middle Ages, and long after, street pageants were set up to welcome distinguished visitors and to celebrate such occasions as royal weddings and coronations. Such entertainments included both processions

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PARADE OF EXOTIC ANIMAL FIGURES. DETAIL FROM A PAINTING BY DENIS VAN ALSLOOT (157D?–1626?) SHOWING THE OMMEGANCK ("PROCESSION") AT BRUSSELS IN 1615 HONOURING THE ARCHDUCHESS ISABELLA. IN THE VICTORIA AND ALBERT MUSEUM

and set pieces, the latter representing allegorical figures who delivered their speeches against a background of elaborate mechanical effects. In 1481, for example, Isabella of Spain was greeted at Barcelona by a pageant of St. Eulalia, which was remarkable for its scenic device of three revolving spheres. In 1514, when Louis XII of France was married to Mary Tudor (the sister of Henry VIII of England), an elaborate pageant was erected outside the Church of the Holy Innocents in Paris, in which the rose of England opened to reveal an actress representing Mary, and, at the same time, the lily of France unfolded to reveal an actor playing the French king. Entertainments of a similar kind were offered to Elizabeth I on her visits to Kenilworth and elsewhere, and in 1660, when Charles II returned to England, the lord mayor's show included a "pageant of the royal oak" set up in Cheapside. It is interesting to note, however, that on this last occasion the diarist Samuel Pepys found the entertainments thus offered "good for such kind of things, but in themselves but poor and absurd." In truth, the popular pageant of those days could not hope to compete with the spectacles provided by the court masques; or even, indeed, with those of the public theatres, which by this time were acquiring elaborate machinery from Italy and France. Hence the street pageant came to be despised by cultivated tastes. Nonetheless, it was popular enough with the common people to survive in many different forms throughout the world into the 20th century. The lord mayor's show still takes place in London; in many cities in Germany, Switzerland, and Austria there are carnival processions at particular seasons (the beginning of Lent and the wine harvest, for example); in France and in New Orleans there are the festivities of Mardi gras; in Siena the *Palio* (a horse race in medieval costume); in Zürich the guild procession of *Sechseläuten;* and in Pasadena, Calif., the Rose Bowl parade.

In 1905 the pageant was given new impetus and form by Louis N. Parker, who, by his pageant of Sherborne, Hampshire, originated the use of this form of entertainment to illustrate local history by means of dramatic episodes, music, dancing, and processions. Pageants of this type were subsequently arranged in many other English towns (Cheltenham, York, Greenwich, etc.) and the fashion spread to the United States. *The Pageant and Masque of St. Louis* (1914) had a cast of 7,500 performers and cost $125,000. It was followed by such other spectacles as the *Cavalcade of Texas* at the Texas Centennial in Dallas (1936), and the *American Jubilee,* produced at the New York World's Fair in 1940. Many of these modern pageants (notably Paul Green's *The Lost Colony,* produced at Roanoke Island, N.C., in 1937) showed a marked tendency to develop into spectacular plays with well-constructed plots and rounded characters. Few of them, however, achieved lasting performance or have been deemed worthy of revival. By its nature the pageant is often designed for a particular occasion and the vastness of staging which it requires defeats the intimacy necessary to true drama. Individual contributions to the pageant have sometimes passed into the realm of literature—notably the choruses written by T. S. Eliot for a religious pageant, *The Rock,* staged in England in 1934. Perhaps the most enduring of all modern pageant-plays, however, is *Jedermann* by Hugo von Hofmannsthal (*q.v.*), first produced in 1911 at Berlin by Max Reinhardt (*q.v.*) and revived in 1920 and thereafter as part of the Salzburg Festival. The characterization and plot in this case scarcely go beyond those of the medieval morality play on which it is based, but the performance is distinguished by poetry, music, and elaborate crowd movement. Indeed, its original director, Max Reinhardt, is perhaps more deserving than Louis N. Parker of the title "father of the modern pageant," for, while Parker gave to the pageant its peculiarly historical significance, his concepts of staging are really part of the international movement for *"Sprengung des Bühnenrahmens"* ("exploding the confines of the stage") inaugurated by Reinhardt at the start of the 20th century. It was Reinhardt who sought to free the theatre from the dominance of literary drama, to stress vast scenic effects, and to experiment with such unusual stage forms as the circus ring and the exhibition hall. His spectacular production of *The Miracle* at Olympia, London, in 1911, with music by Humperdinck, was perhaps one of the most successful of modern pageants.

After World War II a new form of pageant, Son et Lumière, was developed.

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PAGET, SIR JAMES, BART. (1814–1899), British surgeon, who, together with his friend Rudolf Virchow, has been called the founder of the science of pathology, was born at Yarmouth on Jan. 11, 1814. In 1834 he entered St. Bartholomew's Hospital, London, and during his first winter session he detected *Trichinella spiralis,* the parasite that infests human muscles and causes trichinosis. Richard Owen, who gave these parasites their scientific name, is usually credited with the discovery, but he merely confirmed what Paget had detected. By 1851, when he was elected a fellow of the Royal Society, Paget was known as a great physiologist and pathologist.

In 1858 Paget was appointed surgeon extraordinary to Queen Victoria. He specialized in pathology of tumours and diseases of the bones and joints, and was the first to urge enucleation (surgical extraction) of the tumour instead of amputation in cases of myeloid sarcoma (tumour in bone marrow). He gave original accounts of a precancerous affection of the areola and nipple (Paget's disease), mammary cancer, and osteitis deformans, which is known as Paget's disease of the bone. In 1871 he resigned his surgeoncy to the hospital and received a baronetcy. He was president of the Royal College of Surgeons (1875), Hunterian orator (1877), president of the International Medical Congress (1881), and vice-chancellor of the University of London (1884–95). He died in London on Dec. 30, 1899.

See S. Paget, *Memoirs and Letters of Sir James Paget,* 3rd ed. (1903); F. Garrison, *Introduction to the History of Medicine,* 4th ed. (1929).

PAGET, VIOLET: *see* LEE, VERNON.

PAGNINUS, SANTES (1470–1536), Italian Dominican Hebrew scholar, whose Latin version of the Bible made from the original languages greatly aided other 16th-century translators of Scripture, was born at Lucca on Oct. 18, 1470. He joined the Dominican order at Fiesole in 1487 and became a disciple of Savonarola. After holding office in various Dominican houses he went in 1516 to Rome, where Leo X (like Adrian VI and Clement VII subsequently) encouraged his work. He spent three years in Avignon (1523–26), then settled in Lyons, where in 1528 he published his translation of the Bible. Learned in rabbinical studies, he transliterated the Hebrew proper names instead of perpetuating the adaptations used in the Vulgate, and provided a glossary of them at the end. His seems to be the earliest Bible in which the chapters are divided into numbered verses, though in the Apocrypha and New Testament it has fewer and longer verses than those now in use. In 1529 Pagninus brought out a Hebrew lexicon, *Thesaurus linguae sanctae*, an epitome of which was frequently republished. After his death at Lyons on Aug. 24, 1536, his Bible translation was republished in 1541 at Cologne and 1564 at Basel. Meanwhile, in 1542, Michael Servetus had re-edited it with notes in favour of his own dogmatic system; in 1537 Robert Estienne (Stephanus) was the first to publish Pagninus' Old Testament together with Theodore Beza's version of the New Testament. Although more accurate than the Vulgate, and hence more useful to other translators needing help with Hebrew or Greek, Pagninus' version was not intended to supersede the Vulgate save for purely scholarly purposes, and it is now chiefly of historical interest. *See* also BIBLE, TRANSLATIONS OF.

See T. M. Centi in *Archivum fratrum praedicatorum*, 15:5–51 (1945); H. Pope, *English Versions of the Bible* (1952). (J. M. T. B.)

PAGODA, a towerlike, storied structure of stone, brick, or wood, usually associated with the Buddhist temple complex in Indian Asia, China, and Japan. It derives ultimately from the stupa (*q.v.*) of ancient India, which was a domical funeral mound erected over the remains of a holy man or king. Perhaps the most celebrated pagoda in India was the multistoried tower erected by Kanishka I near Peshawar to enshrine a notable collection of the Buddha's relics. This famous tower, built up in the 2nd century of the Christian era, was the inspiration for the later pagodas of China and Japan, where the design always consisted of the repetition of a basic story unit (circular, square, polygonal) in regularly diminishing proportions. Each unit had its own projecting roof and the whole pile was capped by a prominent mast and disks.

The pagoda, like the stupa, was at first thought of as an architectural diagram of the cosmos. The great pillar which runs up the core of the building is symbolic of that invisible world axis which joins the centres of earth and heaven. The Japanese still refer to the four columns at the corners of wooden pagodas as the pillars of the sky. The separate stories, diminishing in size as they mount upward, may be thought of as the many terraces of the mythical world mountain. The disks which crown the structure correspond to the various heavens of the gods. The cosmic diagram, thus fixed in architectural forms, was thought to be animated by the precious relics which were enshrined within. The concept of the building as a magic diagram and its animation by the enshrining of relics probably had its origin in the altar of Vedic India. *See* also CHINESE ARCHITECTURE; INDIAN ARCHITECTURE; JAPANESE ARCHITECTURE. (D. K. D.)

PAHANG, a state of eastern Malaya in the federation of Malaysia (*q.v.*) and a constitutional sultanate. It is the largest Malayan state in area (13,873 sq.mi.) and has the least population density. Pop. (1961 est.) 354,316. Pahang stretches from the central mountain range to the east coast; its axis and traditional tie (by means of local canoes) being the Sungei (River) Pahang (281 mi.) which, after an entrenched north-south course paralleling the range, makes a turnabout loop near Mengkarak before crossing a large, forested swamp to the delta, where stands Pekan, historic royal capital and present seat of the sultan. The Gemas-Kelantan railway runs west of the Sungei Pahang and a road farther west links Raub, Malaya's gold-mining centre, and Bentong (mining alluvial tin) with Singapore. Another road branches to Mentakab and the port of Kuantan, 25 mi. N of Pekan. The Raub-Bentong road links by way of "the gap" across the central range with Kuala Kubu Bahru and Kuala Lumpur. Adjoining the gap is a declining hill station, Frasers Hill. Kuala Lipis to the north, on the Sungei Jelai (a headstream of the Pahang) and the railway, is the terminus of the Malayan road system, and north of it the railway provides the sole route through the thick forest to Kelantan.

With 90% of the total area still forested, Pahang is poorly developed, with only 30,000 ac. under paddy (along levees of the delta) and 202,000 ac. under rubber (mostly close to the central range and west of the middle Sungei Pahang). At Sungei Lembing, northwest of Kuantan, is Malaya's major mine for vein tin using deep shafts; the cassiterite (black sandy material) is exported by a mineral line to Kuantan for coastal movement to Singapore. Kuala Lipis ([1957 pop.] 8,753) was the state capital until 1957, but administration now centres at the largest town, Kuantan (23,000), which has an air service to Kuala Lumpur and is accessible for half the year to small coastal steamers plying from Singapore. Malays (57% of the total population) are dispersed along the Sungei Pahang as self-contained farmers and along the coast, where they process dried and salted fish for export. Chinese (35%) are located in Bentong, Raub, in the market towns, and on the rubber estates.

Cameron Highlands (about 4,000 ft. above sea level) is a hill station northwest of Kuala Lipis, the permanent settlement there being fewer than 5,000 people in the villages of Tanah Rata and Ringlet. Inaccessible by road or railway from Pahang, Cameron Highlands is reached only by way of Tapah in Perak State, which handles its vegetable output (from Chinese smallholders) traded by road into Kuala Lumpur and Singapore. Only tourists from west Malaya normally visit Cameron Highlands, where there is also a hydroelectric station financed by the U.S. The Sungei Pahang has no significance for modern transport. All produce west of the middle Pahang is traded with western Malaya, lessening the economic cohesion of the state. King George V National Park (436,000 ha.), including Gunong (Mount) Tahan (7,186 ft.), is on the border with Kelantan and Trengganu; Krau Wild Life Reserve (65,000 ha.) is in the centre of Pahang State near Gunong Benom and Gunong Tungku.

For history *see* MALAYA, FEDERATION OF. (E. H. G. D.)

PAHARI LANGUAGE (properly Pahāṛī, the language of the mountains), a general name applied to the Indo-Aryan languages (*q.v.*) or dialects spoken in the lower ranges of the Himalayas from Nepal in the east to Chamba of Himachal Pradesh in the west. These forms of speech fall into three groups: (1) Eastern, consisting of the various dialects of Khas-kura, the language of Nepal; (2) Central, spoken in the north of Uttar Pradesh, in Kumaon and Garhwal; and (3) Western, spoken in the country around Simla and in Chamba.

In Nepal, Khas-kura is the language only of the Aryan population, the mother tongue of most of the inhabitants being some form or other of Tibeto-Burman speech. Khas-kura is mainly differentiated from Central Pahari through its being affected by Tibeto-Burman idioms. Central and Western Pahari have not been brought into close association with Tibeto-Burman; their language is therefore purely Aryan.

Khas-kura, as its speakers themselves call it, passes under various names; it is called Nepali or Naipali (*i.e.*, the language of Nepal), Gorkhali, or the language of the Gurkhas, and Pahari or Parbatiya, the language of the mountains.

Central Pahari includes two dialects, Garhwali, spoken mainly in Garhwal and the country around Mussoorie, and Kumaoni, spoken in Kumaon, including the country around Nainital.

Western Pahari includes a great number of dialects. In the area formerly included in the Simla Hill states alone no fewer than 22, of which the most important are Sirmauri and Keonthali (the dialect of Simla itself), were recorded. To these may be added Jaunsari, spoken in the Jaunsar tract of Dehra Dun; Chambiali and Churahi, of the district of Chamba; Mandeali of the district of Mandi; Gadi of Chamba and Kangra; Kuluhi of Kulu; and others.

But the Aryan language of the whole Pahari area is now a form of Rajasthani, exhibiting at the same time traces of the old Khaśa language which it superseded, and also, in Nepal, traces of the Tibeto-Burman forms of speech by which it is surrounded.

Khas-kura shows most traces of Tibeto-Burman influence. The gender of nouns is purely sexual, and, although there is an oblique case derived from Rajasthani, it is so often confounded with the nominative that in the singular number either can be employed for the other. Both these are due to Tibeto-Burman influence, but the non-Aryan idiom is most prominent in the use of the verb. There is an indefinite tense referring to present, past, or future time according to the context, formed by suffixing the verb substantive to the root of the main verb, exactly as in some of the neighbouring Tibeto-Burman languages.

In Eastern and Central Pahari the verb substantive is formed from the root *ach*, as in both Rajasthani and Kashmiri. In Rajasthani its present tense does not change for gender; in Pahari and Kashmiri it is a participial tense and does change according to the gender of the subject. This is a relic of the old Khaśa language, which seems to have been related to Kashmiri. Other relics of Khaśa are the tendency to shorten long vowels, the practice of epenthesis, or the modification of a vowel by the one which follows in the next syllable, and the frequent occurrence of disaspiration.

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PAHLAVI (BANDAR-e PAHLAVĪ), formerly Enzeli, the principal port of Iran on the Caspian Sea, lies 22 mi. N of Rasht by road, on both sides of the entrance into Mordab or Pahlavi Lagoon. The population (31,349 in 1956) is mixed, with many Russians, Armenians, Caucasians, and Turkmen. The town is also a seaside resort and has fine administration buildings and a public garden. Pahlavi is connected by highways with Rasht, with Mazanderan and Azerbaijan (via Astara), and via Kazvin with Teheran where it connects with the Trans-Iranian Railway. There is an airfield at Ghazian (Qazian).

The port lies in the channel between the two sandy peninsulas of Pahlavi proper to the west and Ghazian to the east. The channel is 1,300 yd. long and up to 660 yd. wide and quite irregular in depth. The entrance is protected by two breakwaters. The harbour is entered by vessels of up to 15 ft. draft, except in bad weather, and continuous dredging is necessary. Port installations are mainly on the eastern side. There is a small wharf, a depot of the National Iranian Oil Company, and the chief station of the government-owned Caspian fisheries organization "Shilat." A movable bridge connects Pahlavi proper and Ghazian.

Pahlavi's trade before World War II averaged 150,000 tons annually, with imports forming two-thirds of the total. Exports included rice, hides and skins, raisins and dried fruit, raw cotton and silk, fish and caviar. Imports were mainly machinery and textiles, cement, steel, and sugar. During World War II the port was modernized, and trade greatly increased under the impact of the lend-lease program for the U.S.S.R. In the early 1960s it was about 100,000 tons, of which imports accounted for 60,000 tons. (H. Bo.)

PAHLAVI LANGUAGE is the name given by the Persians to the language of Sasanian Iran (*see* IRANIAN LANGUAGES). The name, which means the same as Parthian, is used in a broad sense by the poet Firdausī (10th century A.D.) in speaking of the pre-Islamic sources of his epic poem. Strictly speaking only that form of Middle Persian found in Zoroastrian books, on coins, and in inscriptions is commonly called Pahlavi.

The script of the Pahlavi books is difficult to read and ambiguous, for the original 22 consonants of the mother Aramaic alphabet have been combined into only 14 in the Pahlavi descendant. The inscriptional alphabet is more archaic, and hence not as condensed and difficult to read as the book script.

Another difficulty and a peculiarity of the language is the use of Aramaic words which, however, are not to be read in their Semitic form but as Iranian. Thus *MN*, "from," which in Aramaic would be read as *min*, would be read as *hač*, the Iranian form. Not only nouns and verbs, but Aramaic numerals, pronouns, and particles are used side by side with Iranian words. It was once thought that Pahlavi was a mixed language with a large foreign vocabulary, but it is now recognized that the Aramaic words are only ideograms, as in English "£" (*libra*) is pronounced "pound"; or "&" (*et*) is pronounced "and." This system, of writing in ideograms and reading them in their Iranian form, was called *Uzvārišn* or "interpretation." The system goes back in Iran at least to Achaemenid times when secretaries throughout the empire wrote messages in Aramaic, but read or interpreted them in the local language.

The *Uzvārišn* peculiarity of Pahlavi was known to medieval Arabic authors, and the explanation of it by Ibn Muqaffa' (8th century) was repeated in the *Fihrist* of Ibn Nadīm, in Yaqūt's geographical dictionary and elsewhere. A preserved glossary, the *Frahang-i-Pahlavik*, gives the Aramaic ideograms in Pahlavi with their Iranian equivalents, but the defective, consonantal script of Pahlavi frequently makes the interpretations dubious. The Pāzand texts of Zoroastrian religious books, in which Aramaic words are replaced by their Iranian equivalents with vowels, are an important help to the reading of the ideograms since these texts are written in the clear Avestan alphabet.

The major part of Pahlavi literature is religious, including translations from the Avesta and commentaries on it. Little has survived from pre-Islamic times, and the *Bundahishn* and *Denkart*, both religious works of the Zoroastrians, date from the Islamic period. There are a few epics and some short secular tracts in Pahlavi, but the preservation of any Pahlavi literature at all after the Arabic conquest of Iran is the result of the efforts of Zoroastrian priests who continued to write the old tongue after the victory of a new religion (Islam) and a new form of the language (New Persian) in the Arabic alphabet. Pahlavi manuscripts were preserved by the Parsees (Zoroastrians) of Bombay and elsewhere (including those in Iran). (*See* also ZOROASTRIAN LITERATURE.)

It was Silvestre de Sacy in the early 19th century who began the decipherment of the inscriptions and laid the foundations for future work in Pahlavi. The discovery in Turfan, Chinese Turkistan, at the beginning of the 20th century of a Christian Psalter in Pahlavi, and other fragments, has greatly facilitated the understanding of the Zoroastrian Pahlavi texts. Other inscriptions of great importance for both language and history have also been found in Iran.

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PAIGNTON, urban district and seaside resort of Devon, Eng., on Tor Bay, 25¾ mi. S of Exeter by road. Area 8.1 sq.mi.. Pop. (1961) 30,292. Although it was a market town as early as 1294, only during the 20th century did Paignton develop as a popular holiday place. Near St. John's Church (mostly 15th century) is a ruined remnant of a former palace of the bishops of Exeter. It is known as the Bible Tower from an erroneous tradition that Miles Coverdale translated the Bible while staying there in 1651.

Oldway Mansion (completed in 1875) was built by I. M. Singer, the U.S. inventor, and altered in 1904–07 by his third son, Paris Singer. It is now Paignton's civic, social, and recreational centre.

PAIN is a specific sensory experience mediated through nerve structures separate from those that mediate other sensations such as touch, pressure, heat, and cold. It is true that a stimulus that excites one of these other sensations may also induce pain, but this is done by exciting the mechanism for pain as well as that for the other sensation. Evidence indicates that the adequate (*i.e.*, minimal) stimulus for pain is tissue damage, slight and altogether reversible, perhaps, but nevertheless damage.

The role of pain in the bodily economy seems to be chiefly to warn of danger—the first evidence of tissue damage, which, if continued or allowed to increase, might ultimately be irreversible. Pain, nevertheless, is not an essential accompaniment of tissue damage; indeed, fatal injuries and even fatal illnesses may occur with little or no pain. Neither is pain essential to human adjustment. Some persons congenitally lack the capacity to feel pain and yet give no evidence of being handicapped by their sensory deficiency. Over the centuries man has learned to react to many warning signals besides pain. In fact the bulk of alarm or defense reactions involved in common experience are initiated by stimuli that do not cause pain.

Pain as a Sensory Experience.—Pain on the surface of the body usually has a pricking or burning quality. From deeper tissue it is felt as an ache. Variations in the aching quality depend mainly upon timing, location, and intensity. Aching pains may be throbbing, wavelike, steady, or intermittent. In addition, pain may radiate from one spot to another. Other factors that appear to lend "quality" to pain are those that characteristically aggravate or relieve it. Assuming they remain intact, the nerves that subserve pain continue to conduct the sensation as long as the stimulus is applied. Thus, for painful stimuli, there is no true adaptation such as there is for touch. There may be apparent adaptation during prolonged stimulation, however, when the local situation in the painful part is altered so that the mechanism for pain is interrupted. For example, an injury to the skin may result in the formation of local edema and thus increase the distance between stimulus and receptor.

Pain differs from other commonly experienced sensations such as sight, hearing, smell, touch, and vibration in that its perception may be modified by analgesic agents. Morphine, codeine, and alcohol do not affect the threshold or intensity of sensory experience other than pain. Pain has other individual qualities. It differs from heat and cold sensations in that it does not display the phenomenon of spatial summation. That is, when the area exposed is increased, the intensity of the stimulus required to produce pain is not changed. Furthermore, the intensity of two pains existing separately at the same time is no greater than that of the more intense of the two. In fact, the existence of one pain actually raises the threshold for perception of another arising in another region of the body. This effect was early noted by Hippocrates and is made use of when persons in pain bite their lips or drive their fingernails into their palms.

Threshold for Perception of Pain.—Pain of intensity so low as to be barely perceptible has been called threshold pain. As indicated above, it appears that the adequate stimulus for pain perception is tissue injury. It is not established, however, whether nerve endings per se have to be injured by the noxious stimulation. Neither is it certain that they need be stimulated directly. It appears rather that nerve endings may be stimulated by products liberated as result of injury to other tissues.

A polypeptide, neurokinin, appears to be involved in the pathophysiology of pain and hyperalgesia. First recovered from tissue juice withdrawn from the painful, tender site of a vascular headache, neurokinin was found to have some properties in common with histamine, serotonin, and bradykinin but to be distinct from them. Neurokinin lowered the pain threshold when injected into normal skin and induced headache when introduced in the neighbourhood of the branches of the superficial temporal artery. Whether neurokinin acts as a neurohumour mediating all pain phenomena is not known. It has been shown that it is produced locally by the action of a proteolytic enzyme in response to local tissue damage or the stimulation of nerve roots.

Pain threshold can be measured quantitatively with an instrument that induces pain without causing major tissue damage. The evidence accumulated from such measurements indicates that all persons whose bodily structures are healthy have approximately the same capacity for perceiving pain. The weakest standard stimulus required to produce a recognizable sensation of pain in one person will have, roughly, the same intensity in all other healthy persons. Moreover, in the same person there is little variation from day to day or from year to year in the threshold for the perception of pain.

Pain Pathways.—Neural impulses from noxious stimulation may be conveyed by nerve fibres of many sizes that follow a rich variety of peripheral nerve channels to the dorsal root ganglia, where the cell bodies send projections into the dorsal horn of the spinal cord. From here secondary neurons carry the impulses across the anterior commissure to the opposite side and through the lateral spinothalamic tract to the brain, where the sensation is registered, interpreted, and reacted to. The fibres involved in aching and burning sensations are anatomically and physiologically different from those involved in pricking pain. The latter, phylogenetically more recent, are myelinated and larger, and conduct impulses more rapidly.

Threshold for Reaction to Pain.—Certain automatic responses to noxious stimuli that occur without awareness of pain are mediated through reflex arcs in the spinal cord and brain stem. These reactions are characteristically inhibited and variously modified by impulses from higher centres set in motion as a result of perception and interpretation of the painful experience. Since most pains are interpreted as unpleasant, they give rise to a reaction of aversion on the part of the affected subject. What he thinks, feels, or does about it constitutes his reaction to pain. Thus the threshold for reaction to pain, unlike the threshold for perception, varies within wide limits for given persons and for the same person under differing circumstances.

Distinction Between Pain Perception and Reaction to Pain.—The ability to perceive pain depends upon the intactness of relatively simple and primitive nerve connections. Reaction to pain, on the other hand, is modified by the highest cognitive functions and depends in part upon what the sensation means to the person in the light of his past experience. This simple distinction between perception of pain and reaction to the experience was not at once appreciated by early investigators, and consequently confusion existed regarding the nature of pain. Some held that it was not a sensation at all but instead was a "passion of the soul" that did not require separate neurologic pathways. However, this notion was dispelled by the demonstration of an apparatus for the mediation and bringing to consciousness of painful impulses.

Range of Pain Intensity.—As already mentioned, distinguishably different sensations carried by nerve fibres that differ from one another in size are commonly classified together as painful. Not only are there distinguishable qualities of pain but there also are recognizable differences in intensity. It has been found possible to recall with reasonable accuracy the intensity of a given pain from one day to the next.

In other investigations, it was learned that when radiant heat was focused on a spot of skin blackened by burnt cork in order to achieve maximal absorption of heat, maximal pain was induced by a stimulus twice as strong as the threshold value. At this level, major tissue damage occurred. Further increase in the strength of stimulation failed to increase the intensity of the pain felt. Thus a ceiling exists for pain intensity.

It has been shown that there are approximately 21 distinguishable increments of intensity between threshold pain and pain of maximal intensity.

Referred Pain.—Painful sensations from structures deep within the body often are felt in areas other than the site of stimulation. This effect has been called referred pain. It depends on the development of an excitatory state in the spinal cord at the level of the incoming noxious impulses. Depending upon the intensity of the impulses, the excitatory state spreads by way of the neurons of the dorsal horn of the spinal cord and the association pathways to segments adjacent to the ones into which

the impulses were originally conducted. In turn, fresh impulses travel to higher levels in the nervous system, where the neural activity is ultimately felt as pain.

Hyperalgesia.—A second aspect of the deep pain experience is the local tenderness, superficial or deep, felt in the neighbourhood of the original noxious stimulus or in an area of referred pain, as in the abdominal wall over an inflamed appendix. The threshold for pain perception from the skin is not altered, but ordinarily nonnoxious stimuli become capable of inducing pain owing to the effects of the central excitatory state referred to above, and noxious stimuli produce hyperalgesia; *i.e.*, pain of greater intensity than they ordinarily would.

The term "hyperalgesia" is also used to describe the exaggerated sensory experience of pain that results from local tissue injury. This type of hyperalgesia is typically encountered in peripheral nerve lesions, where not only is the intensity of a noxious stimulus enhanced but in addition the threshold of one type of cutaneous pain is lowered. In the case of hyperalgesia characteristic of peripheral neuritis, for example, the threshold for the slowly conducted cutaneous burning pain may be greatly lowered when that for the more rapidly conducted pricking pain is elevated. It may be that this form of hyperalgesia is dependent upon the presence of the polypeptide neurokinin referred to above.

Characteristics of Central Excitation.—The damaging of tissue may initiate central hyperexcitation requiring little additional peripheral stimulation for its maintenance. Such hyperexcitation may become self-perpetuating but once interrupted may not recur spontaneously. Central excitatory phenomena are furthered and hindered by a variety of factors in the internal and external environment, and only in part are they dependent upon impulses from the area initially damaged. However, heightened excitation in cerebral cortical and subcortical structures may be built up by prolonged, mild noxious stimulation, either from the periphery or from lesions within the brain itself.

Short, intercalated neurons within the segments of the cord and brain stem and probably in the cerebral cortex are essential to the phenomenology of pain, since they are responsible for the maintenance of augmented central excitatory states such as those that produce itching, hyperalgesia, altered discrimination of intensity, emotional excitement, and complicated behaviour patterns.

Influences on Pain Threshold.—Minor, ordinarily nonnoxious stimuli applied to inflamed areas on the body commonly are painful. In the reddened skin following exposure to ultraviolet light, a lowering of pain threshold as much as 50% was found. In the mucous membranes of the nose a similar lowering of pain threshold was found with hyperemia, as well as in the mucosa of the viscera, including the esophagus, stomach, colon, and bladder. In fact, erroneous beliefs that these visceral mucous membranes were insensitive to pain arose because noxious stimuli that were painful in the skin failed to elicit pain when they were applied to the viscera. It is now clear that pinching, pricking, or stimulation with faradic current induces pain in the mucous membrane of the turgid hyperemic stomach, colon, or bladder. Hyperemia may have special importance with regard to the pain of peptic ulcer, since the stomach in this condition is known to be overactive and engorged with blood. When the stomach is in such a state, normal forceful contractions are found to be painful.

The ability to perceive pain is profoundly influenced by attitude and suggestion. By hypnosis, the threshold for perception of pain was raised 40%. Distraction induced by the clanging of a loud bell induced approximately the same effect. Autosuggestion and placebos thought by the subject being tested to be analgesic drugs had similar but less powerful effects.

Influences on Reaction to Pain.—As noted above, it has been observed that under ordinary circumstances the threshold for pain perception remains relatively constant from one person to another and in the same person from day to day. In contrast, thresholds for reaction to pain were found to be highly variable. It has been found that reaction thresholds of neurotic patients in general are significantly lower than those of healthy persons. Drugs, such as alcohol and morphine, that induce in the subject a feeling of freedom from anxiety may raise enormously the threshold for reaction to pain, thus exerting an effect several times greater than, and in addition to, their influence on pain perception. It has also been found that prizefighters and American Indians, as groups, fail to react to noxious stimuli of intensity great enough to induce a reaction of discomfort in the average white city dweller.

Surgically induced brain damage, notably of the frontal lobes, may profoundly alter reactions to pain without modifying its perception. Thus, a lobotomized patient with a lesion causing low-intensity noxious stimulation, when asked about his experience, may say, "I feel the pain, but it doesn't bother me."

Control of Pain Perception and Reaction.—Therapeutically it is as important to deal with a patient's reaction to pain as it is with his perception, since it is the complaint of pain that the patient brings to the physician. In headaches and other painful states, it has been shown that certain persons overreact to minor disturbances at the end organ and thus may become incapacitated by a sensation that would be ignored by another person. Drugs that interrupt the mechanisms responsible for pain must be distinguished from analgesic agents, which modify sensory perception or reaction by acting on the central nervous system. Examples of the former group, called autonomic drugs since they act on the autonomic nervous system, are atropine (a cholinergic blocking, or parasympatholytic, agent), which may relieve the pain of smooth muscle spasm by relieving the spasm, and ergotamine, which interrupts the mechanism for migraine headache by constricting overdistended arteries. Neither of these drugs is, strictly speaking, analgesic.

Among analgesics, several drugs have been tested for their effect on pain threshold in man. Some, such as acetylsalicylic acid (aspirin), acetanilid, acetophenetidin (phenacetin), and aminopyrine, act primarily on the threshold for pain perception, having relatively less effect upon the reaction to pain. In the case of each agent, an optimal dosage affords close to maximum pain-reducing action.

Members of another group of analgesics, including opiates and alcohol, are effective because of their ability to control reaction to pain as well as to raise the threshold for perception of pain. Furthermore, the relaxation, apathy, and freedom from anxiety that follow the administration of morphine, for example, long outlast its effects on the threshold for pain perception.

Surgery for painful conditions may consist of interrupting sensory pathways by cutting peripheral nerves, sensory roots adjacent to the spinal cord, nerve bundles within the cord (lateral spinothalamic tract), or even within the brain stem (thalamus) itself. When, because of a self-perpetuating central excitatory state or for other reasons, such procedures directed at obliterating pain perception are not feasible, the surgical attack may take the form of a frontal lobotomy.

Until the end of the 19th century pain was considered to be exclusively a feeling state. Later, with the discovery of special anatomic equipment and mechanisms, interest was focused on the perceptual aspects of pain. Pain, to be sure, is a sensation, and yet because of its intimate linkage with strong feelings and other reaction patterns, the latter may be dominant in the experience. It is known that reactions to pain may be modified by strong beliefs. Although the common analgesics actually raise the pain threshold, they have a major function also in changing the attitude and feelings. Thus, support can be found for the old conviction that the feeling state is, to the one who suffers, perhaps the most relevant aspect of pain. Yet there is also support for the inference that pain is a specific sensation with its own structural and functional properties. It becomes apparent that these two concepts do not oppose each other; both formulate fundamental aspects of the pain experience.

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PAINE, ROBERT TREAT (1731–1814), U.S. politician, jurist, and signer of the Declaration of Independence, was born in Boston, Mass., March 11, 1731. He graduated from Harvard

College in 1749 and, after trying teaching and the ministry, turned to the study of law and was admitted to the bar in 1757. He was a delegate to the provincial convention called to meet in Boston in 1768. Paine was associate prosecuting attorney in the case of Capt. Thomas Preston and his men for perpetrating the so-called Boston Massacre of March 5, 1770.

Paine served in the Massachusetts legislature, 1773–74, and as a member of the Continental Congress, 1774–78, signed the Declaration of Independence. Paine was also speaker of the Massachusetts House of Representatives in 1777, helped draft the state constitution of 1780, served as state attorney general 1777–90, as judge of the state supreme court 1790–1804, and was one of the founders of the American Academy of Arts and Sciences. He died in Boston, May 11, 1814. (H. H. P.)

PAINE, THOMAS (1737–1809), English-American author and humanitarian, who was one of the most influential formers of colonial public opinion just prior to and during the American Revolution, was born on Jan. 29, 1737, at Thetford, Norfolk, the son of a Quaker corset maker. His early hardships as sailor, teacher, and exciseman, and the death of his first wife along with his unhappy second marriage, help to explain his lifelong sympathy for the poor and unfortunate and his emigration to America (Nov. 1774) on Benjamin Franklin's recommendation. There he successfully edited the *Pennsylvania Magazine* for 18 months, coming to know such influential people as Pres. John Witherspoon of the College of New Jersey (later Princeton), the scientist David Rittenhouse, and the physician-patriot Benjamin Rush, who encouraged him to publish *Common Sense*, Jan. 10, 1776. This pamphlet, voicing with emotional fervour most of the persuasive arguments for independence from England, is credited by Washington with having "worked a powerful change in the minds of many men," and it had enormous vogue, combining appeals to both the idealists and those interested in the colonies' economic advancement. While serving in the army as Gen. Nathanael Greene's volunteer aide-de-camp, Paine began his series of influential tracts called *The Crisis*, opening with the inspirational lines, "These are the times that try men's souls." As secretary of the congressional committee of foreign affairs, in 1779 Paine became involved in the controversy regarding Silas Deane's agency in obtaining French aid; Paine's indiscretion in publishing secret documents in the hands of the committee made it necessary for him to resign his secretaryship. His later position as clerk of the Pennsylvania assembly acquainted him with many revolutionary leaders, and he accompanied John Laurens to France in 1781 to secure aid. Paine's *Public Good* (1780) included one of the first calls for a national convention (looking toward something like the federal constitution) to remedy the ineffectual Articles of Confederation; this work also illustrates his advocacy of a strong union to which states' rights were to be subordinated.

The same direction of thought is apparent in his six letters (essays) to Rhode Island (1782–83), designed to get that state to pay its 5% impost. Having at first attacked rich men such as Robert Morris, he now accepted pay from Morris and his committee to help persuade the people to accept restraints, notably in the *Dissertations on the Bank* (1786) and other writings, attacking paper money as a balm to debtors, defending the Bank of Pennsylvania to prevent monopoly and enlarge the market for all. His public services were rewarded by the state of New York through the gift of a 300-ac. farm at New Rochelle, and by other gifts from Congress.

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THOMAS PAINE BY A. MILLIERE. IN THE NATIONAL PORTRAIT GALLERY, LONDON

From 1787 to 1802 he was in England and France, initially to perfect and market a pierless iron bridge (one of his many inventions), but mainly to act as a propagandist to get France and England to become republics. His *Prospects on the Rubicon* (1787) attacked Pitt's war policy. The hostile *Reflections on the Revolution in France* by Edmund Burke, whom Paine knew slightly, was answered by Paine in *Rights of Man*, part i appearing March 13, 1791, and part ii the next year, Feb. 17, 1792. Since these not only defended the early events of the French Revolution but provided a persuasive exposition of the principles of republicanism, large numbers of the *Rights of Man* were circulated among the common people by the Society for Constitutional Information and the London Constitutional Society. Pitt, privately admitting the rightness of some of Paine's arguments, feared the masses would be incited by Paine to "a bloody revolution" and had him indicted for treason, but Paine escaped to France before the trial and was triumphantly elected to the revolutionary French Convention. On July 1, 1791, he led in the placarding of Paris with demands for a republic. Having courageously advocated the exile rather than execution of King Louis XVI, Paine incurred the suspicion of Robespierre and was imprisoned from Dec. 28, 1793, to Nov. 4, 1794, when with the fall of Robespierre he was readmitted to the Convention. Paine's *Age of Reason* (part i, 1794; part ii, 1796) was actually written, he said, "lest in the general wreck of superstition" in France "we lose sight of morality, of humanity, and of the theology that is true"—*i.e.*, that which seeks to prove the existence of a divine designer by the mechanistic design of the cosmos. However, the orthodox opponents of political reform both in America and England falsely accused Paine of being an atheist, and such charges, along with his hostile *Letter to Washington* (1796), enabled the U.S. Federalists to make a scapegoat of Paine in a vain attempt to undermine his friend Thomas Jefferson.

While Paine had begun by minimizing the need for government, he came in *Rights of Man*, part ii, *Address to the Addressers* (1792), and *Agrarian Justice* (1797) to advocate that government should become a beneficent agent with a positive humanitarian program including such measures as a progressive income tax to provide for the helpless and the aged. Paine expressed most completely the ideals of the Enlightenment, involving faith in the immutable law and order of nature as a divine revelation; the omnipotence of reason when there is freedom to debate all questions; tolerance; the equal rights and dignity of the individual; a religion of good deeds and humanitarianism; and peaceful cosmopolitanism. Jefferson, who had *Rights of Man* published in the U.S. to counteract Federalistic "heresy," said that he "professed the same principles," and hence Jefferson's election in 1800 would appear to suggest that the majority of Americans at that time approved of those principles, which had been widely disseminated by about 40 Democratic-Republican societies in the U.S.

Paine failed, of course, to persuade the British to turn their monarchy into a republic, but it is possible that the discussion his principles aroused helped to sow the seeds which later flowered in the Reform bill of 1832. Despite the eventual triumph in the U.S. of his political principles, and the partial triumph of his religious principles in Unitarianism, however, Paine's tactlessness and occasional drunkenness (which he confessed to his friend and biographer T. C. Rickman) rendered him unpopular during his last seven years in America. He died in New York City on June 8, 1809, and his bones were removed in 1819 to England by William Cobbett, the noted political journalist.

His great success as a propagandist is partly accounted for by his literary technique. He said he sought to write simply, candidly and clearly; to be bold and forthright in order to shock readers into attention, partly by sharp contrasts; to use wit and satire to bring opposing ideas into ridicule; to appeal not only to reason but to the heart; to balance imagination with judgment; "to fit the powers of thinking and the turn of language to the subject, so as to bring out a clear conclusion that shall hit the point in question and nothing else"; and to reduce "complicated things to method and orderly connection."

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later discoveries ed. by Philip S. Foner (*Complete Writings*, 1945). *See* also other later discoveries by A. O. Aldridge, "Some Writings of Thomas Paine in Pennsylvania Newspapers," *American Historical Review*, vol. lv, pp. 832–838 (July 1951). H. H. Clark's Introduction to Thomas Paine, *Representative Selections* (1944), is followed by a critically annotated bibliography. (H. H. Cl.)

PAINLEVÉ, PAUL (1863–1933), French mathematician who was prime minister first at a crucial period of World War I and then during the financial crisis of 1925, was born in Paris on Dec. 5, 1863. Educated at the École Normale Supérieure, he took his doctorate in mathematics in 1887 and became a professor at the Sorbonne, where he won eminence as a brilliant mathematician. The Dreyfus case aroused his interest in politics and as an independent Socialist deputy for Paris from 1906 he took a special interest in military matters. In Aristide Briand's government of October 1915 he became minister of education and of inventions, and in Alexandre Ribot's ministry of March 1917 he served as minister of war. On Sept. 12, 1917, he formed his own ministry, continuing as minister of war. In October, after reconstructing his ministry, he agreed to the setting up of the Supreme Allied Council at Versailles and chose Gen. Ferdinand Foch to represent France. On Nov. 17 his government was replaced by Georges Clemenceau's great war government.

With Edouard Herriot, Painlevé helped to form the Cartel des Gauches which won the general elections of May 1924, and he was president of the Chamber until on April 17, 1925, he succeeded Herriot as prime minister. Meanwhile, when Alexandre Millerand had to resign from the presidency of the republic in June 1924, an attempt was made to get Painlevé elected in his place, but he was defeated by Gaston Doumergue. As prime minister he was confronted with acute financial difficulties arising from depreciation of the franc and the bad fiscal system. He summoned Joseph Caillaux to help as minister of finance, but his proposals were rejected by the Socialists, and in October 1925 Painlevé had to dismiss Caillaux and take personal charge of finance. When his proposals for another capital levy and a moratorium on certain debts were also rejected he resigned on Nov. 22, 1925. In the succeeding ministries of Briand and Raymond Poincaré he served as war minister; and in 1930–31 and again in 1932–33 he served as air minister.

Though he proved never to be more than a mediocre political leader he was internationally recognized as a mathematician of outstanding ability. His many works on the subject include *Leçons sur le frottement* (1895) and *Leçons sur la théorie analytique des équations différentielles* (1897). He was elected a member of the Académie des Sciences in 1900. He also published *Comment j'ai nommé Foch et Pétain* (1923). He died on Oct. 29, 1933. His *Paroles et écrits* appeared in 1936.

See Mermeix, *Nivelle et Painlevé* (1919); G. André-Hesse, *Painlevé, grand savant, grand citoyen* (1933).

PAINT, a fluid suspension of finely divided colouring matter in a liquid film-forming binder capable of converting to a solid film when a thin layer of it is applied to a metal, wood, stone, paper, leather, cellophane, cloth, or other surface.

Until about 1920 the designation "paint" meant white lead and linseed oil compositions. Varnish vehicles to which pigments had been added and which dried to a smooth, hard film with either a gloss, semigloss, or flat lustre were classified as enamels. Rapid-air-drying compositions, which usually contained cellulose esters or ethers and dried by solvent evaporation, were called lacquers. Today these names apply to a wide variety of products fulfilling similar end uses, without regard to specific composition. Even clear coatings may justifiably be considered paints. The generic term "paint" rightfully encompasses all film-forming pigment dispersions.

HISTORICAL DEVELOPMENT

Although little was known of the protective functions of paint until the modern era, its use for decorative purposes goes back to the cave drawings of Paleolithic man.

Paint played an important part in the colour-conscious aesthetics of classical Greece and was widely used in architecture, sculpture, and the decoration of ships, as well as in interior decoration and easel painting. The Athenian temples that are seen today in austere whiteness were originally partly painted. The colouring, like the architecture, was planned in terms of overall effect, and the buildings of the Acropolis were as carefully harmonized in colour as in line.

The parts of each building that were painted were recessed or projecting surfaces and those surfaces that provided a background for friezes and sculptures. The friezes themselves, such as those of the Parthenon, had touches of colour to indicate details of dress, weapons, etc. Statues also were coloured, at least partially. Lips, eyes, hair, and drapery were painted, and an application of wax, subtly graduated to harmonize with the sculptural effect, was used to indicate flesh tones. The colouring of sculpture, like that of architecture, was employed to fit in with the background, which accounts for the sculptured figures on the Acropolis having green eyes and blue beards. A sculptor usually passed his work along to a painter to be waxed and coloured. According to Pliny, when Praxiteles was asked which of his creations he was most pleased with, he answered that his best works were those that had been finished by Nicias the painter.

The Romans exercised less restraint in their use of colour than the Greeks did, making more use of the encaustic (hot wax) process for the colouring of marble. Pliny, discussing the pigments used by painters, divides them into classes, *colores floridi* and *colores austeri*. The latter were supplied by the artist; the former, which were more expensive, were furnished by the patron in order to ensure work of top quality.

For many centuries paint remained a costly luxury, laboriously produced by individual craftsmen and reserved for those who could afford to indulge their aesthetic sense. It was not until the Industrial Revolution, when newly introduced machinery required protection against corrosion, that production began on a large scale. It was a long time, however, before research caught up with industrial needs; the practice was to repaint equipment frequently rather than to attempt the development of long-lasting protection. As late as 1910, so few chemists were occupied with paint technology that it was said that one of them could probably name all the others. This situation changed abruptly after World War I, and by mid-20th century paint manufacture had become an important phase of chemical engineering.

Well-equipped laboratories were established and well-trained scientists were devoted to the conception of new ideas and the creation of new paint intermediates. Paints were designed to meet specific end uses: fast application and drying, odourlessness, water dilutability, and availability in a wide range of colours. Manufacturing methods changed. Small varnish kettles of 50- to 300-gal. capacity were replaced by resin reactors of 3,000- to 6,000-gal. capacity. Stone mills gave way to high-speed equipment capable of turning out thousands of gallons of finished paint per day. Packaging advanced from simple hand filling to high-speed, automatic filling, labeling, and capping. The basic raw materials, such as pigments, resins, and solvents, are now manufactured to rigid specifications by manufacturers in the chemical and petroleum industries.

PAINT VEHICLES

The vehicle of a paint is a liquid composed of a film-forming binder and a solvent in which the finely divided, insoluble pigment is suspended.

Early Vehicles.—Studies of the paintings of ancient Egypt have revealed vehicles made from gum arabic, egg white, gelatin, casein, and beeswax. Paint vehicles throughout the ancient world differed only slightly, depending mainly on the materials locally available. The Persians used binders of gum arabic, whereas in India crayons were made from boiled rice. Another early paint vehicle in both China and Japan was the sap from varnish trees (*Rhus vernicifera*). Until the 14th century artists traditionally used egg albumin as a binder; later, interest in oils developed. By the 16th century, oleoresinous vehicles had become common.

Modern Vehicles.—A wide variety of paint vehicles are in common use, including drying oils, varnishes, synthetic resin solutions, resin emulsions, synthetic latexes, and many others.

TABLE I.—*Vehicles for Architectural and Industrial Finishes*

Oleoresinous air-dry types	Lacquer types	Catalyzed types	Baking types
Oils Varnishes Alkyds Epoxy esters Silicone alkyds Acrylic alkyds Polyurethane oils Styrenated alkyds and oils	Nitrocellulose Ethyl cellulose Cellulose aceto-butyrate Cellulose acetate Polyvinyl chloride acetate Polyvinyl butyral Chlorinated rubber Acrylics Butadiene styrenes Shellac Zein Natural resins Water-soluble resins	Urea alkyds Melamine alkyds Epoxy amines Epoxy polyamides Phenolic syrups Polyesters Polyurethanes Nitrocellulose-urea	Urea alkyds Melamine alkyds Epoxy resins Epoxy phenolics Acrylics Silicone alkyds Polyurethanes Polyesters

Solutions.—Many film-forming materials are used both as clear coatings and as pigment binders. In solution vehicles the binder is dissolved in a solvent to form a clear, viscous solution, and the pigment is dispersed directly into the vehicle solution. On film formation the solidified vehicle serves to bind the pigment, forming a continuous film phase. Vehicles belonging to this category include drying oils, varnishes, synthetic resins, shellacs, casein solutions, and high polymeric materials such as the cellulosic and vinyl polymers.

Among the solution vehicles are vegetable and marine oils obtained from the seeds and nuts of certain plants and trees and from a few species of fish. These oils are further classified as drying, semidrying, and nondrying.

Linseed is the most widely used drying oil; soybean is a typical semidrying oil; castor, cottonseed, and coconut oils are examples of common nondrying oils. Exterior house paint is the only common finish in which oil is still the sole film-forming constituent, and even its popularity is diminishing with the rise of latex house paint. Although the natural oils have many desirable properties, their weaknesses—a relatively slow drying rate, production of soft films, and lack of uniformity—are no longer tolerable.

To overcome the deficiencies of natural oil vehicles, modifications with hard resins have been made. Oleoresinous varnishes are combinations of drying oils and hard resins that are "cooked" under specified conditions. Other processes have been developed to modify oils and thus increase the rate of drying. Such processes may change the structure of the oil molecule, or another constituent, such as maleic anhydride or styrene, may be added. Such modified oils are referred to as synthetic, treated, or styrenated oils. Treated oils usually have better water and chemical resistance as well as faster drying properties than the original untreated oil.

One of the more important categories of synthetic resins is the alkyd group, basically formed by chemically combining a polyhydric alcohol (*e.g.*, glycerine, pentaerythritol, ethylene glycol) with a polybasic acid (*e.g.*, phthalic, maleic, or sebacic) and a fatty acid or oil (drying, semidrying, or nondrying). The alkyd resins can replace varnishes in part or in whole. They can be modified by changing any of the three types of ingredients and their relative proportions over a wide range of properties. Alkyd resins made with nondrying fatty acids are used in lacquers and baking finishes, particularly those alkyds based on butylated urea and melamine-formaldehyde resins. These resins lead to increased hardness and toughness, improved colour retention at high temperatures, and reduction in baking time to a few minutes.

Since the late 1940s, epoxy resins, made by polymerizing the reaction product of bisphenol with epichlorohydrin, provided additional hardness, adherence, flexibility, and alkali resistance for use as coating materials and textile finishes. When combined with fatty acids, amines, or polyamides the properties of epoxy resins are enhanced.

Vehicles based on silicone resins, in which silicon partially replaces carbon in a complex molecular structure, produce paints with good resistance to high temperatures and weathering.

Lacquer resins are usually film-forming, thermoplastic, solvent-soluble materials capable of drying rapidly to hard films. Nitrocellulose is most commonly used, but the less flammable cellulose acetate, propionate, and acetate butyrate esters; cellulose ethers such as ethyl cellulose; and others such as shellac, polyamide resins, styrene polymers, vinyl and acrylic copolymers are widely used. (For resins, *see* further RESINS: *Synthetic Resins.*)

Various reagents are often used in small quantities to attain special effects. Catalysts are frequently added to paints containing oils or oleoresinous binders to accelerate the rate at which the film converts from a liquid to a solid state. Driers (or siccatives) are catalysts that promote the oxidation of oils and oil-modified resins. Cobalt, manganese, lead, and zinc combine with fatty or naphthenic acids to form oil-soluble compounds (soaps) used as driers. Aluminum soaps are used as thickening agents. Surface-active compounds are employed to assist pigment dispersion, control flow, and maintain colour uniformity by minimizing reflocculation of pigments. Fungicides, defoamers, waxes, buffers, or antiskinning agents are some of the other reagents used.

Dispersions.—In another type of vehicle the resins are dispersed in a liquid. Dispersion resins are in the form of tiny, spherical, insoluble particles suspended in a volatile liquid such as water or any volatile solvent. When the liquid evaporates, discrete particles of pigment and resin are left behind. Film formation is completed by baking this residue, causing the resin particles to fuse into a continuous film. If the resin particles are sufficiently coherent, they may fuse at room temperature. Examples of dispersion coatings include the polyvinyl chloride organosols and synthetic rubber latexes.

Since 1948, aqueous dispersion polymers known as latexes (or polymer emulsions) have come into widespread use. In a latex system, in which the binder is dispersed in water, film formation occurs by fusion of the plastic particles after the water evaporates. In common with dispersion systems, the pigment is segregated from the binder until the film coalesces. Since both the pigment and vehicle of a latex paint are immiscible with water, each component must be separately dispersed before combination. Thus aqueous paint formulation represents a union of separate disperse systems rather than the addition of pigments to a simple solution system.

In latex paints the pigments are identical to those used in conventional solution paints. The desirable features of latex paints, such as rapid drying, ease of application, resistance to alkalinity, good durability, nontoxicity, absence of fume hazard, applicability to damp surfaces, and low odour, are characteristic properties of the latex vehicle.

Many film properties of latexes such as hardness, flexibility, toughness, adhesion, colour retention, and chemical resistance are dependent upon monomer composition. Three families of monomers that have a desired balance of properties and have met with commercial acceptance are the butadiene-styrene, the polyvinyl acetate, and the acrylic systems. The butadiene-styrene latexes are considered self-plasticized unsaturated styrene copolymers. This means that the films are subject to oxidation and discoloration on drying. Butadiene-styrene latexes are usually made without a protective colloid, and their colloidal behaviour is dependent on the soaps and electrolytes used in their manufacturing processes. On the other hand, vinyl acetate latexes are usually stabilized by small amounts of water-soluble polymers such as polyvinyl alcohol, hydroxyethyl cellulose, gum tragacanth, or similar hydrocolloid. Unless plasticized with 10 to 20% of a suitable plasticizer (nonvolatile solvent) or soft comonomer, vinyl acetate polymers are poor film formers. Acrylic latexes are usually copolymers of ethyl acrylate and methyl methacrylate with small amounts of methacrylic acid. Compared to the butadiene styrenes and the vinyl acetates, the acrylic monomers polymerize quite readily to form very high-molecular-weight, highly cross-linked, stable polymers.

Since all latexes are colloidal suspensions, they are sensitive to extremes in temperatures, to violent mechanical action, to the influence of electrolytes, to changes in acidity or alkalinity, and to solvent additions. This requires special care in manufacturing.

Solvents.—Solvents are volatile liquids or mixtures of volatile liquids capable of dissolving or dispersing the film-forming components of paint to a satisfactory consistency for application.

This must be accomplished at the lowest cost possible because solvents are not usually recovered, yet they must have the correct solvent power and rate of evaporation or they will adversely affect the stability of the coating and the properties of the dry film. The solvent power of a solvent for a solute is its ability to disperse the solute. A solvent has a maximum solvent power when it disperses a solute as completely as possible over a wide range of concentration. The rate of evaporation is an indication of the ease with which the solvent leaves a surface.

The solvents in general use for the coatings industry may be classified as follows: terpene solvents, hydrocarbon solvents, oxygenated solvents, chlorinated compounds, nitroparaffins, furans, and water. Terpene solvents (*e.g.*, turpentine), the oldest in use, are obtained from pine trees. They have been largely replaced by lower-cost aliphatic hydrocarbon solvents. Petroleum and coal-tar hydrocarbon solvents are used extensively because of their unlimited availability, low cost, good solvent power for oils and resins, and effectiveness as diluents for nitrocellulose; petroleum solvents are the lighter fractions obtained by the distillation and fractionation of crude oil. Oxygenated solvents (alcohols, esters, ketones, ether alcohols) are better solvents for film formers such as shellac, cellulose esters, urea-melamine formaldehydes, and vinyl resins. Many oxygenated solvents are soluble in water and are used in latex paints to create special effects. Chlorinated hydrocarbon, nitroparaffin, and furan solvents find limited use in certain industrial finishing operations where good ventilation is available.

Film Forming.—The useful life of a coating is determined partly by choice of vehicle and partly by the chemical changes induced by the service conditions of the coating. By judicious choice of vehicle, a wide variety of film properties can be produced. Some films may be flexible, others strong and tough, still others hard and rigid. An endless number of vehicle combinations are needed to meet the diverse requirements of architectural and industrial coatings.

Methods.—Solution film formers change from a viscous liquid state to a solid by one or a combination of three general methods: (1) evaporation of the solvent; (2) oxidation; and (3) polymerization.

Evaporation of the solvent may be illustrated by the drying of shellac. When applied in a thin layer, a solution of shellac in alcohol hardens to an adherent film by the simple evaporation of the alcohol. Spirit varnishes, lacquers, and latex paints also dry by this mechanism. A solvent can simply volatilize under normal room conditions; if desired, evaporation can be accelerated by heating in an oven.

Oxidation may be illustrated by the drying of linseed oil. A thin film of linseed oil changes from a liquid to a solid film by absorbing oxygen from the air. Drying oils, oleoresinous varnishes, oxidizing alkyd resins, styrene-butadiene latexes, and many other film-forming materials also dry by oxidation.

Polymerization (*q.v.*) may occur during oxidation when two or more molecules of oil combine in a more complex structure. This is known as autoxidative polymerization. In addition, condensation polymerization and addition polymerization may occur. Condensation polymerization occurs when heat-convertible (thermosetting) coatings are baked at temperatures ranging from 200° to 400° F (about 93° to 204° C). Usually a small molecule, such as water, is split off between two film-forming molecules, forming a more complex single molecule. This reaction sequence may be repeated until very large molecules are formed. Urea-, melamine-, and phenol-formaldehyde resins convert by this method. Addition polymerization occurs when unsaturated molecules, such as styrene or methyl methacrylate, are activated by a suitable catalyst to combine and form larger molecules. No by-products are formed in this process.

Vehicle Requirements.—Solvents must provide a degree of temporary mobility, to assist application, and a proper balance of volatility, to permit rapid and complete evaporation, while leaving the film smooth and uniform. These multiple requirements preclude selection solely for resin solvency. Although the solvent is completely volatilized during the drying process, the physical properties of the dry film may still be markedly influenced by the solvent. This is true for coatings that dry by simple evaporation as well as by the other film-forming processes. Oxidation, for example, does not begin until most of the solvent has evaporated. Hence the choice of a proper solvent combination is important.

The rate of change in consistency of a paint film depends on the rate of evaporation of the solvent and its solubilizing power. If the solvent evaporates too rapidly, a large difference in solvent concentration will develop between the surface and the interior of the film. This may be sufficient to cause blistering as the last trace of solvent evaporates. It may also produce stresses in the film that could become a source of weakness in the completely dried film. Inadequate solvent power at any stage of drying can result in lack of adhesion, loss of lustre, and poor film performance.

The ability of a coating to flow or level out to a smooth surface depends on the inherent flow property of the solid binder, the characteristics of the solvent, and the pigment concentration. For example, paints made with unbodied oils level poorly and leave brush marks that are evident in the dried coating. Enamels and lacquers made with resinous vehicles at low pigment concentration usually form smooth surfaces, unless these coatings are sprayed with too volatile a solvent; then an irregular or "orange-peel" effect may be observed. Binder composition complicates choice of solvent since few, if any, solvents are universal thinners for all resins. Types and proportions of solvent must be selected to produce fluid paints and film homogeneity at all stages of drying. Modern formulation relies on several hundred varieties.

PIGMENTS

Pigments are finely divided, insoluble, white, coloured, or metallic powders obtained from naturally occurring minerals or prepared by one of many chemical manufacturing operations. Pigmentary compositions may vary from a simple inorganic oxide to a complex heterocyclic organic molecule.

Historical Aspects.—Paleolithic artists used natural pigments, such as chalk, clay, and charcoal, and naturally occurring red, yellow, and green minerals. Red and yellow colours of an ancient Greek painting analyzed by Sir Humphry Davy in 1815 were found to be ochres; the blues and greens were oxides of copper; the blacks were carbonaceous; the whites were carbonates of limes; and the browns were mixtures of ochres and black, plus oxide of manganese in some cases. Some blue and green pigments used by Greek fresco painters were composed of glasses coloured with salts of copper and then ground to a fine powder. One of the finest red pigments known to the Greeks and Romans was made from secretions of the *Coccus ilicis,* a small beetle similar to the cochineal insect.

Artists of the Middle Ages improved on the classical methods of producing pigments inherited from such early handbooks as *Compositiones ad tingenda* (Recipes for Colouring), collected at Alexandria about A.D. 600, and *Mappae clavicula* (Key to Painting), compiled about A.D. 800 in Italy. In the 18th and 19th centuries, the manufacture and use of pigments became an important phase of the growing chemical industry.

Manufacturing Methods.—A procedure for the manufacture of pigments cannot be generalized, although the unit operations are common to chemical engineering practice. For many wet-process pigments, the reagents are added to a vat and are agitated. The precipitate is washed by drawing off the supernatant water, adding fresh water, and repeating this process several times. The washed slurry is then concentrated in a filtre press, and the press cakes are dried in an oven. The dried pigment is in the form of coarse lumps, which are pulverized in a hammer mill or ground and sieved in various ways to form a fine dry powder, generally less than 2 μ in size, but preferably in the fractional micron size. In the manufacture of some pigments, calcination is necessary.

Pigment Materials.—The pigments commonly used in the manufacture of paints include the following:

White Pigments.—Rutile and anatase titanium dioxides, zinc sulfide, rutile calcium bases, lithopone, zinc oxide, basic carbonate and

basic sulfate of white lead, leaded zinc oxide, and, to a lesser extent, antimony and zirconium oxides.

Extender (Inert) Pigments.—Barite (barytes), *blanc fixé* ("permanent white"), gypsum, magnesium silicates (talcs), calcium carbonate (whiting), China clay, clays, silica, diatomaceous earth, mica, and calcium silicate.

Yellow Pigments.—Chrome yellow, zinc yellow, ochre, sienna, ferrite yellow, cadmium sulfide, and organic lakes and toners.

Blue Pigments.—Ultramarine, iron blue (Prussian, Chinese, milori), cobalt oxide, copper phthalocyanine, and organic lakes and toners.

Green Pigments.—Chrome green (iron blue-chrome yellow), chromium oxide and hydroxide, phthalocyanine, and organic lakes and toners.

Red Pigments.—Iron oxide, Venetian red, Tuscan red, red lead, organic lakes and toners (para red, toluidine, lithol, alizarin, quinacridone), and cadmium selenide.

Brown Pigments.—Umber, sienna, iron oxide, and Van Dyck (Vandyke).

Black Pigments.—Carbon black, lamp black, bone black, iron oxide, organic blacks, and graphite.

Metallic Pigments.—Aluminum, copper, zinc, lead, and various alloys.

Properties of Pigments.—Colour (*q.v.*) depends on the ability of the dispersed pigment particles to refract and reflect the light striking the paint film. Black paint absorbs substantially all of the incident light whereas white paint reflects and refracts a high percentage of the light. In coloured paints, the incident light is selectively absorbed, the reflected light giving the hue characteristic of the pigment. Thus a certain pigment is red because it reflects only red wave lengths to the eye of the viewer. However, it will appear to be red only if it is illuminated by light containing the necessary red wave lengths to be reflected. Under other illumination it appears black or colourless.

A white pigment produces the effect of whiteness because it reflects all wave lengths of visible light to the same degree. Under red light it will appear red; under blue light, blue; and under green light, green. It will appear white only under illumination containing all the wave lengths of visible light. A white pigment cannot absorb or reflect any of these wave lengths to a greater degree than some other without losing some of its total brightness and becoming "off-white" in colour. Since even minute traces of impurities can alter the light-absorption characteristics of a substance, pigmentary material must be highly purified and constant in composition, shape, and particle-size distribution to retain spectral constancy.

The ability of a white paint to obscure a dark background—termed its covering or hiding power—is determined by the difference in the refractive indexes of the vehicle and pigment, the state of subdivision of the pigment particle, and the relative proportions of pigment and vehicle. When the refractive-index difference between the pigment and vehicle is large, the paint exhibits high covering power; as the difference becomes smaller the paint approaches transparency. For example, when calcium sulfate, with a refractive index (n) of 1.57, is ground in linseed oil ($n = 1.48$), the resulting dispersion is translucent. When titanium dioxide ($n = 2.72$) is ground into the same oil, a paint of exceptional hiding power is obtained. As a rule, the finer the state of subdivision of the particle of pigment, the greater the hiding power.

Extender or low-opacity pigments contribute no colour or other identifying feature, yet they assume a vital position in paints from the point of view of film integrity, sheen uniformity, film hardness, pigment volume, and much of the economy necessary to reduce the cost of paint. Although these pigments were at one time considered "inert," they are recognized as having a substantial effect on the optical, physical, and chemical properties of paint. Chemically, they are naturally occurring inorganic minerals, with a fairly low specific-refractive index. In oils, varnishes, or alkyds, this characteristic makes extenders optically transparent.

Although pigments are used primarily to provide colour and opacity, they influence many other paint properties. The particle size and shape, wetting by oil and resins, chemical reactivity, effect on drying rate, ultraviolet absorption, etc., vary from pigment to pigment. Similarly, the physical properties of a paint made from a given vehicle vary from pigment to pigment.

The ratio of pigment to binder depends on the type of pigment and vehicle used, as well as on the desired end use for the paint. Gloss paints and enamels contain relatively low concentrations of pigments; flat or matte-finish paints and primers are highly loaded with pigments. A typical white enamel, for example, may contain two to four pounds of titanium dioxide per gallon, whereas a white priming paint may require eight to ten pounds of mixed pigments per gallon. On a volume basis, a high-gloss enamel may contain 20–30% white pigment; gloss and semigloss paints, 30–50%; flat paints and primers, 50–75%. An indication of the differences due to colour is shown in Table II.

TABLE II.—*Concentrations of Pigments*

Colour	Pounds of pigment per 100 lb. of binder	Colour	Pounds of pigment per 100 lb. of binder
Black	6–8	White	90–125
Red	20–30	White exterior house paint	175–225
Blue	20–30		
Green	35–45	White flat wall paint	200–400

In general, pigments enhance the hardness and firmness of coatings. In addition, laminar or platelike pigments such as mica or aluminum powder decrease moisture permeability, but bulky pigments such as diatomaceous silica tend to make the coating spongy or porous. Acicular (needlelike) pigments tend to reinforce film structure.

Some pigments are easily wetted by oil or resins, while others are not. A poorly wetted pigment will produce coatings that are less compact and therefore weaker and more permeable to water. Many binders contain free fatty acids or develop acidic by-products as a result of oxidation. Though many pigments are inert to the action of these acids, basic pigments such as zinc oxide or white lead react to form metallic soaps. When this occurs, zinc soaps tend to harden coatings, whereas lead soaps tend to soften them.

The ultraviolet component of sunlight is one of the most destructive agents for exterior coatings. These radiations accelerate the oxidation of drying oils, alkyds, and synthetic rubber and degrade resins such as nitrocellulose. Some pigments, such as carbon black, aluminum powder, or zinc oxide, absorb or block the ultraviolet rays, thereby protecting the film former. The protective and anticorrosive properties of paint are a function of both the pigment and the binder. For example, inhibitive pigments such as red lead or zinc chromate can be used with suitable vehicles to protect iron against rust.

MANUFACTURE AND USES

Rise of the Industry.—The first technical description of the paint and varnish industry may be found in Jean Felix Watin's varnish formulary (about 1772). Using copals and amber as the principal varnish resins, with turpentine as a thinner, a typical varnish recipe required 1 lb. of resin to $\frac{1}{4}$–$\frac{1}{2}$ lb. of oil. Pigments were ground with the aid of a large stone trough and hall muller.

Varnish factories were established in England in 1790, in France in 1820, in Germany in 1830, and in Austria in 1843. Simple types of buhrstone mills were the principal machines for dispersing pigment during this period. Even in Great Britain and the Netherlands, where the technology of varnish manufacture was more advanced, little was achieved in the paint industry until the 1900s. Until that time, increases in batch size and total volume constituted the only noteworthy changes.

Today paint manufacture involves a series of separate operations, including vehicle preparation, pigment production, mixing, dispersion, colour matching, testing, and packaging.

Manufacture of Paint.—Paint making is essentially the art of reproducibly dispersing pigments in vehicles and duplicating the colour and properties of a finished paint to a given standard. Traditionally, certain vehicles, such as bodied oils, driers, alkyd resins, and varnishes, are manufactured by the paint makers. Even more frequently, however, large chemical producers manufacture pigments, solvents, resins, and synthetic vehicles; these, in turn, are sold to the paint manufacturers.

Pigments are usually added to the vehicle by blending the ingredients in large paste mixers. The pigment-vehicle paste, so

formed, consists of imperfectly dispersed aggregates of pigment distributed through the vehicle; this paste is brought to requisite fineness and uniformity by grinding on a roller mill, ball or pebble mill, sand mill, stone mill, or variations of these machines. Grinding or shearing is designed to wet the individual pigment particles with the liquid vehicle and to reduce the size of the pigment aggregates. There is no grinding (particle-size reduction) in the literal sense.

The roller mill consists of a series of hardened hollow steel rolls that are cooled with circulating water and driven at differential speeds at clearances usually less than 0.001 in. The most commonly used mills have three rolls, although five-roll mills are frequently used. The grinding operation is accomplished by introducing the pigment-vehicle mixture at the first two rolls, where it is subjected to the shearing action of the roll surfaces; the mixture adheres to the second roll and passes on to the third roll, where it is removed by a scraper blade. A five-roll mill subjects the mixture to two additional shearing interfaces. The uniroll mill differs from the multiroll in that shearing of the pigment-vehicle mixture occurs against a stationary pressure bar.

A ball and pebble mill consists of a horizontally placed drum partially filled with steel-alloy or porcelain balls or with flint pebbles. When the mill rotates, the cascading balls shear the pigment-vehicle mixture between the contacting ball surfaces. Stone mills are the oldest and still commonly used devices for dispersing pigments. In these mills, one circular stone revolves against a similar stationary stone. The pigment-vehicle paste is introduced at the centre of the top stone, where it is carried between the stones, subjecting the paste to a shearing action. The grinding surfaces of the stones are cut to provide grooves and channels that transport the paste to the periphery, where it is removed by a scraper.

After the paste is discharged from a mill, it is usually further blended with vehicle, driers, fungicides, etc.; tinted with coloured dispersions to match a desired colour standard; tested for quality; and finally packaged.

The quality of finished paints is controlled by a series of laboratory and field tests. Paints are tested for consistency, percentage of solids, drying rate, hardness, colour, light fastness, adhesion, hiding power, flexibility, abrasion resistance, permeability, electrical resistance, weathering resistance, or other qualities specified by the buyer or seller. In addition, previously established standards must be met. For these purposes laboratory tests have been devised and standardized for use throughout the industry. Fading, for example, is measured by exposing painted panels to radiation from a carbon-arc or mercury-vapour lamp; weathering is simulated in an automatic testing machine that sprays water on to test panels and intermittently exposes them to an intense arc light. To correlate actual use with accelerated test results, outdoor exposures are always in progress.

Precision colour matching requires the judgment of a skilled colour matcher, though instrumental methods are frequently utilized. Optical devices can quantitatively measure the percentage of reflected light (reflectance) in relation to the wave length of light falling on the surface of the film.

Methods of Applying Paint.—The oldest and still most popular method for applying paint, particularly for home decoration and building maintenance, is brushing. With the advent of emulsion, latex, and other interior finishes, hand-roller application has also become popular.

In industrial and assembly-line production, economical and rapid methods are required. Spraying is favoured for industrial usage because spray techniques are readily adapted to high-speed conveyer operations. Even in home use, spraying is possible, since small aerosol packages are available. For intricate objects and large parts such as automobile fenders, paint is economically applied by a dipping operation. Uniform films are possible because the excess paint or drippings can be removed by electrostatic tearing devices or by centrifugal drying. For coating flat surfaces such as venetian-blind slats or sheet-metal stock, roller coating is preferred. For coating very large pieces of equipment, paint is poured through hoses, and the excess is drained off and reused (flow coating).

Regardless of the application method, it is necessary to remove the paint solvent by evaporation either at room temperatures or at low baking temperatures. The film is then dried or converted to its final state by air oxidation or baking in ovens or tunnels. In large industrial installations, the solvent is usually recovered.

Paint Usage.—The modern functions of paint include protection against weathering, corrosion, and microbiological attack; insulation against heat; maintenance of hygienic conditions; control of illumination, and achievement of esthetically desirable appearance. As further evidence of the versatility of paint, fire-retardant paint has demonstrated its importance in minimizing loss of life and property.

Many different types of paint can be made from commercially available raw materials. Many of them can be categorized as trade-sales paints, maintenance and marine finishes, or industrial finishes, according to use.

Trade-sales or "shelf-goods" finishes consist of paints in smaller packages, usually five gallons or less, designed primarily for home use. These paints, based on air-drying vehicles such as oils, alkyds, varnish, and emulsion polymers, are characterized by excellent storage stability (or shelf life) and a wide variety of colours. Normally applied by brushing, paints in this category include house, interior wall, sash and trim, floor and deck, furniture, barn and roof, and metal decorative paints.

In the maintenance and marine fields, the primary objective is to protect property against corrosion, weathering, or biological deterioration. For these purposes, brushing or spray paints are made with air-drying or chemically catalyzed vehicles that provide maximum resistance to sunlight, high humidities, wide temperature variations, and harmful industrial atmospheres without seriously affecting the beauty and colour of the finish. Ship-bottom paints may contain leachable copper or mercury derivatives to provide a surface toxic to marine growth (antifouling paints). Special formulations are available for protecting and decorating office buildings, schools, chain stores, government buildings, military installations, bakeries, dairies, breweries, industrial plants, utilities, railway cars, surface or air-transportation fleets, ships, shipyards, barges, warehouses, highway pavements, etc.

An immense variety of paint products are designed for industrial use. Industrial finishes are ordinarily used in large-scale applications where speed of handling is an important consideration or where special protective properties are required from the finish. Industrial finishes include those for automobiles, refrigerators, washing machines, machinery, prefabricated construction supplies, office and home equipment, weapons, military equipment, furniture and cabinets, wires and cables. Because the solvent removal and film polymerization are usually carried out in heated tunnels or ovens with well-designed ventilation systems, lacquers and catalyzed systems are frequently used for vehicles.

About 60% of all paints manufactured may be classified as trade-sales or maintenance finishes and the remaining 40% as industrial finishes. Exact worldwide figures are not available, but in the United States alone it is estimated that more than 500,000,000 gal. of paint are consumed annually.

See also LACQUER; VARNISH; and references under "Paint" in the Index.

BIBLIOGRAPHY.—H. F. Payne, *Organic Coating Technology*, 2 vol. (1954–61); W. von Fischer and E. G. Bobalek (eds.), *Organic Protective Coatings* (1953); J. J. Mattiello (ed.), *Protective and Decorative Coatings*, 5 vol. (1941–46). (P. HE.)

PAINTBRUSH (INDIAN PAINTBRUSH, PAINTED CUP), any plant of the genus *Castilleja*, of the figwort family (Scrophulariaceae), partially parasitic on the roots of other plants. Most of the species are natives of the New World but there are a few representatives in Asia. They are most numerous in the Rocky Mountain region and on the Pacific coast. They are annual, biennial or perennial herbs, usually one to three feet high, with alternate, often deeply cleft or parted leaves and showy red, yellow or white flowers, borne in dense terminal clusters (spikes), the bracts of which are often highly coloured.

Hieracium auriantiacum, a member of the family Compositae, is commonly known as the devil's paintbrush.

PAINTED DESERT, a section of the high plateau country of north-central Arizona, stretches in a southeasterly direction along the north side of the Little Colorado River Valley, from the Grand Canyon to the vicinity of Holbrook, and is approximately 150 mi. long and 15 to 50 mi. wide and covers about 5,000 sq.mi. The name was first used in 1858 by a government explorer, Lieut. Joseph C. Ives, to describe the brilliantly coloured shales, marls, and sandstones, which are banded with vivid red, yellow, blue, white, and lavender. Elevations range from 4,500 to 6,500 ft. The surface is rolling, broken by isolated buttes, and bounded on the north by vermilion cliffs, rising to broad, flat-topped mesas. The region is barren and arid, with 5 to 9 in. annual precipitation and temperature extremes of −25° to 105° F (about −31° to 41° C). Part of the eastern section is within the 94,189-ac. Petrified Forest National Park and contains Black Forest, one of the four remarkable areas of petrified trees of Mesozoic (Triassic) Age, about 170,000,000 years old.

Reservations of the Navaho and Hopi Indians occupy a large part of the Painted Desert, and these tribes use the variegated, brightly coloured sands for their famous ceremonial sand paintings.

(W. F. H.)

PAINTER, WILLIAM (*c.* 1540–1594), English author whose collection of tales based on classical and Italian originals, *The Palace of Pleasure,* was a source book for many Elizabethan dramatists, was born *c.* 1540. Educated at St. John's college, Cambridge, he was ordained in 1560. In 1561 he became a clerk of the ordnance in the Tower of London, a position in which he appears to have amassed a fortune out of the public funds. In 1586 he confessed that he owed the government £1,000, and in 1591 his son Anthony owned that he and his father had abused their trust, but Painter retained his office until his death in London in Feb. 1594.

The first volume of *The Palace of Pleasure,* which appeared in 1566, contained 60 tales; it was followed in the next year by a volume including 34 new ones. An improved edition (1575) contained seven new stories.

The Palace of Pleasure is a collection of short stories or anecdotes, some borrowed from classical writers such as Herodotus or Plutarch, some from continental writers such as Cinthio (Giovanni Giraldi), Ser Giovanni Fiorentino, Straparola, Margaret of Angoulême, queen of Navarre, Boccaccio (probably through a French translation), Matteo Bandello (through the French of Belleforest) and others. To its popularity, and that of similar collections, is due the high proportion of Elizabethan plays with an Italian setting.

The early tragedies *Appius and Virginia* by John Webster and *Tancred and Gismund* by Robert Wilmot were taken from Painter's book, and it was also the source for Shakespeare's *Timon of Athens* and *All's Well That Ends Well* (from Giletta of Narboune), Beaumont and Fletcher's *Triumph of Death* and James Shirley's *Love's Cruelty.*

See J. Jacob (ed.), *The Palace of Pleasure,* 3 vol. (1890), with an introduction on Italian *novelle* in Elizabethan drama. *The Palace of Pleasure* was also ed. by H. Miles, 4 vol. (1930).

PAINTING, in art, the creation of a pattern of forms on a two-dimensional surface by means of colour and line. The materials of the painter are coloured pigments applied to canvas, wood, paper or wet plaster; for the various techniques *see* OIL PAINTING, TECHNIQUE OF; WATER-COLOUR PAINTING; TEMPERA; FRESCO PAINTING; etc. The origin of painting is probably not later than that of the plastic arts, for it is as ancient as sculpture and, within the somewhat narrow limits that confined it, early reached an astonishing perfection. For the story of its prehistoric beginnings, *see* ARCHAEOLOGY and AEGEAN CIVILIZATION (with which should be read the section *Archaeology* in the article CRETE); sections of the articles GREEK ART; ROMAN ART and BYZANTINE ART continue the story; *see* also EGYPT. The article ART treats in a general way many aspects of painting, and for oriental painting *see* CHINESE PAINTING; INDIAN ART; JAPANESE PAINTING AND PRINTS; and PERSIAN ART.

This article deals with painting in western civilization from the Renaissance to the present; it is arranged as follows:

I. Renaissance and Mannerist Painting (14th–16th Centuries)
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  3. Sienese School
  4. Early Renaissance in Italy
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I. RENAISSANCE AND MANNERIST PAINTING (14th–16th CENTURIES)

1. Background.—Romanesque painting, like architecture and sculpture, was in the service of the church. It was derived from Hellenistic, Byzantine and Celtic forms but developed new characteristics of its own. The Italian, French and Rhenish artists of the Romanesque period painted powerful religious images—sometimes wild and agitated, at times compellingly hieratic—as frescoes on walls of churches or as illuminations in manuscripts. The mosaic pictures on church walls are closely related to them. (*See* ROMANESQUE ART.)

The evolution of art in the 12th century would lead one to suppose that France would take the lead in painting as it had taken it in sculpture and architecture. But the development of Gothic architecture, which is one of the greatest glories of France, had as a result the great reduction of the employment of painting. Sculpture flourished on Gothic portals and magnificently adorned the facades of churches; but where, in the interiors of these cathedrals whose aerial construction almost did away with walls and replaced them by tall windows, could painting have been placed? There resulted another French invention, the art of figures in stained glass, which for nearly three centuries produced a series of masterpieces and replaced monumental painting in those countries to which Gothic architecture spread. (*See* GOTHIC ART.)

On the other hand, a school of miniaturists was founded in Paris. Through the medium of leaves of parchment it created an art which rivaled glass painting for beauty and richness of colour, and exhibited a freedom and flexibility, a curiosity about nature and a subtlety of expression which was beyond the technique of glass work. Great Britain also experienced this development. (*See* ILLUMINATED MANUSCRIPTS; STAINED GLASS.)

2. Giotto.—In Italy Gothic architecture did not take root, or at least Italy adopted from it only the original vault while retaining many forms of Roman architecture and, in particular, the plain walls. Thus in Italy, because of this favourable circumstance and because of Giotto, a man of genius, and others of great talent who preceded, accompanied and followed him, the art of the fresco appeared and developed, and a great tradition of painting arose.

In Italy there was a whole movement of art prior to Giotto. Giovanni Cimabue at Florence showed the way to Giotto in passing from the mosaic, still impregnated with Byzantine legacies, to the more free and flexible fresco work. Giotto, as well as Cimabue, was connected with the Roman school of mosaicists turned painters, Pietro Cavallini and the Cosmati, as well as with the work of Giunta Pisano, Nicolas d'Apulia and Coppo di Marcovaldo. But it was his own personal work that brought him glory. While accepting some of the conventions of his time, Giotto introduced into painting a simpler grandeur of conception, a hitherto unknown force of heroic human expression and that equilibrium of the spiritual and of the perceptible, of nature and of thought, which remain an ideal for the art of all time. Therein he is truly a precursor of modern art. His disciples and successors, without recapturing his grandeur, developed and enriched the heritage of their master. In place of the abstract decorations of Giotto, concrete details accumulated, compositions grew more complicated, and great ingenuity was exercised in the choice of dramatic or picturesque accessories for the scenes depicted. The most justly famous work of the period is "The Triumph of Death," which, with a mixture of brutality and refinement, unfolds its eloquent teachings on the walls of the Campo Santo at Pisa.

3. Sienese School.—Parallel with that of Florence, a school of almost equal brilliancy, less powerful perhaps but more delicate, was developing at Siena from the Byzantine models. The "Maestà" of Duccio di Buoninsegna, painted in 1308–11, seemed to the Sienese, when they first saw it, so much of a miracle that the whole town, led by the bishop, bearing lighted candles in their hands, carried it in state to the Duomo. It is composed almost entirely of Byzantine elements, but its precious novelty lies in the gentle smile animating the face of the Virgin Mary.

Simone Martini (*c.* 1284–1344) gave an even greater sweetness to his religious compositions while, at the same time, he was the first who dared to employ his art for purposes not wholly religious. On the walls of the Palazzo Pubblico, facing his lovely "Virgin in Glory," he painted the *condottiere* Guidoriccio da Fogliano riding armed and caparisoned before the palisades fronted by a hedge of lances.

Martini's contemporary Ambrogio Lorenzetti (*c.* 1290–1348) established himself as a painter of civic life. Combining Simone's purely Sienese tradition with the influence of Giotto's more robust style, he celebrated in another room of the same palace the benefits of "Good Government" to town and country.

4. Early Renaissance in Italy.—At the beginning of the 15th century Italy showed signs heralding the Renaissance.

The painters not only mingled scenes of common life with their religious compositions, but they applied themselves with a kind of scientific realism to the study of the human form. Antonio Pisanello (*c.* 1395–*c.* 1455) was a marvellous draftsman. Masaccio (1401–*c.* 1428), a man of genius who died at the age of 27, was already a sort of classic. He was keenly devoted to the study of anatomy, and the nude made its appearance in painting with his "Adam and Eve" in Sta. Maria del Carmine. Masaccio achieved a plasticity of form by means of modulation of light and shade. He also gives a feeling for space by his use of aerial perspective. The Dominican monk Fra Angelico (1387–1455), who well merited his title of Angelico, seemed destined by his piety to carry on the profoundly religious but abstract and severe tradition of Giotto, or perhaps the gentler one of Guido da Siena. But in everything which concerned him as a painter he showed a preoccupation with the world of nature similar to that of Masolino da Panicale and Masaccio. By a special grace he was able to apply his love of nature to the expression of the purest and most devout soul to be met with in the history of art.

In addition to this group of initiators whose work had already a classic air, more classic even in certain ways than that of their immediate successors who, like Sandro Botticelli, did not escape a certain mannerism, were certain seekers after the scientific spirit. These contributed to the formation of the doctrine of the Florentine school, intellectual and free, which was to become the educator

"Annunciation with SS. Ansano and Judith," triptych by Simone Martini (c. 1284–1344) and Lippo Memmi (*fl.* 1317–57), Italian. Uffizi gallery, Florence

"Virgin of Autun" by John van Eyck (?1385–1441), Flemish. In the Louvre, Paris

"Resurrection" by Piero de' Franceschi (c. 1418–92), Italian. In the Palazzo Communale, Borgo San Sepolcro

"The Annunciation" by Fra Angelico (Giovanni da Fiesole; 1387–1455), Italian. Museum of San Marco, Florence

PAINTINGS OF THE EARLY RENAISSANCE

"The Tribute Money" by Masaccio (1401–c. 1428), Italian. Brancacci chapel, Sta. Maria del Carmine, Florence

PHOTOGRAPHS, (TOP LEFT, CENTRE LEFT, CENTRE RIGHT, BOTTOM) ANDERSON; (TOP RIGHT) COLLECTION ARCHIVES PHOTOGRAPHIQUES

PAINTING

PHOTOGRAPH, THREE LIONS

GIOTTO AND AN EARLY FRENCH MASTER

Left: "The Kiss of Judas," one panel in a series on the life of Christ by Giotto di Bondone (1267?–1337). Arena chapel, Padua, Italy

Below: "Pietà" by an unknown artist of the Avignon school, southern France, 15th century. In the Louvre, Paris

PHOTOGRAPH, CAMERA CLIX FROM PUBLIX

TWO MASTERPIECES

OF THE

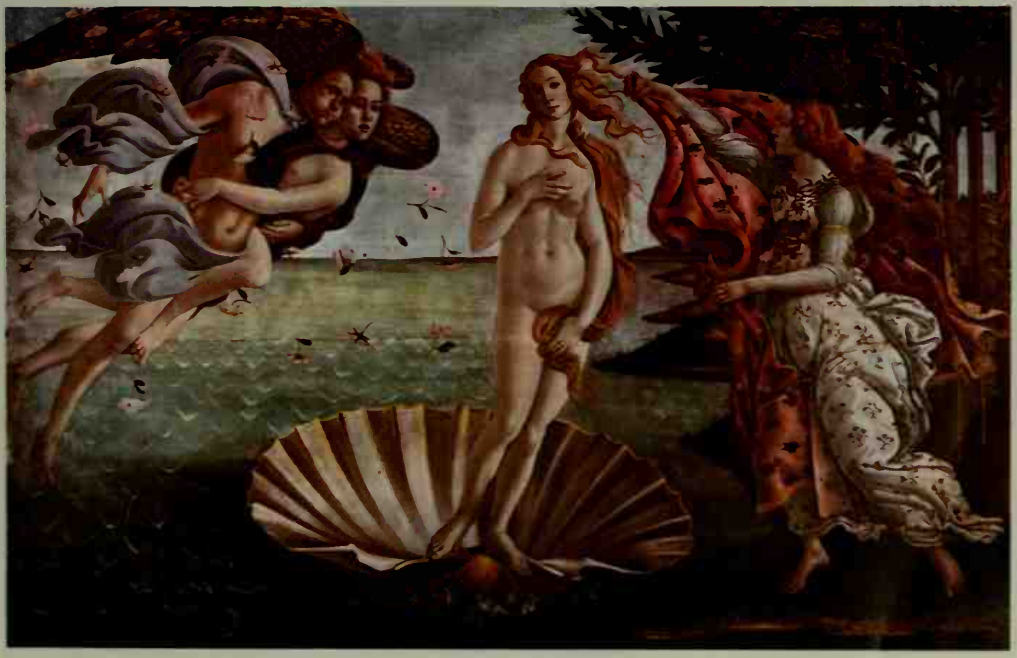
ITALIAN RENAISSANCE

"Bridgewater Madonna" by Raphael (1483–1520). Urbino. In the collection of Lord Ellesmere, Edinburgh, Scot.

PHOTOGRAPH GUNZETT & HUBER FROM BLACK STAR

"Birth of Venus" by Sandro Botticelli (1444–1510). Florence. In the Uffizi gallery, Florence

PHOTOGRAPH CAMERA CLUB FROM PUBLIX



PAINTING

"The Deposition From the Cross" by Rogier van der Weyden (c. 1400–64), Flemish. In the Prado, Madrid

"Sir Thomas More" by Hans Holbein (1497?–1543), German. The Frick collection, New York city

FLEMISH, GERMAN AND ITALIAN PAINTING OF THE RENAISSANCE

"Adam" detail from "Creation of Man" by Michelangelo (Michelagniolo Buonarroti; 1475–1564), Italian. Sistine chapel, the Vatican, Rome

"John and Peter" by Albrecht Dürer (1471–1528), German. Munich Pinakothek

"Madonna della Granduca" by Raphael Sanzio (1483–1520), Italian. In the Pitti palace, Florence

"Mona Lisa" ("La Gioconda") by Leonardo da Vinci (1452–1519), Italian. The Louvre, Paris

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"St. Francis in Ecstasy" by Giovanni Bellini (c. 1430–1516), Venetian. In the Frick collection, New York city

"Concert Champêtre" ("The Pastoral Symphony") by Giorgione (c. 1478–1510), Venetian. In the Louvre, Paris

"The Marriage at Cana" by Paolo Veronese (1528–88), Venetian. In the Louvre, Paris

"Education of Cupid" by Correggio (Antonio Allegri; c. 1494–1534), north Italian. In the National gallery, London

CORREGGIO, CARAVAGGIO AND THE VENETIANS

"Death of the Virgin" (detail) by Michelangelo da Caravaggio (1573–1610), Italian. In the Louvre, Paris

"Venus of Urbino" by Titian (Tiziano Vecellio; c. 1490–1576), Venetian. In the Uffizi gallery, Florence

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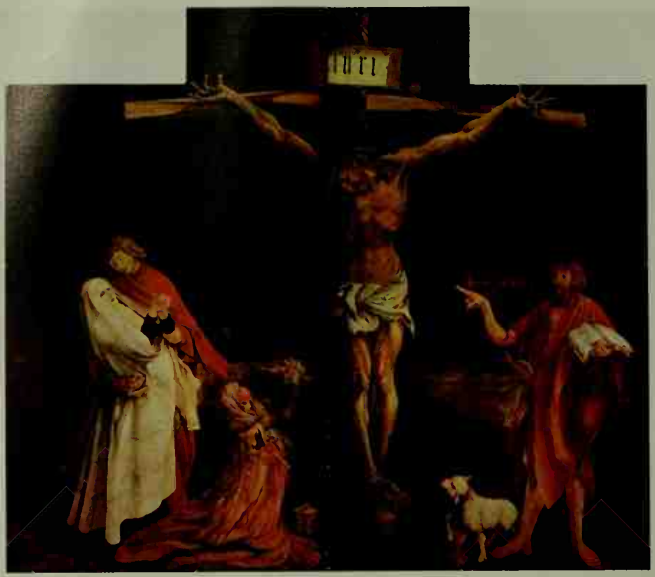

PHOTOGRAPH, ERIC SCHALL, "LIFE"

"Crucifixion" (centre panel of the Isenheim altarpiece) by Mathias Grünewald (active between 1500 and 1530), German. In the Unterlinden museum, Colmar, Fr.

GRÜNEWALD AND BRUEGEL

"Adoration of the Kings in the Snow" by Pieter Bruegel (1525?–1569), Flemish. In the Reinhart collection, Winterthur, Switz.

PHOTOGRAPH, CONZETT & HUBER FROM BLACK STAR

TWO VENETIAN MASTERS

BY COURTESY OF THE ISABELLA STEWART GARDNER MUSEUM

"Rape of Europa" by Titian (Tiziano Vecelli; c. 1490–1576), Venetian. In the Isabella Stewart Gardner museum, Boston

© BY COURTESY OF THE NATIONAL GALLERY OF ART

"Christ at the Sea of Galilee" by Tintoretto (Jacopo Robusti, 1518–94), Venetian. In the Samuel H. Kress collection, National Gallery of Art, Washington, D.C.

PAINTING

Above: "Frans Snyders" by Anthony van Dyck (1599–1641), Flemish. In the Frick Collection, New York city. *Above right:* "Young Woman With a Water Jug" by Jan Vermeer van Delft (1632–75), Dutch. In the Metropolitan Museum of Art, New York city

"Portrait of Helena Fourment" by Peter Paul Rubens (1577–1640), Flemish. In the State gallery, Vienna

"Bohémienne" by Frans Hals (?1580–1666), Dutch. In the Louvre, Paris

FLEMISH AND DUTCH PAINTINGS OF THE 16TH AND 17TH CENTURIES

"A Jewish Rabbi" by Rembrandt (Rembrandt Harmens van Rijn; 1606–69), Dutch. In the National gallery, London

"Courtyard in Delft" by Pieter de Hooch (1629–after 1683), Dutch. In the Mauritshuis, The Hague

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"Las Meniñas" ("The Maids of Honour") by Diego de Silva y Velázquez (1599–1660), Spanish. In the Museo del Prado, Madrid

"Shooting of the Rebels" (detail) by Francisco Goya y Lucientes (1746–1828), Spanish. In the Museo del Prado, Madrid

"St. John on The Isle of Patmos" by Nicolas Poussin (1594–1665), French. In the Art Institute of Chicago

"Blowing Bubbles" ("Les Bouteilles de Savon") by Jean Baptiste Simeon Chardin (1699–1779), French. In the Metropolitan Museum of Art, New York city

SPANISH AND FRENCH PAINTING, 17TH–18TH CENTURIES

"Les Baigneuses" ("The Bathers") by Jean Honoré Fragonard (1732–1806), French. In the Louvre, Paris

Sign for Gersaint's shop by Antoine Watteau (1684–1721), French. In the Kaiser Friedrich Museum, Berlin

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PAINTING

RUBENS AND REMBRANDT

"Rape of the Daughters of Leucippus" by Peter Paul Rubens (1577–1640), Flemish. In the Bayerische Staatsgemäldesammlungen (Bavarian state art gallery), Munich, Ger.

BY COURTESY OF BAYERISCHE STAATSGEMÄLDESAMMLUNGEN

BY COURTESY OF THE NATIONAL GALLERY OF ART

"A Girl with a Broom" by Rembrandt van Rijn (1606–69), Dutch. In the Mellon collection, National Gallery of Art, Washington, D.C.

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

"VIEW OF TOLEDO," BY EL GRECO

El Greco (Domenikos Theotokopoulos, 1541–1614) was born in Crete but lived and painted in Spain. In the Metropolitan Museum of Art, New York city

PAINTING

"Shortly After the Marriage" (from "Marriage *à la mode*") by William Hogarth (1697–1764), English. In the National gallery, London

"Mrs. Siddons as the Tragic Muse" by Sir Joshua Reynolds (1723–92), English. In the Henry E. Huntington library and art gallery, San Marino, Calif.

"Watson and the Shark" by John Singleton Copley (1738–1815), U.S.-English. In the Museum of Fine Arts, Boston

18TH-CENTURY PAINTINGS BY ENGLISH AND U.S. ARTISTS

"Sarah Siddons" by Thomas Gainsborough (1727–88), English. In the National gallery, London

"Isaac Newton" by William Blake (1757–1827), English. In the Tate gallery, London

"Salisbury Cathedral" by John Constable (1776–1837), English. In the National gallery, London

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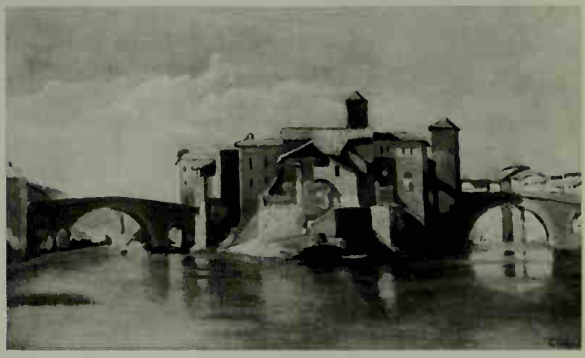
Top: "Portrait of Madame Sériziat" by Jacques Louis David (1748–1825). In the Louvre, Paris
Above: "Madame Rivière" by Jean Auguste Ingres (1780–1867). In the Louvre, Paris

"Radeau de la Méduse" ("The Raft of the Medusa") by Jean Louis Géricault (1791–1824). In the Louvre, Paris

FRENCH PAINTING OF THE 19TH CENTURY

"Island of San Bartolomeo, Rome" by J. B. C. Corot (1796–1875). In the Louvre, Paris



"The Third-Class Carriage" by Honoré Daumier (1808–79). In the Metropolitan Museum of Art, New York city

"Ladies on the Banks of the Seine" by Gustave Courbet (1819–77). In the Petit Palais, Paris

BY COURTESY OF (TOP RIGHT, CENTRE LEFT, BOTTOM RIGHT) THE MANSELL COLLECTION, LONDON, (CENTRE RIGHT) MUSEUM OF FINE ARTS, BOSTON, (BOTTOM LEFT) THE METROPOLITAN MUSEUM OF ART, NEW YORK CITY; PHOTOGRAPHS, (TOP LEFT) COLLECTION ARCHIVES PHOTOGRAPHIQUES, (TOP RIGHT, CENTRE LEFT, BOTTOM RIGHT) GIRAUDON

PAINTING

DELACROIX AND TURNER

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

Left: "Arab Rider Attacked by a Lion" by Eugène Delacroix (1798–1863), French. In the Art Institute of Chicago
Below: "Rockets and Blue Lights" by Joseph Mallord William Turner (1775–1851), English. In the Sterling and Francine Clark Art institute, Williamstown, Mass.

BY COURTESY OF STERLING AND FRANCINE CLARK ART INSTITUTE

"DANSEUSE SUR LA SCÈNE," BY DEGAS

An example of the work of Edgar Degas (1834–1917), a French painter of the Impressionist school, best known for his many paintings and drawings of ballet dancers. In the Louvre

PAINTING

Above: "Bar at the Folies-Bergère" by Edouard Manet (1832–83), French. In the Courtauld Institute of Art, London

Below: "Une Baignade" by Georges Seurat (1859–91), French. In the Tate gallery, London

"At the Moulin Rouge" by Henri de Toulouse Lautrec (1864–1901), French. In the Art Institute of Chicago

"The White Girl" by James A. McNeill Whistler (1834–1903), American-English School. In the National Gallery of Art, Washington, D.C.

19TH-CENTURY FRENCH AND ENGLISH PAINTING

"On the Terrace" by Pierre Auguste Renoir (1841–1919), French. In the Art Institute of Chicago

BY COURTESY OF (TOP LEFT) COURTAULD INSTITUTE OF ART © "COUNTRY LIFE," (TOP RIGHT) NATIONAL GALLERY OF ART, WASHINGTON, (CENTRE LEFT) COURTAULD INSTITUTE OF ART © HOME HOUSE, (BOTTOM LEFT, BOTTOM RIGHT) THE ART INSTITUTE OF CHICAGO

of the great spirits of the full Renaissance. Paolo Uccello made of perspective a kind of mathematical poetry. Others, perhaps under the influence of the great sculptor Lorenzo Ghiberti, laboured incessantly to perfect drawing by the conquest of the third dimension. Andrea del Verrocchio, Antonio Pollaiuolo and Botticelli, who began their careers as sculptors, carvers or goldsmiths, added to draftsmanship, already so penetrating, a kind of trenchant or metallic precision, a sort of precious hardness. The most poetical of them, Botticelli (1444–1510), had also other preoccupations besides that of technical perfection. He was the inventor of a delightful type of Virgin. Better than anyone else of his time perhaps, he translated into painting with a mysterious, and at times rather morbid, grace the reveries of the humanists. The "Birth of Venus" and the "Primavera" opened a new world to painting.

Outside Florence, among the schools which had not had such long and such consistent histories, the fertile finish of the 15th century saw the rise of certain men whose peculiar energy or original grace helped to prepare the complete expansion of Italian art in the first years of the 16th century. In Arezzo, Piero della Francesca (*c.* 1418–92), an independent painter in advance of his time, took up after an interval of 30 or 40 years the researches of Masaccio and invented engaging harmonies in blue and white of which Italian art offers no other example. His frescoes in Arezzo, depicting the "History of the Cross" (1452–66), are perhaps his most famous works. He does not give a picturesque description, but uses his figures and objects for a careful construction of a tectonic composition. His figures, carefully spaced and reduced to almost geometric forms, are composed in much the manner a Renaissance architect would place structural forms. Without ever introducing classical detail Piero comes closer to the true meaning of Greek art than any of his contemporaries who made abundant use of mythological subject matter and classical ornamental detail. Piero felt that harmony and proportion were characteristics of the divine order toward which the artist must strive.

The powerful anatomist Luca Signorelli (*c.* 1445–1523) was a precursor of Michelangelo. Antonella da Messina (*c.* 1430–1479) brought to Italy the brutal but expressive realism he had gained from contact with the Flemings.

Andrea Mantegna (1431–1506), humanist, geometrist, archaeologist, of great intellectual and imaginative intelligence, dominated the whole of northern Italy by virtue of his impervious personality. He had known the Florentine painters and the great sculptor Donatello in Padua. He was the link between Florence and Venice, whose school sprang from him through his more or less direct disciples, the Bellinis and Vittore Carpaccio.

5. France and Flanders.—During the 14th and 15th centuries painting developed through its own strength in the northern countries (France, Flanders and Germany), which came in contact with Italian art in a series of actions and reactions leading to reciprocal exchanges. Largely because of geographical position, France was specially predisposed to serve as a ground of understanding and conciliation between northern and southern influences. With the reservation already made that Gothic architecture did not there encourage the development of mural painting or of fresco, which remained the special province of Italy, France in the 14th century and at the beginning of the 15th century was a centre of artistic inspiration radiating in many directions and receptive of outside influences. Unfortunately, few works, with the exception of the miniatures, have been preserved. The portrait of the king Jean le Bon, in the condition in which it has been preserved, is merely an archaeological curiosity, but its date (*c.* 1350) is significant. It is a little later than the time when Simone Martini, almost in the same spirit and the same style, painted the *condottiere* Guidoriccio.

Later (toward 1415) the *Très Riches Heures* of the duc de Berry, decorated by the three Limbourg brothers, contained little masterpieces, in which the themes of everyday life and of landscapes were treated with as much truth as poetry and, combining the most careful observation of the details of nature with refined fantasy, were executed with meticulous care. Commissioned at the Burgundian court, it is related to the art of Paris, Flanders and Siena.

During this period the disasters and miseries of the Hundred Years' War hampered the development in France of an art which had begun so well. Paris, occupied by the English troops, lost its predominance. The painters worked at Bourges, Dijon and Avignon. At Avignon they came in contact with the Italians, particularly with the Sienese summoned there by the popes.

Only a few important French works have been preserved, the "Annunciation" of Aix-en-Provence (*c.* 1440) and the "Pietà" of Villeneuve-lès-Avignon (after 1450) among those by anonymous artists. They are paintings of extraordinary gentleness of emotion achieved primarily by a highly sensitive line and a subdued glow of colour. Among those by known painters, the "Coronation of the Virgin" by Enguerrand Quarton, painted in 1453–54, and the paintings and miniatures by Jean Fouquet (*c.* 1415–85) stand out. These justify saying that in the midst of its many trials France in the 15th century from time to time still produced original spirits unlike those of other schools and at considerable variance with each other.

Jan van Eyck (?1385–1441) was connected with the duke of Burgundy but he worked mostly in Flanders. He brought Flemish painting from the outset to an extraordinary degree of perfection, as much by his early use of oil paintings as by his aptitude for the representation of people and all manner of things—distant horizons, the bricks and stones of buildings, rich brocades—with an accuracy and precision hitherto unknown. The altarpiece of the "Worship of the Lamb" (the Ghent altarpiece), with its 12 exterior compartments and its 12 interior panels, was carried out between 1427 and 1432. From that moment Flanders dominated all art north of the Alps for almost a century, and was not without an influence on Italy.

There was nothing in the world then to compare with that interior with two standing figures known as the "Portrait of Arnolfini and His Wife" (1434; National gallery, London). This painting is remarkable not only for its careful observation of the visible world, including the painter's skill in representing textures, but also for its design of relating the deeply human figures to the surrounding interior space. Where will anything be found in the history of art superior to the precision and life to which Van Eyck attained from the first? But Van Eyck is more than the genial precursor of the Dutch masters of realism: he is the calm theologian who composes with the logic and authority of a doctor the multiple symbols of the altarpiece of the "Lamb" and who diffuses an equal and white limpidity over the images which unite the mysteries of heaven to the realities of earth.

Rogier van der Weyden (*c.* 1400–64), whose masterpiece, "The Deposition From the Cross," preserved in the Prado, dates from a few years after the completion of the Ghent altarpiece, is the only Fleming who truly carried on Van Eyck's great conception of art, and he added to it a pathos of which there is no other example in his country save, though with less nobility perhaps, that of Hugo van der Goes toward the end of the century. The other Flemish artists of the 15th century shone neither through their invention nor their emotion. They quickly reached either hardness or mannerism. Hans Memling at any rate charms by his graceful sentimentality. But they are all marvelous craftsmen, and even those least spiritually gifted force admiration of their virtuosity, the brilliance and refinement of their colour, all the characteristics which are not found among the French of the same period or, to the same degree, in Italy.

6. High Renaissance in Italy.—The Italian painters of the 15th century not only created significant works of art but, by their careful investigation of nature and by their conviction of the importance of man, solved many problems such as linear perspective and human anatomy. These artists were followed by other men of genius who achieved an ideal of human grandeur which is now conceived as the embodiment of the Renaissance. (*See* RENAISSANCE ART.)

7. Leonardo da Vinci.—Leonardo (1452–1519) was the first in date of the great men who had the desire to create in a picture a kind of mystic unity brought about by the fusion of matter and spirit. Building on the achievement of his predecessors and belonging to another generation and a changing social order, he was

able to pronounce the words which served as a password to all later artists worthy of the name: painting is a "spiritual thing," *cosa mentale*. Leonardo, a man of great curiosity about the nature of the physical world, was a scientist who made important contributions in physics, geology, anatomy and other fields. He was an engineer, a musician and an architect as well as a painter. He developed Florentine draftsmanship and chiaroscuro and was able to give a more three-dimensional aspect to his figures and to integrate them into space and atmosphere. He was concerned not only with physical properties but also with psychological insight for his figures and was able to give them an appearance in which actuality is fused with ideal grace. Among his most important paintings is "The Last Supper" (1494–98) in Sta. Maria delle Grazie in Milan, which in spite of having been in bad repair almost from the time of its completion achieved renown as the typical representation of the scene because of its apparent simplicity of composition and deep human understanding. Leonardo's contributions to painting consist not only of his work as an artist but also of his significant writings, especially his *Treatise on Painting* and his *Notebooks*. In the "Mona Lisa," the "St. Anne," the "Virgin of the Rocks" and his other masterpieces he even used landscape not merely as a more or less picturesque decoration but as a sort of echo of that interior life and an element of a perfect harmony.

Relying on the still novel laws of both linear and aerial perspective, this scientist and artist substituted for the discursive manner of most of his precursors the principle of concentration which is the basis of classical art. The picture is no longer presented as an almost fortuitous aggregate of details and episodes. It is an organism in which all the elements, lines and colours, shadows and lights, compose a subtle tracery converging on a spiritual, a sensuous centre. On a small panel, that of the "Mona Lisa," Leonardo seems to depict an epitome of the universe, creation and created: woman, the eternal enigma, the eternal ideal of man and the sign of the perfect beauty to which he aspires, nature here evoked by a magician in all its mystery and power. Behind the lovely, calm face, behind the forehead, young and yet thoughtful, appear mountains, glaciers, waters and rocks; and, in this very small portion of the painted surface, a vast revelation, beside the eternal feminine, of the earth.

8. Michelangelo.—Of this same Florentine draftsmanship enriched by Leonardo, Michelangelo (1475–1564), like Leonardo a man of great versatility, sculptor, architect, painter and poet, made the apotheosis of muscular movement and effort, which were to him the plastic equivalent of passion. He molded his draftsmanship, bent it, twisted it, constrained it to the extreme limits of possibility and to the pulsation of his great tormented soul. There are not, so to speak, any landscapes in Michelangelo's painting. All the emotions, all the passions, all the thoughts of humanity were personified in his eyes in the nude bodies of men and women. He never conceived these bodies—or rarely—in attitudes of immobility or repose. His great sculptured figures, his "Night," his "Slaves," his "Moses," whether they dream, meditate or command, give an impression of barely restrained tumult. In his great frescoes in the Sistine chapel of the Vatican he transformed sculptured form into awe-inspiring painting. A superhuman humanity seems to thunder down from the Sistine ceiling. There he re-created the mystery of Genesis with extraordinary power and vision. Later he painted a vast "Last Judgment" of extreme intensity on the wall of the Sistine chapel. Michelangelo's influence on later painters—from his own time until today—was perhaps greater than that of any other painter.

9. Raphael.—Raphael (1483–1520) is the modern artist who most closely resembles Phidias. The Greeks themselves said that Phidias invented nothing but that he carried every kind of art invented by his forerunners to such a pitch of perfection that he achieved pure and perfect harmony. Those words "pure and perfect harmony" express, in fact, better than any others that which Raphael brought to Italian art. From Perugino he gathered the rather weak graces and the gentle limpidities of the Umbrian school that died out with him, he acquired strength and certainty in Florence, and created a style based on the fusion of Leonardo's and Michelangelo's lessons under the light of his own noble spirit.

Raphael's compositions on the traditional theme of the Virgin and Child seemed intensely novel to contemporaries, and only their time-honoured glory prevents one now from perceiving their originality. No one before him had treated this holy subject with the poetry of a familiar idyll, with such an air of eternal youth, a limpid gentleness which excludes neither amplitude nor majesty of conception. He has in modern eyes a more magnificent claim to honour in the composition and realization of those frescoes with which, from 1509, he adorned the *stanze* and the loggias of the Vatican. The sublime, to which Michelangelo attained by his ardour and passion, Raphael attained by the sovereign balance of intelligence and sensibility. His two masterpieces, the "Disputa" or "The Holy Sacrament" and the "School of Athens," are self-sufficing worlds created by genius; they are admired for his perfect visualization of great ideas, his suppleness of gesture, ease of composition, the life which circulates everywhere with the light; but, above all, he has placed his figures into exalting spaces, giving an unequaled experience of spatial magnitude.

Rome became for almost two centuries the artistic capital, not only of Italy, but of the entire world.

10. Renaissance in the Northern Countries.—In France, the Italian influence, which had not withered the freshness of Jean Fouquet's inspiration, became toward the middle of the 16th century so all-pervading that true French painting was in danger of losing its originality and even its vitality. The Fontainebleau school was a school of decorators comprising Italians summoned north by the kings of France, Italianized Flemings and some Frenchmen who were no less enslaved by Italian fashions. The national taste, however, showed itself in the fine psychology of the little portraits depicting in all their delicate elegance the men and women of the Valois court.

In Germany the fact that the greatest artist born beyond the Rhine absorbed Italianism did no more than stimulate his own imagination and perhaps widen its scope. Albrecht Dürer (1471–1528) had a genius too powerful to be conquered. His paintings as well as his woodcuts and engravings remained profoundly original in their intense vitality. In spite of all his tense energy, however, Dürer dominated the conflict of the passions by a sovereign and speculative intelligence almost comparable with that of Leonardo. He too was on the borders of two worlds, that of the Gothic age and that of the modern age, and was perhaps even greater as an engraver and draftsman than as a painter.

His contemporary, Mathias Grünewald (1475/80?–1528), painted religious themes of visionary expressiveness and mystical significance, using intense colours and agitated line.

Hans Holbein (1497?–1543) was a cosmopolitan; born in Augsburg, he lived successively in Basle and England. The acute realism of a trenchant and precise draftsmanship combined with a certain Italian elegance to make him an admirable portraitist.

In the Low Countries Italian influence spread almost as widely as in France. But not being, as in France, evoked, sustained and controlled by a monarchical power, it left great individual freedom to the artists. Quentin Massys (1466–1530) was one of the first to look to Italy. The founder of the Antwerp school carried through his conversion to humanism with grace and naturalness.

Still farther north Hieronymus Bosch (*c.* 1450–1516) revealed hardly any Italian influence. His religious scenes and his allegories are treated with a fantastic vision based on his own pessimistic conviction. In his paintings, executed with most detailed realism, the borderline between the phantom and the real is almost eliminated, making his work appear related to 20th-century Surrealism. He does not seem to fit into the general tradition of Flemish painting, but appears to have exerted a profound influence especially on Pieter Brueghel the Elder (*c.* 1525–69), who, however, has a much more optimistic attitude toward life and the world. Brueghel painted vigorous scenes of peasant life and some of the finest landscapes in the history of western art.

Surely there was at this period a current of bizarre imagination circulating from south to north whose principal exponents were Grünewald, Bosch and Brueghel. The differences between them are great, but one characteristic was common to them all—the exaggeration and the oddness of the deliberate discord between the

apparent subject and the pictorial methods.

In its most rigorous form the Italianist movement produced its own form of Mannerism, a hybrid art which amalgamated, more or less, a remnant of Flemish realism with the scenes, costumes, themes and even the rhetoric borrowed from Italy. Much talent was expended in the assimilation of a magnificent ideal, but one quite contrary to the traditions in which these northern artists were still brought up. The results were not often happy. Sometimes, however, they did not lack a certain composite charm when the true nature of the artist pierced his disguise. It must be remembered that this rather ungrateful school of Mannerists prepared the way for the greatest genius of Flanders after the Van Eycks, Peter Paul Rubens. He, however, was a pupil not of Florence but of Venice.

11. Venice.—Great changes had taken place in Italian art by the early part of the 16th century. After the death of Leonardo and of Raphael, Michelangelo pursued his career, while Andrea del Sarto (1486–1531), with his scholarly modeling and his almost feminine gentleness, was the last exponent of the purely Florentine spirit. It was no longer in Florence or in Rome that the true heirs of the creators of classical art were to be found, but in Venice, where a school, the last born of the great Italian schools, prolonged with magnificent brilliance the glory of Italy after the disappearance or decadence of the older schools.

The first Venetian masters, the Bellinis and Carpaccio, were closely related to the robust and hard Andrea Mantegna. But they soon turned toward what may be esteemed the original conquests of their school, colour, light and a new conception of the place of the figure in landscape. Of monumental decoration, which has always been one of the principal vocations of Italian art, they evolved a truly new art by the addition of an indefinable quality, sumptuous and triumphant, which had not hitherto been seen in painting. They decorated churches and palaces, the same splendours and a kind of pagan pomp serving for both.

For some time past a profane or human air had been wafted into art; even at a time when painters treated only religious subjects, it was gradually felt, not perhaps in the frescoes decorating the sanctuary, but in the pictures ordered by kings and princes and chosen from such Bible stories as would with the greatest plausibility allow nude figures, or a certain amorous or voluptuous character, or a great display of processions and costumes: Salome, Susanna, Judith, Bathsheba. Indeed when the Olympian divinities appeared in art they found the way prepared for them.

Since its modest and devout beginnings in the shadow of the church, painting had gradually tried to rid itself of the didactic part allotted to it. On the day when the divorce was complete and irrevocable a new era began in art, an era which still exists, developing all that was germinating in the masterpieces of Giorgione, Titian, Tintoretto and Paolo Veronese—for the Venetians played a preponderating part in this revolution. But this is not to say that either the painters or their paintings were detached from religious feeling. The artists always accepted with pride and joy their task as servants and auxiliaries of the church. But they no longer felt themselves charged with the duties of preaching and instructing. There remained to them the whole vast and multiform domain of sentiment. The delicious and tender Madonnas of Giovanni Bellini and Titian—sometimes familiar, as the "Virgin With the Rabbit," sometimes majestic, as the "Assumption of the Virgin," but always with their eyes glancing affectionately on the faithful spectators—have inspired and accompanied many prayers. As for Tintoretto, in the midst of the brilliant colour harmonies of Venetian painting his feverish and agitated spirit led him to rediscover the pathos of religious drama. Veronese's main preoccupation seems to be the grouping of beautiful young women and noble senators dressed in silk, brocades and gold chains under white arcades. Indeed he once had difficulties with the Inquisition, which inquired whether so many personages of so worldly an aspect were in place at the side of Christ; he replied that he had put them there simply because it looked well.

Because of the original feeling which each of the masters of this privileged school had for colour, and because of their marvelous facility in finding new arrangements, the Venetians were incomparable decorators. Their pictures in the churches, like the detail which for a moment had disturbed the ecclesiastical magistrates, "looked well." It was already a pious action to contribute to the beauty of the house of God. In fine, the least that can be said of these pictures is that they touched the hearts of the faithful.

One is reminded here of the part belonging to music in the celebration of the services of the church. Venetian painting possessed, more than any other painting which had preceded it, a musical quality. In this again it can claim the initiative of a transformation in art which has grown greater and greater up to modern times.

Giorgione's and Titian's beautiful reclining women, whether called Venus or any other name, are among the most original of the creations of the Venetian school. They differ greatly from the Florentine nude, which is generally standing. Venice developed the most complete and perfect subject of profane inspiration, a subject which has thrived in painting through centuries without becoming exhausted. One may describe it as the glorification of female beauty in the beauty of nature. From the first a painter of genius who died at about the age of 32, Giorgione (*c.* 1478–1510) gave the theme its most poetical and, at the same time, its most human realization in certain canvases attributed to him whose subjects are only the more moving because of their enigmatical quality: for instance, the paintings known as the "Tempest" in the Venice academy and "Concert Champêtre" at the Louvre. This development seems to have been in harmony with the aspirations of his compatriots and contemporaries, for four years after Giorgione's death and before Titian developed the theme and added to it the particular bias of his imagination the old Giovanni Bellini, then nearly 85, painted the noble and delicious "Feast of the Gods" (1514), which contained in embryo not only the "Bacchanal" of Titian but that of Nicolas Poussin. Titian, in the "Three Ages" (National gallery, Edinburgh) and the "Sacred and Profane Love," soon affirmed the various possibilities opened by the new theme to the creative faculties. The painter showed that he could dispense with the semblance of mythological fable which remained in Bellini's picture and which Giorgione had already eliminated: beautiful nude figures and others in rich modern costumes are juxtaposed, without any apparent reason, before a vast landscape in which there is a mysterious prolongation of the thought or the dream of the painter, as also of the thought or the dream of these modern deities. From Venice then came the poetry of the nude, of landscape and of the composition of figures in a landscape, as well as a warm tonality in the handling of colour.

This art, emancipated from strict obedience to the church, no longer expressed anything but the nostalgic dream of happiness which exists in the hearts of all men, and which even the worst mortifications and the darkest and bitterest days do not stifle.

The Venetians, particularly Titian, who stands above all the others, and Tintoretto, who sometimes rises almost to the heights of his master, were great portraitists. That melancholy which one perceives floating, as it were, on faces young and lovely imparts to those masterpieces of good painting a spiritual radiation. Between the magnificent nobles and the splendid creatures whom they delighted to deck in silk, velvet, gold and pearls this light shadow from the depth of the heart appears rather on the masculine faces than on those from which the locks of fair hair fall onto bare shoulders. It is this which forms, for example, the haunting attraction of the "Man With a Glove."

12. Italian Mannerism.—Between the Venetians and Rubens, who was their most legitimate and direct heir, were interposed certain eclectic schools in Italy, which could not perhaps boast of geniuses of the highest order but in which the talents were numerous and the activities considerable.

While the Venetian Sebastiano del Piombo became almost Florentine under the influence of Michelangelo, a true master arose near Venice. Is it possible to speak of a school of Parma? It includes only two great names, those of Correggio and Parmigianino. Correggio's art is like a lovely flowering branch detached from the Venetian tree. But Correggio (*c.* 1494–1534) was an original man who imitated no one. He was a brilliant decorator who was undaunted by the greatest tasks. He was a colourist and a harmo-

nist. He achieved grace even in vast compositions as the cupola in Parma, and he painted some of the loveliest of Italian easel pictures—"Antiope," the "Marriage of St. Catherine" and the "Education of Cupid." By his natural affinities he recalls at once Titian, Leonardo and Raphael.

Parmigianino (1503–40), one of the leading Mannerist painters, achieved an extraordinary grace and elegance in his work. His distorted figures occupy a compressed space and are a part of an aristocratic ideal of slender and refined proportions—a new and ennobled and spiritualized beauty in place of the more indifferent norm of the High Renaissance.

Correggio's purely instinctive example suggested to the Carracci the reasoned doctrine which the founders of the Bolognese school applied. There had been painters in Bologna before them, even in the middle ages, and in the time of Raphael, Francia had a great reputation. But the true Bolognese school, which set out to create a style common to all Italy, formed of the finest elements derived from the greatest masters, was the outcome of the initiative of Lodovico (1555–1619), Agostino (1557–1602) and Annibale Carracci (1560–1609). They founded their celebrated academy in 1582 in Bologna. If they were in part responsible for what was later known as academism, that is, an art made of formulas learned by rote, their personal work was by no means negligible. They had ambition and the strength to respond to it. They were great decorators as the Farnese gallery bears witness; and their pupils, Guido Reni, Guercino and Domenichino, deserve almost equal esteem. The "Aurora" of Guido Reni in the Palazzo Rospigliosi is a large decorative work which in his own time was regarded as a worthy return to the ideals of Raphael. Guercino composed large altarpieces with a feeling at once dramatic and picturesque. And Domenichino, less of an improvisor and more unequal than his colleagues, sometimes, as in his charming picture in the Casino Borghese, the "Diana and Her Nymphs," recaptured beyond academism the accent and the freshness of the great painters of the Renaissance. (*See* also MANNERISM.)

13. Spanish Mannerism: El Greco.—The same years of the 17th century which saw so great an expansion of Flemish and Dutch painting brought into the scheme of universal art a school which until then had remained aloof. Scholars began to study the origins of painting in Spain only comparatively recently and much is still obscure.

It seems that Catalonia was the principal seat of art in the 13th, 14th and 15th centuries. Artists first worked there under the almost solitary influence of the French miniaturists; later this influence was shared by the Sienese painters arriving in Spain by way of Avignon, while Flemish art also became popular. The Late Gothic style of painting in Spain, with its lavish use of gold, its emotional quality and its carefully painted detail, is a local manifestation of an international style which spread over Europe from the Atlantic coast to the Moldau in the 15th century.

The 16th century, in Spain as in Flanders, was an epoch of Mannerism. A cold and scholarly combination was created by the artists, who were theorists more than painters, between the Flemish realism and the classical models of the Italian Renaissance. It is curious that the man who in the 16th century seemed to be the most authentic representative of Spain was Anthony More (Antonio Moro) (*c.* 1512–75). Born in the Netherlands, and highly favoured by the courts of Brussels, London and Madrid, he painted portraits of admirable truth and dignity. It was yet another foreigner who soon afterward offered to Spain an art in which it could recognize its mystic and chivalrous spirit.

Domenikos Theotokopoulos, called El Greco (1541–1614), was born in Crete, then under Venetian domination, and studied in Venice, probably in Titian's studio; his first works bore the marks of their Venetian origin, mingled with the influences of Michelangelo and the Florentines and Mannerists. He went to Spain about 1575 and soon settled at Toledo. There was no doubt a mysterious affinity between this Italian-trained Greek, whose imagination seemed to have preserved the hieratic figures of the Byzantine mosaics and icons, and the strange town, the heart of religious and military Spain, where everything spoke of ardour, secrecy, spirituality and a sort of passionate austerity. El Greco, "the pupil of Titian," preferred the dramatic and tormented inspiration of Tintoretto to the nobly balanced conceptions of his master. Though unequaled he was always sincere to himself. This man, who seems more mystic than most medieval painters, links up with the most modern ideas of the pure essentials of art and the specific attitude of the artist, relying on the unverifiable truth of his emotion. He becomes a prototype of Expressionism. What sensation was to painters from the last third of the 19th century, an impulse of the soul was to El Greco, and in spite of the spiritual abyss between the two principles the plastic effects are sometimes similar. No one perhaps has seemed more indifferent, more disdainful even, to material truth. His disproportionately long and twisted figures flout the most elementary rules of anatomy, and in spite of his ability as a portraitist his construction of faces is incorrect by physical standards. He twists lines and colours at his despotic fancy, and, with a cool colour scheme of predominating blacks and whites, all tend to an extraordinary intensity of expression. These lines in truth have the trembling elevation of prayer and ecstasy, sustained by a harmony resembling a night sky broken by violet-tinted clouds, silvery pallors, pale yellows and green lights. This man, who seems to care for nothing but what comes from his arbitrary fancy, was, by a miraculous paradox, a portrait painter when he wished to be.

El Greco's "Coronations of the Virgin," his "Assumptions," his "Resurrections" show that he is the only painter who has really spread celestial visions before mortal eyes; he painted them as he saw them. And in the great canvas which is perhaps his most famous work, the "Burial of Count Orgaz," he achieved, as no one before him had done, an understanding and interrelation, which seem quite natural, between the supernatural and the material. One feels that this marvelous picture must have appeared complete to the imagination of the artist with its composition so bold and, one may even say, so true. Working during the climax of the Counter-Reformation, El Greco's personal mysticism leaves no place for doubt to heretics and skeptics. His figures are caught in a great emotional frenzy. Their elongation removes them from the material world. Religious drama is pictorialized by means of human figures, who themselves have become transfigured into vibrations of light and often appear as the tongues of a cool flame. An almost uncompromising realism and a spontaneous mysticism are thenceforth the two poles of Spanish art. Even in periods in which the desire for realism seems predominant, a sort of mystic vibration is never wholly absent.

II. BAROQUE THROUGH IMPRESSIONIST PAINTING (17th–19th CENTURIES)

The true original and revolutionary talent of the time grew up outside the schools. Michelangelo da Caravaggio (1573–1610) painted still-life subjects for the pleasure of painting independently of subject, and he carried his robust naturalism, his violent contrasts of bright light and opaque shadow, his taste for unusual and striking scenery and a kind of picaresque style, not without tenderness, into his great religious subjects. Caravaggio was one of the innovators of Baroque painting as well as a mainspring of Realism in painting. His influence was immense, first through those who were more or less directly his disciples, such as Bartolommeo Manfredi and Domenico Fetti, both excellent painters, the latter showing in several pictures a sincere observation of rustic life; but it extended farther. The Genoese and Neapolitan schools derived from him, and the great movement of Spanish painting in the 17th century was connected with these schools. In the following generations the best-endowed painters oscillated between the lessons of Caravaggio and the Carracci. The romantic Salvator Rosa and the fertile improvisor Luca Giordano covered the vaults of churches and the ceilings of palaces with brilliant compositions which heralded the work of Tiepolo. (*See* also BAROQUE ART.)

During the last period of its splendour Venice showed the same independence as in its golden age. Academism did not chill its liveliness nor the influence of Caravaggio dull its palette. In the mid-18th century, in the midst of a decadence from which Venice alone in Italy escaped, it gave rise to important genre painters like Pietro Longhi (1702–85), while Canaletto (1697–1768) im-

mortalized the Venetian cityscape. Francesco Guardi (1712–93), a virtuoso of the brush, displayed in his views of Venice a freedom and an accent which were quite modern and seemed to be already of the 19th century. Indeed, his treatment of shimmering colour anticipated Impressionism. Giovanni Battista Tiepolo (1696–1770) was a decorator of the great lineage of Veronese, with a coloration which was less powerful but more delicate, luminous and truly aerial; and he had a flamboyant feeling and a festive liveliness when he portrayed in the Palazzo Labia the "Story of Antony and Cleopatra," his masterpiece.

A. Flanders

1. Rubens.—Peter Paul Rubens (1577–1640), a prolific genius, was a great humanist scholar and an important diplomat as well as a painter. Although he lived the life of an aristocrat, his art shows strong roots in the robust life of the Flemish people. At the same time, however, he was able to absorb the lesson of the Italian Renaissance; he studied Michelangelo and Raphael, the Venetians and Correggio, as well as his contemporaries Carracci and Caravaggio. All this fused in his own personal and dramatic style.

If the Baroque is thought of as powerful, exuberant, sensuous and even explosive, Rubens is its perfect example. He was able to infuse his own astounding vitality into his religious or mythological paintings, portraits and vivid landscapes. He was a painter of never-ending powers of invention, and he organized his complex compositions in wildly moving, dynamic designs. Limitations of form and outlines of shapes are disregarded in favour of a constant flow of movement. His full-blooded, voluptuous women may not be to the taste of a less vigorous age but are related to the full and opulent forms which were Rubens' own ideal of womanhood and life in general.

By no means all of the canvases attributed to Rubens were painted by him. He had established a huge workshop and may have employed as many as 200 assistants and apprentices. But the original inventive designs underlying his paintings are generally his own. Rubens' laborious life was well ordered; the creator of so many delightful pagan feasts went to Mass each morning before proceeding to his studio. He is the most illustrious type of well-balanced genius, who combined passion and science, ardour and reflection. Through his pupil Anthony van Dyck, Rubens exerted an important influence on English painting for several centuries. His successors in France were Antoine Watteau and François Boucher, Eugène Delacroix and Pierre Renoir.

2. Van Dyck.—Rarely seen in one school are a great master and a disciple resembling each other so closely as did Rubens and Van Dyck; or such a resemblance, leaving as it did all freedom of invention to the disciple or, indeed, a fine painter educated by a great genius. Anthony van Dyck (1599–1641) inherited Rubens' marvelous facility in both draftsmanship and colour, and his touch has sometimes a charm and elegance beyond his master's. But this facility was not, as in Rubens, the instrument of a great mind which embraced without effort the whole world of art. Like Rubens, Van Dyck tried to amalgamate the influences of Italy and Flanders and he succeeded in some paintings which have a touching grace, notably in his "Madonnas" and "Holy Families," his "Crucifixions" and "Depositions From the Cross," and also in some of his mythological compositions. But his main glory was as a painter of most elegant and aristocratic portraits. In this sphere he outdistanced his master and had no rivals save the great English portrait painters of the 18th century whose model he was. The great "Portrait of Charles I" in the Louvre and the "Prince of Orange" in the National Gallery of Art in Washington, D.C., are works unique of their kind.

3. Other Flemish Painters.—Around Rubens and Van Dyck a pleiad of excellent painters worked in Antwerp, which, since the first years of the 16th century, had taken the place of Bruges as the capital of Flemish art. Many assisted Rubens in the execution of his great decorative schemes such as the "Life of Marie de' Medici"—Frans Snyders and Paul de Vos, excellent animal painters; Jan Fyt, a still-life painter. Cornelis de Vos (1585–1651) is a remarkable portraitist, even more realistic than his master, Jan Brueghel (1568–1625), an outstanding painter of flowers and animals. Jacob Jordaens (1593–1678) had a powerful temperament. At his best he rose, in his genre compositions, almost to the level of Rubens, in his nudes.

David Teniers (1610–90) developed entirely from Rubens' "Kermesse" (village carnival) pictures, from which he took his dancing and drinking peasants and his fine landscapes. Their joviality is rather conventional and the somewhat superficial observation turns quickly to caricature. But all the material part of Teniers' painting—the surety of his touch, the transparency of his medium, his brilliant and subtle colour—calls for considerable praise. He shows the greatest faithfulness to nature in his landscapes; his delicate greens and his silvery light sometimes give a real distinction to his pictures when he restrains his too facile humour.

Adriaen Brouwer (*c.* 1606–38) is closer akin to the Dutch. He was perhaps the most important 17th-century Flemish genre painter. After an early influence of Pieter Brueghel the Elder, he felt the impact of Frans Hals and the Dutch painters, and his resultant work became more luminous, highly animated and fluid in its movement. In his many tavern interiors he shows the poverty and often the dissolute aspects of life. These small canvases are incisive records in which the artist never passed judgment.

B. The Netherlands: 17th Century

In the Netherlands at this time there was unfolding a magnificent and almost unexpected art. At a period when there was not yet any definite political division between the northern and southern parts of the Low Countries, there were few painters who could be regarded as specifically Dutch, for from the last third of the 15th century to the end of the 16th the Dutch could not be clearly distinguished from the Flemings. Geertgen tot Sint Jans (*c.* 1465–93), whose generally accepted works are rare, is the most remarkable talent in the 15th century. In the following generation Lucas van Leyden (*c.* 1494–1533) was a real innovator. His portraits are almost as incisive as those of the great Albrecht Dürer, his elder by 23 years. Indeed, without the Reformation, with its political and social as well as its religious consequences, the Dutch school would perhaps have continued to represent only a local variation of Flemish painting. But the Reformation won all the northern provinces of the Low Countries, which soon after called themselves the United Provinces; and Spain, after 40 years of fierce warfare, was obliged to recognize the independence of its former subjects.

The Reformation wanted churches devoid of images. The result was a great decline in religious painting. The current of naturalism which, since the Renaissance, had spread over the world, but which in Catholic countries conciliated itself with religious idealism and even placed itself voluntarily at the service of faith and dogma, reigned thenceforth in the Netherlands without obstacle or compromise. Painters no longer had to submit to the commands of a king, a court or a church. They had only to please the republican *bourgeoisie* who now enriched themselves and their country as merchants, bankers and ship brokers. Artists therefore painted pictures of dimensions and subjects suitable for the decoration of elegant but rather small houses. Portraits, landscapes, scenes of everyday life formed the themes of Dutch painting, thus foreshadowing the subjects of the 19th century.

An official and civic art existed only in the form of the collective portrait which displayed, around a banquet or council table, a group of town magistrates, professors, syndics of a corporation or officers of a company of volunteers. The Dutch painters immediately excelled in this untried genre. Hals was the first to interpret it; he was succeeded by Rembrandt, and Bartholomeus van der Helst (*c.* 1613–70) followed worthily in the footsteps of these two leaders. Individual portraiture claimed also skilled craftsmen, Michiel Janszoon van Mierevelt, Paulus Moreelse, Jan van Ravesteyn, Thomas de Keyser and Ferdinand Bol.

Within the limits of a purely prosaic conception the Dutch were inventors, and at once they showed a perfection of a naturalistic technique which has hardly been surpassed or even equaled. It is possible that the first idea of the "Card Players," "The Drinkers,"

the "Concerts," the "Merrymakers" which were multiplied to infinity during more than two centuries derived from Caravaggio. Indeed the connecting link between the Netherlands and Italy is visible in the person of Gerard van Honthorst (1590–1656), who lived a long time in Rome, where he was called Gherardo della Notte, and who took back to his country two or three themes borrowed from his master Caravaggio, and a taste for interior lighting effects, achieved either by the skillful use of chiaroscuro or by a point of artificial light. But the Dutch painters soon abandoned what remained of the decorative and fanciful intentions of the Mannerist Honthorst. They desired no other muse than truth. To give a faithful and recognizable image of all which could be seen in their own and their neighbours' houses, in the cultivation of the fields, by the side of and on the sea which was everywhere so close to them and which was perhaps the principal field of activity of this maritime people—such was the ideal of these painters; it was more exactly in harmony with their national spirit and temperament than any other example which might be cited. From thence came a tranquil certitude which is one of the distinguishing characteristics of Dutch art.

1. Dutch Masters.—Landscape had been brought to a high degree of poetry and truth from the time when the Limbourg brothers illustrated the *Très Riches Heures* of the duc de Berry—and later when the Venetians, in works of infinitely prolonged and magnificent resonances, made of it an ample melody uniting man to nature. At the same time when Poussin, assuming the Venetian ideal, added to it his note of noble and high intellectuality, it remained for the Dutch to create for the first time masterpieces which have no apparent ambition beyond the exact rendering of things hitherto deemed devoid of interest—but this superbly. In this connection may be mentioned the work of the two Ruysdaels, Jan van Goyen, the Van de Veldes, Meindert Hobbema, Jan Wynants, Paul Potter, Albert Cuyp, Jan van der Heyden and others.

Their innovations were hardly less great in genre pictures as they conceived them, though the origins of this style can be traced to the greatest of early Flemish painters, Van Eyck, when he painted "Arnolfini and His Wife" in the midst of the familiar setting of their daily life. The Dutch painters of rich or poor interiors, of taverns, artists' studios, fashionable parties in marble-paved halls hung with gilded velvet, gallant conversations over a table bearing wine and a long-stemmed glass, seem once again wholly preoccupied with a care for exactitude. But they compel admiration and even sympathy by the refinement of their colour, the exactness of the lighting, a touch of incredible sureness, at once precise and soft, and also because one may feel in the best of them a secret and intimate pleasure in the subjects they have chosen, of which their extraordinary virtuosity is only an instrument. Adriaen van Ostade, Gerard Terborch, Jan Steen and Gabriel Metsu, Pieter de Hooch and Jan Vermeer of Delft are painters who combine a positive insight into the life of the people with a perfection of rendering and often excellent pictorial qualities. Frequently the scenes are calm and quiet as in the work of De Hooch, Terborch and Vermeer, or they may be filled with unrestrained movement as in the tavern scenes of Adriaen van Ostade (1610–85) and Jan Steen (1626–79). Steen is uneven, but when he is well inspired he lavishes on the scenes of debauchery which he loved to depict the charms of a lively coloration and a sensitive touch. In contrast, Pieter de Hooch (1629–after 1683) has a more structural quality. His simple genre scenes relate interiors to outdoor space by means of glowing sunlight.

2. Vermeer.—While recognized today as one of the giants in the history of art, Jan Vermeer (1632–75) died a pauper and was completely forgotten until the late 19th century when the time was ripe for an appreciation of his work. He painted middle-class Dutch women reading letters, pouring milk, playing the virginal or selecting jewelry in simple rooms, lucid and quiet in their space. Here everything is clearly structured by means of geometric planes, generally rectangles, and unified by a clear and cool light which floods to every corner of his rooms. His subtle colour has also become a structural element. His translucent surfaces are achieved with faultless certainty and assurance, yet without any apparent virtuosity. Here within the period of the Dutch Baroque was a painter who achieved an almost classic serenity and order.

3. Hals.—Frans Hals (?1580–1666), on the other hand, painted genre scenes of great exuberance and free imagination. He is especially famous for his group compositions, as the "Arquebusiers of St. George" or "St. Andrew" which amply made his reputation. These officers in their fine uniforms, escorting the flag of their company, wished to bequeath to posterity a flattering likeness of themselves. Hals, with his vast facility, his unctuous and flexible medium, his gift of broadly touching in a human being in his own likeness, at least outwardly, found the means of introducing movement everywhere into his faces, into the hands about to grasp an object and also into the sumptuous ampleness of the clothes he painted. In his civic pictures the flags furnished him with picturesque backgrounds. But he was still more at his ease perhaps with the popular models who inspired his imaginary figures: the "Bohémienne" (Louvre), the "Guitarist" and the "Hille Bobbe" (Berlin). In these he achieved a great vigour of expression by the vitality of the brush stroke and the bold and cursory treatment of the canvas.

4. Rembrandt.—When Rembrandt Harmensz van Rijn (1606–69) painted "The Anatomy Lesson of Professor Nicolaes Tulp" in 1632, he showed himself as a worthy successor of Hals as master of the group portrait. His great interest in the revealing and concealing characteristics of light were already evident. It seems probable that he studied Caravaggio and his style of luminist realism.

Rembrandt was born at Leyden, the son of a miller. At the time he was commissioned to paint the "Anatomy Lesson" he was a highly successful portrait painter, sought after by the well-established citizenry of Amsterdam. He was married to the patrician girl Saskia van Uylenburch and was perhaps the most respected painter of the city. He did not at once find the method of which he had need to express the still uncomprehended things he had to say; the audacious, broad and personal method admired in the masterpieces of his maturity and old age, in spite of its subtlety, was adjudged brutal and certainly helped alienate his public. He first had adopted a polished style similar to the manner of the "Little Masters" of his country which ended by degenerating into those *tours de force* of vain minutiae which made the reputation of Gerard Dou. If Rembrandt had only left the large full-length formal portraits which brought him success among the rich burghers of Amsterdam, he would count without any doubt among the excellent painters, but he would not be known as the sibyllic prophet charged with misery as well as blessings, creator of a new tongue for the translation of human sorrow, mercy, goodness and all the contradictions and anxieties of the human spirit.

From the time of his beginnings and of his success, lighting played a major part in Rembrandt's conception of painting, and he made it the principal instrument of his penetration to the essence of humanity. It already revealed to him the poetry of human physiognomy when he painted "The Sacrifice of Abraham" (1635), or that "Holy Family" so deliciously absorbed in its modest intimacy that it was formerly called the "Carpenter's Family," or the "Angel Raphael Leaving Tobias" (both of the year 1637). But soon he asked for something more. The so-called "Night Watch" (1642)—actually a day watch as revealed by the thorough cleaning of the canvas in 1946–47—marks at once the apotheosis of his reputation and the beginning of his fall from favour. Those important personages, the officers of the civic guard, in ordering this large canvas from him, gave him to understand that they regarded him as capable of rivaling the famous civic groups of Frans Hals. Rembrandt believed that he had henceforth enough authority to disregard the rules of this type of work. He painted the portraits and made them richer in profound humanity than the vivacious but superficial effigies of Hals. For the rest, he used imagination and fantasy to relieve a theme he considered too prosaic. Independent of the apparently enigmatic figures like that of the little girl with the cock, he had a genial inspiration which was misunderstood. He applied here fully for the first time his instinct for transfiguring in his own peculiar way even the most banal subject. He illuminates his characters from within as well as from

the outside. As Eugène Fromentin said, the invention here consists in "illuminating an actual scene by a light which was not so, *i.e.*, in giving to a fact the ideal character of a vision."

Henceforth Rembrandt knew what he could do. He did not ever attempt to paint light for its own sake as did later the Impressionists. He used it as an instrument of projection and of expression of the invisible and the imponderable. Increasingly, he did not paint what he saw but what he imagined, giving form to his exploration of the human soul. He created a humanity feeble, tortured, miserable but upon which a ray sometimes fell from above, an ineffable pity, a mysterious consolation. A figure at once divine and human appeared to those who had the eyes to see and concerned itself with the vicissitudes of the life of the humble, the figure of Christ bending over the wounds of soul and body, curing and pardoning, who says, "Remember that I am gentle and humble of heart. . . ." His religious paintings, however, manifest a highly individual moral response and differ significantly from traditional renderings. Like his powerful landscapes, his late biblical paintings reveal a pantheist attitude of mystical oneness. It is no exaggeration to say that, since the middle ages, Rembrandt is, with El Greco, and perhaps more than the exclusively mystic El Greco, the most religious painter. He was religious and human at once. His soul was ennobled by misfortune and his spirit continued to grow more powerful, more inventive, more touching.

According to Fromentin, "All is immersed in a bath of shadow, into which the light itself is plunged, save what is left outside to make it appear more distant, more radiant, turning the dark waves round lighted centres, shading them, crossing them, thickening them, rendering nevertheless the darkness transparent, the half-darks easy to pierce, giving finally even to the strongest colours a sort of permeability which prevents them from being black." Everything is personal invention, but only for his own usage. He had, however, carefully studied the Italians—Correggio and the Venetians as well as Caravaggio. But what he drew from them did not resemble them at all; it resembled nothing but himself.

Rembrandt had pupils, disciples, imitators. Some of them had talent, for example Nicolaes Maes, Govaert Flinck, Ferdinand Bol, Gerbrand van den Eeckhout, Aert de Gelder, Jan Lievens. Carel Fabritius alone was an exquisite painter, but, though a pupil of Rembrandt, he is nearer to Vermeer than to the painter of the "Pilgrims at Emmaus." But what were they beside him? When they rose nearest to him it was only to arrive at the height of his least good and least personal work. For, in the pursuit of an ideal so new and so difficult, how could he avoid partial failures?

Rembrandt suffered lawsuits and bankruptcy and went into debt. But as his official reputation and social standing broke down, he grew in stature as an artist. The ordinary enough portrait painter of the great bourgeois of Amsterdam of about 1640 became the admirable and incomparable painter, unceasingly renewed in the numerous tragic self-portraits of his old age and in those which he made resplendent with the goodness shining in the features of his servant and faithful friend, Hendrickje Stoffels. Then for the first time there is seen, as has been seen frequently enough in modern times, a great artist who renounced the comprehension of the public or even of self-styled connoisseurs, and whose one thought was to satisfy himself, to put the whole of himself and his dreams into his painting.

He never treated the subjects of real life which then formed the repertory of his Dutch contemporaries. But he painted the "Slaughtered Ox," an almost repulsive spectacle before which nearly all specialists in still life would have recoiled. Indeed it is not a still life such as was painted by other painters, even the best, as Jean Chardin. The uncompromising realism of the "Slaughtered Ox" is of the same order, and requires the same effort of imagination, as the pathetic realism of the portraits of old age, his religious scenes or his majestic and awe-inspiring landscapes.

Rembrandt had a universal curiosity. He thought of the great Venetians who breathed a noble and voluptuous liveliness, he borrowed their subjects and made of them an art out of the inner life and full of profound emotion. Mythological and religious subjects were treated as he treated his portraits. For, all that he took from reality and even from the works of others he transmuted instantly into his own substance.

After this magnificent expansion, toward the end of the 17th century the first signs of decadence began in the Netherlands. It was consummated in the 18th century. Nothing remained but a poor ideal of detailed execution which ended in dryness or insipidity.

C. Spain

1. Ribera, Herrera and Zurbarán.—Spanish mysticism was seen in the work of several great painters who represented various regional tendencies, at Valencia in Jusepe de Ribera (1588–1652), at Seville in Francisco de Herrera the Elder (*c.* 1576–1656/57) and in Francisco de Zurbarán (1598–1664). All three had been subjected to Italian influences. Ribera in his early days was a real Neapolitan, and at Naples was nicknamed Lo Spagnoletto. Zurbarán had been in Rome. But the national temperament was so strong in them all that there was no risk of their repeating the experiment of the 16th century and the Mannerists. They had no wish to extract an academic formula from their Italian models. Besides they went by instinct to the masters of naturalism and particularly to Caravaggio. Each in his own way applied to his subjects, whether sacred, profane or even popular, a disdain for convention which gives a new accent to traditional themes and a touch of the crude, the direct and the brutal to their vision of reality, but always with a feeling for the picturesque and the dramatic latent in all the scenes of life. The celebrated "Monk at Prayer" in the National gallery of London (officially called "A Franciscan") shows clearly how Zurbarán, the most idealistic and at the same time the most balanced of the three artists, arrived at an extraordinary intensity of spiritual expression by realistic means, as much in the individual character of the half-hidden face as in the striking rendering of the heavy robe and in the violent opposition of light and shade. This contrast of light and shade was carried by Ribera to its maximum of intensity, and he drew from it by turns effects of realism, tragic horror and even suavity. From Ribera's "Clubfoot" and others like it derive the popular types of Velázquez, the beggars of Bartolomé Murillo, the grimacing or burlesque figures of Goya, and even certain early works by Édouard Manet.

2. Velázquez.—Diego Rodríguez de Silva Velázquez (1599–1660) owed much to these excellent painters. He studied briefly with Herrera before working with Francisco Pacheco; but his youthful works show most strongly the influence of Zurbarán and Caravaggio. The life and career of Velázquez recall Rubens. Both represent a magnificent expansion after a period of fruitful preparation. Both led brilliant lives and enjoyed the favour of princes. The duties of the court occupied an even greater place in the life of Velázquez than in that of Rubens.

Velázquez admired El Greco and even possessed some of his canvases. He made Rubens' acquaintance during the latter's visit to Madrid. Above all, he had carefully studied the great Venetian and Flemish painters whose masterpieces adorned the royal palace. All this explains the development of the finest artist produced by Spain, one of the best interpreters of the visual experience seen anywhere. But it would have been insufficient without the gift of genius. This intelligent but passionless artist, this accomplished example of civilized man, had an almost limitless power over his own faculties. He wished at first to learn his work by principles; he exercised his eye and hand in the manner of Zurbarán in *bodegones*, still lifes and pictures depicting popular types. He succeeded from the first with a prodigious facility. He was not more than 19 years of age when he produced that "El Aguador" in which the distribution of light and shade, the truth of types and poses and their naturalness reveal his keen eye and his mastery of the brush. From that moment it was clear that he was destined to be an admirable portrait painter, elegant even in his popular types and his realism.

He might have been content with similar results and pursued the development of his personality with the aid of this quickly acquired and scholarly technique. But, soon after his arrival in Madrid and from the time that he was appointed painter to the king (1624), his style changed. He created for himself, by an act of his intel-

ligence and his will, that facile, rapid and almost faultless technique, in which he combines power, breadth and mellowness, and seems with one brush stroke to render form, expression and light, a truly incomparable manner. It is unique in satisfying at once both the uninitiated spectator and the connoisseur: Velázquez' heads particularly, since he was primarily a portraitist, may be immediately appreciated by the most unlearned spectator, who can admire without effort their truth, their life and what seems to him their simple and striking effect. However, the initiate delights in the marvelous science, the subtleties and refinements which permit a gifted artist to realize a creation so similar, indeed so equivalent, to a work of nature. Rubens and the Venetians taught Velázquez much; he would not have denied it; but of the generations of painters who also have studied them, none has drawn a style of painting comparable to that of Velázquez. It may be said that the man who found all things easy, save the expression of passion, doubt and anguish, deliberated clearly on the different obligations of his life. With court duties and ceremonies encroaching more and more on his time he had need to evolve a sort of script appropriate to the circumstances. Thus necessity gave the enchantment which one feels in the works of this painter who is, as Manet said, "the painter's painter"—not painting for the sake of mystic expression as with El Greco, but painting for the sake of painting.

Some may say: "But this tremendous imitator of life has no imagination." These captious critics are perhaps right if they mean by imagination the faculty of translating plastically legendary themes, fables and mythology, of composing allegories and covering a ceiling with winged or floating creatures making gestures unrelated to terrestrial usage. But is it not imagination, and that of an order most appropriate to a painter, to compose an original range of colours, full of distinction and subtlety as well as force, and to play on it with the faultless touch of an accomplished musician? These harmonies, at once sober, refined and peculiar to him, contribute to the highly individual impression one may experience before Velázquez' masterpieces, whether they be portraits or compositions in which the portraiture is the essential element.

However, if the picture takes hold of the viewer, it is not only because it makes him see what his eyes ought to have seen and have missed, but because it opens an unknown world created by art, before which he stands thunderstruck. Velázquez was continually painting portraits of the king, the infantes and infantas, and the same princes and nobles. In spite of his loyalty as a courtier, which amounted to devotion, he used no artifice to embellish his models, he hid none of their awkwardnesses or oddities. He painted the dwarfs and buffoons of the Spanish court with the same objective realism. Both his princes and his dwarfs hold one's attention as the artist's vigorous use of pigment is admired.

It may be that Velázquez was not entirely successful in his various essays in religious painting. There again may be noted a trait peculiar to him at a time when the old Ribera and the young Murillo, the one with dramatic intensity, the other with suavity, enjoyed so much success in devotional Spain with their interpretations of Christian themes. Still it may be said that if Velázquez' "Coronation of the Virgin" lends itself to some extent to the reproach of coldness, its composition is of perfect and original elegance, and his type of Madonna resembles no other. If he had executed no more than his large "Christ on the Cross" (in the Museo del Prado), that would have been enough. It is a beautiful image of the Divine crucified, simply conceived from the indications of the liturgy, painted for all the faithful, great and small, and with all the resources of a skilled technique.

Finally three great compositions set the seal to Velázquez' glory; his originality as well as the sovereign elegance of his genius in invention is completely affirmed in them. These compositions are the "Lances" or the "Surrender of Breda," the "Maids of Honour" and "Tapestry Weavers." The "Lances" was an official picture ordered by the king in honour of a military event regarded as glorious for the monarchy. This noble and easy composition overspread with a fine light, this chivalrous air, these fine portraits, this blue and silver sky striped by the line of lances, all is the invention of a supremely intelligent artist.

The "Maids of Honour" and the "Tapestry Weavers," however, are his most significant contributions. Nothing appears calculated or arranged in these two canvases. One represents a corner apparently chosen at random in the tapestry-weaving factory of Santa Barbara, the other a room in the royal palace in which Velázquez himself is painting. They had no precedent and have been followed by no equivalent, though they contain inexhaustible lessons for modern painting. The word realism with its signification of preconceived ideas and deliberate demonstration fails to express them. It is true that the "Tapestry Weavers" is one of the first paintings with a proletarian subject, but the painter here had no fixed intention; he was neither for nor against what he saw, the action he depicted, the human beings, royal personages, children, dwarfs or workers who participated in the action. It seems that he experienced no feeling at all. Is there even a subject—properly speaking—in these two pictures? In the foreground of the one the weavers are occupied by their work and take the various poses necessitated by it. But in the background, under a quite different light, on a different level, some ladies, whose presence seems fortuitous, have just entered the factory and are looking at the tapestries being shown; and they resemble, one does not quite know why, a fairy apparition. There is no discord, however, and above all no striving for effect. In the other picture the whole foreground is occupied by three elegant and charming figures, the little infanta stiff in her rich robes and two maids of honour, from which the picture takes its name. In the shadows are two dwarfs and a large dog. Velázquez is in the middle distance and in shadow, and before him is an immense stretcher on which he is painting. In the background, shown in a dim light still further obscured by the curtains of the windows, there are side by side two rectangles of light, one brighter than the other; the brighter is a door opening on a staircase on which a courtier turns toward the viewer, and the other is a mirror reflecting the image of the king and queen, either posing for the painter or entering the room. Thus there is a problem of subject and intention, or rather the apparent absence of the painter's intention is itself a problem. But his art has the effect of a magical invocation of truth and life.

Good craftsmen worked in Madrid for some time under the influence exerted by Velázquez: his son-in-law Juan Bautista Martínez del Mazo (?1612–67), to whom is now attributed the charming little picture the "Meeting of Thirteen Gentlemen" (Louvre), and Juan Carreño de Miranda (1614–85), a good portraitist.

3. Murillo.—To the eyes of his contemporaries Bartolomé Esteban Murillo (1617–82) perhaps appeared more admirable than Velázquez himself. Murillo's sentimental and popular art was certainly better calculated to touch the heart than were the lucid intelligence, the aristocracy, the apparent insensibility and the infallible mastery of Velázquez. But above all Murillo was legitimately admired with enthusiasm and gratitude by the devout of Spain, to whom, after the reign of the great court painter, he offered an art capable of expressing in easily comprehensible language the tendernesses, the ecstasies and the adoration of a naïve and profound faith. He began, however, much as did Velázquez, in a realist manner more or less directly derived from Zurbarán. Even a little later he did not give up the picaresque and picturesque subjects offered to him by the life of Seville. The "Young Beggar" in the Louvre and other pictures of the same genre show clearly the foundation of solid observation of nature on which he built his ideals. His first pious compositions, for example the "Miracle of San Diego" (Louvre), show that he had found how to associate in an apparently spontaneous harmony a realistic execution with mystic feeling, the faithful depicting of the most humble things with the shimmering vision of miracles and the supernatural.

After Murillo little important painting occurred in Spain. By the 18th century there were hardly any painters in Spain save Frenchmen of secondary talent summoned by the Bourbon kings; the German neoclassicist Anton Raphael Mengs, a good portraitist; and the dazzling decorator Tiepolo, the last of the great Venetians, who went from Italy to decorate the royal palace and died in Madrid. These splendid rococo decorations, dazzling in their dra-

matic space and colour, certainly had a great influence on the young Goya.

4. Goya.—Francisco José de Goya y Lucientes (1746–1828) was in his way Velázquez' heir, and it was in him that the fine tradition of Spanish painting was renewed after nearly a century and a half. He was equally original as a draftsman, an etcher, a lithographer and a painter. Unlike Velázquez, he did not arrive easily and from the beginning at mastery. If he had died before he was 40 years of age he would not perhaps have left a single one of the works on which today his reputation rests. He is one of those who, having invented a new form of art, created a new world, cannot have other masters than themselves and their own experiences of life.

This extraordinarily versatile man is the painter of the finest nude in Spanish painting (the "Nude Maja"). To complete the universality of his genius, this roué and libertine had his hours of Christian inspiration. The "Last Communion of St. Joseph Calasanz" is perhaps the finest 18th-century religious painting. It recalls Rembrandt. The mystery does not come, however, as in Rembrandt, from a source of light springing from shadow, but from the infinite gradations of a twilight gray. The frescoes of San Antonio de la Florida which Goya painted in 1798 are less religious in the accepted sense but a masterpiece of pictorial decoration. Those grays and blacks which play the part of a *sotto voce* bass in light and aerial harmonies are unequaled.

Goya is the outstanding genius of Spanish painting. And, even more than the great Velázquez, he reminds one of the most illustrious name in the literature of his country, Miguel de Cervantes Saavedra, because of the combination in both of lyricism and comic verve, of pathos and satire. Like El Greco and Velázquez he is an admirable portraitist. One may go so far as to say that the portrait is the basis of his art and that, even in his works of pure imagination, the peculiar vision of the portraitist is everywhere manifest. This is also true of the typical masterpieces by El Greco and Velázquez, the "Burial of Count Orgaz" and the "Maids of Honour." The "Family of Charles IV" belongs to the same order of plastic creation. The lively handling, the iridescent and mysterious coloration are already enough to distinguish this unique example among court portraits and formal pictures. But all the admirable inventions of the colourist and the virtuoso would lose half their beauties if one did not see in them brilliant and subtle variations on a heroic-comic theme of psychology.

In all directions Goya renewed and innovated. Whether he worked for the churches or painted patriotic pictures he always did something unexpected. His cartoons for tapestries show that he had studied François Boucher and Jean Honoré Fragonard as well as Tiepolo. But there was nothing conventional about him. In scenes of gallantry or merriment, some even dramatic, all—costumes, types, attitudes—have the accent of popular truth. His inexhaustible verve and the profoundly original turn of his sensibility found an even more favourable field in his little genre pictures. But how insufficient is the term genre pictures for these little masterpieces of invention, observation, emotion and irony. There are carnival scenes such as "El entierro de la Sardina," street processions like the "Flagellants," interiors of prisons and madhouses, fête days in the country; like the celebrated "Pradera de San Isidro," and many other strange subjects, melodramatic, romantic, anecdotal and satiric, every time they are a surprise and revelation, for inevitably one thinks what such subjects would have become in the hands of another painter, and appreciates the more fully what marvels of poetic fantasy and mysterious, almost enigmatic emotion the magician Goya made of them. Goya's own sickness, the death of his close friend the duchess of Alba and then the death of his wife, all may have contributed to his turning inward. After his colourful rococo pictures he paints pungent commentaries on the life of his country, overrun by Napoleon's troops and torn by civil war. And unlike Velázquez he takes sides in the struggle. The "Execution on the Third of May, 1808" shows the heroes of the revolution in irregular arrangement, in terrified and deeply human disorder as they are mercilessly shot by the faceless and regular firing squad. The final gesture of the dying hero is that of the crucified Christ, and there Goya expresses his deepest religious feelings which were those of freedom and humanity.

Goya is the father of 19th-century art and of all modern art. In his own country he left only one expert, a servile imitator, who had, however, animation, Eugenio Lucas (1824–70). His best and truest heirs are to be found in France. In the course of the 19th century, however, outside the brilliant but harsh and petty art of Mariano Fortuny y Carbo, one feels that Spain still keeps its capabilities of favouring again the development of a great painter (see *Picasso*, below).

D. France: 17th and 18th Centuries

The first half of the 17th century was, in France as in almost all the countries where art has flourished, a period of rich development which saw the birth of geniuses of the most diverse types and the most marked originality.

Simon Vouet (1590–1649) was exceedingly precocious. At 14 years of age he already enjoyed such a reputation as a portrait painter that he was invited to pay a visit to England in order to paint the portrait of a lady of quality. He was successful also at Constantinople, at Venice, at Rome, where he received the title of "Princeps" of the Academy of St. Luke, and finally at Genoa, where he decorated the Doria palace. Recalled to Paris by Louis XIII in 1627, he was loaded with honours and for 15 years held sovereign sway over the arts. It is obvious that he was too much carried away by his facility and eclectic style which set the style for French academic painting for centuries. He had more influence than Poussin himself on Eustache le Sueur, Charles le Brun and Pierre Mignard and through them on the great work of Louis XIV's reign, the decoration of Versailles.

1. Poussin.—Although Nicolas Poussin (1594–1665) was only four years younger than Vouet, his influence made itself felt in France only later. He was not precocious like Vouet but may be numbered among those great men who have need of reflection and meditation, whose inspiration comes only with maturity of mind and body. Although earlier work by Poussin has been discovered, his career begins, historically speaking, in 1624 with his arrival in Rome at the age of 30. He had gone to Italy in quest of Raphael, whose genius he had discerned from the engravings of Marcantonio while still in Paris. Raphael did not disappoint him. But Titian was a profound surprise to him, and from that time onward his constant preoccupation was to reconcile the spirit of these two great men. At times in pursuance of his cherished theory he seemed to prefer a method hovering between these two and was able to fuse the linear element derived from Raphael, with the warm and coloured atmosphere which he admired in Titian to produce a new synthesis which is peculiarly his. This clear-sighted and impassioned study which Poussin devoted to Raphael and Titian appears perfectly natural today, but this was not so in 1624, when the foreign artists at Rome had no eyes except for the academic art derived from the Bolognese or from the brutal naturalism of Caravaggio's followers. Poussin felt an equal detestation for both, and with his robust philosophical frankness condemned both unsparingly.

Whether he studied Raphael, Titian or the Romans, Poussin derived from them only salutary inspiration. The first aspect of Poussin's genius is that he put into his masterpieces more thought than it was ever given to any other painter to express, and that he found for that thought, poetic and philosophical by turns, an original and plastic interpretation. He was basically an intellectual painter who strove toward well-ordered design and whose paintings are lucid and clear in their tectonic structure. Like the classical French theatre of the same period he achieves ordered repose even in scenes of great passion, such as "The Rape of the Sabine Women." It is above all when he invents compositions where nature and humanity appear in closest unison that he moves, and, despite his gravity, charms one. It is there that the memory of Titian and Giorgione inspires him to find new treasures.

Poussin was certainly one of the greatest landscape painters, creating landscapes such as the marvelous Homeric and Virgilian poem which forms the background of his "Polyphemus," the Elysian glades welcoming his "Bacchanal" and shading the repose of his sleeping nymphs or biblical themes as "St. John on the Isle of

Patmos." These landscapes are invented to give an ideal vision of an ordered Arcadian world, a world which has a lofty spirituality and an indefinable touch of the heroic.

In 1640 Poussin returned to Paris on the invitation of Cardinal Richelieu. The intrigues of the court, however, caused his removal two years later to Rome, where he continued his study of classical antiquities and his painting of religious and mythological subjects in the grand manner, by which he established his hegemony in French painting.

Poussin had an incomparable prestige, but for the most part his influence was remote and except for his immediate disciples, Gaspard Dughet ("le Guaspre Poussin") and Jacques Stella, was felt only as an aspiration, more or less precise, toward an intellectual and classical ideal. Some, because they died too young or for other reasons, escaped this influence entirely, for example, Jean de Boulogne, called Le Valentin (1591–1634).

2. Claude Lorrain.—Claude Gellée, called Claude Lorrain (1600–82), was neither a great man nor a lofty spirit like Poussin. His genius, however, cannot be denied, and like Poussin he was a profoundly original inventor within the limitations of a classical ideal. While he too almost spent his life in Rome, the art he created was not specifically Italian, but French. For more than two centuries afterward everyone in France who felt called upon to depict the beauties of nature was to think of Claude and study his works, whether it was Claude Joseph Vernet in the 18th century or Jean Baptiste Corot in the 19th. Outside France it was the same.

There is an element of mystery in the vocation of this humble and almost illiterate peasant whose knowledge of French and Italian was equally poor and who used to inscribe at the bottom of his drawings notes in a strange broken French-Italian. What attracted him to Rome and what held him there? Might he not have produced his masterpieces at Nancy, Paris or elsewhere? For this admirable landscapist drew from within himself the greatest number of his pictures. He made sometimes from nature drawings so beautiful that several have been attributed to Poussin, but in his paintings a romantic imagination predominates; it may even be said that it predominated more and more in proportion as Claude realized his genius. Without needing to reason, without any loss of his instinctive poetry, he understood by listening to Poussin and watching him paint that a sort of intellectual background would be an addition to his own visions and reveries.

3. Portraitists.—The French school has always numbered good portrait painters. In the 16th century when the fate of painting in France seemed so gravely compromised, only this feeling for portraiture remained active. Later, at the end of the 17th century, when an academic convention was threatening to stifle originality among painters, Nicolas de Largillière and Hyacinthe Rigaud painted portraits full of force and veracity. Even in the ceremonial portrait, where the subject is mythologically disguised, one feels that the painter will not renounce his rights as an interpreter of human physiognomy. Two men a generation apart, Philippe de Champaigne (1602–74) and Robert Nanteuil (1623–78), were neither of them brilliant painters, virtuosi of the brush as Largillière and Rigaud, yet they rose above them in the quality of their portraits.

Together with Nanteuil must be cited another engraver, a freelance draftsman of genius, Jacques Callot (1592–1635). One cannot be certain of any painting in oils. This is surprising in view of the strictly pictorial qualities with which he was the first to endow etching, and the fact that it was painters most supremely and essentially worthy of the name, Watteau and Goya, who seem, long afterward, to have been most mindful of his lyric masquerades and his "Miseries of War."

4. De La Tour.—Georges de La Tour (1593–1652), like Callot, was active in Lorraine. Although he had been painter to the dukes of Lorraine, his name had been lost and was not rediscovered until the end of the 19th century. Only in the 20th century, in fact, was there real interest in his remarkable painting because of the parallels between his work and modern art.

De La Tour worked with bold, sharply defined contrasts of light and shade, a technique probably derived from Caravaggio by way of the Dutch painters Honthorst and Hendrick Terbrugghen. But instead of the dynamic movement achieved by light and dark patterns in Caravaggio, De La Tour's world is still. Like Poussin he was more concerned with pictorial structure than with the subject matter of his religious paintings. His figures are static, their faces expressionless. An important painter in the French classic tradition, De La Tour built his pictures with large, abrupt planes, stylized in a proto-Cubist manner.

5. The Brothers Le Nain.—For long it appeared impossible to allocate individually among the three brothers Le Nain the works which survived under their common signature. V. P. Jamot among others contributed to the elucidation of this problem. Antoine le Nain (1588–1648), who studied at Laon under a foreign painter (probably from Flanders), painted, in a manner and with a colouring more or less derived from Flemish models, little panels in which persons are assembled in interiors, modest, but rather of the town than of the country. His style was still slightly archaic, but in him already may be discerned that love of humble truth from which springs the inspiration of the most original works bearing the signature, those of Louis (1593–1648), the man of genius, the breaker of new ground. He produced (1640–48) those gatherings of peasants which are painted with such freedom, filled with such dignity, sobriety and humanity and which, in a word, are so different from treatments of similar subjects by contemporary Spanish and Italian followers of Caravaggio on the one hand and by the Flemish and Dutch on the other. Mathieu (1607–77), the youngest of the brothers, who survived the others by almost 30 years, had less depth but painted family gatherings in which he shows himself almost as good a judge of human physiognomy and expression as his brother Louis.

6. Royal Patronage.—After this generation of creative artists, the condition of French art was completely changed by the action of the absolute monarchy in setting out to patronize and develop but also to organize, discipline and centralize this force, among others, for the furtherance of its great designs. King and nation became one. The French saw no better way of advancing their own reputation than by making themselves the architects of the royal glory. Charles le Brun (1619–90), though he had none of the qualities by which true lovers of painting set most store, possessed the energy, ambition and clear-sightedness of a leader. He gave proof of merit in every genre but none of his works provides that emotional satisfaction which inspires such affection for more unassuming work. Nevertheless his role was important because he codified the academic tradition. At Versailles he commanded an army of architects, painters, sculptors, goldsmiths and cabinetmakers. He had the true genius for decoration; the Galerie des Glaces at Versailles and the Galerie d'Apollon in the Louvre bear witness to it, and, secure in the king's esteem, he reigned for 20 years over the kingdom of the arts. Pierre Mignard (1610–95) on his return from Italy, where for 22 years he had enjoyed brilliant successes, alone sought to dispute his supremacy. It was a purely personal rivalry, for both were steeped in Italianism and, while claiming descent from Poussin, were followers of the Bolognese.

Le Brun had no sooner disappeared than signs were manifested of a reaction against academic and Italianate art. This is what is called the "struggle between the Rubenists and the Poussinists," Poussin's name having been wrongfully invoked by the followers of Le Brun. A part of the French school then discovered that the Italian ideal was not the only one possible, that colour is as important as design, and that grace, intimacy and freedom have their place in art as well as sublimity and grandeur.

Jean Jouvenet (1644–1717), Antoine Coypel (1661–1722) and Charles de Lafosse (1636–1716) were all pupils and collaborators of Le Brun, but as regards colour and feeling were already precursors of the 18th century. This reaction was equally marked among the portrait painters, from Jean François de Troy (1679–1752) to Jean Marc Nattier (1685–1766). The animal painters Alexandre François Desportes (1661–1743) and Jean Baptiste Oudry (1686–1755) render Frans Snyders' hunting scenes in French idiom; their greatest merit is perhaps an already very modern sense of landscape.

7. Watteau.—Antoine Watteau (1684–1721) incarnates all the grace, all the intelligence, all the poetry of the 18th century, when

French taste was triumphant throughout the whole of Europe. He, like Poussin, stood alone; he typified a new attitude in French art, the charming and graceful style of the rococo, its delight in dream-like and decorative elements. These characteristics also can be observed in the transformations of architecture. The immense galleries and stately apartments beloved by the *Grand Roi* were then succeeded by salons and boudoirs designed with a view rather to elegance and convenience than to display.

Watteau was born in Valenciennes in the Flemish provinces of France; he certainly had a Flemish atavism which fitted him peculiarly to understand the lesson of Rubens, and he found the first idea of his *fêtes galantes* in Rubens' charming variants of the "Garden of Love." When he was employed in Claude Audran's studio at the Luxembourg he studied Rubens' "Life of Marie de' Medici"; later at Pierre Crozat's he copied his drawings and placed them side by side with those of the most illustrious Venetians, of which that amateur of unerring taste possessed an incomparable collection. "Jupiter and Antiope" (Louvre) shows how Watteau succeeded in blending and adapting the influences of Antwerp and Venice. But all that may hereafter be said about Watteau's youth, all that may be added about his teacher Claude Gillot, who himself drew and painted masquerades, will be completely inadequate to account for his work. His landscapes—tall trees in parks and glades with marble fountains and statues—and the drooping glance of lovers' eyes, that high-born grace of his young men and women clad in satins and laces, that fairyland, play acting, with its actors and actresses, fantastic disguises and clandestine serenades, fair unknown ladies wooed by tremulous swains uncertain of their bliss, walks without aim and departures for unexplored isles, all this is lovelier than everyday life and just as true and sufficed to establish his fame. But only two or three years before his death this young genius who had no time to lose showed himself more and more audacious. "The Embarkation for Cythera" is an end, not a beginning; it is the masterpiece of romantic fairyland. Watteau was not content to remain the painter of the *fêtes galantes;* he felt that he could create poetry with subjects drawn from everyday life. He painted "Gilles": still a character from the stage, but the spirit has changed. Then came the "Sign for Gersaint's Shop." Persons in the dress of the period are inspecting pictures in a shop, a scene which might have made a genre picture. Watteau aimed much higher, and at the first attempt achieved, in a masterpiece that was without precedent and that bore no fruit until long afterward, the new manner of which the 19th century dreamed and to which it came back incessantly with Gustave Courbet, Edgar Degas, Manet. French taste succeeded in reconciling style with the realism inherited from the old Flemings.

8. Boucher.—François Boucher (1703–70) cannot be placed on the same plane as Watteau. If Watteau is essentially a man whose works have a mysterious meaning and who himself, urged by the power within him, has visions stretching beyond that mystery, Boucher is, on the contrary, typical of the artist whose ambitions are clearly defined and exactly proportioned to his capacity: he desired to please his contemporaries, to decorate walls and ceilings for them, and, in his better moments, realized perfectly what he had set out to do. Thus it is he who best sums up the taste of his century. He had decorative talent and the gift of composition, facile, elegant and always perfectly balanced. As a decorator he had gifts in no way inferior to those of his fascinating contemporary Tiepolo; he could also paint excellent portraits such as the "Mme. de Pompadour" (Louvre), or render with brilliance and deftness intimate scenes such as the "Déjeuner" (Louvre) or the "Modiste" (Stockholm).

Even among the court a strain of realism, visible in Oudry's, Michel Lépicié's and Étienne Jeaurat's works, made its appearance in France side by side with gallant mythology and decorative pastorals.

9. Chardin and Greuze.—Jean Baptiste Siméon Chardin (1699–1779) in 1728 gained admittance to the French academy with two large canvases which were merely still lifes: "The Ray" and "The Buffet." Their technical merit is immediately apparent: in these pieces, handled with extraordinary tact and felicity, are found all the riches and subtlety of oil painting. But there also appears, even thus early, the sense of intimacy and the poetry of humble things which give to Chardin a place apart from even the best still-life and genre painters. His still lifes do not bulge with appetizing foods but are concerned with the objects themselves and with the treatment of light. He carefully constructs his still life. He was far nearer to the feeling of meditative quiet which animates the rustic scenes of Louis le Nain a century earlier than to the spirit of light and superficial brilliance surrounding him, even in the so-called realism of his time. In his genre scenes he does not, as his predecessors, seek his models among the peasantry; he paints the petty *bourgeoisie* of Paris. But manners have been softened, and his models seem to be far removed from Le Nain's austere peasants. The housewives of Chardin are simply but neatly dressed and the same cleanliness is visible in the houses where they dwell. Everywhere a sort of refinement and good-fellowship constitute the charm of these little pictures of domestic life, unique in their way and superior, both in feeling and subject, to the masterpieces of the lesser Dutch masters. Equidistant in point of time from Louis le Nain and Corot, Chardin also attained through truth a wholesome and honest poetry, truth as seen through selective eyes, without rhetoric or pretensions.

Already, however, there was creeping into the work of more than one of his contemporaries the ideology which at that time invaded literature and was one of the worst enemies of good painting. The same causes then proceeded to bring forth the same effects both in England and in France. Jean Baptiste Greuze (1725–1805) corresponds to William Hogarth. Not that he felt the immediate influence of the painter of "Marriage à la mode"; it is perhaps Chardin, imperfectly understood, who awakened him to his vocation, and whom he desired to surpass by a choice of subjects to him more interesting and a setting to him more moving. "The Father's Curse," "The Son's Punishment," these overly ingenious compositions, where every detail is characteristic of an actor playing a part, seem borrowed from some contemporary melodrama. Nor does any technical novelty afford relief from the mawkishness and falsity of sentiment. The mordant quality of his satire saved Hogarth; nothing of the kind could be expected from the mediocre temperament of Greuze, who showed, in the opinion of some critics, the first example in painting of a brilliant success which was not ratified by posterity.

10. Pastelists.—Portrait painters, during the 18th century, formed a remarkable galaxy headed by Louis Tocqué; his lieutenants were not to be disdained, particularly Jacques Aved and Joseph Duplessis. But pastel then assumed an unexpected importance under the stimulus of an observer of genius, Maurice Quentin de la Tour (1704–88), and a charming colourist, Jean Baptiste Perroneau (1715–83). La Tour was rather a draftsman than a painter, and for a man thus inclined—as already seen in the case of Robert Nanteuil and as was to be seen again in that of Degas, pastel was the chosen medium which freed the artist from the limitations of oil painting. But for La Tour, drawing, pencil, pastel, all these were means, in themselves indifferent, to seize upon the personality of his model. Human faces, human expressions, he cared for nothing else, but loved them passionately with a sort of disinterested frenzy. No one equaled La Tour in rendering the vivacity, mobility and sparkle of wit in a French face of the 18th century.

Perroneau was neither impeccable in the structure of his faces nor impassioned in his analysis of expression; but at its best his work possesses great charm. He was a born colourist, and had not the same reasons as his illustrious predecessor and rival for preferring pastel. He painted a number of excellent portraits in oils. But La Tour had made pastel fashionable, and Perroneau and many others followed suit. Pastel, which charmed all by its lightness and unalterable freshness, seemed an invention peculiarly suited to the spirit of the times, the light woodwork of interiors and pale dresses. But Perroneau alone had the gift of making it subserve his charming discoveries in colour.

In this women's century, it was natural that women painters would win a place which had not yet been accorded to them. Their talents were principally devoted to portraiture. In Watteau's time the Venetian Rosalba Carriera (1675–1757) won a great suc-

cess in Paris and helped to create a fashion for pastel. She subsequently carried her chalks and amiable mannerisms into every European capital. In Fragonard's time it was a Frenchwoman, Marie Anne Vigée-Lebrun (1755–1842), who immortalized in her pictures of queens and great ladies, and especially in those canvases where she depicted herself with her own daughter, the graces of the dying century.

11. Fragonard.—In the gay society of 18th-century Paris there suddenly arose one who was, at least in some respects, a great painter. Jean Honoré Fragonard (1732–1806) closed with delicate hedonism the curve of the 18th century opened by Watteau. Watteau's work is aerial and profound; Fragonard's is merely light. He amused others while amusing himself; he was never moved. But he understood the art of pleasing, and he imparted charm to everything he touched. He had so much grace as to be forgiven the daring gallantry of certain subjects which would be intolerable from another artist. Sometimes he dashed off a canvas in an hour, with the flair of improvisation, sometimes he pursued to the point of the most delicate affectation a little picture full of charm and mystery. Then at Grasse he decorated a house with five great panels in which he showed himself the worthy rival of Tiepolo and Goya, the Goya of the cartoons for tapestries.

In landscape Fragonard almost had a rival in the person of his fellow sojourner in Rome, Hubert Robert (1733–1808). Robert conceived landscape principally as a decorative theme more or less derived from the views of antique ruins of the Italian Baroque painter Giovanni Panini, but he imbued it with a romantic charm unknown to the latter and with luminous harmony, a distant reflection of Claude. In spite of the residue of convention in his pleasing works, they contain the first signs of a change. A return to simplicity and truth heralded a new conception of landscape which was to be that of the 19th century. Claude Joseph Vernet (1714–89) in his "Ports of France" and numerous other pictures was a brilliant and facile narrator; his seascapes and marine scenes were popular. Vernet was an eclectic painter relying greatly on the work of Claude Lorrain and Salvator Rosa, but he also became an important link with 19th-century romanticism.

12. Neoclassicism: David.—In France first signs of the return to the antique were already visible in the discourse on the life of Watteau pronounced in the French academy by the comte de Caylus, an old friend but at the same time a good archaeologist. This was in 1748, about the time of the discoveries of Herculaneum (1738) and Pompeii (1748), which roused the artistic and literary world to enthusiasm; earlier even than the first publications of Johann Joachim Winckelmann (1717–68), the German archaeologist who restored to the world the sense of Greek art. There he found "noble simplicity and silent grandeur"—a true standard of beauty for the neoclassical movement. Winckelmann, working in Rome and approaching antiquity with more information and a more knowledgeable attitude than that of the Renaissance, became the arbiter of taste for Europe during the late 18th century. He was the father of the neoclassicism which ruled Europe and the American colonies for some 50 or 60 years. An extraordinary interest in antiquity and classicism spread through England and is perhaps evident in English architecture. In France Mme. de Pompadour copied books of reproductions from the antique under the tutelage of the engraver Gay, and encouraged the great change which was taking place in furniture and architectural form. The style which has been christened Louis XVI sprang up in the middle of Louis XV's reign, while that destined to be called Empire was already almost fully formed under Louis XVI. In painting, Joseph Marie Vien (1716–1809) caught the fashion with his "La Marchande d'Amour" and "Belisarius." Jacques Louis David (1748–1825) passed through Vien's studio and had been Boucher's pupil before coming to Vien. Until his departure for Italy, when after long and determined effort he had won the Prix de Rome (1775), he painted like a docile enough imitator of Boucher. At Rome he suddenly adopted, with the uncompromising and inflexible enthusiasm natural to him, the doctrine of Winckelmann.

Winckelmann's doctrine was amplified and codified for the French by a writer whose pen was no less authoritative than David's brush, Quatremère de Quincy (Antoine Quatremère). Between them they laid down the principles of the new aesthetic. It was admitted that true beauty, as realized by the Greeks in their masterpieces, is a creation of reason capable of satisfying the needs of all men in all ages. Greek painting having disappeared (at least that of the great painters of the classical period), they were driven to ordain that painters should draw their inspiration from antique statuary; by way of consequence the superiority of design over colour was proclaimed and it was decided that the only noble arrangement was grouping in bas-relief. The "Oath of the Horatii" (1784–85), illustrating these principles with a vigour and austerity hitherto unknown, forthwith exalted David's reputation. His contemporaries saw in it the promise of a rebirth of art through a heroic ideal suited to a humanity uplifted by what were called the republican virtues: severity, simplicity and heroism. David was therefore the author of the most fundamental breach which has ever occurred in French tradition. His paintings, such as the "Oath of the Horatii" and "Brutus," not only reflect the political situation of his times but were able actually to exert an influence on political events. David himself, as a delegate to the national assembly, became one of the leaders of the French Revolution. He abolished the old academy in the name of freedom, but he soon thereafter established its successor which permitted even less free expression in the name of the revolutionary state.

David himself possessed the means of combating to some extent the dangers of the uncompromising doctrine despotically preached to his pupils, so that he did more harm to others than to himself. When one looks at the sketches by Pierre Guérin or Girodet Trioson, who, whether or not they had passed through his studio had subjected themselves to his rules, one recognizes the light and pleasant touches that denote the real artist of which, however, they were obliged to divest themselves when painting their huge canvases, in order to conform to the rigid aesthetic of their master. David was saved by that love of a somewhat rugged truth, which was natural to him and from pre-Revolution days onward made him an excellent portraitist. The false antique ideal was, mercifully, entirely absent from the numerous and admirable portraits which he painted at all periods of his life, from the old people dressed up in their Sunday best of the Louis XV style "M. et Mme. Pecoul" down to that canvas dating from his last years, his exile at Brussels, "Mme. Morel de Tangry and Her Daughters." Perhaps his greatest portrait is "The Death of Marat" (1793), where the tragedy is presented by means of the simplest severity in terms of a basic structure of horizontal and vertical shapes and large, even colour planes.

His gift of portraiture enabled David to paint "The Coronation of Napoleon," a pretentious official picture, and to breathe life into a huge ceremonial composition. It is no small achievement to have arranged and animated this immense composition, the only canvas which can, in a certain measure, be compared to Veronese's "The Marriage at Cana." David had not, moreover, awaited the commissions which made him the historiographer of the empire, before deserting, at least intermittently, the Greeks and Romans in order to paint the doings of his contemporaries. At the beginning of the Revolution he outlined in large canvas the "Oath of the Tennis Court," then painted Marat dead in his bath, and another murdered man, "Last Moments of Lepelletier de Saint-Fargeau." Without necessarily sharing the revolutionary passion which was his inspiration, one cannot help admiring unreservedly in his works, then so novel, the striking atmosphere of truth and the style, truly heroic in its grandeur and simplicity. Thus this doctrinaire had a deep-seated love for classical form; and, although his successors were obliged, in order to restore to French painting its essential liberties, to react against the doctrines of David's school, one may yet find in him the source of the chief currents which stirred 19th-century art. (*See* also NEOCLASSICAL ART.)

E. BELGIUM

After the return of the Bourbons, David, as a regicide, spent the last eight years of his life in Brussels. He then created a new school in a country in which art appeared to be on the verge of extinction. If the ascription Flemish is reserved for the art of Van Eyck, Van der Weyden, Brueghel, Rubens and Van Dyck, one

may say that Flemish art was dead. But just when Belgium was winning independence, a Belgian school was about to be born. David was its father, or at least its godfather.

When David arrived in Brussels in 1815, the young painters gathered around the famous exile. The most gifted among them, an excellent portraitist, François Navez (1787–1869), had for a long time admired David, whom he had known in Paris. The highest possible praise of his talent is to say that, as a disciple of David, he did not give up his own freedom. Outside France, it was in Belgium that the soundest element of David's art was best understood, while elsewhere—notably in Switzerland with Leopold Robert (1794–1835)—the Davidian influence with the assistance of a mild romanticism led to an anecdotic genre which stiffened in a pretension little approximating to the style.

Once embarked on this course, development of the Belgian school synchronized almost exactly with the stages of French painting. Unfortunately Belgium produced no Delacroix. There the development of romanticism was confined to the externals, to archaeological or historical imagery. Instead of the poet who, heedless of material exactitude, interprets the emotion he experiences in meditating on the great events of life, the heroes of history, legends or fiction, these were annalists, who, by all sorts of detail in costume and decoration, claimed to reconstitute the past by presenting the illusion of authentic evidence. Their errors spread almost throughout Europe, beguiling the masses and producing immense success for painters who today are relegated to obscurity. The movement started in France with Horace Vernet (1789–1863) and Paul Delaroche (1797–1856). In Germany it gave rise to the schools of Düsseldorf and Munich, and was continued to the end of the century by the Viennese Hans Makart (1840–84), the Pole Jan Matejko (1838–93) and the Hungarian Mihály von Munkacsy (1844–1900).

Of all the champions of romanticism Louis Gallait (1810–87), who studied at the Tournai academy under Philippe Hennequin (himself a pupil of David), most closely resembled Delaroche. In a similar style, also literary and pseudohistorical in origin, Hendrik Leys (1815–69) demonstrated, by the genuine qualities of his work, that the old Flemish heritage was not entirely lost. At times he painted historical pictures of a decorative pageantry, while in some of his less pretentious works he used an almost Impressionist freshness of approach. Henri de Braekeleer (1840–88) brought ancestral Flemish desire for finished workmanship. Others include Charles de Groux (1825–70), Constantin Meunier (1831–1905) and Alfred Stevens (1828–1906). Stevens was the most Parisian of the Belgians, an intimate of Manet and of French men of letters. He did much to direct his countrymen to the study of modern life and to what was called, after the name of a review upholding it, the Free Art movement. Among landscape painting must be noted the works of Hippolyte Boulenger (1837–74) followed by L. Artan de St. Martin (1837–90) and Albert Baertsoen (1866–1922). Artists concerned with the realistic representation of social and human problems were Léon Frédéric (1856–1940), Émile Claus (1849–1924) and Eugène Laermans (1864–1940). In the following generation painters such as Théo van Rysselberghe (1862–1926), Henri Evenepoel (1872–1899) and Rik Wouters (1882–1916) came under the influence of Impressionism and Post-impressionist trends. James Ensor (1860–1949) similarly had experienced the impact of the most recent experiments in Paris but created a fantastic imagery of extraordinary violence which brought him into the heritage of Bosch and Brueghel and at the same time characterized him as precursor of Expressionism and Surrealism. Ensor is also the father of the Flemish Expressionist movement of the 20th century.

F. The Netherlands: 18th and 19th Centuries

From the middle of the 18th century, the Dutch school seemed to linger in the final stages of anemia. No other name worth mentioning is to be found after the death of Cornelis Troost (1697–1750), who was rather amusing in his comedy scenes but a poor painter. Nevertheless the genius of painting was still alive in the country of Rembrandt, of Ruysdael and of Vermeer. In the 19th century the Netherlands was to give the world of art two powerful personalities whose work had great influence on the fate of modern painting: Johann Barthold Jongkind (1819–91) and Vincent van Gogh (1853–90; see *Postimpressionism*, below), but it was within the orbit of French painting that their work found its true place. Jongkind prepared the Impressionist landscape and—in the best possible way—without having wished to do so; and, though so original in the modest limits he set himself, he was no theorist.

Already in the period of romanticism, Ary Scheffer (1795–1858) also adopted France as his country. However, his romanticism bears a particular stamp of mystic sentimentality; Jozef Israëls (1824–1911), Jacob Maris (1837–99) and his brothers William (Willem) and Matthew (Matthijs), with Anton Mauve, Johannes Bosboom, Bernardus Blommers and Hendrik Mesdag did not escape the irradiating influence of French art but retained that discreet and somewhat enigmatic melancholy that was characteristic of their national spirit.

G. Italy

In Italy classicism had no need of David to become known; it was in Rome that the movement had immediately encountered an illustrious native adept in the person of the great sculptor Antonio Canova. No painter of that time, be it Andrea Appiani (1754–1817), Pietro Benvenuti (1769–1844) or even the romantic Francesco Hayez (1791–1882), produced any painting comparable with Canova's masterpieces, in spite of Canova's own tendency toward an academic grace.

Generally, neither neoclassicism nor romanticism had much effect on Italian art. After the great outburst of Italian rococo painting on the part of the last Venetians—Tiepolo, Canaletto and Guardi—in the late 18th century, Italian art did not really come into its own again until the latter half of the 19th century with a group of painters in Florence and Naples who were called *I Macchiaioli*, after *macchia* or "patch." These artists reacted against the academies and their rules and looked to nature for instruction.

The *Macchiaioli* felt that the patch of colour was the most significant aspect of painting. The effect of a painting on the spectator was thus to derive from the painted surface itself rather than from any ideological message or narrative. The *Macchiaioli* used a sketch technique to record their initial impressions of nature—often as seen from a distance—by means of colour and light. Their theory was certainly similar to that of the French Impressionists, but they were still more concerned with the colour structure of their painting than were the Impressionists.

During a short period of 20 years (about 1865–85) the *Macchiaioli* produced some startlingly fresh and vivid paintings. The most outstanding painter among them was the Florentine Giovanni Fattori (1825–1908), who sometimes attained amazing effects of light and colour by means of the strong colour patch. Other important painters were Telemaco Signorini (1853–1901), the critic and theoretical leader of the group, who employed the patch with great sensitivity in his usually socially significant scenes; Silvestro Lega (1826–95), who combined a clearly articulated handling of the patch with a personal poetic feeling; and Raffaello Sernesi and Giuseppe Abbati, also artists of original creativity.

But the continuous tradition of Italian art had been broken. Just as there was no significant painting in Italy during the first half of the 19th century, there was again little of more than local importance until the Futurist movement just prior to World War I.

H. Germany

Anton Raphael Mengs (1728–79) worked in Rome during the greater part of his life and was one of the leaders of the neoclassical movement in its early stages. In Germany itself a special and often mystical romanticism sprang up. Philipp Otto Runge (1777–1810) was concerned not only with allegorical subjects but also with the symbolic aspects of colour and form. His contemporary, Caspar David Friedrich (1774–1840), stands out as the most important painter in Germany during the first half of the 19th century. A landscape painter imbued with mysticism, he interpreted his melancholy landscapes as symbols of the universe, reflections of the soul. In most of his paintings solitary human beings are confronted with vast expanses—the experience of the infinite.

Under the leadership of Johann Friedrich Overbeck (1789–1869) and Peter von Cornelius (1783–1867), a group of painters, the Nazarenes, moved to Rome where they came under the influence of both Winckelmann's classicism and the neo-Catholic movement. In strong revolt against the rococo they emphasized linear draftsmanship and devoted themselves to Christian and Germanic scenes. Their style generally tended to be dry and pedantic. Later, as directors of the academies of Düsseldorf, Munich and Berlin, the Nazarenes exerted an enormous influence on German 19th-century painting, especially on the more popular style of such painters as Wilhelm von Kaulbach (1805–74), Moritz von Schwind (1804–71), Alfred Rethel (1816–59), Karl von Piloty (1826–86) and Emanuel Leutze (1816–68), who attained fame in the United States.

Around the middle of the 19th century Realism became as important in Germany as in France. Adolf von Menzel (1815–1905), a superb draftsman and brilliant colourist, painted historical and genre scenes with an astonishing economy of means. Perhaps incidentally, perhaps under the influence of John Constable's landscapes, Menzel was utilizing an Impressionist technique before paintings by the French group could have traveled across the Rhine. While Menzel worked in Berlin, Wilhelm Leibl (1844–1900) painted his peasant subjects and portraits with a slow and deliberate Realism which is at times reminiscent of Gustave Courbet. Realism in Germany came to a climax in the work of Max Liebermann (1847–1935), who developed toward Impressionism in the 1880s. The Realist-Impressionist trend was carried on during the final years of the century in the sensuous canvases of Lovis Corinth (1858–1925) and the light improvisations of Max Slevogt (1868–1932).

At the same time the neoclassical tradition was fused with romantic overtones in the large history paintings of Anselm Feuerbach (1829–80), the grotesque, modernized mythology of the Swiss-born Arnold Böcklin (1827–1901) and the pseudo-Wagnerian idea painting of Max Klinger (1857–1920). Böcklin and Klinger dressed fantastic subject matter in naturalistic and conventional garb and produced some startling, although not always successful, works.

Hans von Marées (1837–87), on the other hand, created mythological compositions of severe architectural structure and measured serenity. He achieved a monumentality of form comparable with the work of Pierre Puvis de Chavannes and even occasionally with that of Paul Cézanne.

I. Great Britain

Of all the countries of Europe, England was perhaps the least subject to French influence at a time when that influence was so important throughout the continent. The reason was not that the English were indifferent to painting in general or to the merits of French painting in particular. From early times they were as great collectors as travelers. English amateurs welcomed French artists, whether summoned or arriving of their own accord, with every sign of favour, and London saw in succession Nicolas de Largillière, Charles de Lafosse, Watteau and Maurice de La Tour, but there was almost no patronage for domestic painting in England.

Some of the greatest foreign masters were attracted there, loaded with honours and even in some sort received into the nation by the titles of nobility conferred upon them. Holbein, Anthony More, Rubens and Van Dyck were almost English painters during a longer or shorter period of their lives. The last-named in particular, who was called in England Sir Anthony Vandyke and who married the daughter of a lord and died in London, was really in virtue of the supreme elegance and aristocratic poetry of his portraits the father of the English school. He trained a few English pupils, William Dobson, George Jamesone and the miniaturist Samuel Cooper. Nevertheless his principal imitators and successors were also foreigners settled in London: the German-born Sir Godfrey Kneller (1648–1723) and especially the Dutchman Pieter van der Faes, who became in England Sir Peter Lely (1618–80). Of the English-born artists, Sir James Thornhill (1675–1735) gained distinction as a historical painter in the Italian baroque tradition, but the first important painter who was truly English in style was Thornhill's son-in-law, William Hogarth (1697–1764). Van Dyck set before the English school an aristocratic ideal; Hogarth was a curious observer of men and manners, noted for his frank, robust personality and vigorous technique. His first works date from 1730. For rather more than a century England was to see a brilliant succession of painters, Sir Joshua Reynolds, Thomas Gainsborough, William Blake, Thomas Lawrence, John Constable and Joseph Turner. No country has had so exclusive and strongly marked love of the portrait. England and Holland were deprived of religious painting by the Reformation, and mythology met with no better fate. Scarcely any decorative painting is found, and what little survives is mediocre. Holland compensated by inventing the small genre picture, street scene or interior which was brought there to refinement. But England practised genre painting only from the beginning of the 19th century, in imitation, moreover, of the Dutch, though diluted with sentimentality and humour in the little school of anecdotal painters, Gilbert S. Newton, Charles Leslie, George Morland, Sir David Wilkie and William Mulready. The three last named were the best, by reason of their preference for rustic scenes combined with landscape. If portrait painting is one of the glories of English art, landscape is another; in both directions it rose to supreme heights.

Characteristic of the English school is the moral strain emanating from the old Puritan tradition. It sometimes favours a conception of art closely akin to that of the novel, which from the 18th century onward is so living and original a part of English literature. An example of this is the narrative and descriptive method of Hogarth. Sometimes, as in the work of Blake, it presents apocalyptic visions—in aim always profoundly moral—and sometimes it results in movement which is to all appearances entirely poetic, such as that of the Pre-Raphaelites, but with a poetry that is more literary than visual and in which the idea of purification is applied almost as much to the intentions of art as to its specific processes and sensible effects.

1. Hogarth and Reynolds.—Hogarth's case is a strange one. The famous series of paintings, "A Harlot's Progress" (1731), "A Rake's Progress" (1735) and "Marriage à la mode" (1745), are pictorial moralities of a kind which seems completely outside the domain of art; for Hogarth considerations of morality counted infinitely more than those of art and beauty. He himself said he created "painted comedy" and considered it as a work "of public utility." His morality was founded on good sturdy practical truths not stirred by any breath of heroism, but he imbued it all with verve and powerful vitality; he paraded and set in motion such a gallery of types, of characters whose blatant truthfulness is so prominent, that criticism is silenced and reservations of the fastidious melt away.

This autodidactic personage, disdainful of all culture, this Englishman who desired to be nothing more, was not without influence on the most refined, intelligent, learned and cosmopolitan of the great English painters, the instigator and first president of the Royal Academy of Arts, a great amateur and collector and perfect gentleman, and author of remarkable writings on art and the training of artists—Sir Joshua Reynolds (1723–92). It is impossible to imagine a greater contrast between two men and their works; but it may be said that Reynolds was, in his fashion, the legitimate heir of Hogarth, not of Hogarth the moralist and satirist, but of Hogarth the aesthetician and author of the treatise *Analysis of Beauty*, and Hogarth the portrait painter. The painter of "Marriage à la mode" and the "Shrimp Girl" gave a decisive impetus to the national temperament. But the original school thus created still needed to be brought into line with the great continental tradition. This youngest school had a long leeway to make up and Reynolds was the man to assist it. He attempted to lead English painting away from anecdotal pictures toward a plastic art "in the grand manner," a feat to be achieved by enabling English art to profit by the treasures of experience accumulated during centuries by the other schools. Reynolds was never a pupil of Hogarth, but certainly owed more to him than to Thomas Hudson (1701–79), his official master, who has no other title to fame. But his debt to the great masters of the past, Titian, Rembrandt, Raphael,

Michelangelo and the Bolognese, not to mention Rubens and Van Dyck, was still greater. He studied them not as an amateur but as a craftsman and student of aesthetics, in order to assimilate everything in their genius and technique. In his writings, he outlined the essence of the grand style and suggested pedagogical means of achieving it. His *Discourses* remain among the most important critical writings of his century. His own painting, while often impressive, was perhaps a little too calculated and eclectic, but it attained a supremely aristocratic quality which appealed to his contemporaries and which accounts for his success. He seems at his best in his less pretentious paintings when he forgets all his calculations and abandons himself to inspiration.

2. Gainsborough and Wilson.—Thomas Gainsborough (1727–88), four years younger than Reynolds, rivaled him in fame. He was no theorist, teacher or leader of a school; he never thought of combining in his art skillful borrowings from the greatest artists of various foreign schools. Unlike Reynolds he never left England and after several years of apprenticeship in London passed most of his life successively at Sudbury, Ipswich and Bath, before returning to London, where he died.

Gainsborough was not so studied a draftsman, his compositions were not so carefully balanced as those of Reynolds, and his figures often seem disposed haphazardly on the canvas. But his work is not contrived. He never lost his attitude of detachment. Although he painted some good portraits of men he was pre-eminently the painter of women and children. A profound admirer of Van Dyck, he took him for model; but this admiration did not detract from his originality, which has a unique quality of seductiveness, and retains the directness of his own visualization. On Van Dyck's themes—such as that of the boy clad in costly satin, with the woman's face, long and delicate in its aristocratic grace—he composed entirely new variations. His "Sarah Siddons," lacking the rhetorical grandeur of Reynolds' portrait, has the vitality of original artistic vision. Because of his passionate enjoyment of the landscape, he was the veritable creator of the great English school of landscape painters.

England had long shown a great appreciation of natural beauty. Connoisseurs had collected in their London salons and the galleries of their country houses the works of Jacob van Ruysdael, Cuyp, Canaletto, Guardi, Claude; but it was not without good reason that no work bearing an English signature was ever seen there. It was still in imitation of Canaletto that Samuel Scott, the companion of Hogarth, painted his views of London, valuable as historical records. He was one of the founders of that Society of Water-Colour Painters which was to have such important developments. The real creators of English landscape, however, were Wilson and Gainsborough. Richard Wilson (1714–82) took to landscape somewhat late, having first devoted himself with success to the portrait, whereas Gainsborough started as a landscape painter. It was at Rome, where he lived for six years, that, encouraged by Francesco Zuccarelli and Claude Joseph Vernet, Wilson painted his first landscapes. Having returned to England, he pursued his career as a landscape painter in the Roman style, sometimes interrupting his reminiscences of Italy to paint the beauties of Wales, where he was born. Wilson's landscapes combine a classicist serenity with picturesque effects: wide skies shed a limpid light upon the waters of a lake surrounded by the harmonious lines of mountains. While Wilson went to Claude for inspiration, Gainsborough was influenced by the Dutch when he painted Harwich harbour or the country around Sudbury. But from the start Gainsborough announced much more clearly than Wilson the road to be followed by English landscape. His canvases painted between the ages of 20 and 25 already heralded Constable's earliest works. His "The Watering Place" and "Return From the Market" show a rustic poetry and a receptivity to atmospheric conditions altogether new at that time.

3. Norwich School.—After Gainsborough and Wilson, there was no lack of landscape painters in Great Britain. The Scotchman Alexander Nasmyth (1758–1840) and Thomas Barker of Bath (1769–1847) deserve mention; John Crome, called Old Crome (1768–1821), was an artist of different calibre. Except for the journey to Paris in 1814, from which he brought back a work of great beauty, the "Boulevard des Italiens," he never left his native county of Norfolk, although he was certainly strongly influenced by the 17th-century Dutch landscape painters, especially Van Ruysdael and Hobbema. He was the glory of Norwich, which on his account gave its name to the Norwich Society of Artists, responsible for a new conception of landscape which was to be, with a few modifications, that of the 19th century, both in Great Britain and abroad.

Of Crome's pupils, John Sell Cotman, James Stark and George Vincent, who continued to shed lustre on the Norwich school, the most gifted was Cotman (1782–1842). Simultaneously with Thomas Girtin and John Robert Cozens he brought about the revival of that water-colour painting which assumed in England the character of a national institution.

During this time, three men, working on diverse lines, made themselves felt as far more original personalities. Two of these were geniuses, Constable and Turner, and the third a charming painter and colourist, Richard Parkes Bonington, who should have gone far had he lived longer.

4. Constable.—John Constable (1776–1837) was the first English landscape painter to ask no lessons from the Dutch. He was instead indebted to the landscapes of Rubens, but his real model was Gainsborough, whose landscapes, with great trees in well-balanced masses planted on land sloping upward toward the frame, have a rhythm often found in Rubens. His originality did not lie in choice of subjects, which frequently repeat themes beloved by Gainsborough. Nevertheless, Constable seems really to belong to another century; he ushered in a new era and this difference resulted at once from technique and feeling. He no longer calculated picturesque effects but painted nature with great humility and sincerity. Constable was the first landscape painter to consider as a primary and essential task the sketch made direct from nature at a single sitting, an idea which contains in germ a great part of the destinies of the modern landscape, and even perhaps of modern painting. It is this momentary and spontaneous impression—of all things the most irreducible and individual, the least susceptible of voluntary reproduction—which is preserved in his paintings. He discovered the exuberant abundance of life in the simplest country places where there is a sky across which the white or gray clouds hasten, where trees rustle their innumerable leaves and waters glide between tall weeds starred with dewdrops and flecks of light; and he expressed all these primitive things which enchanted him with the palette of a creative colourist and a technique of vivid hatchings heralding that of the French Impressionists. He audaciously and frankly introduced green into painting, the green of lush meadows, the green of summer foliage, all the greens which, until then, painters had refused to see.

Constable recognized light as the all-pervading element in the landscape and saw the visual interrelationship of all objects which was due to their mutual reflection. In order to capture the movement of light he broke up his colour areas and introduced white high lights. His rough textures also add to the spontaneous vitality of his paintings. Then so as to impress the academy, he would later elaborate on his first visual impressions and create a replica which was actually a careful and conventional machine. By doing this he was able to succeed in being elected a member of the Royal academy toward the end of his life.

Constable's technique and particularly his method of securing the freshness and intensity of his greens by the juxtaposition of multifarious tones were a revelation to Delacroix, as is evidenced by his *Journal* and *Correspondence*. After seeing the works of the illustrious English landscapist he repainted, it is said, the whole background of his great canvas "Massacre of Chios." Of great landscapists who occupy so important a place in 19th-century art Jean Baptiste Corot probably was the only one to escape the influence of Constable. All the others are more or less direct descendants of the master of East Bergholt.

5. Bonington.—Richard Parkes Bonington (1801–28), who spent most of his too short life in France, was to a still more marked degree another connecting link between England and France. He painted water colours which are little masterpieces of brilliance and limpidity, and oil paintings no less attractive. He

brought the force of English landscape painting to France and at the same time he became a disciple of the budding French romanticism with a grace, fantasy and freshness of colouring all his own. In some few landscapes such as his water colours and oils of Versailles, Venice or Normandy he shows a breadth of vision and a sureness of touch foreshadowing the greatness he might have achieved had he not died at the age of 27.

6. Turner.—At 15 years of age, Joseph Mallord William Turner (1775–1851) was already exhibiting a "View of the Archbishop's Palace, Lambeth." He soon acquired the reputation of an immensely clever water colourist. A disciple of Girtin and Cozens, he showed in his choice and presentation of theme a picturesque imagination which seemed to mark him out for a brilliant career as an illustrator. He traveled, first in his native land and then on several occasions in France, the Rhine valley, Switzerland and Italy. Soon, even in works in which one is tempted to see no more than picturesque imagination, there appears his dominant and guiding ideal of lyric landscape. He chose a single master from the past and studied profoundly such canvases of Claude as he could find in England, copying and imitating them with a marvelous degree of perfection. His choice of Claude as a master never failed. He desired his "Sun Rising Through Vapour" and "Dido Building Carthage" to be placed in the National gallery side by side with two of Claude's masterpieces; and there one may still see them and judge how legitimate was this homage.

It was only, and this is worthy of note, in 1819 that Turner went to Italy, to go again in 1828 and 1843. These journeys did not serve the purpose of direct representation, but certainly Turner experienced emotions and found subjects for reflection which he later translated in terms of his own into dynamisms of light and colour. Where Constable expressed his experience of nature, Turner, after absorbing nature's lessons, recreated it from his imagination.

The logic of reason does not count for this northern imagination. But no southern painter had the logic, which to him would appear almost monstrous, of the Englishman who was consumed by a solitary and royal dream, indefinable and full of marvels, and who, thus possessed, did not distinguish reality or life, even his own, from the pictures he created to reflect at least some traces of the dream. The dream of most southern painters is one of happiness, at once heroic and human. Ardour is tempered with melancholy, as shadow strives with light. Melancholy finds no home in Turner's protean fairyland; what place could it have in a cosmic dream? Humanity does not appear there, except perhaps as stage characters at whom one hardly glances. Compare his "Ulysses Deriding Polyphemus," one of his masterpieces, with Poussin's. Turner's picture fascinates the viewer and yet he thinks of nothing precise, nothing human; only unforgettable colours and phantoms lay hold on the imaginations. Humanity really only inspired him when linked with the idea of death, but strange death, a lyrical dissolution—as the finale of an opera. In his "Rain, Steam and Speed" the balance is disturbed, design is dissolved, and there seems to be no harmony. There is an almost completely abstract composition of pictorial elements conceived as forces of energy and light.

7. Blake.—The England of that day also had other visionaries; none was comparable with Turner as a craftsman. Johann Heinrich Füssli, of Zürich, Switz., known in London as Henry Fuseli (1741–1825), was a writer and painter who belonged by his life, work and successes to the English school. He pursued the painting of fantasies with an uninspired brush and a coldly complicated imagination. John Martin (1789–1854) illustrated John Milton's *Paradise Lost* and showed, perhaps, more talent in mezzotints than in painting.

William Blake (1757–1827), poet, draftsman, engraver and painter, created work made up of a strange array of elements—medieval art, the Bible, Milton and Shakespeare, to which were added Dante and a certain taste for linear design, which, resembling a geometrical diagram, relates him, through Fuseli and John Flaxman, to the great classical movement inspired by Winckelmann and propagated by David. This is the sole point of contact discernible between the classicism of David and English art, and it is fugitive, indirect and different in spirit. Blake was the most mystic of the English painters, perhaps the only true mystic who existed at that time among painters the world over. He was ingenious and his inner imaginations and interpretations of the ancient and modern poets reveal as true and candid a spirit as the title of his first work—poems composed, illustrated and set to music by himself, the *Songs of Innocence* and *Songs of Experience*. His drawings were not based on an experience of the visible world, however. He found his reality with the mind's eye rather than the retina. His illustrations to Dante's *Divine Comedy* and the Book of Job seem to be indeed hallucinatory inventions of the unconscious mind, expressed with a baffling vehemence. While he is often compared with Michelangelo, he altered High Renaissance form to an abstract linear style reminiscent of early Celtic manuscripts.

8. Portraitists.—Side by side with isolated figures such as Turner and Blake flourished the second generation of portrait painters, George Romney (1734–1802), John Hoppner (1758–1810), Sir Henry Raeburn (1756–1823), all excellent painters who are relegated to the second rank only by the achievements of Reynolds and Gainsborough. The first left numerous and impassioned pictures of the celebrated Lady Hamilton and displayed talent and distinction in his family groups. The pictures of young men and maidens painted by Hoppner are full of charm and refinement. Raeburn's colour is rich and warm, and his touch broad and vigorous; he had the gift of posing his sitters with decision, and possessed some of the attributes of a great painter. Sir William Beechey (1753–1839), a skillful technician, but more commonplace, should also be mentioned. At this moment virtually all English painters produced fair and sometimes even good portraits, even the historical painters whose heavy compositions, once so fashionable, now appear so poor and uninteresting. Among these were Benjamin West (1738–1820), born in the American colonies and Reynolds' successor in the presidency of the Royal academy, and John Opie (1761–1807). John Russell (1745–1806) was the pastellist of this school.

Sir Thomas Lawrence (1769–1830) was the painter of kings, of princes, of great diplomats and generals; the pope himself sat for him. All these are presented in large full-dress portraits painted with sovereign verve and elegance. Lawrence was an important figure at Aix-la-Chapelle and at Vienna during the famous congresses which settled the fate of Europe after the downfall of Napoleon. The Holy Alliance is mirrored in the 24 canvases which adorn the walls of Windsor castle—a collection of official portraits forming a unique historical document. There is, moreover, in Lawrence's work something more than a mere caprice of fashion. His success was greater than that of Reynolds; though he had not the thoughtful learning and the rich and refined taste of his more illustrious predecessor, he excelled him in facility. At the age of ten he was already a portraitist. Before he was 22 he had painted the ravishing full-length portrait of Miss Farren, later the countess of Derby. Lawrence at once leapt into fame, becoming an associate of the Royal academy and a favourite of the king. Henceforth he lavished on his portraits, and especially on his portraits of women, his facility of execution, his fluid touch, his rich and always highly distinguished colour, his talent for depicting the pearly bloom of flesh, the sparkle of bright and limpid eyes, the moist quiver of parted lips, the light softness of muslins, the gleam of silks and of velvets. There is superficiality and artifice, but artifice handled with such vitality and verve becomes second nature. It is nonetheless true that the painter of George IV and his court could lay claim at a critical moment to an important influence on the destinies of painting, not so much, moreover, in his own country as in France and through France to the whole world. When Delacroix arrived in London he was seeking, as Géricault had already sought some years before, to fight against the systematic desiccation of the school of David. Lawrence showed him that by a return to harmony, richness of colouring and beauty of touch founded on the example of the great masters of the past it was possible to create a modern art full of vigour and capable of every expression. Thus Lawrence stimulated the energies of French painting almost as efficaciously and opportunely as Constable. Later, in France, England or elsewhere, every time that the need was felt of a supple and brilliant execution to ex-

press the quality of life, it was more or less consciously to Lawrence that men turned.

9. Pre-Raphaelites.—After English painting had shed its lustre over a great part of the world, England withdrew within itself in an effort, praiseworthy in its intentions but, in spite of a few incontestable talents, slight in its results and adding little to the treasures of universal art. This movement must nevertheless have responded to some general spiritual need, for it is impossible to deny the sentimental and intellectual analogies which produced Böcklin in Germany, Gustave Moreau in France and the Pre-Raphaelites in England. To a certain extent it may be said that Pre-Raphaelitism was a continuation and transformation of the idealist movement, fantastic and mystic by turns, which produced at the beginning of the century Fuseli and Blake. Thomas Stothard (1755–1834), with his pictures from Shakespeare and Chaucer, which were painted in a style imitated to some extent from medieval illuminations, continued this movement in his own way. A little later Ford Madox Brown (1821–93) painted his first Gothic pictures filled with an arid precision, a scrupulous attention to minute detail, a harsh colouring, in a word almost everything which was to become the rule in Pre-Raphaelitism. In 1848 the new school found its name; it might rather be said the new brotherhood, for under the influence of John Ruskin—an imperious aesthetician with a passion for French cathedrals and the *quattrocento* Italians, a poet in his way but impregnated with the spirit of puritan asceticism—the group assumed an almost religious character and each of its members had to append to his signature the initials P.R.B. ("Pre-Raphaelite Brotherhood"). Their intention was to react against the facile frivolity of the Lawrence tradition in art, but they traced its decadence farther back to the remote effect of the academic style for which Raphael himself has to be the first to answer. There must be a return to the simplicity of the primitives and a pious copying of nature which carried craftsmanship to the point of compulsiveness. Yet in spite of all this naïveté to which they ardently aspired, the works of the Pre-Raphaelites were everywhere filled with artificiality—and an artificiality more literary than plastic. This is not surprising, since from the start the new school was influenced by two men of letters, the critic Ruskin and Dante Gabriel Rossetti (1828–82), who was poet and journalist before becoming a painter, and always pursued his two callings simultaneously. The Pre-Raphaelites believed that painting must convey a moral message, and that true morality could be found only in Christian teaching. They were truly shocked by the excesses and human suffering caused by the Industrial Revolution, but their answer was an escape from it. Their art was related to the contemporary revivals in architecture and in theology. The group included William Holman Hunt (1827–1910), Sir John Millais (1829–96) and Sir Edward Burne-Jones (1833–98).

George Frederic Watts (1817–1904), who was older than the first Pre-Raphaelites and even than Ford Madox Brown, and who outlived for a considerable time the youngest disciples of the brotherhood, had a career parallel to theirs. But while he too believed that art should serve a moral function, he made no pretense of restoring the naïve and scrupulous technique of the primitives. His portraits are the best part of his work. Frederic Leighton (1830–96) and Sir Lawrence Alma-Tadema (1836–1912) retain, on the other hand, some of the careful precision of the Pre-Raphaelites. While Burne-Jones was still painting his reveries, other artists were attracted by new currents of thought.

J. America

Painting in the American colonies reflected generally the portrait styles in the mother countries, though with a tang of provinciality. In the late 17th and early 18th centuries the Dutch colony of New Amsterdam (New York) had painters whose names today are forgotten. Their work lives on and is signified by names such as the "Master of the De Peyster Boy" and others. Gustavus Hesselius (1682–1755), Swedish born, was painting in Maryland and Jeremiah Theus (*c.* 1719–74), a Swiss, was at work in South Carolina. Peter Pelham (*c.* 1695–1751) and John Smibert (1688–1751) arrived from England, and in the second quarter of the 18th century were painting portraits in Boston, Mass. These two limners were succeeded by John Wollaston (active in America 1749–67) and Joseph Blackburn (*c.* 1700–60); Robert Feke (?1705–?1750), a native American, realized his forms more solidly and with greater originality.

Another native American, John Singleton Copley (1737–1815), working in Boston until 1774, when he went to live permanently in England, was responsible for the finest painting produced in the American colonies. His portraits are racy, original, decidedly un-European in conception.

Benjamin West, another important figure in the history of American painting, settled in London in 1763 and there helped to mold the styles of two generations of American painters. Charles Willson Peale (1741–1827), John Trumbull (1756–1843), John Vanderlyn (1775–1852), Washington Allston (1779–1843), Samuel F. B. Morse (1791–1872) and Rembrandt Peale (1778–1860) all benefited from West's hospitality and teaching in London. Some of their portraits have decided merit (*e.g.*, Morse's "Lafayette," in the city hall, New York), but their pretentious historical pictures were generally unsuccessful. An exception is Vanderlyn's "Ariadne," one of the finest achievements in American figure painting.

Almost a generation older than these painters but younger than West was the portrait painter Gilbert Stuart (1755–1828), who went to England in 1775 and returned to America after 12 years. In London he appears to have spent some years in West's studio and to have been influenced by Gainsborough's work. On his return to America his style became highly individual, and his portraits, polite in spirit, were deftly handled and fresh in colour, the flesh having an extraordinary silvery beauty.

Other popular portrait painters were Thomas Sully (1783–1872) and John Neagle (1796–1865) in Philadelphia, Pa., and Henry Inman (1801–46) in New York city. Sully's fluent style was based on Lawrence, but he developed his own colour and handling.

Landscape painting, which became an important expression of the mild, poetic idealism of America, began about 1825 with the work of the indigenous Hudson River school, Thomas Cole (1801–48), Asher B. Durand (1796–1886) and Frederick E. Church (1826–1900) being some of the most notable masters. Out of this movement came George Inness (1825–94). His early landscapes have a classic spaciousness which gradually gives way to a formless but effective resonance. Others were William Morris Hunt, George Fuller, Elihu Vedder, John La Farge and somewhat later Frank Duveneck and William Merritt Chase.

Picturesque James A. McNeill Whistler (1834–1903) went to Paris as a young man and soon settled in London. He was influenced by Courbet and Ignace Henri Fantin-Latour but especially by Japanese colour prints. His paintings transform people and familiar scenes into colour harmonies of exquisite subtlety. Such portraits as those of his mother and Thomas Carlyle are masterpieces.

Another distinguished painter was the thoroughly American Winslow Homer (1836–1910). He was concerned with life in the open, especially with the sea, and his water colours of such subjects constitute the most powerful expression in American painting.

Thomas Eakins (1844–1916) was another strong personality. His portrait subjects and figures are observed with superb scientific self-discipline, but there is a forbidding renunciation of sensuous appeal. His temperamental opposite was Albert Ryder (1847–1917), who escaped from dingy actuality into dreams. The 19th century closed on the work of the thoroughly expatriate member of the French Impressionist group, Mary Cassatt (1844–1926); of Childe Hassam (1859–1935), exponent of crisp Impressionism; and of the famous John Singer Sargent (1856–1925), whose precocious bravura astonished the English-speaking world.

K. France: 19th Century

At the risk of oversimplifying, French 19th-century painting may be considered as a series of movements or schools representing differing points of view that are common to the other arts of architecture, sculpture, literature and music. Neoclassicism in the late 18th century persisted as the first of the major 19th-century styles. It was followed by a strong trend toward romanti-

cism and that in turn was superseded by Realism. Impressionism, an intense form of Realism limited mainly to the representation of colour and light, gave rise to the Postimpressionist styles which were, in effect, a revolt against the limitations of Realism and Impressionism. Modern art stems from the variety of Postimpressionist painting.

The new art movements, as they first appeared on the scene, seemed to flaunt their differences from the current, prevailing movement. In addition to schools of painting there were painters such as Honoré Daumier who fit into none, and yet seemed to have overtones of several.

The Salon, or public exhibition of painting under government auspices, was another important factor in art in France. In the Salon the conflicts of the schools can be seen in sharp focus. With few exceptions, it was held every year and was under the control of the reigning artists and prevailing styles of the day. The younger artists, the new schools, had to struggle for admission. Classicism was the first of the 19th-century schools, and its first master was Jacques Louis David (*see* above).

The pupils of David were in general marked with an indelible stamp. Some knew how to retain, in one way or another, part of their freedom. Francois Gérard (1770–1837) in his allegorical or mythological compositions did not escape academic frigidity. But when he painted his celebrated picture "Cupid and Psyche," he accomplished elegance and grace. Antoine Gros (1771–1835) had a stronger personality, a sense of drama and an aptitude for expressing it by composition and colour. In the "Pest House of Jaffa" and the "Battle of Eylau" he showed himself as the authentic forerunner of romanticism and of Delacroix. But a strange return of fidelity to the teaching of David paralyzed his natural impulses in the second part of his career.

Jean Louis Géricault (1791–1824), who had the makings of a great artist, was alone capable of finding in David the solid basis of a classic art, and infusing this with passion and life. Unfortunately he died prematurely. "The Raft of the Medusa" (1819) proves that he would have been capable of the highest achievements and the boldest efforts. It deals with a contemporary event but is extremely strained and intense in its emotional power. At once romanticist and Realist it is a forerunner of both movements as well as one of the finest paintings of the first half of the 19th century.

1. Ingres.—Jean Auguste Dominique Ingres (1780–1867) continued the classic Davidian tradition in an age of romanticism. But he looked at Raphael and Poussin rather than at copies of Greek sculpture. He continued history painting in the grand manner but the results lack pictorial unity and are often thin and mannered. In his more modest works, in his nudes and portraits, he attained an astonishing beauty of undulating line. He was only 26 years of age in 1806 when he painted "Madame Rivière" and he already had emancipated himself from David's more static composition. The dynamic movement of the intersecting circles of this portrait, the relationship of interior lines to the oval frame, the swirling flow of drapery make an exciting and vivacious characterization. More than that, the sweeping lines take on an almost independent life of their own. His contemporary opponents were attacking archaic and singular taste when they dubbed him Gothic and Chinese. The sculptor Antoine Auguste Préault, celebrated for his witty sayings, called him a "Chinaman lost in Athens."

One may perceive eccentricity in some of the most beautiful of Ingres' works. A pedant, seeing the back of the "Odalisque," the neck and arm of Thetis in the picture of "Jupiter and Thetis" (Aix museum), the shoulders of "The Bather" in the Louvre, and various exaggerations of form in the "Turkish Bath," would point to this incomparable draftsman's faults. But are not these merely the means by which a great and extremely sensitive artist interprets his passion for the beautiful female form? Ingres has an impeccable sureness, original taste, a fertile and appropriate invention, especially in the pictures where he deals with only a single volume and not with the intricacies of pictorial space. He remains the supreme master of the rhythmic contour line.

2. Delacroix.—Eugène Delacroix (1798–1863), who had learned much from Géricault, became the master of the romantic movement and the unswerving adversary of Ingres. The champions of Davidian classicism claimed to defend order, and accused the romanticists of introducing anarchy and revolution into art. In reality, romanticism, taking the word in its widest sense, prevailed everywhere in the atmosphere of the time, as an aspiration to liberty, poetry and lyricism. There is romanticism in Ingres himself, especially regarding subject matter. As for Delacroix he always repudiated any claim to being the head of a school and liked to pose as a pure classic. Yet if one thinks of romanticism as the transference of the artist's personality in its most intimate, emotional and secret aspect into his work, Delacroix embodies in himself its vital principle. But he had no liking either for painters or men of letters who paraded romanticism. Seen as a whole his work is strong and sound, notwithstanding his tragic sadness, because it aims at great objectives and uses the most rational and efficacious means to attain them. In short, it happened by good fortune that the two men whose influence was to succeed that of David, the one more instinctive and more enamoured of form, the other more intellectual and more preoccupied with dramatic expression, were champions of order, deserving each in his own way the name of classic.

If Ingres had difficulty in the handling of large and complex compositions, it is generally in the relationship of several figures that Delacroix found the natural and striking expression of his ideas. His work is an immense and multiform poem, at once lyrical and dramatic, on the violent and murderous passions which fascinate and dominate humanity. In elaboration and execution, Delacroix does not forego any of his faculties as a man and an artist of vast intelligence standing on a level with the thoughts of the greatest in history, legend and poetry, but he makes use of a feverish imagination always controlled by lucid reasoning and cool will power, of expressive and lifelike drawing, strong and subtle colour, sometimes composing a bitter harmony, sometimes overcast by that sulfurous note, already observed by contemporaries, producing an atmosphere of storm, supplication and anguish. With Delacroix as with Rubens, there hovers over the saddest representations, over tumults, horrors and massacre, a kind of serenity which is the sign of art itself and the mark of a mind master of its subject. Delacroix was willing to take a stand regarding the political events of his time, as in the dynamic "Liberty on the Barricades" (1831), where allegory is fused with social realism, and he also exploited the possibility of exotic subject matter and lush Mediterranean colour in his lion hunts and scenes of oriental life.

Delacroix, who hardly ever painted isolated figures, did paint some portraits of friends. The best is the fine portrait that he made of himself. His *Journal* shows his acute ability at critical analysis and psychological introspection. It is only a series of fragments of which many are made up of careless and unfinished phrases. Nevertheless, this book, unique in being the work of a painter, shows his extraordinary capacity for sensitive understanding of the world of music and poetry as well as of painting.

3. Landscape Painters.—The development of landscape is one of the most salient facts in the history of French painting in the 19th century. David had secured for landscape painters the recognition of their right of citizenship in official art, and at his initiative what was called historic landscape became one of the sections for the Prix de Rome. But this academic and conventional landscape painting was soon renounced by the young men of the generation born around 1810—Louis Cabat, Théodore Rousseau, Jules Dupré, Paul Huet, Jean François Millet, Alexandre Decamps, Camille Flers, Narcisse Diaz de la Peña, Constant Troyon, Antoine Chintreuil, Charles François Daubigny. With unequal merits and varying aspirations they conquered, after many trials, the right to represent nature in either its grandiose or familiar aspects.

The leader of the French landscapists of this period was Théodore Rousseau (1812–67). He profited by the lesson of the English, especially Constable and Bonington, and also by the examples of Delacroix. But he had a philosophic individual mind which gives his meticulous works an aspect of austere grandeur. Starting from an almost scientific analysis, Rousseau terminates in generalizations which out of the fringe of a forest, a chaos of rocks, form a

microcosm, mirroring innumerable terrestrial activities.

4. Corot.—J. B. C. Corot (1796–1875), 16 years older than Rousseau, remained aloof from the disputes between Ingres and Delacroix, between the classic and romantic camps. He spent many years in Rome and painted landscapes not unrelated to Poussin's, but actually closer to a still life by Chardin. In his early paintings, as "Island of San Bartolomeo, Rome," plastic volumes are composed carefully, the planes defining the picture space, while the whole landscape is flooded with carefully controlled light. His figure compositions attain a similar monumentality. His later landscapes, painted in the forest of Fontainebleau, became more hazy and gray in tone, and—they often included dancing nymphs—sentimentally romantic in feeling. Yet it was these late landscapes with their soft, cottonlike trees that became most popular. Corot, owing tribute to the 17th-century painters Poussin and Claude, became a major influence on succeeding generations of Impressionists, who admired his sensitivity to nature and his mastery of light effects.

5. Millet.—At the time when landscape attracted to itself free inquirers in large numbers Jean François Millet (1814–75) and Daumier had the merit of introducing the representation of contemporary life not in the anecdotic form of the *tableau de genre,* which had reached its apex with Ernest Meissonier (1815–91), one of the most prodigious, precious and impeccable virtuosi of soulless painting. Millet sought an epic style in order to paint peasants, their fields, their work, their domestic life and referred to himself as the "peasant of peasants." Having begun with paintings in the romantic fashion high in tone, he turned gradually to simplified design and muddy earth colour, still keeping contact through his studies with this nature which he so religiously loved. His paintings, always and entirely composed in the studio, are the acts of a considered wish, assisted by a methodically exercised memory. "The Gleaners" and "The Angelus," his most famous paintings, while new in subject matter, are actually academic in form, as well as sentimental in content. His drawings, water colours and etchings show a greater sensitivity.

After 1865 the mannerism but not the spirit of his work altered a little, evolving toward more liberty, more suppleness, more cleanness. His pastels multiplied and landscape occupied a larger and larger place. In "Spring" the artist, for the first time, meant not so much to picture a certain site arranged in a certain way as to seize, as the Impressionists were to do, an effect of light not yet observed or rendered with so much truth.

6. Daumier.—Honoré Daumier (1808–79) was best known as a graphic artist during his lifetime. He produced nearly 4,000 lithographs and his prints probably had a wider public than have the works of any other modern artists. But his paintings remained unknown during his time, aside from the recognition of a few exceptional critics such as Charles Baudelaire. Daumier was an illustrator and a deeply human caricaturist who understood the psychological implications of his political and social subjects. Where Millet might strike one as being theatrical, Daumier's more sincere drama profoundly moves one, perhaps because of his magnificent sense for the evocative possibilities of a quickly drawn line and the powerful plastic volume of his figures. His paintings were inspired with such animation and built on a framework of such expressive drawing, the brush handled the colour with such vigour that their vital force is astounding. Daumier explored the action in the law courts, the theatre, and even in the railway carriage—a subject no other painter considered proper for the art of painting. In his "Third-Class Carriage" he developed formal means to bring a haphazard combination of people into a pictorial unity. Yet each individual remains carefully characterized by the artist's personal insight and mastery of form.

7. Courbet.—Gustave Courbet (1819–77) called himself a Realist and was equally opposed to romanticists and classicists for the faraway and long-ago subjects adopted by the painters of both groups. Like Daumier he was highly conscious of social conditions. He believed that instead of dealing with ideas and concepts, or instead of glorifying the past, the painter must represent only both visible and tangible objects. While his pictorial form was rather traditional, his subjects were often strong social commentaries such as "The Stone Breakers" of 1849. He felt that it was incumbent upon the artist to be a spokesman for the people in their social and political struggles and he allied himself with the progressive forces of his day. Yet most of his paintings—nudes, portraits, landscapes, flower pieces—have no political overtones. His work is important for its clarity of statement and his break with the tradition of history painting. It is admirable for its audacity and robust strength, his understanding of formal relationships, and its sheer delight in the material reality not only of its subject but also of the paint itself.

8. Academicians.—The painters discussed were only on the periphery of the Paris art world, while the widely recognized and popular painters continued to adhere to eclectic academic doctrines. Alexandre Decamps (1803–60) and Meissonier were greatly admired for their extremely skillful and deceiving genre paintings. Thomas Couture's (1815–79) vast and tedious canvas, "Romans in the Decadence of the Empire," was considered officially to be the masterpiece of the time. Jean Léon Gérôme (1824–1904), Alexandre Cabanel (1823–89) and Adolphe Bouguereau (1825–1905) combined the now stale classical style with just enough erotic overtones to titillate the Parisian public. Heaped with official awards and commissions, they were able to retain control of French art and the Salon until the end of the century. Pierre Cécile Puvis de Chavannes (1824–98), while basically a conservative painter steeped in the Renaissance tradition, developed a unique style of mural painting in which diffuse light, a unified tonality, an almost geometric order create a slow, measured rhythm of human form and gesture. His murals in Amiens, the Panthéon and city hall in Paris, and the Boston (Mass.) public library constitute a successful approach to an association of painting and architecture. Gustave Moreau (1826–98) created a cycle of fantastic visions and was concerned with the world of thought rather than with appearances. The teacher of many of the Fauve painters (*see* below) including Georges Rouault and Henri Matisse, Moreau, while still using academic form, can also be considered a precursor of the Surrealist movement.

9. Manet.—After Courbet there arose an even more outstanding personality, that of Édouard Manet (1832–83). Then commenced violent press campaigns which little by little inspired the public with horror, disgust and even a kind of incredible hatred for the young artists whom they considered as revolutionaries. Those young artists were first Manet, then the whole group of comrades of whom he was the eldest, and who used to meet in the Café Guerbois: Degas, Cézanne, Renoir, Monet and the others. Even Manet's person was scandalously misinterpreted; most Frenchmen thought that the author of the "Luncheon on the Grass" and "Olympia" not only ignored the first rudiments of the art of painting and that his pictures were ridiculous, but that he himself was a kind of coarse, extravagant, unconventional Bohemian. Until his premature death, the charming, witty and elegant, but also nervous and irritable Manet could not become reconciled to this injustice. He knew the fascination that he exercised on his friends, and he would have liked to please everyone: conscious of his exceptional gifts, he felt he was destined for the acclamations bestowed on Rubens or Velázquez. As they had done he developed a new visual form. He abandoned all shadows and gray tones and simply laid on light and dark immediately next to each other without soft traditional modeling. Forms were kept flat and colour areas were applied solidly much as in Japanese woodcuts which were just coming to the attention of European painters and which exerted an enormous influence on Manet and his Impressionist and Postimpressionist followers. While critics and public both exhibited only animosity to Manet's painting, the younger (Impressionist) artists rallied around him, and he himself was to be influenced by their light palette and interest in the quick and momentary impression. Toward the end of his life, in a masterpiece such as the "Bar at the Folies-Bergère" of 1882, he documented a contemporary scene, and here showed his great interest in a complex space structure and in harmonies of colour and sparkling light.

10. Monet and the Impressionists.—Impressionism was a movement which carried the realist and pragmatist ideas of the period to their logical conclusion. The Impressionist painter like the

Realist was concerned with the visible aspects of reality, but was also interested in the immediate appearance at a momentary glance. He was fully conscious of the continuous change in nature and felt that the changing appearance was due to changes in light. Colours became brighter than ever before in the history of painting because they were conceived of as a function of light. The Impressionists wanted to achieve the brightness of sunlight on their canvases. They soon realized that even a bright yellow could be reinforced by placing it next to its complementary, violet. Colour and light were to create shape and space. Space as it had been known since the Renaissance was abandoned as an important structural factor. Reality, to be sure, has many faces, and the Impressionists were concerned almost exclusively with the way reality appeared to their eyes. Inner reality, thought and vision had no place in their theories except insofar as the painters were concerned with their personal reaction to visual facts. Claude Monet (1840–1926), the originator and most complete protagonist of the Impressionist movement, made dozens of different paintings of the same subject, always completed outdoors. In his series of haystacks, cathedrals or water lilies he was not interested primarily in his subject—one painting would have sufficed if he had been—but in the light reflections on the subject. He therefore had to paint many pictures of the same subject, but the content had become the reflected light and this, in a way, is an abstract concept. Monet's energy and passion made him to a certain extent a visionary, and it is surely not the characteristic of a narrow conception of art to close a career of landscapist with that unprecedented and unclassifiable work, "Le Bassin aux Nymphéas," a vast cyclic poem of the water, flowers, leaves and light, to which he devoted in solitude at Giverny the last 20 years of his long life.

Alfred Sisley (1839–99) was no theorist; once provided with the technique acquired from Monet, his only ambition was to be a charming minor painter of the countryside. Camille Pissarro (1830–1903) was the oldest member of the group. He had the greatest admiration for Corot and in certain pictures where at first glance only the technical preoccupations are seen, there may also be discovered a desire for order and organization, which the doctrine of Impressionism did not encourage. Pissarro wandered more than once beyond the horizons of pure Impressionism, and was able to play the curious and glorious role of teacher to Cézanne, Paul Gauguin and Georges Seurat, the three men who, with different means, were to lead French art into new paths.

11. Renoir.—Pierre Auguste Renoir (1841–1919) studied under Charles Gleyre at the French academy, where he met Monet and Sisley. Leaving the atelier he came under the influence of Courbet, but he soon dissolved his colour areas and began to work outdoors. As a leader of the Impressionist group, he helped develop the Impressionist technique for the representation of the human figure which was to remain his prime interest. The contours of his figures were dissolved. His people became an integral part of their natural environment, and a dancing light pattern is created on them from the effect of sunlight coming through foliage. Renoir used a warm, sensuous palette for the movement of leaves, water and the human figure. After 1880 Renoir felt that momentary effects were not enough and that the painter had to draw and compose. He disciplined and tightened his painting under the inspiration of Raphael and Ingres. Finally, about the turn of the century, Renoir evolved a unity of colour, line, volume and light for his glorious paintings of large nudes set into rich landscapes. Almost intuitive in his technical accomplishments, Renoir was the least conscious theorizer among his contemporaries. His love for colour and his insistence upon the sensuous elements of nature counteracted much of the subjective and overanalytical tendencies of the art of his own time, and contributed immeasurably to a painter such as Matisse who was later to appear as the leader of *Les Fauves*.

12. Degas.—Hilaire Germain Edgar Degas (1834–1917) was still less an Impressionist, if it is possible, than Renoir. An incisive designer and prodigiously accurate, he was indebted to Holbein and Ingres. The public called him the painter of ballet dancers. Degas was no more a specialist of dancers than he was of modistes or jockeys. What attracted him successively or simultaneously to these subjects of study was the desire to grasp in an extraordinarily precise and expressive stroke gestures and movements which the eyes of painters until then had ignored. He loved the disciplined movement of the ballet dancer and the race horse. It was with the same preoccupations that, during 10 or 15 years, he made himself a portrait painter. The impression of truth conveyed was secured by the drawing with its closed form and unusual composition. Finding entirely new types of composition was a great part of his research; his inventions in this field were most original and bold, and have had capital consequences for modern painting and photography. He did not share the Impressionists' love for light and colour, and the disdain he had for the open air was a final trait contrary to the process and convictions of the orthodox Impressionist. He did share with the Impressionist his intention to convey a momentary scene, but while Monet would be satisfied with the impression of the object, Degas caught the essence of action itself.

III. MODERN PAINTING (LATE 19th AND 20th CENTURIES)

A. Postimpressionism

1. Toulouse-Lautrec.—Henri de Toulouse-Lautrec (1864–1901), descendant of one of the oldest families of the French nobility, became a great admirer of Degas and chose similar subject matter and related means of expression. In his paintings, drawings, lithographs and posters he developed an evocative line which expressed his understanding of human action. He frequently used large bold planes of colour and was likely to tilt his space upward. Toulouse-Lautrec lived in Montmartre and painted the cabaret, theatre, dance hall and circus—the entertainers and the customers. A dance hall by Toulouse-Lautrec, such as the famous "At the Moulin Rouge," was no longer the pleasant, graceful and gay garden party seen by Renoir; it became a joyless place where people seek escape and where Toulouse-Lautrec could observe them with deep psychological insight. He was less concerned with the play of light and shadow and much more with the human comedy or tragedy.

2. Seurat.—Among the Postimpressionists, the contributions of Georges Seurat (1859–91) were many. He never concealed how much his inventive technique owed to Monet. He personified an intellectual reaction against the dispersive and undisciplined tendencies of Impressionism. He possessed a sense of order and grandeur and he found a technique and style to convey this sense of disciplined form. Along with his exacting colour science, his classic sense of composition and space division was almost unrivaled since that of Piero della Francesca and Paolo Uccello. His formality of design, discipline of pattern and understanding of space interval were executed in a refined colour scale broken into tiny, perfectly matched strokes, which earned this movement the names of Divisionism, Pointillism and Neoimpressionism. Seurat's contribution is largely summed up in his masterpiece, "Sunday Afternoon on the Isle of Grande Jatte." He was also one of the immediate ancestors of both the Cubists and *Les Fauves* (*see* below). Followers of Seurat who stylized his idiom of brush stroke and broken colour to various points of exaggeration, though their work is not without charm and sometimes importance, were Paul Signac (1863–1935), Henri Edmond Cross (Delacroix) (1856–1910) and Van Rysselberghe. Of all Seurat's followers Signac was the best known and is credited with actually having originated the colour system practised by Seurat, mainly that of painting in tiny mosaics of warm and cool colour and of uniform stroke, which were perfectly adjusted according to preconceived theories based upon the writings of Michel Chevreul, Hermann von Helmholtz and Ogden N. Rood. In Seurat's case there was perfect balance of hue, value and intensity. Signac's contribution lies not in his overstylization of this colour theory in his oil paintings but rather is to be seen in his water colours, which have a lyrical and compelling charm.

3. Van Gogh.—Vincent van Gogh (1853–90), appearing as a meteor at the time when Impressionism began to triumph, did not dwell upon repetition. He made use of the conquests, but only as instruments for the lyricism and mysticism through which his sparkling genius looked on nature. In Feb. 1886 he arrived in

BY COURTESY OF THE ART INSTITUTE OF CHICAGO, PHOTO BY RICHARD J. BRITTAIN

"Artist's Garden at Argenteuil" by Claude Monet (1840–1926), French. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

MONET AND CÉZANNE

"Gulf of Marseilles, Seen from L'Estaque" by Paul Cézanne (1839–1906), French. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

BY COURTESY OF THE MINNEAPOLIS INSTITUTE OF ARTS

"Tahitian Landscape" by Paul Gauguin (1848–1903), French. In the Minneapolis Institute of Arts

GAUGUIN AND VAN GOGH

"Boats at Ste. Maries" by Vincent van Gogh (1853–90), Dutch. In the V. W. van Gogh collection, Stedlijk museum, Amsterdam, Neth.

BY COURTESY OF STEDLIJK MUSEUM

BY COURTESY OF THE MINNEAPOLIS INSTITUTE OF ART

"Dining Room in the Country" by Pierre Bonnard (1867–1947), French. In the Minneapolis Institute of Art

BONNARD AND MATISSE

"Red Studio" by Henri Matisse (1869–1954), French. In the Museum of Modern Art, New York city

BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK, MRS. SIMON GUGGENHEIM FUND

PAINTING

"La Noce" ("The Wedding") by Henri Rousseau (1844–1910), French. In the collection of Mme Jean Walter, Paris

"Figure in an Interior" by Henri Matisse (1869–1954), French. In Crowningshield collection

"Portrait of a Girl" by Amedeo Modigliani (1884–1920), Italian

EARLY 20TH-CENTURY EUROPEAN PAINTING

Above: "Les Amoureux" ("The Lovers") by Pablo Picasso (1881–), Spanish-French. In the National Gallery of Art, Washington, D.C.

Right: "The Old King" by Georges Rouault (1871–1958), French. In the Carnegie Institute, Pittsburgh

BY COURTESY OF (TOP LEFT) THE MANSELL COLLECTION, LONDON, (TOP RIGHT, CENTRE RIGHT, BOTTOM LEFT) THE REINHARDT GALLERIES, (BOTTOM RIGHT) CARNEGIE INSTITUTE, PITTSBURGH: PHOTOGRAPH, (TOP LEFT) GIRAUDON

BY COURTESY OF THE MUSEUM OF MODERN ART

"GIRL BEFORE THE MIRROR," BY PABLO PICASSO (1881–)

A painting of 1932 by the Spanish-born artist. In the Museum of Modern Art, New York city (gift of Mrs. Simon Guggenheim)

PAINTING

"Still Life: Le Jour" by Georges Braque (1882–1963), French. In the National Gallery of Art, Washington, D.C.

"La Table du Café, Abstraction in Gray" by Juan Gris (1887–1927), Spanish-French. In the Art Institute of Chicago

CUBISM AND EXPERIMENTAL PAINTING OF THE 20TH CENTURY

"Nude Descending a Staircase" by Marcel Duchamp (1887–), French. In the Philadelphia Museum of Art

"Dog on a Leash" by Giacomo Balla (1871–1958), Italian. In the Museum of Modern Art, New York city

"Le Grand Déjeuner (Three Women)" by Fernand Léger (1881–1955), French. In the Museum of Modern Art, New York city

BY COURTESY OF (TOP LEFT) NATIONAL GALLERY OF ART, WASHINGTON, (TOP RIGHT) THE ART INSTITUTE OF CHICAGO, (CENTRE RIGHT) A. CONGER GOODYEAR, (BOTTOM LEFT) PHILADELPHIA MUSEUM OF ART, (BOTTOM RIGHT) THE MUSEUM OF MODERN ART, NEW YORK CITY; PHOTOGRAPHS, (CENTRE RIGHT) THE MUSEUM OF MODERN ART BY SOICHI SUNAMI, (BOTTOM RIGHT) SOICHI SUNAMI

"The Street" by Ernst Ludwig Kirchner (1880–1938). German. In the Museum of Modern Art, New York city

"Portrait of Dr. Schwarzwald" by Oskar Kokoschka (1886–), Austrian. In a private collection, Krefeld

EXPRESSIONISM AND THE GERMAN SCHOOL

"Masks" by Emil Nolde (1867–1956), German. In the William Rockhill Nelson Gallery of Art, Kansas City, Mo.

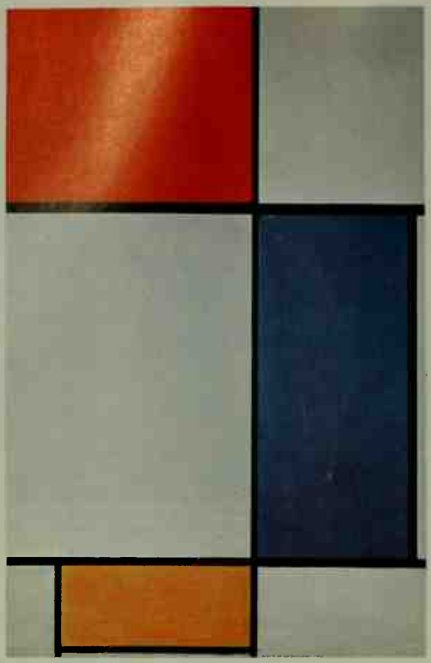
"The Cry" by Edvard Munch (1863–1944), Norwegian. In the National gallery, Oslo

"Self-Portrait" by Max Beckmann (1884–1950). German. In the Busch-Reisinger museum, Harvard university

BY COURTESY OF (TOP LEFT) THE MUSEUM OF MODERN ART, NEW YORK CITY, (TOP RIGHT) PAUL CASSIRER, (CENTRE LEFT) WILLIAM ROCKHILL NELSON GALLERY OF ART, KANSAS CITY, MO., (BOTTOM LEFT) BUSCH-REISINGER MUSEUM, HARVARD UNIVERSITY, (BOTTOM RIGHT) NASJONALGALLERIET, OSLO; PHOTOGRAPH, (TOP LEFT) SOICHI SUNAMI

PAINTING

MONDRIAN AND KANDINSKY



BY COURTESY OF JOHN L. SENIOR, JR., PHOTO FROM TIME, INC

Left: "Large Composition with Red, Yellow, and Blue" (1928) by Piet Mondrian (Pieter Cornelis Mondriaan, 1872–1944), Dutch. In the collection of John L. Senior, Jr.

Below: "Black Lines" by Wassily Kandinsky (1866–1944), Russian. In the Solomon R. Guggenheim museum, New York city

BY COURTESY OF THE SOLOMON R. GUGGENHEIM MUSEUM

"I and the Village" by Marc Chegall (1887–), Russian. Museum of Modern Art, New York city

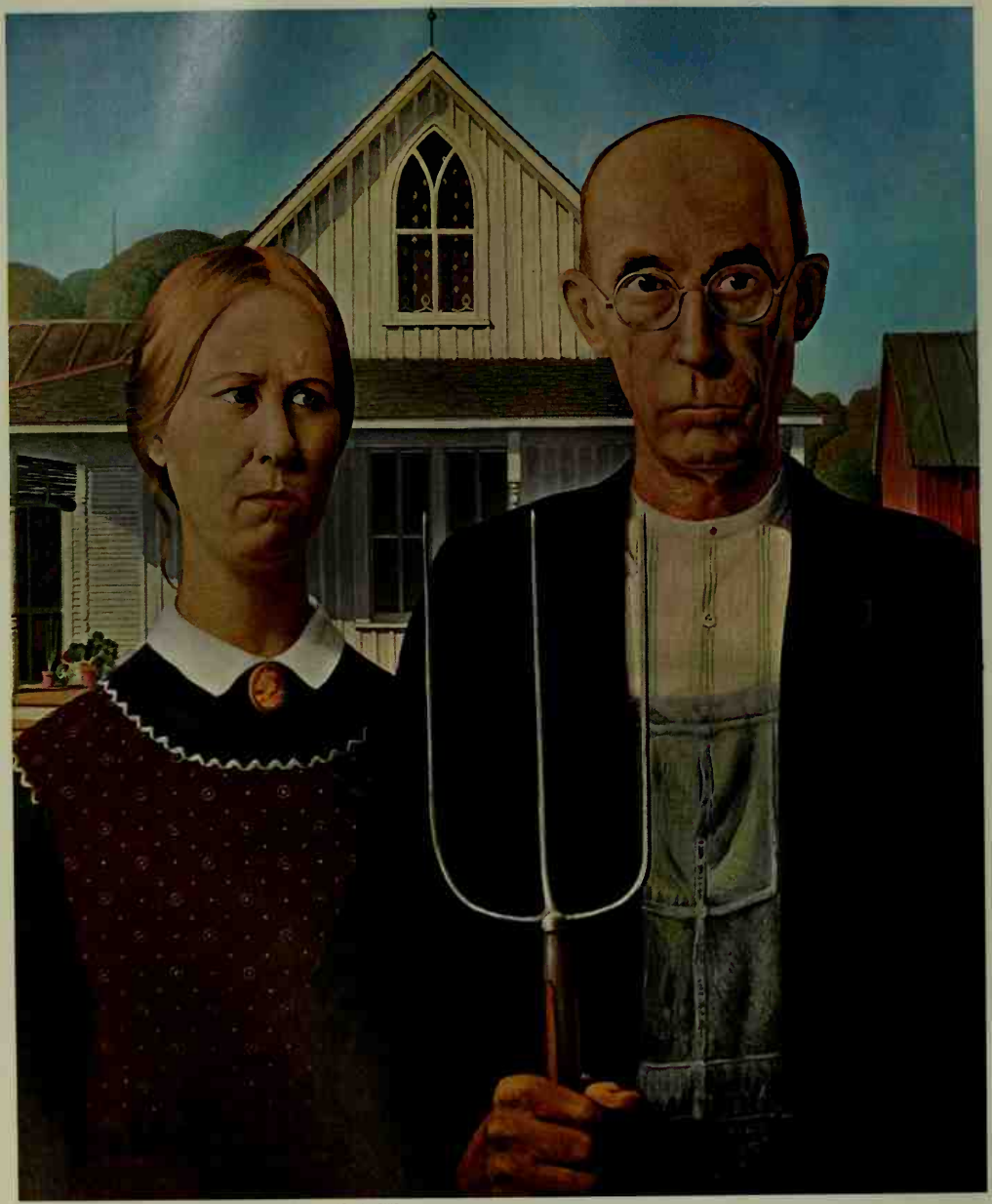
"Evil Genius of a King (Toys of a Prince)" by Giorgio de Chirico (1888–), Italian. Museum of Modern Art, New York city

"Soft Construction With Boiled Beans; Premonition of the Civil War" by Salvador Dali (1904–), Spanish. Philadelphia Museum of Art

FOUR PAINTERS OF FANTASY

"Person Throwing a Stone at a Bird" by Joan Miró (1893–), Spanish. Museum of Modern Art, New York city

BY COURTESY OF (TOP LEFT) THE MUSEUM OF MODERN ART, N.Y.; MRS. SIMON GUGGENHEIM FUND. (TOP RIGHT, BOTTOM RIGHT) THE MUSEUM OF MODERN ART, N.Y., (CENTRE LEFT) PHILADELPHIA MUSEUM OF ART; ARENSBERG COLLECTION; PHOTOGRAPHS (TOP LEFT, TOP RIGHT, BOTTOM RIGHT) SOICHI SUNAMI



THE ART INSTITUTE OF CHICAGO; PHOTOGRAPH COURTESY OF LIFE MAGAZINE

"AMERICAN GOTHIC," BY GRANT WOOD (1892–1942)

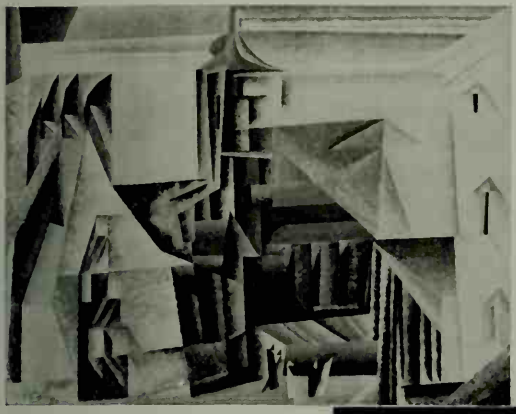
Oil on panel, painted in 1930. In the collection of The Friends of American Art, The Art Institute of Chicago

"Toilers of the Sea" by Albert P. Ryder (1847–1917). In the Addison Gallery of American Art

"Dempsey and Firpo" by George Bellows (1882–1925). Whitney Museum of American Art

U.S. PAINTINGS, 19TH AND 20TH CENTURIES

"The Church" by Lyonel Feininger (1871–1956). Städtisches Museum, Wuppertal-Elberfeld, Ger.



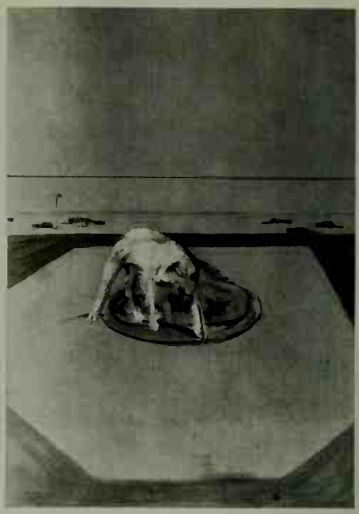
"My Egypt" by Charles Demuth (1883–1935). Whitney Museum of American Art

"Daughters of the Revolution" by Grant Wood (1892–1942). Private collection

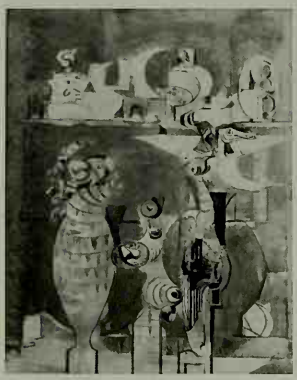
BY COURTESY OF (TOP LEFT) ADDISON GALLERY OF AMERICAN ART, PHILLIPS ACADEMY, ANDOVER, (TOP RIGHT, CENTRE RIGHT) COLLECTION OF THE WHITNEY MUSEUM OF AMERICAN ART, NEW YORK, (BOTTOM) EDWARD G. ROBINSON; PHOTOGRAPHS, (TOP LEFT) ANDOVER ART STUDIO, (CENTRE RIGHT) SOICHI SUNAMI, (CENTRE LEFT) HANFSTAENGL, (BOTTOM) INTERNATIONAL

PAINTING

"Seaton Delaval" by John Piper (1903–). In the Tate gallery, London



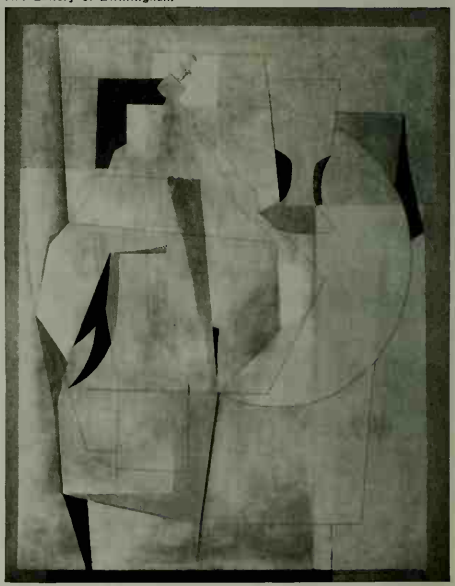
"Study of a Dog" by Francis Bacon (1910–). Tate gallery



"The Origins of the Land" by Graham Sutherland (1903–). Tate gallery

20TH-CENTURY ENGLISH PAINTING

"Still Life (Dolomites)" by Ben Nicholson (1894–). Museum and Art Gallery of Birmingham



"Small Assembly of Figures" by Keith Vaughan (1912–). Tate gallery

BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE LEFT, BOTTOM LEFT) THE TRUSTEES OF THE TATE GALLERY, LONDON, (BOTTOM RIGHT) MUSEUM AND ART GALLERY OF BIRMINGHAM, ENG.

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

"The Herring Net" by Winslow Homer (1836–1910), U.S. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

HOMER AND HOPPER

"Nighthawks" by Edward Hopper (1882–), U.S. In the Friends of American Art collection, Art Institute of Chicago

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

BY COURTESY OF SIDNEY JANIS GALLERY, NEW YORK

"Woman II, 1952" by Willem de Kooning (1904–), U.S. In the Sidney Janis gallery, New York city

THREE CONTEMPORARY U.S. PAINTERS

"Transit" by Mark Tobey (1890–), U.S. In the Metropolitan Museum of Art, New York city

BY COURTESY OF THE ARTIST

"No Turns Permitted" by Reginald Marsh (1898–1954), U.S. In the collection of Mrs. Reginald Marsh, New York city

BY COURTESY OF IVAN ALBRIGHT

"Poor Room—There Is No Time, No End, No Today, No Yesterday, No Tomorrow, Only the Forever, and Forever, and Forever, Without End" by Ivan La Lorraine Albright, U.S. Property of the artist

IVAN ALBRIGHT

PAINTING

BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK CITY, ABBY ALDRICH ROCKEFELLER FUND

"Handball" by Ben Shahn, U.S. In the Museum of Modern Art, New York city

SHAHN AND GRAVES

BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK CITY

"Little Known Bird of the Inner Eye" by Morris Graves, U.S. In the Museum of Modern Art, New York city

Paris, and at once his originality burst forth like an explosive placed too near a fire. Brief was the period of his short life in which was created all that made him a great painter. He had become acquainted with Degas, Seurat, Toulouse-Lautrec and Gauguin, and owed much to each of them. He shared their passion for the Japanese print.

Van Gogh had an intense empathy with natural forces and with human emotions. Where the Impressionists were interested in sunlight, Van Gogh became a worshiper of the sun. He went to Arles in the south of France where there was little haze and the bright sunlight isolated all details in the landscape and gave it pronounced outlines. In his mature paintings, done during four or five years, he used line, colour and brush stroke with extreme intensity, employing them arbitrarily and rather abstractly to make them yield the greatest force. He set out to recreate the feeling evoked by a field, a poolroom, a starlit sky; his work succeeds in stimulating the spectator into a complete emotional response. The ecstasy of his colour and the vigour of his surfaces communicate to the observer a heightened awareness, which, after all, may be considered the essence of the aesthetic experience. When Van Gogh committed suicide in 1890 he left a remarkable body of work to stimulate future generations of artists as well as that public which had shown no appreciation of him during his lifetime.

4. Gauguin.—Both Van Gogh and Paul Gauguin (1848–1903) were able to raise subject matter of their own choosing, through intensity of colour and breadth of design, to the power of a symbol. These two painters had the greatest influence on the parallel movements of Expressionism which developed in France and Germany during the first decade of the 20th century. Van Gogh created a type of frenetic, spiritual Expressionism through temperamental violence expressed in intensity of colour and impassioned calligraphy. The elements of Van Gogh's art are perhaps more personal and direct than are those of his associate. Gauguin found his point of departure in the combined influences of Puvis de Chavannes and Impressionism. His character, his life and his work are nothing but contrasts. Gauguin threw himself into his work with a wild vehemence and with a mixture of brutality, refinement, impulsiveness and reflection. He searched for the primitive and savage in Tahiti, where, after years of rage and disillusionment, he died miserably. But it was not only idyllic savagery that he went so far to find, but also order. Introduced by Pissarro to Impressionist vision and technique, he felt the need to control form. Together with a group of disciples in Pont Aven in Brittany he developed a style called Synthesism or Cloissonism. Here the artist flattened out space, simplified design, and heightened colour by using large, flat colour areas bounded by dark lines. The final composition was rather arbitrary or synthetic and no longer determined by the visual forms of nature. The evocative force of line, shape and colour to suggest broad ideas and thoughts was considered more important than the imitation of nature. Gauguin finally left the sophisticated art world of France altogether for the South Sea islands. He reflected a growing trend in modern painting with his return to the primitive in both art and nature, and his measurement of great areas of colour with their subsequent symbolic effects. He disagreed with the minute brush strokes and the disintegration of recognizable physical forms through colour, practised by the Impressionists. He cried for "a metre of green," rather than the stroke by stroke vibration of mingled hues pursued by the original Impressionists. But even in the works composed during his Tahiti period the colour scale which he used for synthetic effects is traceable more or less directly to that handed down by Pissarro as an instrument of analysis. But, in proportion to the development of his singular personality, he withdrew farther and farther from Impressionism, while, underneath the brown skin of the South Sea "Vahines," the relationship of his Maori dream with the imaginary world of the Greco-Latin Puvis de Chavannes shines through.

5. Redon.—While Gauguin's influence on the succeeding generation of painters in France and in Germany was enormous, his contemporary Odilon Redon (1840–1916) had less effect. Redon as well as Gauguin was close to the Symbolists in French poetry and was preoccupied with the power of suggestion and inference. The artist, they felt, must "clothe the idea in visible form" and explore the world of the imagination. Redon was an artist who was essentially a visionary and a colour poet, in some ways related to mystical painters of inner vision such as William Blake and Gustave Moreau. The Surrealists, who were also concerned with the meaning of the symbol, were to pay homage to Redon.

(P. Ja.; P. H. S.)

6. Cézanne.—The greatest revolutionary figure of Postimpressionism and acknowledged father of modern art was Paul Cézanne (1839–1906). Cézanne was typically a French painter in the historical, traditional sense, inasmuch as his art and spirit both consummately derived from studying the masterpieces in the museums. Many historians have noted that the most revolutionary figures in modern French painting have been largely trained through intense study in the museums and picture galleries, principally the Louvre. Cézanne's ideal was to make the art of the Impressionists "something solid and enduring, as the art of the museums." He also stated in spite of his ardent admiration of Delacroix that he wished "to re-do Poussin after nature." While always deeply concerned with the analysis of the object, he still liberated painting from imitation or narration. In discussing Cézanne's water colours, Lionello Venturi noted that his conception of the true nature of painting as distinct from that of reality made him unique. This, in a sense, described the complete difference between the concepts of painting in the 20th century and those of any other time; that is, the artist re-created the world, and it lay definitely and abstractly within the limitations of the picture frame or the boundaries of the canvas or paper.

Added to this theory of painting for its own sake is Cézanne's often-quoted advice to his friend and pupil, Émile Bernard, that he "Interpret nature in terms of the cylinder, the sphere, the cone; put everything in perspective, so that each side of an object, of a plane, recedes toward a central point." Though the Cubists were to use this as their justification for laying bare the geometric essentials of nature, it should be noted that nowhere did Cézanne speak of the cube as such, nor in his desire for "realization of the subject in nature" was there any indication that he would have adopted, let alone approved, Cubism itself. Cézanne's formal contributions became of increasing value and interest to other artists after his death in 1906. His conception of reality was based on the fundamental structure of the subject in nature which he often called the motif. For this aspect of structure, which was of an architectonic nature, he sacrificed all literary and most personal overtones, along with incidental, naturalistic detail. Consequently his still-life compositions, landscapes, portrait studies and figure compositions achieve a singularly monumental and often austere quality. In recreating an image or object, Cézanne's physical or plastic forms are analyzed in planes of colour, in which he, to quote his own term, "modulates" the colour, rather than modeling or blending it in the conventional sense, or using chiaroscuro.

Cézanne used the prismatic colour scale of Claude Monet and that of his close friend and teacher, Pissarro, painting in planes of warm and cool colour. However, he often sacrificed the purity and intensity of the local colour (*i.e.*, the essential redness of the apple) for reflected colour and refracted colour. He would change also the local or natural colour to establish a unity or synthesis, thus establishing a definite colour balance. He constantly reinforced the contours of various parts of the composition to create emphases and tensions within the picture plane. In relation to his pattern forms, there is a tremendous tension between the surface of the picture and the implied depth or what might be described as acoustical space.

Cézanne conceived a composition in which all solids contain a certain inherent energy made up of many faceted forms or planes. Each form in the composition exerts an influence as it impinges on another form, often resulting in distortion and tension. The spatial relationship between forms was more important to Cézanne than the individual forms themselves. The physical forms themselves seem to exert certain tensions against the surrounding space, whereas the intervals of surrounding space are modulated, measured and timed with counter force in relation to the forms. This approach alone is enough to suggest the beginnings of both ana-

lytical and synthetic Cubism. This contributed to Futurism, which was in turn related to Cubism.

From the various aesthetic points of view of his contemporaries, such as the Impressionists, along with their reinterpretation of the old masters, Cézanne created a new kind of pictorial composition or organization in which the vertical was used to give a greater depth. He also created a new architecture of landscape as well as of still-life painting. He evolved a symbolic attitude which was the integrity of painting for painting's sake, vastly different from the ivory tower art for art's sake.

7. Early 20th-Century Trends.—During the first half of the 20th century Paris was no longer the only significant art centre of the world. The all-important Expressionist movement had its nucleus in Germany, and nonobjective painting began in Germany and Russia. Yet Paris maintained its position as the most important focal point at least until the outbreak of World War II.

Modern painting, in one sense, began with the closing years of the career of Cézanne. Actually, Cézanne's personal preoccupation was to achieve a new kind of realism, but many of his remarks, especially when lifted from context, pointed toward abstraction, for he was almost obsessed with the geometric understructure of natural forms. There can be little doubt that this led quite directly to many of the formulations contained in Cubist painting. The use of Cézanne as the authority, along with the discovery on the part of Maurice de Vlaminck, Ernst Ludwig Kirchner, André Derain and Pablo Picasso of African sculpture with its ultrasimplified forms, led the Cubists, Fauvists and Expressionists into an entirely new manner of representation. Beginning with Cézanne each movement was in a sense first a revolt against Impressionism and second a revolt against the preceding rival group.

However, there were several other acknowledged masters of the late 19th century who extended their influence and laid the foundations of the various trends which made up the movement known generally as Postimpressionism, a journalistic term used both by Roger Fry and by Clive Bell, English critics. Included among the Post-impressionists were Van Gogh, Gauguin, Seurat, Renoir and Redon. Added to these was Henri Rousseau (1844–1910), the so-called primitive or naïf, whose example led to a whole school of untutored modern primitives flourishing both in Europe and America. Few of these, however, attained the force of design and intensity of fantasy found in the work of Rousseau.

In addition, the more isolated figures of the Belgian James Ensor and the Norwegian Edvard Munch had an influence on 20th-century painting.

B. Intimism

The tradition of Impressionism (*q.v.*), which began officially with the first exhibition in Paris held in 1874, continued in the careers of two outstanding artists, Pierre Bonnard (1867–1947) and Jean Edouard Vuillard (1868–1940), generally referred to as the Intimists. Bonnard was famous for his burning landscapes and arrangements of luscious fruits that seemed to burst with the intense sunlight of southern France. He also brought the luminous touch and iridescent colour scale of the Impressionist landscape painters to the tender and familiar studies of women placed in the quiet surroundings of garden or boudoir. Vuillard, with a lighter staccato touch and conversational intimacy, through many adroit considerations of space and the placing of his figures in richly patterned surroundings, created a new decorative art with the genre of interior painting. Vuillard, in particular, carried over the orientalism of the 19th century along with an original and sensitive feeling for the same unusual spatial elements that imparted such vitality and commanding vision to the posters of Toulouse-Lautrec. The importance of Bonnard and Vuillard lies in their ability to partake of the tradition of the Symbolists (*q.v.*) and of the Nabis, a group led by Maurice Denis. Bonnard and Vuillard maintained much of the intensity of Gauguin's colour, at the same time keeping the perennial "innocence of the eye" often used to characterize the original Impressionists. It may be considered that Bonnard in particular added essentially to the history of modern colour usage, whereas Vuillard called attention to new combinations of space interval and subtle relationships of values even in the most humble and unpretentious vignette.

C. Fauvism

The first significant revolt against Impressionism occurred in 1906 in the autumn Salon. By that time Impressionism had become a nearly international formula and was soon to be a vehicle for merely sketching from nature. With the discovery of African sculpture and the growing activity in fields of archaeological research, artists found a wealth of new inspirational material. Among these sources of inspiration were Persian and Indian miniature painting, all the arts and crafts which appeared to be exotic and a revaluation of the Gothic. The artist turned to the anthropological and archaeological collections and drew directly. Beginning with Whistler and other painters working in France, generous use had been made of oriental material, particularly the Japanese print, along with Chinese porcelains and textiles. The Impressionists continued the exploitation of these sources, whereas Gauguin went a step further and established the cult of the primitive.

Both Fauvism and Cubism were respectively named as derisive comments and supposedly each by leaders of the opposing movements. *Les Fauves*, variously called the "Wild Beasts" or the "Wild Men," were distinguished by a general freedom of colour usage and design elements. Actually the entire movement was a form of subjective Impressionism, in which the formal elements of painting appeared to be used quite arbitrarily. The leaders of the movement were Henri Matisse (1869–1954), Georges Braque (1882–1963), Raoul Dufy (1877–1953), Maurice de Vlaminck (1876–1958), André Derain (1880–1954), Émile Othon Friesz (1879–1949), Kees van Dongen (1877–), Georges Rouault (1871–1958), Charles Dufresne (1876–1938) and André Dunoyer de Segonzac (1884–). Some of these painters, such as Braque and Derain, also worked along with the Cubists. Braque especially was the most consistent master of Cubism among French painters. Derain occupied the position of a museum painter since he was the most apparent in self-conscious scholarship and the revival of historical styles and mannerisms.

1. Matisse.—The greatest contribution of the group centred in Matisse, whose use of colour alone completely revolutionized its decorative and emotional values in modern painting. In point of view of colour Matisse many times revised the practices of the interior decorator, elevating him to the position of a "colour engineer." Matisse, first academically trained under Adolphe Bouguereau, became an official copyist in the Louvre, supplying for the government replicas to be placed in provincial museums and for sale to private buyers. He was invited by Moreau to work in his studio along with Rouault. Later he worked in the Impressionist manner, and it was then that he turned to Japanese prints and Persian sources. Along with Derain he discovered Cézanne, and also began to make personal variations on old master themes which he had successfully copied. About the time of the first showing at the autumn Salon Matisse began to establish a definite style of intense, unmixed colour, broadly applied on a flat, two-dimensional surface. He later stated: "What I am after above all is expression . . . the whole arrangement of my picture is expressive . . . composition is the art of arrangement in a decorative manner . . . for the expression of what the painter wants . . ."; but also, "What I dream of is an art of balance, of purity and serenity, devoid of any troubling subject matter . . . like a good armchair in which to rest from fatigue." Matisse may be regarded as the most important successor to Renoir, inasmuch as his long procession of still-life arrangements, interiors with figures, odalisques and compositions taken from the Riviera form an unbroken sequence of colourful essays in sensuous objectivity. The work of Dufy ran closely parallel to that of Matisse, conditioned, of course, by his personal temperament and marked by a witty and highly personal calligraphy which described vignettes of the race track, the château country, the yacht harbour. To all of these and to even conventional subjects Dufy lent his gay and descriptive handwriting and feeling for playful decoration.

2. Rouault.—The other painters of this group are discussed as members of the School of Paris, but Rouault must be singled out. Long considered the most significant painter of religious subject matter in the 20th century, Rouault was a solitary master following a mystic line of inner vision. At one time keeper of the collection of Moreau, he absorbed from his teacher much of the intensity and hallucinatory atmosphere that so inspired Moreau's literary friends, the novelists Gustave Flaubert and Joris Karl Huysmans. Once a designer of stained glass windows, he interpreted the troubled passion of the Gothic with deeply felt religiosity. The vivid and heavily encrusted colour and leaded black line used to interpret rather than depict the martyrdom of mankind—whether the subject be that of Christ, clowns or prostitutes—came close to the actualities of medieval life and sentiment. His is a strange, sorrowful, sometimes bitter and strident note in the modern world.

3. Dufy and Vlaminck.—Both Dufy and Vlaminck were still young painters at the time of their association with the Fauvists, neither of them having arrived at the individual style that marks their mature work. Dufy painted with simple, solid and brilliant colour. Vlaminck, who is credited with creating a sudden enthusiasm for African primitive sculpture, freely improvised with both structure and colour, and for a time was perhaps the wildest of the Fauvists. However, his mature style which identified him with the School of Paris is represented by a series of vigorous and impetuous landscapes and still-life studies largely painted in dramatic colour contrasts and an irregular, heavy impasto applied with the palette knife. But he finally settled down to a constantly repeated formula of stormy landscapes. Another painter sometimes associated with *Les Fauves* was Albert Marquet (1875–1947), who usually worked in a quiet colour key, but whose simplifications of natural forms relate him to phases of the earlier Matisse.

D. Cubism

Pablo Picasso is generally considered the first painter to produce an important Cubist composition—"The Ladies of Avignon," painted in 1906–07, partially based upon Negro sculpture as well as Iberian masks, and related also to the structural simplifications of Cézanne. It is perhaps more of a document than a completed masterpiece.

There are many classifications of Cubism. However, three aspects of the movement largely dominate its history: (1) Negroid, which is combined with (2) analytical Cubism (seeking the geometric understructure of natural forms) and (3) synthetic Cubism, in which a freedom of improvisation is introduced with a suggestion of timing and space relations and a greater variety of colour and texture. In this latter phase mixed mediums played a part and foreign substances were introduced. Sometimes sand was mixed with pigment to ensure a variety of surface textures. This slowed down the colour vibration and helped create dissonances of various kinds from passage to passage. Bits of paper, cloth, playing cards, wire, wood, string and other materials were introduced. The final result was a *papier collé* or collage.

Both the Cubists and the Italian Futurists (*see* below) used a device known as simultaneity—the practice of combining various parts of an object, or profiles of face and figure, within a design concept. This succession of various points of view, of attempting to present all aspects of the object or figure—back, front and sides—simultaneously, had its origin in many primitive arts including Egyptian painting, the designs of the northwest Indians, and some of the *santos* of the United States southwest, in Negroid and Oceanic sculpture, as well as in Chinese bronzes. The most famous example to show motion and simultaneity of timing is Marcel Duchamp's "Nude Descending a Staircase," painted in 1912. This technique of indicating motion in space, used by both the Cubists and Futurists as well as subsequent schools, developed before the elaborate technique of the animated cartoon or the motion picture.

Aside from Georges Braque, the real leader of this movement, other members of the group were Albert Léon Gleizes (1881–1953), Jean Metzinger (1883–1956), Marcel Duchamp (1887–), Francis Picabia (1879–1953), Fernand Léger (1881–1955), Juan Gris (1887–1927), Louis Marcoussis (1883–1941) and Roger de La Fresnaye (1885–1925).

The analytical Cubists kept to a rigid geometric discipline, presenting their subjects in structural plane patterns without losing the basic likeness of the subject. They also reduced their colour scale to a series of neutral tones of browns and grays in what may be considered almost a puritanical protest against the colour of the Impressionists. Gradually the Cubists created a pictorial vocabulary composed of bottles, newspapers, playing cards, wine goblets and guitars, that became personal to them. Contrasting with this to a certain degree, the synthetic Cubists, led by Braque in 1910, complicated the original forms of Cubism not only by adding imitation textures and foreign substances to their paints, but by borrowing freely from other techniques such as Pointillism; they also introduced softer and more decorative elements than formerly, and used organic forms along with geometric shapes and patterns in a kind of counterpoint of passage which moved from the static to the dynamic.

1. Picasso.—Along with Braque, Pablo Picasso (1881–) evolved the painting of natural and inanimate forms reduced to more or less geometric shapes, which Matisse in a moment of derision labeled Cubism. In the beginning Cubism appears to have derived from two sources: from nature itself and from geometric patterns and solids. Later the feeling of tempo, simultaneity of phrase, the disintegration of the physical object and its reconstruction came into practice. Also, great means of time and dimension expression were realized by the illusion created through the use of superimposed and crisscrossed planes. Through his rich inventiveness and his constant experimentation with new mediums, as well as expression, Picasso provided the nervous force and stimulation which largely provoked the development and persistence of Cubism. Since he was the greatest single influence in painting since Cézanne, he is considered more fully later in this article. (*See* also *Further Contributions of Picasso*, below.)

2. Braque.—It was in 1908, after several years of identification with *Les Fauves*, that Georges Braque with Picasso founded Cubism. More than any other artist he gave it a permanent place in contemporary painting. His experimentation was bold yet sure, and in all matters of taste he was unexcelled. His joyous colour combinations were equaled only by those of Matisse. At his best in his still-life paintings, pure colour pattern welded into design is substituted for chiaroscuro. There are striking dislocations of realistic intervals within his rigidly disciplined patterns. Colour is placed flatly, almost vertically, on the surface; yet through changes of touch and pressure it is given body and weight and actually modeled without resorting to the devices of tonal gradation. Braque creates a lyrical and controlled feeling of dissonance that always bears a delicate sense of shock and a delightful feeling of surprise. His bold patterns are in contrast to his almost loving handling of paint and materials. He is essentially in the French tradition in his understanding of still life's being composed of objects that have energy and magic of themselves and also in his mastery of the beautiful surface. He never loses the wonder of the eye nor destroys the magic of the object.

3. Gris.—Perhaps the most quoted statement by the Spanish Cubist Juan Gris is: "Cézanne makes a cylinder of a bottle; I begin with the cylinder in order to create an individual unit of a special type. Of a cylinder I make a bottle—a particular bottle." Gris, along with Picasso and Braque, was able to raise the highly disciplined and severely mathematical art of Cubism into an individual pictorial-plastic expression. In spite of his order and formality there is no astringency in his art; rather it is lyrical, poetic and at times even sonorous. He synthesizes many complexities of pattern, texture and object shapes without losing their individual painterly and pictorial identity and significance. Every foreshortening, every cross section of an object, every contour seems freely related and yet held together in a type of irregular repeat that takes cognizance of the importance of space interval.

4. Léger.—The machine as an aesthetic tool was one of the preoccupations of Léger, one of the founders of Cubism. Severity

of machine-turned forms, metal spinnings, the slow curves of the structural engineer, the precise adjustments of the gun bore, all seem to have something to do with more-or-less mechanized forms of Léger's art. His severely stylized forms remain always close to the objects from which they are taken. Force rather than subtlety and power rather than sensitivity motivated his long series of paintings, many of them variations on similar themes. Along with this treatment, which at times became as hard and polished as a metal casing, Léger gave great consideration to the positive architectural elements depicting space. His interest in modern architecture led to his association with Le Corbusier and Amédée Ozenfant. Léger's painting contains the precision and the vulgarity of the machine world.

The most consulted document on the philosophy of Cubism is Guillaume Apollinaire's *The Cubist Painters—Aesthetic Meditations—1913*, in which the writer traces the complicated variations of the movement, creating a poetic and exalted atmosphere of growth and spirit.

E. Futurism

In 1909 Filippo Tommaso Marinetti (1876–1944), Italian poet and dramatist, published in *Figaro*, of Paris, the first official manifesto of Futurism. This proclaimed in general the love of danger, the admiration for speed in the machine, the glorification of war and general destruction of the past, including the museums, in order to free a rising generation of Italian painters, sculptors and literary men. The movement gathered a number of writers along with three young painters, Umberto Boccioni (1882–1916), Carlo Carrà (1881–) and Luigi Russolo (1885–). In 1910 this group was joined by two other artist friends, Giacomo Balla (1871–1958) and Gino Severini (1883–). The same year this group published a further manifesto which embodied the ideals of the painter and sculptor and was a further glorification of dynamism, war and the machine. Typical of their sentiments is the statement: "We proclaim . . . that universal dynamism must be rendered as dynamic sensation; that movement and light destroy the substance of objects." The Futurists felt indebted to the Cubist break-up and reassembly of form but wished to introduce dynamic movement. Futurist pictures have been compared with a frozen motion picture, a series of superimposed candid camera stills, or the later stroboscopic photography. Perhaps the simplest and most direct example of Futurist painting was the well-known "Dog on Leash" by Balla, 1912, depicting, by a sequence of multiple positions of the moving forms, a small dog being walked. Each man contributing to the movement, which actually ended with the beginning of World War I, was a distinguished artist, and the work they produced as Futurists, though quite uneven in quality, nevertheless had distinction.

F. Orphism, Synchromism and Vorticism

In 1912 Robert Delaunay (1885–1941) founded a movement which Guillaume Apollinaire named Orphism. Delaunay applied to his canvases spots or patches and, later, swirls of intense contrasting colours, hence the designation simultaneousness; *i.e.*, simultaneous contrast. He was probably the first nonobjective painter in France. In his painting colour is both form and object.

In 1913 Morgan Russell (1886–1953) and Stanton Macdonald-Wright (1890–), two U.S. painters, under Delaunay's influence started the movement known as Synchromism. In some aspects, Synchromism became an almost nonobjective art, using passages or rhythms of pure colour moving from the primaries through many gradations to the secondary or intermediary colours. The later paintings are lyrical and poetical, those by S. Macdonald-Wright often combining the use of pure colour with draftsmanship and subject matter related to that of the Chinese and Japanese masters.

In England, in 1914, the magazine *Blast*, published by Percy Wyndham Lewis, a painter and writer of some accomplishment, heralded and championed a new movement called Vorticism. Vorticism related loosely to German Expressionism, Cubism and Futurism. Altogether it was more of a literary philosophy whose iconoclasm was short-lived. However, it did act as a stimulus to a number of painters, including Lewis himself and C. R. W. Nevinson.

G. Expressionism and the German School

Two general ideas appeared to dominate German painting. The first was an ideal literary composite of both neoclassicism and 19th-century romanticism in its more sentimental aspects. The second, which comes under the general heading of Expressionism, revealed the German psychology and temperament at its best and in its greatest intensity. German Expressionism had a marked influence on world painting, permeated the countries of middle Europe, had some influence on the Russian school and was in turn slightly influenced by it. In 1900 the predominating influence on German painting was the newly founded *Berliner Sezession*. It was organized by Max Liebermann and Paul Cassirer, a prominent art dealer. The main interests of their exhibitions from 1900 to 1908 were provided by the paintings of Manet, Monet, Degas, Renoir and Liebermann. Their influence caused the formation of the German Impressionists under Lovis Corinth and Max Slevogt.

Lovis Corinth developed a freedom of individual style which fell just this side of bombast but was saved by the integrity of his gifts as a colourist and his discipline as a draftsman. He developed a broad, loose technique which is essentially painterly, and his late landscapes and portraits are related to the truly Expressionist work of Oskar Kokoschka.

Expressionism exhibits many varieties of interpretation. Basically, the artists linked the background of German medieval feeling for characterization—which at times amounted to caricature—to a tremendous inner tension of struggle and individualism which demanded perfect freedom in the use of colour and line for the exposition of subject matter. These men sought to express by any means—heightened colour, distortion of the figure and a general disregard for perspective—a range of personal emotions which ran from a tender mysticism to harsh, often violent graphic statement. The Impressionist—distort as he might according to the tenets of the academies—was still preoccupied with the object he painted. The Expressionist infused his own personality even into inanimate objects. He looked at the object and then in the mirror—to examine its effect upon himself.

1. Die Brücke.—The first real manifestation occurred in Dresden in 1905 with the formation of an artists' group called *die Brücke* ("the bridge"), which included Ernst Ludwig Kirchner (1880–1938), Karl Schmidt-Rottluff (1884–), Erich Heckel (1883–), and was soon joined by Max Pechstein (1881–1955), Emil Nolde (1867–1956) and Otto Müller (1874–1930). Kirchner and Nolde stand out as the most important painters in this north German group which developed a vehement language to express a fervent and agitated imagination. The particular interest of the *Brücke* painters centred on the forces of nature, the erotic, the primitive and the antibourgeois. The aims of this group influenced and to a certain extent involved many of the inventive painters of the time who were concerned with the problem of finding an adequate expressive form for their personal insights.

About 1910 there were various exhibitions in Germany of the French Cubists which were of lasting influence. A new secession group, known as the *Sonderbund* ("special league"), formed in Cologne. Soon all manifestations of 20th-century painting from every country could be compared in the *Sturm* ("Tempest") under the avant-garde leadership of Herwath Walden. The influence of Cubism figured strongly in the painting of the Blue Rider.

2. Der Blaue Reiter.—Two painters, the Russian Wassily Kandinsky (1866–1944) and the German Franz Marc (1880–1916), published an important book *Der Blaue Reiter*, in Munich in 1910, and by 1911 the first Blue Rider exhibition was organized. This group was comprehensive in its interests. It attracted painters from all over Europe, especially Russia and France. Among the most active participants were Alexi von Jawlensky (1864–1941), August Macke (1887–1914), Heinrich Campendonk (1889–), Lyonel Feininger (1871–1956) and Paul Klee (1879–1940). Kandinsky, who was the guiding force of this group, found his way toward complete liberation from the object by 1910. He estab-

lished thereby a new basis for art, free from traditional bonds, be they the limitations of material reality or considerations of accepted formal values. His paintings, with titles from the world of music such as "Composition No. 3," followed the dictates of the "inner necessity of the spirit." The other painters remained much closer to the figurative and representational. Marc found a unique mystic expression in rendering animals and plants. He left a series of pictures of horses, deer and enchanted landscapes that have the glow of colour inspired by Gauguin and a stylization of planes and patterns derived from the Cubists. The influence of Klee and Feininger was of such importance that it will be considered in subsequent developments.

3. Die Neue Sachlichkeit.—A revival of realism in Germany during the 1920s was known as *die Neue Sachlichkeit* ("the New Objectivity"). This group was largely dominated by Max Beckmann (1884–1950), Otto Dix (1891–) and George Grosz (1893–1959). Each used the power and freedom of a latent Expressionism for a heightened, almost brutal objectivity. Beckmann gave epic significance to his imaginative figure compositions and landscapes, often based upon almost trivial subject matter such as domestic scenes and carnival incidents. Later he was to move toward a monumental pantomime of figure composition that recalls the stark and terrible quality of Greek tragedy. He evolved an equivocal iconography, based on the condition of man, which raised him to the position of one of the most significant painters of the first half of the 20th century.

George Grosz, who had been associated with all the new movements in Germany, was relentless in his social criticism of the German war profiteer, the politician and the military caste. In his graphic social commentaries he followed naturally in the line of Goya, Daumier and Toulouse-Lautrec. Otto Dix turned his talents to a meticulous super-real or highly naturalistic rendering of his subject. He was also relentless in his contrast of youth and old age, of the horrors and decay of war presented with the tender flowering of nature, which often occurred in the details of his composition. Both Beckmann and Grosz later moved to the United States, where they became influential teachers.

4. Kokoschka.—Oskar Kokoschka (1886–) first worked in Vienna under Gustav Klimt (1862–1918), one of the leading Austrian painters of his day, whose work shows a certain affinity to Toulouse-Lautrec, Redon and Aubrey Beardsley. However, Kokoschka was soon to develop a highly individual form of portraiture in which the apparent distortions of both the heads and hands of his sitters developed into a recognizable style of almost neurotic intensity. In this series of portraits and in the drawings of that period his use of line, exploding in punctuations of ornament, produced a highly personal type of nervous calligraphy. Later he took part in the advanced movements of German painting, and the result was a series of landscapes and other compositions done in broad, irregular planes of intense colour contrasts. After some service in the Austrian army during World War I, he visited Paris, London and other cities. These visits left a definite impression on his style, it being especially influenced by the pictures of Turner which he saw in London. His violence was modified toward a more lyrical statement. He developed a unique style for the cityscape, capturing the mood and atmosphere of an entire city. During World War II he left first Vienna, then Prague, fled to London, later visited the United States, and finally returned to his native Austria after the war.

5. Bauhaus Group.—In 1919, as part of the reconstruction of post-World War I Germany, the architect Walter Gropius (1883–), encouraged by the grand duke of Saxe-Weimar, established a comprehensive laboratory school for the purpose of developing artist-craftsmen who could work in conjunction with the engineer-architect. The aim was to reintegrate the artist into society and to make him a functional member of a technological culture. Attention was given to materials, both the usual and the new and experimental. Emphasis was laid upon textures as well as combinations of materials.

All art forms were experimented with and exploited, not only painting, sculpture and architecture, but also the dance and the stage. Yet the house as the nucleus of man's life was the focal point of attention. Each student was expected not only to become a master craftsman, but to become familiar with all the arts, with special recognition of the machine as a tool. They believed that the products of the machine should be guided by the artist craftsman who was fully aware of the limitations and possibilities of both the individual and the machine. It is interesting to note that both abstract films and musiclike scores for the projection of colour on a linen screen were a part of this experiment.

The Bauhaus was a reaction to the melancholy and subjective individualism of Expressionism. It also tried to correct some of the mistakes of the group which earlier surrounded William Morris in England, by making use of the machine as a tool, rather than trying to compete with it. The English had striven to revive the crafts spirit of the middle ages as a protest against the machine. The Bauhaus suffered by being misinterpreted as being narrowly "functional," and many of its discoveries were misappropriated. In 1926 the school was moved to Dessau, where it flourished until 1928. It was completely dissolved in 1933 after Adolf Hitler's rise to power, and its members scattered throughout the world. Klee and Feininger returned to their native countries, Switzerland and the United States, Kandinsky went to Paris, László Moholy-Nagy (1895–1946), Josef Albers (1888–) and Herbert Bayer (1900–) went to the United States. Similar schools were established in Chicago, Ill. (Institute of Design of Illinois Institute of Technology), and in North Carolina (Black Mountain college), as well as at Harvard and Yale universities. Other painters who worked within the group were Johannes Itten (1888–) and Oskar Schlemmer (1888–1943).

6. Klee.—Paul Klee stands apart from all groups, yet his work reflects many diverse art forms, including drawings of children. If Expressionism can be considered as the "direct visualization of individual emotion," Klee belongs to this movement. He was able to create a new language of colour, form and space and to develop a private symbolism which communicates deeply. To Klee "art was a symbol of creation, an example much as the earth exemplifies the cosmos." He proceeded to create his own reality, which does not represent the familiar reality but penetrates to a reality that is not known until one sees his paintings. The present state of things, he felt, is only a momentary and accidental arrangement, and he attempted to communicate a world as it might once have been or is in the process of becoming. If a work of art is able to be more than a pleasing decoration, if it is able to give insight and perhaps change lives, then it may be understood why Klee is one of the most admired artists of one of the most creative periods in the history of art.

7. German Art After 1933.—Hitler's government assumed complete direction of German creative activity, including the censorship of art criticism in all its forms. Artists sought exile when possible, or stayed on in Germany, either submitting to the controls or going into the concentration camp. But no man worked freely.

There was little immediate development in the arts in Germany after the termination of World War II in 1945, largely because the nazi regime had successfully interrupted the thread of creative tradition. However, gradually a number of imaginative painters, such as Theodor Werner (1886–), Ernst Wilhelm Nay (1902–) and Fritz Winter (1905–)—all working in the abstract idiom—began within a decade to gain international reputation.

H. Nonobjective Painting

Following the inception of Cubism there developed a number of minor movements that were more or less abstract. Some of these were of short duration and are known through a few pictures only. It is difficult to define them with any exactitude, since they used influences and ideas of concurrent experimental groups working in other countries. For instance, even the serious work conducted by the Bauhaus was influenced to a certain extent by Dadaism. Cubism and Expressionism sometimes mingled to produce new forms, as in the work of Feininger. Often the influences of these movements were of even greater significance in the theatre, experimental literature, architecture or design.

1. Rayonism, Suprematism, Constructivism.—From 1910

to 1920 Moscow was one of the great artistic centres of Europe and carried on a series of exhibitions brought from Paris. Comprehensive private and public collections were formed. No less than a half dozen short-lived experimental movements put in their appearance within a few years. Abstract art in Russia had begun under the tsarist regime and was carried over until its influence was generally diffused. The first completely nonobjective painting was created by a Russian painter working in Munich, Wassily Kandinsky (*see* above). Kandinsky also evolved an aesthetic theory of abstract painting.

Rayonism, created by Mikhail Larionov (1881–1964), an important nonrepresentational experiment, had something in common with Futurism and started with the reduction of forms in figure and landscape composition into rays of light. It had some influence upon the settings for the Diaghilev ballets through Larionov and his wife, Nathalie Gontcharova (1881–1962).

Suprematism was originated by the Russian-Polish painter Kazimir Malevich (1878–1935). He was the first artist to establish a system of nonrepresentational composition in terms of pure geometric shapes and patterns. His most important picture, painted in 1918, was "White on White" (a white square set on an angle within a white square). His influence on graphic design and typography was especially important.

Aleksandr Rodchenko (1891–), an associate painter who became a rival to Malevich, formed a group under the general title of the Nonobjectivists. His best-known picture, also painted in 1918, was "Black on Black" (a circular pattern crisscrossed by two pointed ellipses, all in black). This picture was sent to the 1919 Suprematist-Nonobjectivist exhibition as an answer to Malevich's famous "White on White." Later Rodchenko worked in the Constructivist manner.

El Lissitzky (1890–1941), one of the best-known of the Russian abstract painters, spent much time in Germany between 1921 and 1928 and exerted a considerable influence on the development of design, especially at the Bauhaus.

For a time the influence of Russian Constructivism was far-reaching, particularly in the theatre, where attempts to build various settings of an abstract nature were carried on by all the small advanced groups. This activity carried into the rest of Europe and America. Constructivism was largely instigated by the brothers Naum Gabo (1890–) and Antoine Pevsner (1886–1962). It must be remembered also that the Hungarian Moholy-Nagy made intelligent use of every possible innovation suggested by these experiments. Constructivism was largely inspired by the collage of the French Cubists and literally carried it into three dimensions in which wood, wire, sheet metal, glass and even concrete were used. The brilliant constructions by Pevsner and Gabo, however, belong legitimately in the realm of sculpture.

2. De Stijl and Neoplasticism.—The year 1917 marked the formation of the *de Stijl* group in the Netherlands. It included the painters Piet Mondrian (1872–1944), Theo van Doesburg (1883–1931) and others, along with the sculptor Georges Vantongerloo (1886–) and the architect J. J. P. Oud (1890–). Alfred H. Barr, Jr., in *Cubism and Abstract Art*, wrote of this group: "Two elements formed the fundamental basis of the work of *de Stijl*, whether in painting, architecture or sculpture, furniture or typography: in form the rectangle; in color the 'primary' hues, red, blue and yellow." By 1920 Mondrian had published his manifesto on Neoplasticism in Paris. His painting had evolved from the conventional 19th-century Dutch pictorial style to a form of absolute nonrepresentationalism. His compositions are characterized by precise measurement of rectangular spaces on a white canvas ground, with the introduction of an occasional rectangular lozenge of absolutely pure colour. His most complex picture was his unfinished "Broadway Boogie-Woogie," on which he was working at the time of his death in New York. Various members of this particular group had a great influence upon architecture, and at one time affected the Bauhaus trend in Germany.

3. Purism.—From 1916 to 1925 the teacher-painter Amédée Ozenfant (1886–) and the architect Charles Edouard Jeanneret (1887–), known as Le Corbusier, created a functional classicism known as Purism. This group was not unlike *de Stijl* in that it insisted upon precision, a clean line and the impersonal quality of machine design and engineering. As for the painting, it was more or less an admonition to the more rococo effects of Cubism and any of the playful variations that may have entered painting by way of Dada. The pictorial vocabulary was more or less limited to bottles and other still-life forms which exhibited an endless series of rhyming profiles of shapes and patterns somehow forced into deep space. Similar to *de Stijl*, its influence upon functional architecture and modern applied design was widespread. The German painter Willi Baumeister (1889–1955) is closely related in style to the Purists.

I. Dadaism

According to Tristan Tzara and reported by Jean (Hans) Arp (1887–), the word Dada was discovered by Tzara on Feb. 8, 1916, at six o'clock in the evening at the Terrace café in Zürich, Switz. Dada was more of an influence than an actuality, although it was supposedly a serious criticism of 20th-century civilization. It took its name from the French word for hobbyhorse or plaything, and sought through terms of derision to destroy all sense of tradition in the arts and ethical codes, as well as traditions and values of conduct. Dada groups sprang up in New York, Barcelona, Cologne, Hanover, Berlin and Paris. Most of the serious artists connected with the movement used it as a means to playfulness and further experiment in combinations of mediums. One of its chief exponents was the painter Kurt Schwitters (1887–1948), who created the *Merzbild* or collages made out of the leftovers from the trash barrel, thus proving—to himself, at least—his famous statement, "Anything the artist spits is Art." Marcel Duchamp, Francis Picabia, Max Ernst (1891–) and others were associated with it for a time. Man Ray (1890–) also made significant contributions. The positive side of the movement was in the field of experiment: the negative, the despair, feigned or real, which for a time invaded the theatre, ballet, the novel and poetry, as well as painting and sculpture. Completely anarchic, it used the materials of fantasy and destruction; its ultimate aim was chaos.

J. Surrealism

The spokesmen for the Surrealist group, like those for Dada, claimed that it was not limited to a purely aesthetic point of view but was a philosophy of life. Dealing in terms of the irrational, it sought to exalt the unconscious into an active, creative role. Greatly indebted to the teachings of Sigmund Freud, Surrealism began in 1922 in Paris, but it was not until 1924 that André Breton issued its manifesto and published the first number of *La Révolution Surréaliste*. A great deal of the material written by the Surrealists in defense and definition is not clear. However, here is Breton's own definition (from *What Is Surrealism?*, translated by David Gascoyne [Faber]):

> SURREALISM, n. Pure psychic automatism, by which it is intended to express, verbally, in writing, or by other means, the real process of thought. Thought's dictation, in the absence of all control exercised by the reason and outside all aesthetic and moral preoccupations.
>
> ENCYCL., Philos. Surrealism rests in the belief in the superior reality of certain forms of association neglected heretofore; in the omnipotence of the dream and in the disinterested play of thought. It tends definitely to do away with all other psychic mechanisms and to substitute itself for them in the solution of the principal problems of life.

The movement in painting had for its best-known exponents the Spaniard Salvador Dalí (1904–), Joan Miró (1893–), Yves Tanguy (1900–55), Pierre Roy (1880–1950), Jean (Hans) Arp, André Masson (1896–) and the Chilean Matta (Roberto Matta Echaurren) (1911–). Some of these men carried over from Dadaism certain ideas and forms. Each artist varied greatly from the others in his handling and choice of subject matter, many subscribed to the idea of associating ordinarily unassociated objects and environments in such manner as to create surprise and shock the spectator. The most obvious example is Dalí's picture "The Persistence of Memory" (1931), a picture of wet, limp watches, which is conventionally painted, the realism being pushed to the point of a coloured photograph. Only the elements of space and the fluidic form of the melting timepieces provide the

paranoiac shock of the dream. The Surrealists claim the Italian Giorgio de Chirico (1888–), to whom they are heavily indebted, for his use of space shock and strange juxtapositions which resulted in images of anxiety; also, the Russian Marc Chagall for his fantasy, and Paul Klee for his provocative use of automatic writing and freedom of meandering line. None of these three artists ever actually joined the group.

Associated with Surrealism was the movement of neoromanticism, which included at one time Pavel Tchelitchew (1898–1957), Eugène Berman (1899–) and Christian Bérard (1902–49). Again, both the neoromanticists and the Surrealists called upon Picasso and De Chirico. The chief effect of the neoromanticists is a concern of a stage-set world in which Renaissance perspective often exploits vistas of space which contain nostalgic ruins and lone figures that cast ominous shadows. It is almost a manneristic revival.

K. School of Paris

Many of the painters of the School of Paris were identified with the changing movements after the inception of Cubism and the broadly interpreted movement of *Les Fauves*. A consistent and recognizable style was achieved by De Segonzac in his richly painted landscapes and brilliant figure drawings. Maurice Utrillo (1883–1955) followed somewhat in the tradition of his gifted mother, Suzanne Valadon (1867–1938). He developed a series of pictures of Paris and its environs in all seasons and weather which are famous for their poetic content and richly textured quality. André Derain and Maurice de Vlaminck have been treated under Fauvism, above. It must be remarked that scores of gifted painters of every nationality were a part of the development of this school.

Outstanding as a personality of great talent was Amedeo Modigliani (1884–1920), an Italian by birth, who was among the first to interpret the forms of Negro sculpture in modern painting. He combined this with a superb draftsmanship—a sensitivity to line which recalls Botticelli. His elongated nudes are at once sensuous and melancholy.

Jules Pascin (1885–1930), along with Modigliani, personified the lingering tradition of Bohemia. A world traveler, born in Bulgaria, he finally became a U.S. citizen, but largely worked in Paris. He generally depicted adolescent beauty in pearllike tones of colour with a revealing and meandering line. His influence in both Paris and New York was considerable.

Chaim Soutine (1894–1944), born in Lithuania, was essentially an Expressionist whose intensity of style and colour went beyond Van Gogh, and each of his dynamic and passionate paintings was a personal characterization worked in heavily loaded pigment with a wild stroke.

Marc Chagall (1887–), Russian by birth, created an art of delightful fantasy. Often his pictures seem based upon Jewish folk legends and fairy tales. His subjects include the circus, cows, roosters, bouquets with floating figures of lovers, often placed in the streets of provincial Russian towns.

Contributions of particular interest were also made to the School of Paris by Jacques Villon (1875–1963), André Lhote (1885–1962), Marcel Gromaire (1892–), Marie Laurencin (1885–1956), Moïse Kisling (1891–1953), Louis Marcoussis, Jean Lurçat (1892–), Leopold Survage (1879–) and Jean Hélion (1904–).

There was a consistent interest in the growth of a school of more or less untrained painters broadly labeled Modern Primitives, who varied greatly in individual style. Camille Bombois (1883–) and Louis Vivin (1861–1936) were among the best known.

Among later painters of a controversial nature was Jean Dubuffet (1901–) of France. He combined the naïve with the brutal. He painted oversized heads, distorted, flat bodies, and low-keyed landscapes from which scratched-in figures emerge. Dubuffet used tortured surfaces, often mixing sand and other elements into the painting medium, and the general effect is uneven and splotchy. Because of the great solitude yet brutally affirmative quality of some of his figures, some writers related him to the literary movement of Existentialists.

Further Contributions of Picasso.—Pablo Picasso was the greatest single influence after the time of Cézanne; his versatility, curiosity and inventiveness epitomized the transient quality of the modern movement.

Picasso was born in Malaga, Sp., in 1881. His father was a drawing master, and early in life Picasso became his most apt pupil. He went to Paris about 1903, and his early work, sensitive and enormously talented, reflected influences of the Impressionists and the draftsmanship of Toulouse-Lautrec and Théophile Alexandre Steinlen (1859–1923). Until he developed Cubism, he painted a series of haunting pictures of the family of Harlequin, clowns, circus troupes and generally interpreted the wandering European poor. This group of pictures became generally known as his "blue period." Then followed the "rose period," which, at times, took a more objective and classical turn. Throughout, Picasso's extraordinary draftsmanship and command of forms carried on. Prolific and constantly changing in his interests, he was likely in a single year (in the 1920s especially) to exhibit a sudden new development of an earlier interest or manner. He turned also to the art of ancient Greece and Rome during the 1920s and developed a classic and monumental figure style of his own in his "Lovers" of 1923. In the late 1920s he made his own Surrealist experiments which, together with his work in all the other movements of the 20th century, turned out to be more successful than that of the originators of the various schools. In 1937 he produced his famous mural panel "Guernica" for the Spanish pavillion at the Paris exposition. This huge mural, done in black, gray and white, was painted as a protest against the destruction of the Basque town of Guernica by German bombers flying for Gen. Francisco Franco Bahamonde. This composition created more discussion than any single painting since the exhibition of Marcel Duchamp's "Nude Descending a Staircase." The symbolic details of Picasso's historic work are handled ruthlessly with no attempt for the academic considerations of fine painting. It was perhaps the greatest document of intellectualized pain that the modern movement had produced. Using all the knowledge and the devices at his disposal, he made a transcription of the elements of horror and catastrophe, creating a series of moving concepts which are poignant symbols, in his own unmistakable style.

After painting "Guernica," Picasso did an especially provocative series of figure compositions in which the swiftly changing expressions of the face are melted into one moving plastic image. His portraits of his secretary, Jaime Sabartés, and those of Dora Maar are typical examples. In various periods of his life Picasso also experimented in sculpture and ceramics and created a large and brilliant series of drawings, etchings and lithographs.

L. National Development

1. Italy.—Italy's first contribution to 20th-century painting was Futurism. Working independently of that movement were the artists Giorgio de Chirico and Giorgio Morandi (1890–1964), joined by Carlo Carrà, who grouped themselves as the *scuola metafisica*. De Chirico was mesmerized by what the U.S. critic James Thrall Soby termed "the magic of the object." He painted a series of landscapes that seemed to be set in the fixation of a dream, featuring architectural subjects with an emphasis upon perspective; accompanying these motifs of antiquity often appears a lonely symbol of modern civilization, such as a toylike locomotive. The symbology of most of his subjects was of a metaphysical nature, often making use of mannequins, elaborate still-life arrangements of separate elements and dream-shock vistas. Many of these, flawlessly painted in dramatic contrasts of colour and light, almost parody certain old masters.

Carrà was often close to De Chirico in feeling, as was Morandi in his work of about 1917 and the early 1920s. Morandi later took to painting simple poetic landscapes or still lifes made up of multitudes of bottles. De Chirico returned to his early love for the manner of Courbet and the persistent influence of Arnold Böcklin.

Arturo Tosi (1871–1956) must be considered a late Impressionist, related to the intimism of Bonnard, while Mario Sironi (1885–1961) painted expressively romantic pictures and Felice Casorati (1886–1963) developed a classic studio painting of his own. Massimo Campigli (1895–) created a unique style related to

Etruscan and Pompeian mural painting. Among the artists who reacted strongly against the forced isolation during the Fascist regime was Renato Guttuso (1912–), who became a central figure in Italian painting. Others, such as Giuseppe Santomaso (1907–), Armando Pizzinato (1910–) and Afro (Basaldella) (1912–), worked in various idioms of abstraction, also helping to bring Italy back to an important place in world painting.

2. Spain.—Except for artists such as Picasso, Miró, Gris and Dalí, all internationalists, Spain remained conservative and little influenced from the outside. Of the older painters, Ignacio Zuloaga (1870–1945) produced a series of popular decorative portraits. Other well-known Spanish painters include Joaquín Sorolla y Bastida (1863–1923) and Valentin de Zubiaurre (1874–).

3. Switzerland.—Swiss painting was affected by Impressionism and touched by the subsequent movements. Ferdinand Hodler (1853–1918), a symbolist, was the most important Swiss painter early in the 20th century. Paul Klee, though of Swiss nationality, spent most of his life in Germany. Cuno Amiet (1868–) was an important painter working in a more traditional idiom. After World War II Swiss painters turned to a rather international style of abstraction.

4. Belgium.—In 1887 Cézanne exhibited with the "XX Group" in Brussels. The Belgians in their recognition of many of the advanced painters in other countries at that time were to set a precedent for many galleries devoted to the exhibition of modern art. Théo van Rysselberghe brought French Neoimpressionism into Belgium. The most important figure for many years was James Ensor (*see* above). In the following generation the artists of the group of Laethem-Saint-Martin were significant, and among them Constant Permeke (1886–1952) made with his rough-hewn peasant figures the most valid contribution. Others in that group were Gustave de Smet (1877–1943) and Frits van den Berghe (1883–1939). Paul Delvaux (1897–) and René Magritte (1898–) belonged to the Surrealist group and both of them made use of shock value, especially in regard to the nude figure.

5. The Netherlands.—At the turn of the century the symbolists Jan Toorop (1858–1928) and J. Thorn Prikker (1868–1932) were producing the most original work in the Netherlands. In the 1920s leadership was taken over by the *de Stijl* group of Piet Mondrian (*see* above) and Theo van Doesburg. The Expressionism of Leo Gestel (1881–1941) and Jan Sluyters (1881–1957) was of primary national importance. By mid-20th century the stark realism—with a symbolic social flavour—of Charley Toorop (1890–) and Pyke Koch (1901–) and the heavily textured abstractions of Karel Appel (1921–) seemed outstanding.

6. Scandinavian Countries.—The School of Paris and the advanced movements of Germany made themselves felt in Scandinavia, partly through exhibitions and through the influence of a few important individual painters such as the Norwegian Edvard Munch, the greatest of their artists; Per Krohg (1889–1965), also a Norwegian; and the Swedish portraitist Ernst Josephson (1852–1906). Per Krohg was naturally influenced by Munch, but should be considered more a member of the School of Paris whose work was modified by certain national characteristics.

Although the contribution of the Scandinavian countries was relatively small in the field of painting, their influence was widely felt in crafts, the decorative arts and architecture, as well as in sculpture. Undoubtedly most important among the younger Scandinavian artists was Rolf Nesch (1893–). Born in Germany and a student of Kirchner, Nesch made his home in Norway in 1933. By means of his experimental technique and his lyrical fantasy Nesch enriched the pictorial surface.

7. U.S.S.R.—The chief innovations in Russian painting were in the various movements that developed around Constructivism (*see* above). Many leading Russian artists worked successfully in the theatre and ballet. The Diaghilev Ballet Russe, famous for its sets and costumes, attracted the leading artists of Europe as well as such well-known Russian painters as Léon Bakst and Alexander Benois. Other painters who contributed to the stage were Nicholas Roerich (1874–1947), Ivan Bilibine, Matislav and Rostislav. Running a gamut from romantic realism to decorative individualism were the following, some of whom were influenced by the School of Paris: Gregor Chiltian, Alexandre Jacovlev (1887–1938), Nathalie Gontcharova, Alexis Gritchenko, Schoukaeff, Zenaide Serebriakova, Vladimir Polunin (1880–1957) and Nadia Benois. Much of the art of the U.S.S.R. after the experimental period of the 1920s was largely illustrative, devoted to extolling the virtues of various aspects of the proletarian state.

8. Great Britain.—Walter Sickert (1860–1942), student of Whistler and admirer of Degas, combined realistic subject matter with Impressionist form. Another exponent of Impressionism was Phillip Wilson Steer (1860–1942). Augustus John (1878–1961) painted portraits which vigorously characterize such famous persons as George Bernard Shaw and James Joyce.

Postimpressionist painting was introduced to Great Britain by an important exhibition held at the Grafton galleries in 1910. It became the standard of criticism for Roger Fry (1866–1934) and Clive Bell (1881–1964), who established a new and significant basis for art criticism, concerned with the pictorial form itself.

The Contemporary Art society was formed in 1910 to bridge the gap between artist and public. Duncan Grant (1887–) became important among the Postimpressionists and Matthew Smith (1879–), in contact with Matisse at one time, developed his own vigorous Fauvism. Early abstract art made its inroads in England with Wyndham Lewis' (1884–1957) short-lived Vorticism.

During the 1930s there was the beginning of an important revival in the visual arts in Great Britain, which was greatly encouraged by critics such as Herbert Read and by the programs in art education sponsored by the government's British council.

Paul Nash (1889–1946), official artist of both wars, turned to a magic realism with Surrealist overtones. Sir Stanley Spencer (1891–1959) approached religious subjects with an often eerie magic realism. Victor Pasmore (1900–) developed from his earlier realism to the totally abstract style of highly sensitive collages. Henry Moore (1898–), though essentially a sculptor, had an important influence on painting. His use of organic forms seems to encompass an evolutionary sequence that moves from fossils, prehistoric monuments and indeed a personal archaeology to forms of the present times. His shelter drawings, made during World War II, remain among the most poignant visual records of the war. John Piper (1903–), an abstractionist before the war who was commissioned to record the bomb damage in London, in his post-World War II work dramatized old buildings in a neoromantic fashion. Graham Sutherland (1903–), recognized by many as England's leading painter at mid-20th century, achieved a fusion of romanticism and Surrealism. He transformed thornbushes, insects and other hostile-seeming organic forms into powerful and frightening totemic images. His "Crucifixion" in Northampton is considered one of the most important religious paintings of the 20th century. Attention should be called to Francis Bacon (1910–), Keith Vaughan (1912–), John Minton (1918–1957), John Craxton (1920–) and Michael Ayrton (1921–) among the younger generation. Bacon went beyond Sutherland. Recognizing the importance of the shock value of Surrealism, he became obsessed with horror and tragedy and sometimes seemed to comment ironically on a world of utter cruelty and ugliness.

Completely different from the painters mentioned and outside the main current of English painting was Ben Nicholson (1894–), who renounced romantic statements and like Mondrian explored the realm of pure form in a search for an absolute simplicity of statement. His geometric abstractions indicated an extraordinary sensitivity to formal relationships.

9. United States.—The first wave of modern art struck the United States in 1913 when the famous Armory show brought to the U.S. artist and public for the first time in any volume the work of all the leading experimental painters of Europe and those of the immediate past. Duchamp's "Nude Descending a Staircase" became a source of nation-wide controversy. Actually the foundations for modern painting in the U.S. were laid in 1908 by a new group of painters with great gifts known as "The Eight." One of this group, Arthur B. Davies (1862–1928), largely responsible for the Armory show, painted canvases of idyllic and romantic mood.

Maurice Prendergast (1859–1924) did scenes with a Postimpressionist patchwork of colour and was far ahead of his U.S. contemporaries in his visual statements. Ernest Lawson (1873–1939) also painted Postimpressionist landscapes. The other members of this important group, Robert Henri (1865–1929) and his followers John Sloan (1871–1951), George B. Luks (1867–1933), Everett Shinn (1876–1953) and William Glackens (1870–1938), were concerned with developing a vigorous style for the depiction of the urban environment not unrelated to reportage writing. They were popularly dubbed the "Ash Can school."

During the 1920s and 1930s painters such as George Bellows (1882–1925), William Gropper (1897–) and Reginald Marsh (1898–1954) continued in this tradition, while others, such as Edward Hopper (1882–) and Charles Burchfield (1893–), interpreted the U.S. scene more romantically.

In the same period there were a number of U.S. painters of extraordinary talent, who, largely under the leadership of the photographer and art dealer Alfred Stieglitz (1864–1946), presented unique formulations based on highly personal fusions of Expressionism and Cubism. Foremost among them were John Marin (1870–1953) with his vital water colours of city and ocean and Max Weber (1881–1961) with his deeply felt distortions, often religious in subject matter. Of great importance were the lyrical abstractions of Arthur G. Dove (1880–1946), the bold expressions of the New England coast by Marsden Hartley (1877–1943), the semi-Cubist precisions of Charles Demuth (1883–1935), and Georgia O'Keeffe's immaculate flower pieces and landscapes. Feininger, who returned to the U.S. in 1937, continued painting his poetic landscapes and seascapes with prismatic light. Abraham Rattner's (1895–) brilliantly coloured canvases were more closely akin to French painting, especially to Rouault. Stuart Davis (1894–1964) evolved a bold abstraction of colour and shape based on synthetic Cubism but adhering to the U.S. scene. Ben Shahn (1898–) developed a unique personal form of flat colour planes and piercing lines for his canvases advocating social justice. Charles Sheeler (1883–) painted the U.S. industrial landscape with a precision of vision which shows the often close relationship of realism and abstraction, and Ivan Le Lorraine Albright (1897–) using a similar sharp focus vision placed familiar objects in unfamiliar relationships with an extraordinary clarity of detail giving a strong emotional effect.

During the same period, there was also—after the depression of the 1930s—a group of homespun regionalists led by Thomas Hart Benton (1889–), John Steuart Curry (1897–1946) and Grant Wood (1892–1942). Their style, however, and especially that of their many followers, led to a narrow provincialism.

In 1935 under the administration of Pres. Franklin D. Roosevelt, two government art projects were established—the Treasury Relief Art project and the Federal Art project of the Works Progress administration. The latter gave great impetus to the development of U.S. art generally through art centres which conducted exhibitions and teaching programs. A major contribution was the "Index to American Design," which recorded in painting and photography the significant variations of indigenous arts and crafts in the United States. This also provided a measure of security for artists and made important post-World War II developments possible.

Mark Tobey (1890–), working in the Pacific northwest, became widely recognized after World War II for his calligraphic abstractions, his automatic white writing, much indebted to Japanese calligraphy. Morris Graves (1910–) was in turn influenced by Tobey and painted symbolic birds in soft colours.

New York city became an important artistic centre of western art after World War II when abstraction of various kinds grew to be the most vital strain in American painting. Arshile Gorky (1904–48), himself related at times to Picasso and Miró, evolved a symbolism of soft organic forms in which the fantastic is fused with the biomorphic. Willem de Kooning (1904–), recognized as one of the leading U.S. painters in the 1950s, was greatly concerned with the painting process itself, evolving at times a frightening human imagery. Jackson Pollock (1912–56) created most controversial paintings by trickling his paint on the canvas to produce a rhythmic labyrinth of linear colour streams. Mark Rothko (1903–) offered large canvases covered with vast expanses of hazy contrasting colour. William Baziotes (1912–63) looked to amoebic forms for his inspiration and Adolph Gottlieb (1903–) found his stimulus in ancient pictographs. All of these artists, while deriving in certain aspects from European trends, evolved an abstract and evocative art based primarily on the extreme subjectivity of their own feelings and emotions. Others such as Rico Lebrun (1900–64) in Los Angeles, Hyman Bloom (1913–) in Boston and Leon Golub (1922–) in Chicago found by means of personal introspection, poignant, often enigmatic images of death, decay and suffering, which nevertheless are direct in their communicative and purifying power.

10. Mexico and Latin America.—Around 1910, during the social revolution in Mexico, Diego Rivera (1886–1957) and other Mexican artists returned from Paris. Although saturated with the current French tradition, they turned to the historic arts of ancient Mexico and created a new background which developed into a national idiom. Rivera headed the newly formed syndicate of painters which undertook a large official project to decorate the walls of public buildings. He created a monumental series of wall decorations, easel paintings, drawings and prints.

Perhaps the greatest individual genius of the Mexican movement was José Clemente Orozco (1883–1949), muralist, easel painter and lithographer. His drawings and paintings of war, revolution and scenes from the life of the people became widely known, and many of these themes were transcribed into fresco. His frescoes in Mexico and the United States combine a monumentality of concept and execution with Expressionist force. In the service of his social and political ideas, his frescoes have an incomparable persuasive power of form and content. When compared with the harmonious and human proportions of the figures in Renaissance frescoes, the figures in his murals look gigantically distorted and dissonant. A similar expressive grandeur in concept is found in the frescoes of David Alfaro Siqueiros (1898–). Both absorbed the message of Aztec art. The Mexican mural painters proved most successful in finding a functional relationship of art to society. Other well-known Mexican painters were Dr. Atl (Gerardo Murillo), painter, draftsman and writer (1877–1964), Federico Cantu (1908–), Jean Charlot (1898–), Miguel Covarrubias (1904–57), Carlos Mérida (1893–) and Roberto Montenegro (1885–). Among the following generation, Rufino Tamayo (1899–) is most important.

From 1930 on there was increased interest in the development of contemporary painting, sculpture and architecture in the Latin-American countries. Several important exhibitions were held in the United States, some of them as part of the state department cultural interchange. The work of various artists such as the Argentinian Emilio Pettovrutti (1895–) and the Brazilian Cândido Portinari (1903–1962) were circulated in special exhibitions throughout the United States. The experimental work of the Chilean painter Matta (Echaurren), as well as that of the Cuban Wilfredo Lam (1902–), gained widespread attention.

(D. BEA.; P. H. S.)

11. Canada.—In Canada, the modern movement in art dates from James Wilson Morrice (1865–1924). Although Morrice lived for years abroad, his later figure and landscape paintings, which have much in common with the subtle colour equations of Matisse, inspired many young Canadian artists to greater experiment. A more regionalist approach was that of Tom Thomson (1877–1917), who made direct renderings of the wilder aspects of Canadian nature. His artist friends, among whom were J. E. H. MacDonald (1873–1932), A. Y. Jackson (1882–) and Lawren Harris (1885–), formed with others the Group of Seven in 1920. The boldly patterned landscapes of these men attracted many followers; later, however, Canadian art became more varied and subjective in reference.

To landscapes of the forest, Emily Carr (1871–1945) brought a new freedom of expression; David Milne (1882–1953) combined logic and lyricism in his treatment of nature; equally individual are Goodridge Roberts (1904–), Jean Paul Lemieux (1904–) and Jacques de Tonnancour (1917–). The influence of the School of Paris can be traced in the works of Alfred Pellan

(1906–) and many other French-Canadian artists, although in reaction to this a completely unshackled type of painting called *automatisme* developed in French Canada after 1945. It began with Paul Emile Borduas (1905–1960) and influenced Jean Paul Riopelle (1923–).

Each section of Canada has developed active and original painters; for example, in Vancouver J. L. Shadbolt (1909–), in Toronto Harold Town (1924–) and in New Brunswick the romantic realist Alex Colville (1920–). (D. W. Bn.)

12. Australia.—Australian art is European in tradition. The influence of the aboriginal is negligible, but the physical environment has had great impact. When the first fleet dropped anchor in Sydney cove in 1788, it brought topographical artists and surveyors, some of whom were sailors, soldiers or free settlers, some of whom were convicts. One of the first paintings of Australia to be exhibited in the Royal Academy, in 1805, was by William Westall (1781–1850) who accompanied Matthew Flinders in the "Investigator" on its voyage of circumnavigation (1801–03). The convict artists Thomas Watling (b. 1762) and Joseph Lycett (fl. 1810–25) had "limmed" the new landscape, and the notorious Thomas Griffiths Wainewright (*q.v.*) made exquisite drawings of the colonial gentry of Hobart.

By the 1880s there were Australian art colonies in London and Paris, outstanding members being John Russell (1858–1931), the friend of Van Gogh and Rodin, the sculptor Sir Bertram Mackennal (1863–1931), E. Phillips Fox (1865–1915), Rupert Bunny (1864–1947), Tom Roberts (1856–1931) and Charles Conder (1868–1909).

The founding of the Heidelberg school by Tom Roberts, Fred McCubbin (1855–1917) and Sir Arthur Streeton (1867–1943) originated from a series of painting camps along the river Yarra, near Melbourne, and the subsequent Exhibition of 9 × 5 Impressions did much to develop the Australian school of landscape painting. Outstanding figures of this period (*c.* 1886–1910), apart from the Impressionists,were George Lambert (1873–1930), Max Meldrum (1875–1955), Sir Hans Heysen (1877–) and the Lindsay brothers, Norman (*q.v.*), Percy (1870–1952), Sir Lionel (1874–1961), and Sir Daryl (1890–), each making a unique contribution to the development of Australian art.

The coming of Postimpressionism, Cubism and Abstraction has its pioneers in Roland Wakelin (1887–), Roy de Maistre (1894–) and Rah Fizelle (1891–). Roy de Maistre completed his first abstract composition in Sydney in 1919 and his work can be seen in most Australian galleries and in the Tate Gallery, London.

The opening of a new dimension in Australian painting can be said to have started between World Wars I and II and continues with the use of myths and images in the paintings of Russell Drysdale (1912–) and Sidney Nolan (1917–). Albert Tucker (1914–), who spent several years abroad, also brought fresh vigour to his interpretation of the Australian scene. Nevertheless, William Dobell (1899–), among artists of this period, stands alone. He studied in England for some years and is perhaps best known for his characteristic and salty portraiture.

Melbourne was the scene of the lively "Antipodean" movement headed by Charles Blackman (1928–), the Sydney-born Robert Dickerson (1924–), Arthur Boyd (1920–), David Boyd (1924–), John Brack (1920–), John Perceval (1923–) and Clifton Pugh (1924–). They aimed at reintroducing figurative painting into a world of disintegrating forms.

Ralph Balson (1890–), Godfrey Miller (1893–1964) and Ian Fairweather (1890–) belong to an older generation of abstract painters, and John Passmore (1904–) provides a link between James Gleeson's (1915–) surrealism and Lawrence Daws's (1927–) stylized compositions and the Postimpressionists and the school of pure abstraction. Brett Whiteley (1939–) and Leonard French (1928–) represent the newer generation of abstract painters. French with formal patterning and Whiteley with free and formless shapes have a considerable reputation outside Australia. (D. J. Fl.)

13. South Africa.—South African art stems directly from Europe, for the tradition of rock painting and engraving of the Bushmen made no impact on the Europeans who arrived in 1652 or on the Bantu who migrated from central Africa at the same time and have remained without an art form of their own.

The early artists were, with few exceptions, chroniclers of the new scenes and experiences. The first artist of any distinction was Anton Anreith (1754–1822), a German sculptor. During the British occupation of the Cape in the 19th century, three names stand out as recorders of the passing scene: W. H. F. Langschmidt (1805–60), T. W. Bowler (1813–69) and Thomas Baines (1820–75).

The first painter in a "modern" idiom was Pieter Wenning (1874–1921) but even he was painting in the style of the Impressionists when Picasso and Braque were already experimenting with Cubism. Most of the artists were strongly influenced by the foreign schools—British, French, Dutch, German—where they had served their apprenticeship. Among the leading practitioners were Gregoire Boonzaier (1909–), H. S. Caldecott (1886–1929), Maggie Laubser (1898–), Hugo Naude (1869–1941), Jacob Pierneef (1886–1957), Edward Roworth (1880–1964) and Irma Stern (1894–).

However, as the rest of the modern world "discovered" Africa, South African artists, surrounded by the light and forms of Africa, instinctively responded to the same stimuli. Almost for the first time South African art—whether figurative, graphic or abstract—became unashamedly of Africa. In addition, in the republic of the 1960s general awareness of the artist's function received further impetus from commissions given for the decoration of public and private buildings. (M. C. Lo.)

See also LANDSCAPE PAINTING; PORTRAIT PAINTING; STILL-LIFE PAINTING; biographies of major painters; and references under "Painting" in the Index.

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PAINTINGS, CONSERVATION OF. Paintings that have been saved from damage and decay are probably few in proportion to those that have been painted. The range of kinds within that number is very wide. There are pictures on the walls of tombs painted with gum and pigment over plastered stone; pictures on the whitewashed clay of cave temples in the desert; others on silk or linen that have been buried for centuries; altarpieces on wood laid with grounds of gold leaf; drawings, representations on parchment and paper; paint on stone, metal, glass and ivory. The paint in all of them is composed of coloured dust held together by wax, glue, egg, gum, oil or resin. The survival of so many of these works done over thousands of years is evidently the consequence of careful conservation.

During ancient times little was known of the causes of decay in picture materials, and it was impossible to foresee the threat of conditions which later would injure them: heating systems, smoke-filled air, prolonged dampness, mold, insects, rough handling and transportation by rail, by automobile, by aircraft and by ship. Besides these regular hazards there have been the recurrent risks of calamity—fire, storm, flood and bombardment during wars. In earlier days, pictures were likely to be made for a particular place and to stay in that place. After a long time decay took hold of them. They became steadily weaker and their appearance changed slowly, imperceptibly. If they were left alone, the harm went unnoticed. It seems evident from the surviving records that until the 17th or 18th centuries paintings were not expected to be kept indefinitely. Pliny, writing in the first century of the Christian era, mourns the passing of the great art of painting which had existed in Greece four centuries before his day, but the loss of the works themselves he seems to have taken as a matter of course. With changing times and changing styles it can be supposed that paintings were expected to decay and to become forgotten with a forgotten past. The art of ancient Greece and Rome probably had a low evaluation during the centuries that intervened until the Renaissance brought back an interest in it, and it took another span of centuries before the paintings in a Gothic style had recovered any general esteem.

Development of Conservation.—The 19th century was eclectic in its evaluation of pictures. All styles of painting came in for their share of approval, and steady and progressive concern over matters of conservation probably came about as the result of this eclectic taste. It became apparent that things once discarded and neglected were later retrieved and held to be objects of value and importance. In consequence, most objects of art acquired a position of respect, and the means of preserving them were given serious consideration. Until about 1850 the care of paintings was assumed to be the proper responsibility of artists and painters, and they had carried out this work evidently as a secondary part of their occupation. By the middle of the 19th century, however, the artist's knowledge of the technology of paint and paintings had somewhat declined. Painters were being trained primarily in the problems of representation. They had less panel building to do than had the painters of a few centuries before. They no longer were required to mix their own paints and had lost touch with the manufacture of colour, medium and varnish coatings. These preparations were available to them in shops. They were less well-equipped to deal with the mechanics of conservation. Their work in this field was also clouded by a lack of comprehension of its essential purpose. Evidence shows that many artist-restorers considered it their duty to rework a picture so that it looked new instead of old.

By the end of the 19th century when old pictures had come to be highly valued and when critical historical studies of them had advanced, efforts were made to improve methods of preserving them. Sporadic but definite improvement was made, and probably the first clear sign of the general development of practice in this field was furnished in 1930 when the International Museums office, a dependency of the League of Nations, sponsored in Rome a conference on the examination and conservation of works of art. In the proceedings of that conference it was evident that many agencies had made contributions to the field. The sciences, with such facilities as radiography, filtered ultraviolet light, infrared photography, spectroscopy and spectrophotometry, together with chemical and microchemical analysis, had provided means for identification of materials and for a marked expansion of techniques for determining the condition of paintings. The 1930 conference showed that application of scientific investigation to preservation of materials in paintings had been made, and certain principles to safeguard the conservation and particular character of a work were endorsed.

The causes of damage and decay in paintings can be arranged, for the sake of convenience, into two groups: those which are from natural causes and those which are from handling, moving, treatment or accident. The natural agents of deterioration are familiar. They are light and dark, extreme dampness and extreme dryness, heat and cold, mold and insects and dust and grime. The imposed agents are also easy to review—jolts and vibration, direct violence, fluids that are spilled and splattered on surfaces, careless scrubbing or other causes of abrasion, and fire.

Construction of Paintings.—Agents of damage may strike at different parts in the construction of a painting. These parts may be different in number and widely different in kind. Some paintings have only two: a support such as paper, fabric, stone, plaster, wood, ivory or metal, and a paint layer, pigment in a medium. In some instances the latter component of a picture has no medium at all. Charcoal marked over paper or stone can produce a picture, but this generally has been called a drawing and is distinct from paint. The substance which carries the picture, usually called the support, may be one of a large number of materials. Western paintings, those of Europe and the Americas, have been done on a wide variety of supports. In ancient times both wood and fabric are known to have been used. Glass, metal, parchment and paper were added later. A few pictures have been made on stone and on leather. Ivory came in as the common support for miniatures, and from 1800 synthetic boards,

usually of wood fibre, became common. These are the supports for movable paintings. In the far east a smaller number has prevailed; most of the movable works there are on paper or fabric. Paintings on a wall have naturally been adapted to the wall material, and this, broadly, has been some kind of plaster, dried clay, gypsum or the lime plaster which gave rise to fresco painting.

A review of these parts of the construction of paintings is necessary for a survey of the problems of conservation. The paint proper, that part of the whole work which carries the pictorial design, is usually made up of two components mixed together at some time before the paint is put on. These are colourant and medium, or, by other terms, pigment and binder. The pigment of paint is powder. For the most part it is inorganic, but a few organic dyes have been used, precipitated on an inorganic base such as aluminum silicate. The finely ground powder is mixed with an adhesive which will yield a workable paint and will dry in such a way as to hold the colour particles in a firm layer. The paint may contain little binding medium and leave the grains of pigment chalky in the film, or it may contain little pigment and make a film rich in medium and translucent. The latter is a glaze. The defects of paint that have to be dealt with in procedures for conservation are greatly influenced by this matter of structure. Lean or chalky paint is apt to lose pigment by general wear and has frequently been changed in tone and in general character by the application of varnishes which have soaked into it. Rich paint tends to react more to moisture or solvents and is more apt to crack and flake.

Between paint and support in the usual pictures of the west is another coating called ground, a uniform layer which serves to smooth the support, provide a convenient and highly reflecting tone on which the painter can work, and a substance that will take the paint evenly and firmly. In a mechanical sense, the ground is a paint but, since its purpose is not pictorial and since pictures can be made without it, the distinction according to use is a reasonable one. Movable paintings of the far east rarely have a ground. The illuminations in European manuscripts and the water-colour paintings done with a gum medium directly on paper also go without it. The powder or granular material of a ground may be pigment. Usually it is a so-called inert substance, not classed among pigments; chalk and gypsum are common. White lead is the pigment usually found in the ground.

Since the 16th century, it has been the practice to put a layer of varnish over oil paint. Varnish also has been used on tempera paintings, those executed with an aqueous medium and often with a background of gold leaf. This varnish or surface coating is an important component in many pictures and one that is often critical in their deterioration and conservation. Although it was not consistently used on tempera paintings and is not certain to have been a regular coating before the 17th or 18th century, it has an ancient history. Its story is connected with medicine and probably the resins used along with oils in early European painting were more commonly employed by physicians in the preparation of ointment. They are mentioned, however, in treatises on the art of painting that originate as early as the 8th century A.D. Broadly, there are two types of resin. One is, in fact, a fossil, the buried excretion of trees long extinct. The most familiar of these is amber; the other common one is copal. These were not soluble in spirits and had to be fused in an oil at high temperature. The spirit-soluble resins which made possible the manufacture of spirit varnishes are softer than the fossils and are taken from living trees. The common names among them are mastic, dammar and sandarac. All natural resins have somewhat the same defects. They follow a slow but persistent course of chemical and physical change, becoming more brittle, more dark and more cloudy as time goes on.

Air Conditioning.—If paintings could be kept away from dirt, from changes in the moisture of the air, from mold and worms and from handling and accidents, they would deteriorate very little even over long periods of time. Beyond a doubt, prevention of deterioration is the most valuable means of conservation and to a large extent it is possible to establish sound, preventive conditions in the housing of pictures. Air conditioning can be maintained day and night at a fixed level of relative humidity. Air can be washed and filtered and, in consequence, carry little or no dust or damaging gas. A few collections of important works have such housing but they are very few. In some collections special storage with stable conditions of atmosphere is used for certain objects that are in a fragile state. The requirements in conditioning of the air are not quite the same for all kinds of objects, but for paintings a mean can be fixed which is acceptable. A low relative humidity is desirable to prevent the risk of mold and to delay chemical and photochemical reactions. It is good for paper and for fabric. Pictures on wood and vellum, however, are subjected to a great deal of strain if the supports under them shrink or twist in a dry air. A relative humidity of approximately 55% will avoid risks of both kinds; and stability, a fixed, continuous, night-and-day level, is far more important than the exact position in per cent. Temperature is important only as it affects relative humidity.

Where pictures cannot be given air-conditioned housing or special storage, a great deal of advantage has been found in tight framing with glass. Such a frame has its disadvantages and is inconvenient to the observer because of reflections. It is, however, a great advantage in preventing extreme and rapid changes of relative humidity in the air immediately surrounding the picture. A deep frame is required and one that is mechanically firm and well-fitted. The glass needs to be sealed into the rabbet. The picture stands back of the glass at least one-quarter inch and at the back of the picture is another seal of a firm and dampproof material. Such a frame has a further advantage of keeping out dust and any concentration of those gases—hydrogen sulfide or sulfur dioxide—which might do harm to painting materials. Mold, which is also a threat to the conservation and the appearance of pictures, can be prevented in a sealed space. The common molds, spores of which are carried in the air, will grow at a relative humidity above 65% and in enough oxygen for their survival. In a sealed frame, when the relative humidity could become excessive, a toxic material, as paradichlorobenzene, inside the sealed area will prevent mold plants from developing.

REPAIR

Conservators of works of art have been much more busy with repair than with prevention of damage, and before the second quarter of the 20th century, the practice of repairing pictures usually went by the name restoration. The restorer was a painter or a gilder who had learned something about routine procedures and was usually capable in the necessary manipulations. He rarely had a thorough technological knowledge of materials or a wide range of special techniques. Under his care the old and damaged work was made firm according to the best advice at hand, usually that of a competent cabinetmaker, and when this was done the painter went over it with the definite and unquestioned aim of making it look as well as he could. That was restoration, a term signifying an effort to do the impossible. The practice it represented, however sincere the motives behind it, brought about some distortion in the appearance of pictures and may have caused a small amount of actual damage.

Any procedure in the repair of a painting begins with recognition of two main kinds of defect: flaws in the structure and disfigurements in the design.

Structural Flaws.—A structural flaw or defect may be partial loss of material in any of the component parts of a picture—corners or edges broken away from panels, pieces torn or cut from paper or fabric, parts of ground and paint that have come loose from the support and fallen out. Breaks, tears, cracks, splits and checks are other kinds of structural defect. Another is known as cleavage—the separation of layers in a painting along a plane parallel to the picture. Usually this is more marked in paintings on wood than on any other kind of support. The shrinking and swelling of wood as the air becomes drier or damper tend toward a shearing action of the support and a separation from the ground. Distortion of the support is another kind of structural defect; this includes warping of panels, bulging or wrinkling of canvases and wrinkling or cockling of paper or vel-

"Portrait of a Lady" by Franz Pourbus the Younger (1570–1620), "restored" by extensive reworking. This approach to conservation of paintings was common in the 19th century

A shadowgraph X-ray view showing a different face under the newer paint

The subject as originally portrayed, after the overpainting was removed with solvents. This cleaning was done in 1925 and is an early instance of the use of modern techniques in conservation of paintings

USE OF THE X-RAY IN CONSERVATION OF PAINTINGS

BY COURTESY OF (TOP LEFT, BOTTOM LEFT) THE METROPOLITAN MUSEUM OF ART, NEW YORK CITY, (RIGHT) THE FOGG MUSEUM OF ART, HARVARD UNIVERSITY

PAINTINGS, CONSERVATION OF

Ground and paint losses: the painting has been relined and the losses filled with a luting material having a composition like the ground

Accretions: the head of the Virgin, a detail from a 15th-century altarpiece attributed to Antoniazzo Romano, is shown here covered with grime and a discoloured film material

The discolorations shown in the photo at left have been removed and the losses in the paint have been compensated for by inpainting

A tear in the canvas, repairable by relining

Cleavage with buckling of the paint and losses from flaking

REPAIR PROBLEMS IN THE CONSERVATION OF PAINTINGS

Wear or abrasion of paint. The dark spots are the upper level of threads in a canvas support

Extensive cleavage between ground and support may be treated by a transfer to another support. The "Holy Family," illustrated here, is said to be the first picture so transferred. The work was done by Picault in Paris in 1750

BY COURTESY OF (TOP CENTRE, TOP RIGHT) FOGG MUSEUM OF ART, HARVARD UNIVERSITY; PHOTOGRAPH, (BOTTOM RIGHT) COLLECTION ARCHIVES PHOTOGRAPHIQUES

lum. Paintings on other kinds of support—plaster, stone, metal or leather—are subject to similar defects.

Disfigurement.—All defects are accompanied by disfigurement, but the second main type of defect involves disfigurement alone without any basic structural flaw. The more serious of these disfigurements is change of tone in the pigment or other colourant of the pictorial design—fading or darkening. Those pigments known as lake colours, made from dyes that are precipitated on a base, are apt to fade in strong light. The colour most used among the dyes is crimson and it may have come from the madder root, from cochineal, from the resin called dragon's blood, or other sources. Darkening often occurs in drawings or *gouache* paintings (thin water colour with admixed white) in which white lead was used. Even small quantities of hydrogen sulfide in the air will turn this black where it is not sealed by a rich binding medium or by a surface coating.

Less damaging than chemical changes of tone are those disfigurements caused by accretions. The main kinds are obvious and there is no limit to the number of accidents or of applications that can cause them. Most common is grime—dust from the air, splatters of mud or of food, smoke deposits and fly specks. The other main kind of accretion has been deliberately put on and is usually a varnish of soft resin, more rarely an oil, or an overpainting. It is not uncommon to find pictures with repeated surface coatings that have been laid over each other until they form a heavy layer. They are not permanent. In time the resins change, evidently in consequence of oxidation, turn from a translucent straw colour to a dull brown, become extremely brittle and are shot through with fine cracks. Painting done over a picture at a time later than its origin is not unusual in works a century or more old and on panel or canvas.

Examination of Condition.—The means of treatment for repair of defects in paintings do not fall into regular categories and cannot be rightly represented by a series of recipes. Work of this kind is highly technical and all determinations of method or decisions about the use of materials need to be made on the grounds of knowledge that is the product of special training and experience. It was only during the 20th century that such training became regularly and systematically developed and that a body of knowledge in any measure adequate for the practice of the conservator was formed.

With the development of knowledge related to the conservation of paintings, the tools that need to be commanded by the conservator became numerous and complex. The extent of deterioration in original paint and subordinate parts of pictures can be appraised with the aid of laboratory science. Probably the instruments which are most discussed in this connection are not those which have the greatest and most regular utility. X-rays, ultra-violet rays and photography by infra-red radiation are all useful and may at times provide surprising revelations. They are not to be ignored, but they cannot take the place of the more direct evidence available through microscopy and microchemistry.

With training and experience a conservator can learn most about the condition of a picture by observation—general observation with the naked eye, followed by increased magnification up to 30 times. A binocular microscope rigged for examination of paint in a well-illuminated field is the standard instrument for procuring such magnification. This cannot distinguish the essential identity of materials, particularly pigments, and in doubtful cases discrimination between original and later work in a picture may require such identification. This can be done, and is regularly done in the laboratory, by microchemical analysis. The samples needed are microscopic and their loss from a painting is not visible to the eye. With samples of this size, spot tests can be made. These can fix, beyond a reasonable doubt, the identity of most of the pigments which would be critical in fixing the date of a particular paint layer. An early date cannot be confirmed by this means. Practically, there were no pigments used prior to 1900 that were not available in some way after that date. Many pigments, however, are known to have been invented, even patented, at definite times. Most of these originated after 1700 and it is likely that one of them will turn up in the overpainting of a picture that has an earlier date of origin.

Relining of Canvas.—For the repair of damaged paintings, a few standard manipulations were developed prior to the 20th century and, with a few modifications, remained in practice. Probably the most common is known as relining, the procedure of attaching a new or secondary canvas at the back of a canvas support when that fabric has become too weak to serve its purpose or when the ground or paint has become loosened from it. Usually relining involves removal of a former relining. Until the 19th century the common choice as an adhesive for the attachment of the new canvas was a glue or glue mixture. The shortcomings in this had become evident and, in the Netherlands, a method of relining with wax as the main ingredient of the adhesive mixture was demonstrated as satisfactory. Wax got away from the swelling and shrinking of the adhesive film in changes of humidity and greatly reduced the tendency toward development of mold in the picture support. In addition, it served effectively, if well-applied, to reattach loosened ground or paint and permit it to be set down if it had buckled from cleavage.

Procedure in relining begins actually at the surface of the picture. The paint needs to be protected and held firmly before work on the support can be safely undertaken. If the surface coating is very brittle and is putting a strain on the paint, it may have to be removed at the start. If there are tears, the edges will have to be aligned. Occasional fabrics need a preliminary stretching to smooth them. At some stage in the process, the face of the painting is covered with paper (long-fibre and without any sizing), usually put over the varnish with a starch paste; attachment must be uniform. The painting is taken from its stretcher. If it has been relined before, the old relining canvas is removed and then all of the old relining adhesive that remains stuck on the back of the original canvas. There is likely to be a thick and obdurate crust of this adhesive. The new relining canvas, washed linen of even, heavy thread, is stretched on a provisional stretcher of wood to leave a clear working space at least six inches beyond each edge of the original support. When both canvases are made ready, the picture is placed face down on the smooth and covered worktable and the relining canvas on its stretcher is placed over it. The wax adhesive is put on usually at the back of the new linen and in a melted state. It is then worked over with special irons, at a temperature just above the melting point of the wax, until the fabrics are thoroughly impregnated and held together, and until all cleavage and crevices, through to the surface of the paint, have been filled and reattached. After this is satisfactorily done, the facing may be removed and the support placed properly on its permanent stretcher.

Although the adhesive used for relining is commonly referred to as wax, it contains, as a rule, other ingredients. A few experimental relinings with pure wax have been reported but for most purposes this is too hard and it lacks stickiness and flexibility. Addition of a natural resin or balsam improves its working properties and such additions may run to 40% of the total volume. Lower proportions seem to be satisfactory. Tests were made by H. J. Plenderleith and Stanley Cursiter on many of these mixtures. Pure beeswax, for example, would hold a breaking load between two canvases of 5.4 lb. per square inch. Beeswax taken as a proportion of 75% and with addition of 19% resin and 6% gum elemi would hold 20.6 lb. per square inch in a relining system. Beeswax, 80%, with 20% gum elemi, is found to be still unbroken as an adhesive film at a load above 25 lb. per square inch. The melting point of the mixtures is somewhat lower than that of pure beeswax and lies between 59° and 61° C.

Transfer.—Another established repair operation was originated, so far as the records can be followed, in the mid-18th century. This is called transfer or transference. In every instance it is a difficult and possibly hazardous kind of treatment, although if it is well-carried out it does not contain any baffling sleight-of-hand performance. The result of a transfer is the removal of the paint, with or without the ground layer beneath, from one support to another. It is necessary only in those cases in which there exists a large amount of cleavage that threatens to

bring about flaking and loss, and in cases where the cleavage cannot be reached or reattached either from the face of the painting or from the back through the support. Consequently, transfer is commonly done with paintings on a heavy, thick support—wood, plaster or the clay wall of the orient. There is no fixed procedure for this operation, but certain regular principles apply. The paint is first given a temporary support at its face in addition to that at the back. Paper and fabric are the common materials of the temporary support. The adhesive for them has to be one that can be removed without injury to the paint and without disturbing the attachment of the paint to the new permanent support. After the temporary facing is applied and is satisfactorily in place, the work is turned face down and the old support is removed. On the painting, still in this inverted position, a new support is built or attached. Finally, the facing, or provisional support at the front of the paint, is taken off.

A condition that usually requires transfer as a means of conservation of a painting is found in a work on panel with a heavy gesso ground which has lost its integrity as a firm layer and has become powdery. Movement of the wooden support loosens the powdery mass and the paint with part of the ground is ready to fall out if jarred or subjected to repeated vibration. The gesso is made of gypsum or chalk mixed with glue. Dampness and mold weaken or destroy the glue. If there is no access to this layer from the front, it must be reached from the back. Paint on pictures of this kind may be impervious to moisture. It can be made resistant by a thin coating of spirit-soluble resin or plastic and a first paper of the facing is often applied with such an adhesive. Outer layers of the facing can then be attached with starch paste or weak glue. The work is then put face down. The panel is cut off from the back and the deteriorated part of the ground is removed. At this point, transfers in the 18th century were completed by attachment of a canvas with glue. In time this took on a distortion that was a disfigurement to a work done originally on a panel, and by the late 19th century the drawbacks of the panel-to-canvas transfer had become apparent. Thereafter, the favoured procedure was to apply a new panel. This also had its drawbacks, particularly if the new wood was attached with glue. By 1930 methods were introduced for building a composite panel at the reverse of the ground and for this strips of light wood were set together with a mixture of wax, resin and inert filling material which could be handled like putty when warm.

Treatment of Cleavage and Distortion.—Cleavage, if it is not extensive and if the pockets can be reached, is usually treated by reattachment. An adhesive is infused into the pocket or, in some instances, the paint is lifted and the adhesive is applied directly by brushing. Sealing of a panel at the reverse reduces the activity of wood in changes of humidity and tends to cut down a chief cause of cleavage. The experienced conservator who has followed the results of treatment for repair over a number of years can notice that reattachment of cleavage in paint is likely to be deceptive. The loose and buckled crusts of ground and paint layers may be somewhat softened and flattened by the work. They may be stuck down in places, but while panels, in particular, are subject to changing conditions in the air, there is always a chance that they will become loosened again. Relining, if carefully done, is the most satisfactory solution to this problem. On panel supports reattachment is less satisfactory.

Distortion in supports is a problem largely of paper and of panels. Fabrics or canvases supporting most paintings are carried on a stretcher and relining is an adequate correction of any distortion in them. Paper can usually be flattened if the paint will stand a moderate amount of dampness. Exposure in a humid chamber containing fungicide to prevent the start of mold, followed by drying under pressure, will often smooth out ordinary wrinkles if there is no continuing cause. A heavy film of glue around the edges, used for mounting, is a frequent cause. In some instances, paintings or drawings on paper will stand immersion in water, provided there is adequate control and proper equipment for handling.

Attempts to flatten panel supports have led to definite structural damage of a worse kind than the warp. This is particularly noticed in cases where fixed crosspieces have been attached to hold the wood in line. The cradle was a device introduced as a means to correct distortion without cramping the wood in its normal reaction to the moisture of the air. In construction the cradle has wood strips firmly fixed to the reverse of a panel in the direction of the grain. On the underside of these strips next to the old wood are notches into which are slid movable cross members.

Probably most panel paintings carry or have carried a cradle. In many instances it has done no damage but in others it has caused multiple warping, cracking of the panel and cleavage in the ground. The causes are complex but, in general, lie with the tendency of wood to recover a warp which is the result of the natural forces of contraction. Over a long period of time these forces overcome the slip of the cradle and pull the cross members tight. The wood breaks against the constriction that results.

Treatment of Discoloration.—There is no remedy for faded pigment in paint but the commonest discoloration, the darkening of white lead, can be corrected. Chemically, this change is from the white hydrated carbonate of the metal to the dark sulfide. Treatment of the sulfide with a solution of hydrogen peroxide will convert it to a white sulfate of lead without change in the general appearance of the paint. This is usually done on drawings in which the white is used for the light modeling tones against a tinted paper. To prevent the medium from being softened, the hydrogen peroxide is diluted with alcohol or ether to speed drying of water and reduce its effect on an aqueous adhesive used as binder for the pigment.

A few water-colour sketches and most drawings have the paper support as part of the design. In these, stains, general darkening or development of the small brown spots known as foxing, all occurring in the support itself, are a disfigurement to the picture. If the paper is normally strong and if the material of the drawing or painting will stand treatment, a procedure for bleaching is safe and practicable. Many methods and combinations of methods have been used. A representative one is the following: The paper is detached, if mounted. Three baths are used for bleaching. The first is water, 2,700 ml., with a 5% solution of sodium hypochlorite, 150 ml., and concentrated hydrochloric acid, 15 ml. The bath, when ready, should not change the colour of litmus paper; it is practically neutral and so compounded as to release free chlorine. The second bath is a very dilute hydrochloric acid, 0.5 ml. of the concentrated acid in 2,700 ml. of water. The third bath has 2 ml. of concentrated ammonium hydroxide in 9,000 ml. of water. This should give an alkaline response with litmus paper to make certain that it can neutralize any remaining acid. The paper is left in the first or bleaching solution a matter of seconds or minutes until stains are almost removed. It is then put in the bath of weak acid. When the bleaching is completed, the paper is transferred to the weak ammonia solution and left about ten minutes. After that it is thoroughly rinsed in clear water. The techniques of handling paper in a bath have to be varied for different conditions. Usually the sheet is carried on plate glass. After it is thoroughly washed, drying is done under observation and with slight pressure to prevent distortion.

Removal of Accretions.—By far the greater part of disfigurement to pictures comes from accretion of materials that were not originally used by the artist. Removal of these is a common necessity in the conservation of paintings but, owing to the wide variety of the accretions themselves and to the extreme variations in the material, structure and condition of paint, no single procedure or even set of procedures can be called standard. Dust, smoke and grime, if adhered to paint, may be taken up on an absorbent material such as loose cotton fibre dampened with fluid. Selection of the fluid for this purpose depends upon the determined solubility of the paint. In some instances a water mixture with a surface-active agent such as sulfonated alcohol is safe. Combinations of water and wax in an emulsion are frequently usable, and a wide range of organic solvents is available. Solvents generally are used to take off accretions of varnish. If the material of these is a soft resin, it is soluble slowly in coal-

tar hydrocarbons such as xylene or toluene, is more quickly dissolved by chloro- compounds such as chloroform and ethylene dichloride and, more quickly still, in the cellosolve group, the alcohols and the ketones.

The number of organic solvents available can be numbered in scores and the possible combinations are infinite. There is no rule for a safe solvent that will also be effective. Petroleum naphtha is harmless to either tempera or oil paint unless it has been infused with wax. It can, of course, dissolve waxes. In themselves, fully dried and seasoned oil and tempera paints are not disturbed by the ordinary solvents. (These do not include substances of a basic or alkaline nature which would act as reagents—ammonium hydroxide or morpholine, for example.) The difficulty with solvents in the removal of accretions is the risk that a resin has been mixed with an oil paint or that any paint may have become chalky at some previous time and have been saturated with the resin of a surface coating until the paint proper has the solubility of the resin.

Compensation and Recoating.—It is not important and it may not be desirable to make a damaged picture look as if it had no defects. It is generally regarded as necessary, however, to treat the badly damaged areas of a painting in such a way that they will not unduly disfigure the work. Holes, flaked losses and other blemishes are usually filled with paint, toned suitably to the surrounding area but with no intrusion upon the original paint. Since each case, in which such inpainting or compensation of loss is needed, has its own problem, this part of the work of conservation is, in effect, a part of the practice of design. The aim is not deception but appropriate reduction of accidental and damaging contrasts.

Most paintings which have had old and discoloured surface coatings removed and losses compensated with appropriate inpainting must have a coating put over them as a protection from dust and grime and as a partial seal from dampness and injurious gases in the air. Complete air-tight protection in a frame might make this final coating unnecessary. Without that protection even further application of a resinous film is better than exposure of the paint. If the varnish is kept thin it can be given a superficial layer of hard wax after thorough drying. This makes a combined layer that is more impervious to damp and more inert than is the varnish alone. In addition, the wax can be removed, if it collects dust, by solution in a petroleum naphtha, a solvent which will not disturb the thin varnish layer beneath. Because of that, removal of the wax carries no risk of abrading the paint. Beeswax alone is too soft to serve as a satisfactory outer coating. It is usually combined with ceresin and with carnauba, the hard wax that comes from the leaf of a Brazilian palm.

This mixture can be smoothly applied and polished. After 1925 many conservators used synthetic plastic materials instead of the natural resins in surface coatings. The longest experience up to mid-century was with polymerized vinyl acetate. This and the polymers of acrylic acid furnish coating materials that are clear and colourless, soluble in suitable organic solvents, and are not subject to oxidation or auto-oxidation as are the natural resins. They are highly permeable to moisture, but a superficial coating of wax overcomes this defect.

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PAISIELLO (PAESIELLO), **GIOVANNI** (1740–1816), Italian composer of opera, was born at Taranto on May 9, 1740. Educated at the Jesuit school at Taranto, he later studied at the Conservatorio di S. Onofrio at Naples under Francesco Durante. For the theatre of the conservatorio, which he left in 1763, he wrote some *intermezzi*, one of which attracted so much notice that he was invited to write two operas, *La Pupilla*, for Bologna, and *Il Marchese di Tulipano*, for Rome. His reputation established, he settled for some years at Naples, where he produced a series of highly successful operas.

In 1776 Paisiello was invited by the empress Catherine II to St. Petersburg, where he remained for eight years and where he produced, among other works, his masterpiece, *Il Barbiere di Siviglia* (1782). (When, in 1816, Rossini set the same libretto to music, under the title of *Almaviva*, it was hissed from the stage. Nevertheless, under its changed title, *Il Barbiere*, it became known as Rossini's greatest work while Paisiello's opera was forgotten until the 20th century.)

In 1784 Paisiello left Russia and entered the service of Ferdinand IV at Naples. He composed many of his best operas there, including *La Molinara* (1788) and *Nina* (1789). After many vicissitudes resulting from political and dynastic changes, he was invited to Paris in 1802 by Napoleon, whose favour he had won five years previously by composing a march for the funeral of Gen. Lazare Hoche. Napoleon treated him munificently, while neglecting the resident musicians Cherubini and Méhul. Paisiello conducted the music of the court in the Tuileries; the Parisian public, however, received his opera *Proserpine* so coldly that in 1803 he returned to Italy.

On his arrival at Naples, Paisiello was reinstated in his former appointment by Joseph Bonaparte and Joachim Murat, but he was unable to meet the demands for new works. The power of the Bonaparte family was tottering and Paisiello's fortunes fell with it. He died on June 5, 1816, at Naples.

Paisiello is known to have composed about 100 operas. His church music comprises about 40 Masses and many smaller works. His instrumental music includes symphonies, a harp concerto, string quartets and sonatas for harp and for violin and cello. In the 20th century *Il Barbiere* and *La Molinara* were revived and several of his operas and piano concertos, string quartets and keyboard pieces were republished.

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PAISLEY, a large, royal, and parliamentary burgh of Renfrew, Scot., on the White Cart Water, 3 mi. from its junction with the Clyde, 7 mi. WSW of Glasgow by road. Paisley is the county town of Renfrew. Pop. (1961) 95,753. In 1791 the river, which bisects the town and is crossed by several bridges, was made navigable for vessels of 50 tons. Later it was further deepened and made navigable for vessels drawing 15 ft. The old town contains most of the principal warehouses and mills; the new town, begun toward the end of the 18th century, occupies much of the

ground that once belonged to the abbey. To the munificence of its citizens the town owes many of its finest public buildings, among them the town hall, the public library and museum (with a collection of Paisley shawls), the Coats Observatory, the John Neilson Institution, and the fine Thomas Coats Memorial Church. Of the 14 public parks, covering 1,572 ac., the biggest is Barshaw Park (144 ac.). Paisley was created a parliamentary burgh in 1833. In the abbey precincts are statues to the poet Robert Tannahill (1774–1810) and Alexander Wilson (1766–1813), the U.S. ornithologist, both of whom were born in Paisley. John Wilson ("Christopher North"), the writer, was also born there.

The abbey was founded in 1163 as a Cluniac monastery by Walter Fitzalan, first high steward of Scotland, the ancestor of the Scottish royal family of Stuart, and dedicated to the Virgin, St. James, St. Milburga of Much Wenlock in Shropshire (whence came the first monks), and St. Mirinus (St. Mirren), the patron saint of Paisley, who is supposed to have been a contemporary of St. Columba. The monastery became an abbey in the 13th century, was destroyed by the English under Aymer de Valence, earl of Pembroke, in 1307, and rebuilt in the latter half of the 14th century, the Stuart kings endowing it lavishly. In 1553 Lord Claud Hamilton, then a boy of about ten, was made abbot, and the abbacy and monastery were erected into a temporal lordship in his favour in 1587. The abbey lands, after passing from his son the earl of Abercorn to the earl of Angus and then to Lord Dundonald, were purchased in 1764 by the 8th Earl of Abercorn, who let the ground for building purposes.

The abbey church originally consisted of a nave, choir without aisles, and transepts. The nave and tower were restored, and careful work was done on the choir. The nave is used as the parish church. Robert III was interred before the high altar of the choir in 1406. Over his grave a monument to the memory of the royal house of Stuart was placed by Queen Victoria (1888). In the south transept is St. Mirren's Chapel (founded in 1499), with the tombs of Abbot John Hamilton and of the children of the 1st Lord Paisley, and an effigy, possibly of Marjory, daughter of Robert Bruce, who married Walter the Steward and was killed while hunting at Knock Hill between Renfrew and Paisley (1316). Her son became Robert II.

The village originally grew up around the abbey, and the town of Paisley has been an important manufacturing centre since the beginning of the 18th century, but the earlier linen, lawn, and silk-gauze industries have become extinct, and the famous Paisley shawls (imitation cashmere) are now objects of art. (*See* SHAWL.) The manufacture of linen thread gave way in 1812 to that of cotton thread, and Paisley became one of the greatest thread-manufacturing centres in the world. Paisley is also famous for its tobacco, starch and corn flour, marmalade and jam. Other industries include bleaching, dyeing, calico printing, weaving, engineering, tanning, iron and brass founding, timber yards, and the making of machinery and chemicals, besides some shipbuilding. A Roman Catholic bishopric was established at Paisley in 1947.

About 2 mi. SE of Paisley stand the ruins of Crookston Castle, dating probably from the 13th century and associated with Mary, queen of Scots, and Lord Darnley. Elderslie, 1 mi. SW, is the traditional birthplace of William Wallace, the Scottish national hero.

PAIUTE designates two distinct American Indian groups who speak languages of the Plateau branch of Shoshonean. The Southern Paiute, who speak Ute-Chemehuevi, occupied southern Utah, northwestern Arizona, southern Nevada, and southeastern California, the last being known as Chemehuevi. The Northern Paiute, who have also been designated Mono (*q.v.*) in California and Paviotso (*see* GHOST DANCE) in Nevada, and more loosely as Diggers, occupied east-central California, western Nevada, and eastern Oregon. An offshoot, the Bannock, lived with the Shoshone (*q.v.*) in southern Idaho, where they were bison hunters.

The Northern and Southern Paiute were simple food collectors who subsisted primarily upon seeds, pine nuts, and small game, although many Southern Paiute planted small gardens. They occupied temporary brush shelters, wore little or no clothing except rabbitskin blankets, and made a variety of baskets for gathering and cooking food. Families were loosely affiliated through intermarriage, but there were no formal bands or territorial organizations, except in the more fertile areas, such as Owens Valley east of the Sierra Nevada (*q.v.*) Mountains in California.

When the Ute (*q.v.*) acquired horses and became predatory nomads early in the 19th century, they became distinct from the Southern Paiute. Many Northern Paiute, especially along the Humboldt and Oregon immigrant trails, also acquired horses and developed predatory bands during the middle of the 19th century. In the 1960s the Northern and Southern Paiute lived largely on or near reservations, numbering about 4,000.

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PAJOU, AUGUSTIN (1730–1809), French sculptor, who became official sculptor to Louis XVI, was born in Paris, Sept. 19, 1730, and died there, May 8, 1809. A pupil of J. B. Lemoyne, he won the Prix de Rome in 1748. He was elected to the Academy in 1760. Like his master's, Pajou's main work consists of portrait busts, probably the most famous of which is the bust of his former patron, Mme Du Barry (Louvre).

Also a decorator on a larger scale, he directed the decoration of the Versailles opera, and when Bernard Poyet reconstructed the Fontaine des Innocents (by Pierre Lescot, 1547–49) Pajou provided several figures for it. (AA. B.)

PAKHOI: *see* PEI-HAI.

PAKHTO: *see* PASHTO.

PAKISTAN, properly the REPUBLIC OF PAKISTAN (PAKISTANI JAMHOORIAT), a country in southern Asia and member of the Commonwealth of Nations. It came into existence on Aug. 15, 1947, and covers those parts of the former Indian empire with a predominantly Muslim population, those parts with a predominantly Hindu population forming India (*q.v.*), or Bharat. In the years preceding the grant of independence to India the movement for a separate Muslim state to be known as Pakistan took firm hold and eventually resulted in the partition of 1947. The name Pakistan was first used in 1933 and can be interpreted as meaning the land (*-stan*) of the (religiously) pure (*pak*), but is said to have suggested itself to a group of expatriate students at Cambridge, Eng., from the initial letters of Punjab, Afghania (Northwest Frontier province), Kashmir and Sind with the termination from Baluchistan. This is approximately the area covered by West Pakistan. The movement claimed a larger area and also advocated other Muslim states but did not visualize the Muslim areas of Bengal as part of Pakistan itself. With partition, however, the Muslim eastern two-thirds of Bengal became part of Pakistan. The republic is thus unique among major countries of the world in consisting of two parts separated by 1,000 mi. of alien territory. The total area of Pakistan (before the 1963 boundary adjustment with Communist China) was 365,529 sq.mi. and the population (1961) 93,831,982, (1963 est.) 98,612,000.

The actual boundaries were decided on the principle of Muslim-Hindu majorities by Sir Cyril (later Lord) Radcliffe, since the Muslim and Hindu members of the commission of which he was chairman failed to agree. The Radcliffe award followed existing minor administrative boundaries rather than physical features. The cutting of roads and railways and especially of irrigation canals in the Punjab by the new boundary created many difficulties. Hindus found it difficult to forget 500 years of Muslim rule and it would have been too much to expect friendly relations between the two new states, at least at the start of the new regimes. Partition gave rise to the greatest mass migration in history, involving at least 8,000,000 to 10,000,000 people. The Pakistanis had expected to include East Punjab and the Sikh city of Amritsar and when the Sikhs decided to throw in their lot with India reaction was violent and there was much bloodshed. Kashmir, with a predominantly Muslim population but with a Hindu ruling class, was also the scene of fighting; in 1962 when Chinese invaded this area Indian and Pakistani troops were still facing one another across an armistice line.

West Pakistan is extensive, and on the whole sparsely populated

by stalwart peoples used to life in an arid environment and for the most part relying on irrigation. The dominant languages are Punjabi (Panjabi) and Sindhi, though the old court language Urdu is widely understood and used. East Pakistan is in complete contrast. It is a small area, but one of the most densely populated in the world, its population exceeding in total that of most western lands. The population is composed of homogeneous, slightly built people, speaking Bengali and living in the wet environment of alluvial rice-growing lands. Only religion ties together these contrasted halves of the country. East and West Pakistan are each organized as a single administrative whole with capitals respectively at Dacca and Lahore. The temporary capital of the whole country was at one time Karachi and later Rawalpindi, until the new capital, Islamabad, was built on the cool plateau farther north.

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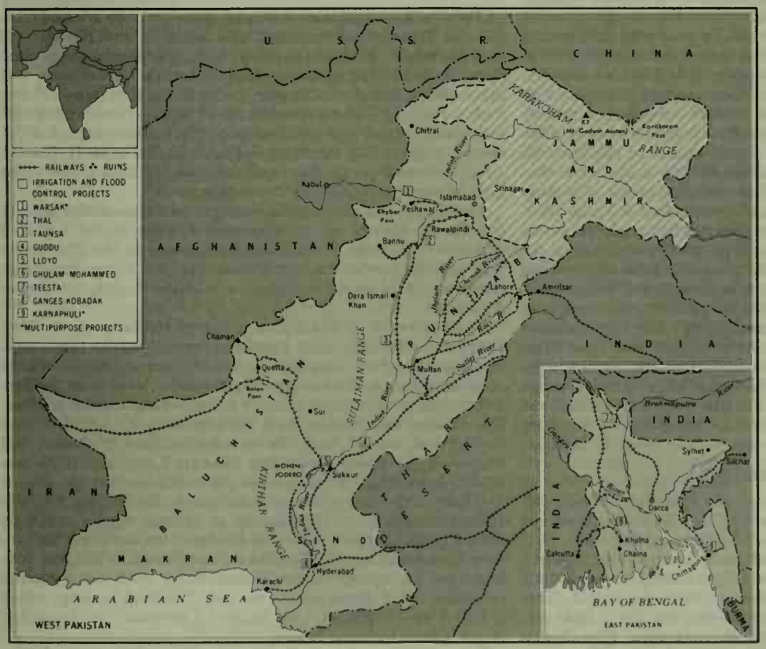
I. PHYSICAL GEOGRAPHY

The geology, physiography, climate, vegetation and animal life of Pakistan are discussed in INDIA-PAKISTAN, SUBCONTINENT OF (*q.v.*). As explained in that article, the subcontinent, occupied mainly by the two republics of India and Pakistan, comprises a great enclosing mountain wall, a huge crescentic alluvial plain (the Indo-Gangetic plain) and the great plateau which makes up peninsular India. There are also certain parts, outside the mountain wall, which form part of the two countries concerned.

1. West Pakistan.—This occupies the northwestern sector of the subcontinental complex and hence comprises a number of contrasted regions. The old regional names, which applied also to administrative divisions, are likely to persist. The plateau of Baluchistan occupies the west of the country. It consists of arid plains with many ridges rising from the surface merging westward into similar country in Iran and northward into Afghanistan. There are no perennial rivers; streams which flow after the rains for the most part drain inward to shallow transient lakes. In the south is the arid and rugged Makran coast, while to the east a succession of dry rocky ranges separate the Baluchistan plateau from the Indus plains. These ranges comprise the Kirthar in the south, then a re-entrant with the Bolan pass leading to Quetta, then the Bugti hills and Sulaiman range. These merge northeastward into the tangle of dry hills which constituted the old North West Frontier province. In contrast to the 1,400,000 tribesmen scattered over the 133,000 sq.mi. of Baluchistan, here a considerable population lives in the main valleys especially where irrigation water is available—in the valley plains of Dera Ismail Khan and Bannu, and especially in the rich vale of Peshawar. In the north Pakistan includes considerable sections of the Himalayas (*q.v.*) proper; there the state of Jammu and Kashmir (*q.v.*) is claimed by both Pakistan and India. The western Himalayas are broad and complex when compared with parts farther east; there is an arid foothill belt, then the Outer Himalayas or Pir Panjal range; then the Lesser (middle) Himalayas or Pangi range; next the Inner or main Himalayas or Zaskar range; then the great Muztagh and Karakoram mountains with finally that small sector of the Tibetan plateau in Ladakh claimed not only by India and Pakistan but also by Tibet. All these trend northwest-southeast, and between them the five rivers of the Punjab—Sutlej,



PRINCIPAL CITIES, RAILWAYS AND IRRIGATION-FLOOD CONTROL PROJECTS IN PAKISTAN

five rivers of the Punjab—Sutlej,

Beas, Ravi, Chenab and Indus—take their rise and have long courses before they turn and cut through the ranges to unite on the plains. South of the Himalayas but east of the Indus, Pakistan includes a plateau around Rawalpindi bounded on the south by the Salt range. This plateau has enough rainfall, mainly in winter, to permit dry zone crops; elevation tempers summer heat and there Pakistan's new capital Islamabad is sited. It has also some small oilfields. South of the Salt range, the valley plains of the Punjab (the word Punjab meaning "five waters") constitute the most populous and developed region of West Pakistan, with the administrative centre Lahore. Most of the cultivation depends upon canal irrigation from the rivers; large areas were settled only when the large-scale works of British engineers made this possible. With the coming of partition and independence in 1947 the boundary was drawn, according to Muslim or Hindu majorities, across plain and mountain alike, cutting rivers and canals in such a way that a waters dispute became a serious political issue for the next 15 years. The five rivers join to form the lower Indus shortly above where it enters the old province of Sind. Sind was long known as the "unhappy valley" because with an annual rainfall as low as or even below five inches it depends on irrigation from the river. From early times inundation canals were filled with floodwater, though in bad seasons they might never be filled and famine resulted; hence the construction of the Lloyd or Sukkur barrage (completed 1932) with a perennial canal system was of immense importance. Other works have followed and the valley plain of the lower Indus is fast becoming one vast irrigated and highly productive region. It focuses on the town of Hyderabad; its natural outlet (on the west of the Indus delta) is Karachi. The discovery in the 1950s of a vastly rich field of natural gas near the little village of Sui in the hills north of Sukkur changed the whole economic position of Pakistan. Gas is now piped to Karachi and to Lahore. Eastward of the Sind valley and southeast of the Punjab plains, the land rises, ceases to be irrigable and merges into the Thar or Indian desert. The India-Pakistan boundary leaves the old princely state of Bahawalpur in Pakistan.

2. East Pakistan.—This is utterly different from West Pakistan. It comprises the eastern two-thirds of the Ganges-Brahmaputra delta, stretches northward to include the triangular wedge of land between the Ganges and the Brahmaputra before they unite, and eastward to embrace the valley plain of the Surma. Abruptly in the east the alluvial plains give place to wet forested ridges, running mainly north-south, which form part of the mountain divide with Burma. There have been boundary changes but broadly East Pakistan is the eastern two-thirds of the prepartition province of Bengal. In the course of centuries the main outlet of the Ganges has shifted steadily eastward so that West Bengal, India, is a land of dead and dying rivers with many *bhils*, or cut-off lakes and marshes, whereas in East Pakistan much water moves down the distributary rivers and through connecting creeks and the delta is still in active development. Apart from the mangrove forest swamps toward the coast, this is all rich rice and jute land, liable to annual floods, with innumerable villages and isolated farmsteads perched on mounds or strung out along levees. The rainfall is everywhere in excess of 60 in. The administrative centre, Dacca, is centrally placed. Between the Ganges and Brahmaputra is a low ridge known as the Barind and relatively infertile. Since partition Pakistan has paid much attention to the development of water power and forestry in the eastern hills and this has permitted the great growth of Chittagong. Natural gas has been discovered in the Sylhet area. (L. D. S.)

II. THE PEOPLE

Separated by nearly 1,100 mi. of Indian territory, West Pakistan and East Pakistan are marked not only by geographical but also by racial, linguistic, religious and cultural differences.

1. Races.—Human skeletons and skulls found among the ruins at Mohenjo-Daro reveal that at least four racial types, viz., Mediterranean and Alpinoid (both Europoid), Proto-Australoid (Veddoid), and Mongoloid, were present in this area in *c.* 2500 B.C., and that there was much racial intermixture. (*See* INDIA-PAKISTAN, SUBCONTINENT OF: *Anthropology.*)

CAMERA PRESS—PIX FROM PUBLIX

PATHANS FROM KHYBER PASS AREA

The present-day peoples of West Pakistan may be grouped into: (1) the "true" Mediterranean type found in the Punjab; (2) the "oriental" Mediterranean type in the Punjab and Sind, characterized by an unusually long and often convex nose and lighter skin colour, but otherwise similar to the first type; (3) the Pashto-speaking Pathans (*see* PATHAN) of the Northwest Frontier: Semitic traces among these people have been alluded to by several writers; (4) the brachycephalic (round-headed) Balochi (*q.v.*) derived from Iranian stock and found in Baluchistan. The Balochi are often called the Aryan type.

The peoples of East Pakistan belong to two major racial groups: (1) the Mediterranean, an important element in the nontribal population; (2) the Paleo-Mongoloid, found in the Chittagong hills and along the Pakistan-Burma border. Some immigrant tribal people of western origin, such as the Santal, are Proto-Australoid.

2. Languages.—Urdu (*q.v.*) is the official language in West Pakistan. Although most Pakistanis understand it, they speak some other regional language as their mother tongue. Urdu (a mixture of Arabic, Persian and Hindi words), written in the Persian script, is traced by historians to early Mogul times in India. The regional languages of West Pakistan are: (1) Sindhi, spoken in Sind and derived from the *virachada* dialect of Prakrit and written in the Arabic script (*see* PRAKRIT LANGUAGES). It was written however in the Malwari or the Ardhanagari script at least up to the 11th century A.D.; (2) Balochi in Baluchistan (*see* BALOCHI LANGUAGE); (3) Makrani in Makran (*q.v.*) bordering Iran; (4) Pashto (*q.v.*, Pushti) or Pakhto in the frontier areas bordering Afghanistan; (5) Punjabi in west Punjab. The last four languages are written in the Persian script. All the foregoing languages are of Aryan origin; the only Pakistani language which is non-Aryan is Brahui (*see* BRAHUI LANGUAGE) of Dravidian origin spoken by some Balochi.

Bengali is the official as well as the spoken language of East

Pakistan. It is written in one of the Nagari family of scripts and has a closer relationship with Sanskrit and Hindi than with any Pakistani language. It has a rich literature to which modern poets like Buddhadeva Bose and Nazrul Islam have made important contributions. (*See* BENGALI LANGUAGE.) English, which is spoken widely in government and education circles, was still an official language for both wings in the 1960s.

3. Religions.—The great majority of the people of the Republic of Pakistan are Muslim. All the religious minorities (notably Hindus, Christians, Buddhists and Parsees) together constituted in 1961 less than 12% of the total population.

Most of the Muslims are Sunni Hanafis, but there are a few Sunni Shafi'ites and Shi'ites (Shiahs). Other distinctions made by the Muslims among themselves include Sayyids (believed to be the descendants of Mohammed through his daughter Fatima), Moguls, Pathans, Khojas (a business community found in Sind), and Isma'ilis (followers of the Aga Khan). The Muslim status of the Qadianis of West Pakistan (the followers of Mirza Ghulam Ahmad Qadiani) is uncertain as they do not subscribe to the finality of the prophet Mohammed which is one of the basic tenets of Islam (*q.v.*).

Hindus, the major religious minority (10,001,474 in 1961), are concentrated in East Pakistan where they numbered 9,379,669; Christians (732,787) are found mostly in West Pakistan. Nearly all the 376,312 Buddhists live in East Pakistan, and the 5,412 Parsees in West Pakistan. Other non-Muslim groups including Jews and the tribal peoples total 47,872. (*See* also *Population*, below.)

4. Cultures.—The cultural pattern of Pakistan presents interesting diversities within different religions, within geographical regions, and between tribal, peasant and urban societies, and also within these societies. There are also similarities which spring mainly because the majority of the people are Muslims.

Though religious minorities are numerically very small in West Pakistan, the Islamic way of life there has been influenced by centuries of contact with Indian civilization. Thus the Muslims have developed a caste system which is basically incompatible with the egalitarianism of Islam. This has happened not only in the Punjab, but also in the frontier areas; *e.g.*, Swat valley. Besides caste, a characteristic feature of Punjabi rural life is the institution of *vartan bhanji*. This involves the exchange of food, money, clothes, services and favours between the various groups that make up the society. Through this mechanism of exchange people are able to achieve not only social integration through interdependence but also social status and prestige.

In the ordering of social life the Pathan society lays considerable stress upon ownership of land, patrilineal descent, ranked social groups and Islamic injunctions such as reverence for saints. A highly developed sense of honour is linked with revenge, and that of prestige with hospitality. Public and private aspects of Pathan life are controlled by assemblies (*jirga*), the functioning of which has been compared with Athenian democracy.

The tribes of East Pakistan (including Chakmas, Moghs, Tripuras, Murungs, Banjugis, Pankhoos, Lusheis and Khyangs) practise *jhum* ("slash-and-burn" or "shifting") cultivation. Social life is organized on the basis of patrilineal descent and settled village life. Although many of them still profess the so-called animist religions some (like most of the Khyangs) are Buddhists, and the influence of Christian missions has been considerable.

In the cultural pattern of East Pakistan, the Hindu way of life is important. Ancient traditions are preserved through such institutions as the *tol* where students learn Sanskrit, scriptures, philosophy and the *Ayurvedic* system of medicine. *Ayurveda* (based on homeopathy and naturopathy), though traditionally Hindu, is popular with many other sections. There are a number of annual religious ceremonies (*puja*), well known for their colourful festivities; these include Durga *puja*, Kali *puja* and Sarasvati *puja*. The rural people of East Pakistan have developed a variegated culture rich in folk music, dance, drama and literature. (T. N. M.)

III. HISTORY

1. Background to Partition.—The movement among the Muslim population of the India-Pakistan subcontinent which culminated in the creation of Pakistan stemmed from the historical fact that for more than six centuries before the effective domination of the British in India, Muslim soldiers and administrators had ruled over much of a population in which Hindus were a numerical majority. When the British replaced Muslim domination by their own, this imperial tradition hindered the community from adapting itself to the new situation as readily as the Hindus; but after the failure of the risings of 1857 (*see* INDIAN MUTINY) had dashed Muslim hopes of a restoration of their authority, enlightened leaders like Syed Ahmad Khan (who has been called "the first Pakistani") persuaded the community, while not forgetting their heritage of the past, to qualify themselves by education and hard work for a share in the future. While Hindus were pressing for constitutional reform through the Indian National Congress, the Muslims sought various guarantees for their position and finally founded their own political organization, the All-India Muslim League, at Dacca in 1906.

Common disappointment—though on different grounds—at British policy after World War I drew Congress and the league closer together for a short time; but the gradual clarification of the British intention to grant self-government to India along the lines of British parliamentary democracy aroused Muslim apprehensions regarding ultimate political subjection to the Hindu majority of the population. Mohammed Ali Jinnah (*q.v.*), who was as eager as any Hindu nationalist to bring British rule to an end, strove for many years to secure the future of the Muslim minority inside the main freedom movement by means of constitutional guarantees, but was at length driven to the conclusion, at which the renowned poet-philosopher Mohammed Iqbal (*q.v.*) had already arrived, that the only way to preserve Indian Muslims from complete political, economic and cultural subordination to the Hindus was to establish a separate Muslim state. In taking this decision, Jinnah, a man of the 20th century, was animated by no narrow sectarian bias; his fear was that Hindu "clannishness," combined with Hindu business ability and Hindu superiority in education, would leave no "place in the sun" for Muslims in any conceivable set-up based on an independent, undivided India. He was confirmed in this view by the virtual exclusion of Muslims from office in every Hindu-majority province after the overwhelming victory of Congress in the elections of 1937. Undaunted by criticism, abuse and ridicule, he converted the league into an organization which inspired and guided a genuine national movement among three-quarters of the Muslim community throughout India. By 1940, the demand for Pakistan had been formally endorsed by the league under his leadership.

British policy, supported by the whole weight of the Hindu nationalist movement, laboured hard to avoid disrupting the economic and political unity built up under British rule; but none of the many suggested alternatives to Pakistan commended themselves to Jinnah, whose acute perception of Muslim needs and intimate acquaintance with Muslim apprehensions had satisfied him that only in the establishment of a Muslim homeland could security be found. His leadership of the bulk of the community was unchallenged, and without his co-operation—of which the price was Pakistan—Indian independence was impracticable. His courage and implacable determination triumphed in the end.

2. Birth of the New State.—The new state came into existence as a dominion within the Commonwealth in Aug. 1947, with Jinnah as its first governor general and his ablest colleague, Liaquat Ali Khan (*q.v.*), as its first prime minister. With West and East Pakistan separated by over 1,000 mi. of Indian territory, and with the major portion of the wealth and resources of the British heritage passing to India, Pakistan's survival seemed to hang in the balance. Of all the well-organized provinces of British India, only the comparatively backward areas of Sind, Baluchistan and the Northwest Frontier came to it intact; the Punjab and Bengal were divided; Kashmir became disputed territory. Economically, the situation seemed almost hopeless; the new frontier cut off Pakistani raw materials from the Indian factories, disrupting industry, commerce and agriculture. The infant government set up in Karachi had scarcely a typewriter or a telephone; its of-

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PRINCIPALS AT INDIAN PARTITION CONFERENCE, 1947

Seated around table, from left: Jawaharlal Nehru, Lord Mountbatten, Mohammad Ali Jinnah, and Liaquat Ali Khan

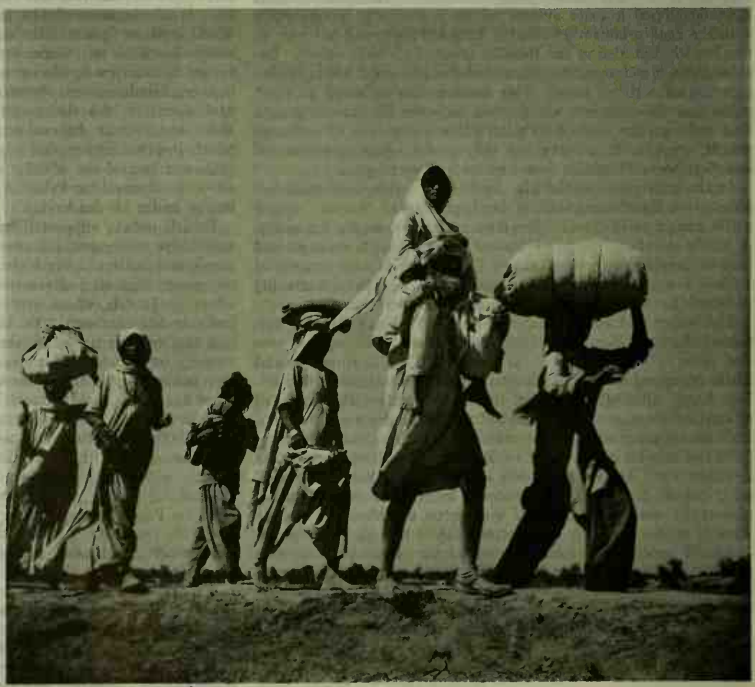
ficers lived in tents and issued their orders on penciled scraps of paper. The partition and the movement of refugees were accompanied by terrible massacres for which both communities were responsible. India remained overtly unfriendly; its economic superiority expressed itself in a virtual blockade. The dispute over Kashmir (for an account of which *see* JAMMU AND KASHMIR) brought the two countries to the verge of war; and India's command of the headworks controlling the water supplies to Pakistan's eastern canal colonies gave it an additional economic weapon. The resulting friction, by obstructing the process of dividing, according to plans previously agreed, assets inherited from the British *raj*, still further handicapped Pakistan in solving its problems.

3. Under Two Great Leaders.—The new government, supported by a remarkable upsurge of patriotic feeling, faced every difficulty with courage and resourcefulness. The initial great influx of refugees from India was temporarily regulated, thanks in no small measure to the heroic efforts of Pakistani women of the upper and middle classes, who emerged from purdah to organize social services and to relieve distress, thus setting in motion a process which gave Pakistani womanhood a position superior to that to be found in any other Islamic country. Nor was the refugee problem a mere passing phase. In East Pakistan and Bengal, in particular, the movement of populations was resumed on a great scale in and after 1950. After the division of the former Indian army between India and Pakistan the Pakistani defense forces were reorganized and withdrawn from tribal territory—a gesture of trust which initiated the policy of winning the confidence of the tribes, affording them economic and educational facilities, and leading them to civilization without encroaching on their jealously guarded freedom. Within a decade this policy brought peace and relative prosperity to an enormous stretch of once turbulent frontier. The same civilizing process was applied to the former Chitral Agency states, as well as to Gilgit and Baltistan, when these two latter areas, as a result of the fighting in Kashmir, threw off the rule of Srinagar and joined Pakistan. The government also took under its protection, but without incorporating it, the territory known as Azad ("free") Kashmir, where those who resisted the Indian occupation of Jammu, the valley of Kashmir, and Ladakh, had set up a provisional administration pending the holding of a plebiscite (for which Pakistan never ceased to press) under supervision of the United Nations to enable Kashmiris to determine their own political future. In 1947–48, other predominantly Muslim princely states, including Bahawalpur and Khairpur, had acceded to Pakistan without incident.

At the same time, the economic and administrative problems of the new state were tackled with vigour and imagination. New channels of foreign trade were opened up, foreign investment was encouraged and an entire reorientation of the former economic pattern was effected to make good the loss of the Indian market. New industries were established, foreign experts were employed to rationalize taxation, the budget was balanced. The permanent outlines of foreign and domestic policy were laid down. Pakistan at that point identified itself unhesitatingly with the western democracies against Communism.

Only the enormous personal prestige of Jinnah, backed up by the tireless work of Liaquat Ali Khan, could have held together, and guided into constructive efforts for their common nationalism, two areas so different in physical characteristics, cultural traditions, and ethnic composition as East and West Pakistan. The difficulty of linking the two wings, 1,000 mi. apart, was overcome by the organization of air services, whose efficiency soon became a source of national pride. Because of vigorous leadership and strong administration, the solid achievements of Pakistan during the first 13 months of its existence surprised not only India but also the world outside. A new nation was built out of mere bits and pieces. But the cement which bound that nation together, as the next few years were to show, depended for its tenacity upon effective leadership at the top and patriotic support from below.

Pakistan suffered a grievous misfortune in Sept. 1948 when its founding father, Jinnah, died worn out by hard work. Although



MARGARET BOURKE-WHITE, "LIFE," © 1947 TIME INC.

REFUGEES FLEEING COMMUNAL STRIFE IN THE INDIAN SUBCONTINENT, 1947–48

he was in theory a constitutional governor general (if with powers greater than those laid down in the Government of India act of 1935 which had been taken as the basis until Pakistan could build its own polity) his hand had been everywhere, guiding, directing, restraining, encouraging. Even the politically conscious Bengalis of East Pakistan, who in their heart of hearts inclined to regard the West Pakistanis as rough men of the sword, were proud to accept his leadership. With his disappearance from the political scene, the risk of differences between the two wings loomed larger. Moreover, he had conferred on the office of governor general a prestige, a pivotal position, which was to prove ill-suited to the inferior gifts, and untrained political judgment, of certain of his successors. But fortunately for his country, Liaquat Ali Khan's powers of leadership developed as the need for them grew greater. He controlled effectively every detail of government policy at home and abroad, appointing his ministers, redistributing their portfolios and managing the provisional parliament, which was also the constituent assembly charged to draw up the new constitution, with consummate skill. Under his able rule, Pakistan became respected abroad while remaining united at home. But the moderation of his attitude toward India, though based on unanswerable arguments, excited the ire of fanatics who clamoured for a holy war and led to his assassination in Oct. 1951. His tragic death ushered in a steady process of national decline which was not arrested until the revolutionary government emerged seven years later to take up his work.

4. Political Decline.—On the death of Jinnah, Khwaja Nazimuddin, a gentle man of unaffected piety, became governor general, thus inaugurating a convention of dubious value that the governor general and the prime minister should come from different wings of Pakistan. When Liaquat Ali Khan was murdered, Nazimuddin became prime minister and was replaced, as governor general, by Ghulam Mohammed, an able but impulsive financial expert. Ghulam Mohammed, regarding his position as equivalent to that occupied by Jinnah, quarreled with Nazimuddin in Oct. 1953 and replaced him by the genial Mohammed Ali of Bogra, a diplomat rather than a political leader. When the constituent assembly essayed to limit Ghulam Mohammed's powers, he summarily dismissed it, alleging with some justification that in the course of seven years it had become unrepresentative and was out of touch with the people. A protracted dispute broke out, in which both sides invoked the courts of law; but eventually in July 1955 the governor general was obliged to summon a new assembly. Shortly afterward his health broke down, and he was replaced in September of that year by Maj. Gen. Iskander Mirza, the first of the soldier statesmen to whom Pakistan owes so much.

The new constituent assembly accepted as prime minister Chaudhuri Mohammed Ali, an able and experienced public servant who had held a number of key administrative posts. He found himself handicapped in the unfamiliar atmosphere of political intrigue which at once surrounded him; and in Sept. 1956 he was replaced by H. S. Suhrawardy, a trained politician with a great mastery of parliamentary tactics. A political miscalculation obliged Suhrawardy to give place in Oct. 1957 to I. I. Chundrigar, an able lawyer, who in turn fell victim to party intrigue and was followed by Malik Firoz Khan Noon, a highly respected public figure of unimpeachable integrity. He in turn was powerless to arrest the serious decline in domestic conditions.

During 1951–58, Pakistan performed all the external functions of a respected sovereign state. It took an influential share in the work of the UN. It became a member of the Colombo plan (*q.v.*) and cultivated good relations with Commonwealth countries, with the United States (to which it became closely bound in a defensive alliance) and with other Islamic states (except Afghanistan, *see* below). It joined the Southeast Asia Treaty organization and the Baghdad pact. It sought better relations with India, negotiating over Kashmir, refugee property, boundary rectifications, commercial agreements, the division of the Indus basin waters (*see* below) and other contentious matters. In March 1956 it became a republic without leaving the Commonwealth. Its foreign policy, in short, was both prudent and successful, as was shown by the increasing support which it won for its views in the Kashmir dispute with India. But internally its condition was lamentable. Public life was honeycombed with faction, and corruption in the grossest forms raged unchecked. The political leaders, though frequently personally estimable, like many of the officials, lacked the fibre to resist the venal pressures exerted by "big business" and by quasi-feudal landowning interests which dominated West Pakistan, since 1955 unified into a single province to match East Pakistan. There also corruption and intrigue dominated public life.

5. Military Government.—The reputation of the administration fell as a formidable list of popular grievances accumulated: the shelving of agrarian reform; the failure to settle the constitution; the burking of refugee rehabilitation; serious inflation and soaring prices of foodstuffs; financial chaos and the rapid depreciation of sterling balances; the inability of successive governments, preoccupied by the problem of remaining in power and deaf to the needs and interests of the country, to give an effective lead. All these combined to produce dangerous unrest. In Oct. 1958, Gen. Ayub Khan, the commander in chief of the army, induced Pres. Iskander Mirza to proclaim martial law in order to avoid the bloody revolution that seemed imminent. The army, traditionally the home of some of the best brains of Pakistan, took over, with the enthusiastic support of the masses. Iskander Mirza retired; Ayub Khan succeeded him and soon proved himself a statesman of liberal views whose only aim was to serve his country. He formed an administration out of the best brains, civil and military, available and set himself to take up the work of Jinnah and Liaquat from the point at which it had been broken off. One of his early reforms was to transfer the capital from Karachi to Rawalpindi while a new capital, Islamabad, was being built nearby. Grievances were redressed; agrarian reforms were effected; all vestiges of feudalism were abolished; the refugees were resettled; financial stability was restored; industry was stimulated and foreign investment grew. Inside 12 months the face of Pakistan was transformed as hope replaced despair and as teamwork between the government and the people steadily pulled the country together. In accordance with his announced policy of taking the masses into partnership, Ayub Khan launched in Jan. 1960 his system of basic democracies, under which small constituencies of about 1,000 voters returned, by adult suffrage, to councils representing about 8,000 people, the men or women whom they trusted to run local affairs. The councils thus formed exercised considerable powers and were represented on the successive stages of a tier of assemblies on which officials sat side by side with the men and women whom the public had chosen. In Feb. 1960, a referendum to the 80,000 elected representatives of West and East Pakistan confirmed Ayub Khan as first president under any constitution that would be adopted following the report of a constitution committee set up in the same year. The basic democracies gave scope for public service, and brought the government and public closer together than at any time since Jinnah died. By March 1962 Ayub Khan found it possible to withdraw martial law and to inaugurate a presidential type of constitution with central and provincial legislatures, using the basic democracies as the electorate (see *Constitution* below).

KEYSTONE PRESS AGENCY

PRES. AYUB KHAN IN 1958, THE YEAR HE ASSUMED POWER

External and Internal Security.—The military aid granted by the western powers to India after the Chinese incursions into Ladakh and the North East Frontier agency (1962) evoked strong protests from Pakistan, the strengthening of India's armed forces being regarded by Pakistan as a threat to its own security. In March 1963 the Pakistani government reached agreement with the Chinese government on the demarcation of their common boundary in Kashmir. Diplomatic relations between Pakistan and China were thereafter conducted on an increasingly friendly basis. Despite further ministerial meetings, however, no progress was made in the dispute with India over Kashmir.

By the Press and Publication (Amendment) ordinance promul-

gated in Sept. 1963 the provincial governments of Pakistan assumed considerable powers of control over the press.

6. Special Problems.—During the early years of independence Pakistan was confronted with two especially intractable problems, apart from Kashmir. One problem was the dispute with India over the division of the Indus basin waters. The other was the agitation sponsored by Afghanistan and later supported by the U.S.S.R. for a separate Pathan state (to be named Pakhtunistan or Pathanistan).

In the Indus basin waters dispute the point at issue was the use for irrigation purposes of the waters of the three eastern rivers of the Indus system, the Sutlej, the Ravi and the Beas, which served both countries. India required more water for irrigation and gave notice that in due course it would need all the waters available from the three eastern rivers for its own irrigation canals. In 1952 an offer from the International Bank for Reconstruction and Development to arbitrate in the dispute was accepted. For a number of years temporary agreement on the division of the waters was reached, but finally in 1960 the Indus Waters treaty was signed. The treaty granted the waters of the three western rivers, the Indus, the Jhelum and the Chenab to Pakistan and the waters of the three eastern rivers to India. During a transition period, until Pakistan had built more canals from its western rivers, India would continue to supply Pakistan from the eastern rivers. Financial help toward the cost of the necessary works would be available to Pakistan, through the International bank, partly from a consortium of powers, partly from India and partly from the bank itself (*see* INDUS).

The demand by Afghanistan for an independent Pathan state was first launched in 1949, following Abdul Ghaffar Khan's Red Shirt agitation for the same purpose in 1947. Pakhtunistan was to comprise the former Northwest Frontier province (later incorporated in West Pakistan), which included the tribal areas up to the Durand line (the Afghan border). A propaganda campaign continued intermittently throughout the 1950s with occasional violent episodes such as the Afghan attack on the Pakistani embassy in Kabul in 1956. The Pathans themselves who received considerable benefits from their association with Pakistan showed little enthusiasm for the scheme, but it received support from the U.S.S.R. when N. S. Khrushchev, the Soviet premier, visited Afghanistan in 1960 and spoke in favour of establishing a separate state. The Afghan propaganda campaign against Pakistan was thereupon intensified. Some fighting took place in the Bajaur frontier area in Sept. 1960 and again in March 1961. In Sept. 1961 diplomatic relations between the two countries were broken off. The shah of Iran attempted to mediate in the dispute during July–Aug. 1962 and diplomatic relations were resumed in May 1963. (*See* also INDIA-PAKISTAN, SUBCONTINENT OF: *History;* NORTHWEST FRONTIER.) (L. F. R. W.)

IV. POPULATION

According to the 1961 census Pakistan had a population of 93,831,982 (including 111,369 non-Pakistanis) within an area of 365,529 sq.mi., giving an average density of 256.7 persons per square mile. Thus it ranks sixth among the countries of the world in population. The two separated wings of the country, East and West Pakistan, have both unequal territory and unequal population. West Pakistan (area 310,403 sq.mi.) had a population of 42,978,261 persons and a density of only 138.5 persons per square mile; while East Pakistan with a much smaller area (55,126 sq.mi.) had a population of 50,853,721 averaging a density of 922.5.

The growth of population of both provinces of Pakistan has been rapid. From 1901 to 1931, the population of the areas that now comprise Pakistan increased by 13,700,000 or 30%. In the next 30 years the increase was nearly double that of the first 30—34,600,000 or 58%. West Pakistan's population has grown faster than that of East Pakistan, although the latter is among the most densely populated parts of the world. During the decade 1951–61 West Pakistan's population increased by 12.1% (in relation to the total population of Pakistan), while East Pakistan showed a rise of only 11.8%. But in terms of increases within the two provinces (West Pakistan 27.1%, East Pakistan 21.2%), there is much variation both on a district and on a regional basis. West Pakistan with 84.9% of the total area of Pakistan has 45.8% of the population of the country, while East Pakistan with an area of only 15.1% has 54.2% of the population. The three southwestern divisions of West Pakistan, namely Dera Ismail Khan, Quetta and Kalat, together have 44.2% of the total area of the province, whereas their population is only 5.5% of the province. By contrast the northeastern part of West Pakistan in an area of 6.5% has 24.3% of the population.

Population and Administrative Divisions of Pakistan, 1951 and 1961

Administrative divisions	Area sq.mi.	Pop., 1951	Pop., 1961	Density 1961
West Pakistan	310,403	33,779,555	42,880,378†	138.1
Babawalpur	17,508	1,823,000	2,574,066	147.0
Dera Ismail Khan	11,130	673,191	1,205,719	108.3
Hyderabad	36,821	2,537,959	3,290,956	89.4
Kalat	72,944	497,112	530,893	7.3
Karachi, Federal Territory of	8,405	1,202,186*	2,134,870	254.0
Khairpur	20,293	2,470,674	3,133,712	155.1
Lahore	8,907	5,339,873	6,448,575	724.0
Multan	24,826	5,305,667	6,602,924	266.0
Peshawar	28,153	4,857,395	6,372,467	226.4
Quetta	53,115	533,579	630,118	11.9
Rawalpindi	11,206	3,439,364	3,979,139	355.1
Sargodha	17,095	4,743,111	5,976,939	349.6
East Pakistan	55,126	42,062,610	50,830,235†	922.3
Chittagong	17,032	11,745,629	13,629,650	800.2
Dacca	11,937	12,674,540	15,293,596	1,281.2
Khulna	12,810	8,252,159	10,066,900	785.9
Rajshahi	13,347	9,390,282	11,850,089	887.8
Total	365,529	75,842,165	93,720,613†	256.4

*According to source population of 37 villages which were transferred from Hyderabad to Karachi is not included; pop. 356,444.
Note: Divisions and their capitals have the same name.
†Excludes non-Pakistanis: West 97,883; East 13,486; total 111,369.

In East Pakistan, densities of population are generally high, except in the area of the Chittagong Hill Tracts where live tribal groups practising a slash-and-burn economy. In the four divisions densities are almost evenly balanced: Dacca (1,281 persons per square mile); Rajshahi (888); Chittagong (800) and Khulna (786). The most densely populated district is Dacca (1,768), while Khulna district with half the area under the Sundarban forest has the lowest density (526). There are parts of Dacca and Comilla districts which have densities exceeding 2,000 persons per square mile in the rural areas.

Pakistan has generally a high proportion of rural population: East Pakistan 94.8%, West Pakistan 77.5%. A trend toward a more rapid growth of urban population with the speed of industrial development is, however, clearly indicated. In 1961 there were 390 towns in Pakistan, of which 16 had a population of over 100,000. The largest are: Karachi (1,912,598), Lahore (1,296,477), Dacca (556,712), Hyderabad (434,537), Lyallpur (425,248), Chittagong (364,205), Multan (358,201), Rawalpindi (340,175), Peshawar (218,691), Gujranwala (196,154) (*qq.v.*).

Pakistan is predominantly a Muslim country, and Muslims constitute 88.1% of the population. West Pakistan has only 1.5% of Hindus in its population as compared with East Pakistan's figure of 18.4%. In the whole country the small numbers of people professing other faiths than Islam are: Hindus, 9.9%; Christians, 0.8%; Buddhists, 0.4%; others 0.05%. West Pakistan has more Christians while the overwhelming number of Buddhists are in East Pakistan, largely in the Chittagong Hill Tracts.

(N. AH.)

V. ADMINISTRATION AND SOCIAL CONDITIONS

1. Constitution.—The constitution which was proclaimed on March 1, 1962, provided for a national assembly for Pakistan consisting of 156 members (75 each from East and West Pakistan with six special seats provided for women) elected by 80,000 "basic democrats" (see *Administrative Structure* below). The two provinces of East and West Pakistan also have their own assembly of 150 members each, elected by the same voters. The president, elected by an electoral college for a term of five years, is not only the head of state but also the chief executive. He appoints the two provincial governors and the central council of ministers. The provincial ministers are appointed by the governor with the concurrence of the president. It is not necessary for ministers to be members of the central or provincial assemblies.

The constitution laid down both principles of lawmaking and principles of policy. The first of these principles is that no law shall be repugnant to Islam and the second that all citizens shall be treated alike in all respects. Freedom of expression, association, religion and movement, the right to acquire property, to follow vocations, etc., are all safeguarded. The principles of policy lay down that Islamic life and teaching of the Koran and Sunna are compulsory for Muslims. Minorities are guaranteed fair treatment and equal opportunities. The responsibility for ensuring that no law is contrary to fundamental human rights has been placed on the lawmakers. The constitution provides for the creation of an advisory council of Islamic ideology consisting of 5 to 12 members to be appointed by the president. The function of the council is to tender advice as to whether a proposed law disregards the principles of lawmaking and also to advise the central and provincial governments how to enable the Muslims to order their lives in accordance with Islam.

2. Administrative Structure.—For historical and geographical reasons the administrative machinery differed in various parts of Pakistan in the administration of justice, the assessment and collection of land revenue, etc. The revolutionary government set up a number of commissions to examine the whole administrative system, to introduce uniformity and to make the machinery less cumbersome. By the mid-1960s a considerable amount of decentralization had been introduced; except for certain matters such as the judiciary, the magistracy and irrigation, the administration was decentralized. Among decentralized matters were education, village aid, "basic democracies," public health and to a certain extent industries and food.

The whole country is divided into administrative divisions (*see* Table). Each division is under a commissioner and is subdivided into districts and subdistricts. The district magistrate and the collector continue to be the pivot of the administration.

"Basic democracy," agreed upon at the governors' conference in 1959, provides a pyramid of authorities for (1) towns and unions of villages; (2) subdistricts; (3) districts; (4) divisions; and (5) provinces. Each basic unit at the lower levels (villages and towns) elects a council, and from these are chosen the 80,000 "basic democrats," who in turn elect the national assembly. The aim is to bring about the participation of the people in the administrative, economic and social effort at all levels.

The civil services which had been created on the pattern of the prepartition administration were, in the 1960s, reorganized under the recommendations of the Pay and Services commission presided over by the chief justice, A. R. Cornelius. The centrally controlled police services also were reorganized.

3. Political Parties.—When the constitution was abrogated in 1958 all political parties were also abolished. With the ending of martial law in 1962, the national assembly permitted the restoration of political parties. By the mid-1960s all the old parties, the Muslim league, the Awami league, the National Awami league and the Nizam-E-Islam were again functioning.

4. Living Conditions.—After Pakistan had passed through a very difficult period which was ended by the revolutionary government, measures of reform were taken. These included steps to halt inflation; to increase the availability of goods and services; to create conditions conducive to an expansion of production and investment; to improve administrative efficiency; to produce more food; and to improve health, education and welfare. As a result, living conditions improved. The inflationary spiral was halted. Agricultural and industrial production increased and the cost-of-living index was steadied. Controls were lifted in several directions, and the importation of consumer goods encouraged. Though pressure on prices did not slacken generally, the prices of several commodities remained steady. The government was able to reduce taxation, and in particular the reduction of indirect tax and excise duties on many items of food and consumer goods brought relief to ordinary people.

According to the governor of the State Bank of Pakistan the rate of economic growth in the early 1960s exceeded the rate of population increase, resulting in an increase in the per capita income. At this time the upper classes and the upper middle classes in Pakistan could be described as well off. Because of the improvement in agricultural and industrial conditions, agricultural and working classes were better off than before. The conditions for the lower middle-class people living on small fixed incomes remained difficult. The cost-of-living indexes for different classes tended to decline though they continued to be about 30% higher than the 1948–49 base.

5. Wages and Employment.—Wages in Pakistan vary from locality to locality even in the same industry. It is therefore possible to state only the barest average. The wages of unskilled workers were Rs. 2 to Rs. 3 per day in large towns such as Karachi. The wages of skilled workers, however, ranged from Rs. 5 to Rs. 10 per day. By the mid-1960s with the increased tempo of industrialization and increased production, employment had improved generally. No figures for unemployment or partial employment were, however, available.

In 1962 the Employees' Social Insurance ordinance was passed entitling workers to sickness, maternity and employment injury benefits and burial expenses. It also provides medical care. An insured woman receives maternity benefit for 12 weeks. In the case of an insured person's death as a result of employment injury, his widow (for life or until re-marriage) and each dependent child (until 16 years of age) would receive a pension. The cost was to be met from the contributions of employers and workers in the ratio of 2 to 1 and was to be administered by the employers' social insurance institutions.

6. Trade Unions.—At the time of independence the regions constituting Pakistan were industrially backward and the trade-union movement, in spite of the Trade Unions act, 1926, was weak. With the rise of new industries it gathered strength and some employers began to adopt an attitude of greater understanding and co-operation with trade unionism. The government has encouraged genuine trade-union activities and ratified the relevant conventions of the International Labour organization (ILO), of which Pakistan became a deputy member of the governing body. The Trades Union act, 1926, was amended by the insertion of two chapters on the recognition of unions and unfair labour practices; the last named include illegal strikes and the coercion of workers to join a union, and interference by an employer or his refusal to negotiate with a recognized union.

Trade unions have partly been organized rather on a plant basis than by crafts or industries; *e.g.*, that of the General Motors workers. The All-Pakistan Confederation of Labour (organized in 1962 and considered the largest body) is affiliated to the International Confederation of Free Trade Unions. Another body is the Pakistan Mazdoor federation. Between 1950 and 1960 the number of registered trade-unions increased from 240 to about 630. Average membership of unions submitting returns was 541 in 1959–60, a decrease in ten years from an average of 1,111 members, largely because of the formation of many small unions.

Most important industries, and some professions, have their own unions, though not always organized on an all-Pakistan basis. The National Union of Seamen has the largest membership. The textile, jute, tea, mining and road transport industries have their own unions, and there is a Bank Employees' association. Since 1959 various ordinances have dealt with hours of work, minimum wages, working conditions, overtime, welfare, vacations, etc., in several of these industries. On the whole there has been a slow but steady growth in the trade-union movement. A new labour policy announced in 1959 aimed at ensuring the welfare of labour in agriculture, industry and commerce.

7. Welfare Services.—In 1958 a separate ministry of social welfare was created. A National Council of Social Welfare was set up in Jan. 1960. Later a directorate of social welfare was established to co-ordinate and implement social welfare schemes. Large numbers of urban community welfare centres were set up throughout the country with the object of assisting the improvement of health, education and handicrafts. Most of these institutions were given financial support by the government. By the mid-1960s more than 100 voluntary social welfare agencies were working in Pakistan. The All-Pakistan Women's organization, created in 1958, is the most important voluntary organization. It

started several projects in fields such as education, health, maternity and child welfare, rural reconstruction and cottage industries. It received considerable financial assistance from the government and from the Ford foundation. It is affiliated to several international women's organizations, and is linked with the United Nations as a nongovernmental body.

Village Aid.—The village agricultural and industrial development program was started in 1953 to assist villagers in developing co-operative self-help efforts, and to teach them modern techniques of production. With the advent of "basic democracies" the Village Aid organizations were merged with them. About 20,000 village councils were functioning, and among other things had set up thousands of youth clubs and women's social centres. Rural development, communications, improved farming, health, sanitation and family planning were some of the fields of activity.

Rehabilitation.—In 1947 and 1948 about 9,000,000 refugees came into West Pakistan in utter destitution. Farmers, peasants and agricultural labourers were settled expeditiously and were soon absorbed. The settlement and housing of urban refugees presented a formidable task, but determined efforts to meet the problem were made, including the creation of a number of townships throughout Pakistan. Around Karachi alone seven townships were created and nearly 80,000 families were provided with cheap accommodation. Further, in 1960–61, more than 500,000 urban private properties, houses, shops and industrial concerns were allocated to evacuees (the official name for those who voluntarily left India for Pakistan or Pakistan for India). They were given a certificate of temporary possession while their claims were examined with a view to the eventual issue of title deeds. An Evacuee Property Trust board was set up to supervise and manage public or community ("trust") property abandoned by Hindus who had left Pakistan.

Health.—Medical relief in Pakistan has always been free but medical resources at the time of independence were woefully lacking. Most of the medical colleges and all public health institutions were in India and practically all the Hindu doctors and medical practitioners left Pakistan. In the first five-year plan considerable money was devoted to the development of health services. New medical colleges, research laboratories and institutes were set up. In 1959, a Medical Reforms commission was appointed and following on its recommendations the entire medical system was reorganized. Under the second five-year plan Rs. 530,000,000 were allocated to the health services.

There was still, however, in the 1960s a shortage of doctors and nurses. But a national health centre and several hundred rural centres had been established. A cholera research laboratory under the auspices of the Southeast Asia Treaty organization (SEATO) had been set up. Annual inoculations against cholera were more than 40,000,000 and smallpox vaccinations around 7,000,000. A plan to combat smallpox was drawn up with the help of experts from the World Health organization (WHO); the incidence of this disease was especially heavy in East Pakistan. In Dec. 1960 a National Malaria Eradication service was set up to take active measures aimed at the eradication of malaria by 1974.

8. Justice.—The judiciary consists of the supreme court, two high courts, and district and session courts with subordinate civil and criminal courts. The supreme court of Pakistan is a court of record. It has three-fold jurisdiction, original, appellate and advisory. It is the highest court of Pakistan and took over the jurisdiction of the judicial committee of the privy council (*see* PRIVY COUNCIL, JUDICIAL COMMITTEE OF). The high court of Lahore, West Pakistan, has two permanent branches in Karachi and in Peshawar; the high court of East Pakistan is at Dacca.

At the time of independence Pakistan inherited a most extensive set of codes and acts which were continued after suitable modification. Frequent demands were made that the laws of Pakistan should be made to conform to the Koran and Sunna but the size and the complexity of the task is likely to deter hasty action.

9. Education.—In 1961 there were 14,335,809 literate persons in Pakistan. Literacy rates as computed from the population aged 5 years and over were 19.2% for the whole of Pakistan, 21.5% for East Pakistan and 16.3% for West Pakistan.

In the early 1960s primary education in Pakistan was neither free nor compulsory. By the early 1960s more than 5,000,000 boys and girls were attending primary schools. The number attending secondary schools was about 1,500,000. There were 6 universities with 204 arts and science colleges, 13 medical colleges, 7 engineering colleges and 42 other colleges covering a wide range of subjects such as law, commerce, agriculture, etc. The universities are Dacca (founded 1921), Karachi (1950), The University of the Punjab (Lahore, 1882), Peshawar (1950), Rajshahi (1953) and Sind (Hyderabad, 1947).

By the mid-1960s the education commission's recommendations were being implemented. These include introduction of compulsory primary education in two stages spread over a period of 18 years. During the second five-year plan it was proposed to spend Rs. 1,323,000,000 on education. Apart from a general improvement of standards, the commission proposed the creation of two agricultural universities, national archives and a national library.

The advance in women's education is striking. Women are attending practically all educational institutions. Their demand for medical education was so great that special medical colleges had to be set up, and a large proportion of medical students are women. Practically all the services and all the professions have been thrown open to women and these developments have in turn given impetus to their education.

10. Defense.—Pakistan signed a mutual defense assistance agreement with the U.S. in 1954. It is a member of the Central Treaty organization (CENTO), which succeeded the Baghdad pact, and of the Southeast Asia Treaty organization (SEATO).

Army.—The army is the senior service. It consisted in the early 1960s of 8 infantry regiments, 6 armoured corps units, 8 artillery regiments and 34 engineering units. It is manned entirely by volunteers. All officers have to pass through the military academy at Kakul. For higher training there is a staff college at Quetta.

Navy.—The naval forces consisted of 1 cruiser, 5 destroyers, 2 frigates, 6 minesweepers and several other auxiliary units. The total strength was 700 officers and 7,000 ratings—all volunteers. It has its own training establishments and two bases, at Karachi and Chittagong.

Air Force.—The air force was composed of Canberra jet bombers, wings of Sabre fighters and squadrons of Bristol freighter transports. The total strength was 15,000 all ranks, all of whom were volunteers. It has its own flying college at Risalpur and an apprentice college at Karangi. The air headquarters are located at Peshawar.

Civil Defense.—Measures have been taken to organize a civil defense force. They included the education of the public to look after themselves and their families, the training of a large body of voluntary workers for organized civil defense work, and the maintenance of a fully trained and properly equipped force for any eventuality whether in peace or war. Training schools were set up in several towns and the many publications distributed include a civil defense magazine in English, Urdu and Bengali.

(M. I.)

VI. THE ECONOMY

Pakistan's economy is essentially based on agriculture to which 60% of the national income is attributable and, in which at least two-thirds of the working population are engaged. Even so, the country is not self-sufficient in food grains and heavy imports are necessary. The second five-year plan (1960–65), following the first five-year plan (1955–60), accordingly gave the highest priority to agriculture; the target was an increase of 20% in food grain production, to provide the country with a solid foundation for the industrial superstructure.

Pakistan at mid-20th century had great development potential, and there were indications that its economy was gradually rising above the subsistence level. Most prominent of these was the progress of industrialization. The manufacturing industries contribute 13.3% to the national income, and their growth can be measured by the fact that the index of industrialization (base: 1954 = 100) in 1961 stood at 213, while in 1950 it was 37.7.

The main obstacle to expansion—one which is common to almost all underdeveloped countries—is a chronic shortage of foreign exchange for financing imports and external payments generally. This was being met by a massive program of foreign aid and by the early 1960s Pakistan had received more than $2,000,000,000, about 80% of which came from the U.S., in the form of capital goods, industrial raw materials, consumer goods, food grains and technical assistance. The development program was governed by the second five-year plan, which was estimated to cost Rs. 23,000,000,000. Its main objectives were to increase the national income by 22% (with an increase of 10% in the per capita income), to bring about self-sufficiency in foodstuffs, to increase industrial and mineral production by about 50%, and to improve the balance of payments position so as to enable the level of imports to be raised in line with the country's reasonable needs. Assuming no diminution in the flow of foreign aid, and the continuance of an austere regime at home, it can be said that the objectives were not beyond the bounds of attainment.

A. Production

1. Agriculture.—The main food crops are rice and wheat, the staple diets of East and West Pakistan respectively. The average annual production of cleaned rice (about 90% in the eastern wing) is about 10,000,000 tons and of wheat, which is almost exclusive to West Pakistan, 3,500,000 tons. Minor food crops are the millets (bajra and jowar), maize (corn), barley and gram. Production of food grains has failed to keep pace with the population increase for a variety of reasons: it is constantly affected by waterlogging, salination and erosion in some parts of the country; it is periodically affected by droughts or floods; and until 1961 shortage of canal supplies because of the dispute about the waters of the Indus basin was an adverse factor in the western wing. In consequence of the shortfall, heavy imports of food grains have been necessary to the detriment of Pakistan's foreign exchange resources. It has however been found profitable to export some of the high-quality rice grown in West Pakistan and to meet East Pakistan's deficit by importing cheaper qualities from Burma.

Other crops include jute, cotton, tea, sugar cane and tobacco. These play a very significant part in Pakistan's export earnings as well as forming the basis for the country's most promising lines of industry. Production of jute amounts to more than 1,000,000 tons yearly and this, together with the manufactured product, forms by far the most important export commodity. Production of cotton remains steady at about 300,000 tons, though exports dwindled with the growth of the local textile industry; it is mostly of the long-staple type known as Punjab American. Nearly 80,000 ac. in East Pakistan are under tea, and the annual production is about 25,000 tons. Sugar cane production was increasing in the mid-1960s but was still inadequate for the needs of the country's sugar industry. Tobacco growing has expanded, and the quality has been improved, influenced by the rapidly developing cigarette industry; nearly 100,000 tons a year were produced in the mid-1960s.

An over-all increase of 14% in agricultural production was envisaged in the second five-year plan. This entailed a massive program of subsidized provision of fertilizers and insecticides, extension of irrigation, reclamation of land affected by waterlogging or salinity, and flood control or drainage over about 9,500,000 ac. Major projects in the irrigation field in East Pakistan include the Ganges-Kobadak scheme, which is designed to irrigate 2,000,000 ac., and the Teesta barrage, the scope of which is almost as large. In West Pakistan the Taunsa, Guddu and Kotri (Ghulam Mohammed) barrage projects, the three major irrigation works started since the country became independent, were designed to bring about 6,500,000 ac. under irrigation. Irrigation is also a feature, though a secondary one, of the multipurpose Warsak project which was completed in 1961. Three link canals were also to be constructed, in implementation of the Indus Basin Settlement plan, to add to the water supplies in the Sutlej valley canals which suffer from a persistent shortage. In the sphere of reclamation there are salinity control and drainage projects in West Pakistan aimed at improving 843,000 and 3,600,000 ac. respectively, while in the eastern wing there are various drainage and embankment projects covering over 1,000,000 ac. These projects, however, would need time to have a beneficial effect on the economy. (*See* also Ganges; Indus; India-Pakistan, Subcontinent of: *Natural Resources;* Sind.)

Livestock.—Cattle (oxen and buffaloes) are raised for milk, draftwork, meat and hides; goats and sheep for hair, wool, milk, meats and skins. The best breeds of cattle are in West Pakistan, some being exported for breeding purposes. Numbers of livestock, however, are inadequate to meet demand and official efforts are made to improve animal husbandry and to prevent indiscriminate slaughter. Encouragement is also given to poultry keeping. In the early 1960s Pakistan possessed about 24,000,000 oxen, 6,000,000 buffaloes, 9,500,000 goats and 6,500,000 sheep. Of the total milk supply about one-third was consumed as fluid and the remainder converted into ghee, butter, curd, etc. Among inedible products wool exports were worth about Rs. 77,000,000 annually and hides and skins about Rs. 60,000,000.

2. Forestry.—Forests cover 2.7% of the total land area. In West Pakistan only the forests of the mountainous areas (mainly coniferous) are of real commercial importance, but their yield is not nearly sufficient to meet the demand for construction timber. In other parts of the province conservation and reafforestation are of the utmost importance for the prevention of soil erosion, which has badly affected much cultivable land, especially in the Salt range and other hilly areas. In East Pakistan the forests of the Chittagong Hill Tracts and the Sundarbans were being fully exploited and after the mid-1960s were expected to yield 100,000 tons of timber a year. An important paper industry, including a paper mill on the Karnaphuli river near Chittagong and a newsprint factory at Khulna, has grown up from the produce of these forests, and Pakistan has a surplus of paper for export. Other end products are railway sleepers, telegraph poles and other kinds of treated timber.

3. Mining.—Pakistan is not rich in minerals. There are valuable deposits of chromite in Baluchistan, and coal of rather poor quality is mined in the Salt range, where limestone, gypsum and rock salt are also abundant. Iron ore deposits have also been found in Baluchistan, Chitral and the northwest Punjab and although the high-grade ore is unfortunately in the areas most difficult of access there remains the possibility of establishing a steel industry based on indigenous ore and coal. The main interest, however, centres in the search for oil. The oil fields in northern Punjab in the early 1960s yielded over 2,000,000 barrels of crude oil a year, and exploration was being pushed on vigorously in both the eastern and western wings. In both it has yielded remarkable results in the form of vast deposits of natural gas, which is piped from Sui to Karachi and to Multan, and furnishes power for industrial and domestic use; it is used in developing a petrochemical industry and also helps to reduce the import bill for fuel.

4. Fisheries.—The fishing industry, both marine and inland, has been carried on in traditional ways and was formerly relatively unimportant to the economy. It has, however, attracted attention by making an increasingly large contribution to export earnings, and a good deal was being done in the mid-1960s to develop its considerable potential including marine surveys, credit provision for purchase of mechanized craft and gear, and the construction of a modern fish harbour, with cold storage plant, at Karachi. Canning and freezing plants were also established at other places.

5. Power.—Great headway has been made in meeting the growing power requirements of industry and in carrying the benefits of electricity to rural areas. Installed generating capacity was nearly trebled between 1955 and 1960, and at the end of 1962 stood at 839,000 kw. (not including installations in industrial establishments). In East Pakistan the Karnaphuli hydroelectric scheme, with an initial capacity of 80,000 kw. and a projected capacity of 120,000 kw., has come into operation. A complementary project for modernizing existing power distribution systems in the province so as to make full use of the power available was undertaken at a cost of Rs. 188,300,000. In West Pakistan the new hydroelectric power station at Warsak has a peak load capacity of 160,000 kw. and a thermal station at Multan of 135,000 kw. There too rural electrification was being tackled on a large scale.

Generation of electricity remained far from adequate to meet all power demands, and the second five-year plan provided for public expenditure of no less than Rs. 950,500,000 under this head.

6. Industries.—Until the 1962 constitution, control of industry rested mainly in the hands of the central government. After that it became a subject of provincial legislation, except in respect of nuclear energy, mineral oil and natural gas, and undertakings owned wholly or partly by the central government.

The acceleration of the program of industrial development owes much to the Pakistan Industrial Development corporation (P.I.D.C.) set up by the government in 1952 to undertake projects considered essential in the national interest (under the new constitution the P.I.D.C. was split into two independent corporations, one for each wing). Even so, it is the industries which have proved most attractive to private capital which have expanded most rapidly. Especial success has been achieved by the cotton textile industry, which produces annually more than 600,000,000 yd. of cloth and 400,000,000 lb. of yarn; the jute manufacturing industry (nonexistent before partition) producing in the early 1960s about 250,000 tons of goods; the cement industry (over 1,000,000 tons); the sugar industry (150,000 tons); and the cigarette industry—in all these the increases in production have been remarkable. The pulp and paper factories (with a production of about 25,000 tons of newsprint and about 40,000 tons of paper and other products), fertilizer and other chemical plants, and steel re-rolling mills, all owe their inception to the P.I.D.C.

It is to industry that the government chiefly looks to raise the national income, to improve the balance of payments position and to provide employment. No rigid plan for industrial development has been laid down, but priority is allotted to producer goods industries and manufacture of essential consumer goods; new ventures in production of nonessential consumer goods are given less encouragement. An Investment Promotion bureau exists to help private enterprise with its problems. The government hoped to see large sums of money invested in industrial development during the second plan period. Textile manufactures continued to claim the largest share, followed by chemical industries, food manufacture and basic metal industries.

B. Trade and Finance

1. Foreign Trade.—The pattern of imports is largely governed by the adverse balance of payments (there was a deficit of Rs. 219,600,000 on current account in 1961) and consequent need to reduce outgoings of foreign exchange to the minimum. A tight control over imports of consumer goods is in force and is likely to remain so, but care is taken to see that industrial requirements are satisfied. Imports of machinery have absorbed most of Pakistan's foreign exchange resources, an inevitable consequence of the industrial expansion, but food grains have also made heavy inroads. The strict quantitative control over imports of consumer goods has served as a protection for nascent indigenous industries, but has created austere conditions and has had the effect of increasing sharply the middle-class cost of living. As regards the direction of trade, the U.S. leads the United Kingdom as the chief source of Pakistan's imports. West Germany and Japan come next in importance to these two.

Primary products constitute the main exports of Pakistan, though the pattern is gradually changing and in the mid-1960s manufactured goods were contributing substantially to the country's foreign exchange earnings. This was particularly true of jute and cotton textiles. Raw jute was the most important single item, exports amounting to more than Rs. 800,000,000 (more than 45% of total export earnings) and jute manufactures were valued at well over Rs. 300,000,000. Raw cotton exports, at one time equally important with jute, have fallen steadily with the growth of the local textile industry, and accounted for only about Rs. 120,000,000, while cotton manufactures earned about Rs. 65,000,000. Other valuable exports are wool, hides and skins, fish, rice and tea, though exports of the last named have dwindled with increasing local consumption. The U.K. remains easily the best customer for Pakistan's exports, followed by the U.S., Japan, India and Hong Kong.

To provide incentives for exporters, and to diversify and expand exports, an export credits guarantee scheme was in force, and also an export bonus scheme under which exporters of certain classes of goods were granted special import licences up to a fixed percentage of their export earnings. Even so, without a marked improvement in the terms of trade, which in the mid-1960s were as unfavourable to Pakistan as to most other countries exporting primary commodities, there was little hope of a balance being achieved in the foreign exchange budget during the second plan period without continued foreign aid on a generous scale from the consortium consisting of Canada, France, West Germany, Japan, the U.K. and the U.S., together with the International Bank for Reconstruction and Development and the International Development association.

2. Banking and Currency.—The State Bank of Pakistan, 51% of the shares in which are held by the government, is the central bank and chief monetary authority of the country. It has wide powers of monetary and credit control, and the sole right of note issue. The state bank also performs various agency functions for the government, and has a considerable responsibility for the economic stability of the country. There has been much expansion in the business and the number of the Pakistani scheduled banks. These play an important part not only in the financing of foreign trade but in meeting the working requirements of industry.

In order to meet certain special credit needs the government has established a number of finance corporations and commercial undertakings. These include the Agricultural Development Bank of Pakistan, the Pakistan Industrial Development bank, the Pakistan Industrial Credit and Investment corporation (the primary object of which is to channel to private industry foreign exchange received from the International Bank for Reconstruction and Development and other outside sources) and the House Building Finance corporation.

Decimal coinage was introduced in Jan. 1961. The currency is the Pakistani rupee, equivalent to 1*s*.6*d*. or U.S. $0.21.

3. National Finance.—Customs duties account for more than 25% of the revenue of the central government, though central excise duties and income tax (including corporation tax) are contributing an increasing share. Sales tax is another important head. The provincial governments derive their revenues mainly from land revenue, irrigation receipts, provincial excise and stamp duties; but they are heavily supplemented by the allocation from the centre of 50% of the net proceeds of income tax and corporation tax, 60% of the proceeds of the central excises on tea, betel nuts and tobacco, and the whole of the export duties on jute and cotton.

The defense services form the major item of the revenue expenditure (more than 50%) of the central government and constitute a very heavy burden on Pakistan's resources. The remaining expenditure goes to civil Administration, debt service and a little more than 5% is available for development expenditure. Industrial development fares better, however, in the capital account, which forms a separate part of the budget; excluding the amount disbursed on loans and grants to provincial governments, it absorbs 15% of capital disbursements. The railways formerly featured as the largest single item in the capital budget (excluding grants to the provinces) but the constitution of 1962 made them the responsibility of the provinces.

C. Transport and Communications

1. Roads, Railways and Inland Waterways.—There are about 64,000 mi. of roads in Pakistan, but only about 10,000 mi. are "high type motorable." East Pakistan accounts for no more than 900 mi. of the latter, the nature of the country making it far more suitable for water transport. In West Pakistan the main arterial roads are the grand trunk road from Lahore (or more precisely from Wagah on the Indo-Pakistan frontier) to Rawalpindi, Peshawar and Landi Kotal; the road from Lahore to Karachi; and the road connecting Lahore with Quetta and Chaman on the Afghan border. There is a considerable mileage of feeder roads, but a big program of improvement is needed to provide agriculturists with adequate access to markets. Road building is financed

by a central road fund, which is made up by allocation of a portion of the yield of the customs and excise duty on motor spirit (gasoline). There is also a special fund for roads of national importance, financed by central revenues. These resources are supplemented by loans granted to provincial governments.

The control of railways in Pakistan was transferred in 1962 from the centre to the provinces, and they are run as two separate organizations under the provincial governments; they make a profit and a substantial contribution to the revenues of the country. The Pakistan Western railway has a route mileage of 5,334 mi., and the Pakistan Eastern railway, which faces strong competition from inland water transport, of 1,712 mi. Since independence railway traffic nearly doubled in respect of goods, but did not increase greatly in volume of passenger traffic, which tended to favour road transport.

Inland water transport plays no part in the economy of West Pakistan, but is vital to that of East Pakistan, which has 2,700 mi. of perennial navigable waterways and 4,000 mi. of seasonal waterways; as much as 75% of its traffic is carried on the inland waterways in preference to road or rail. Formerly the organized traffic had been mainly in the hands of private companies, but in 1958 the Inland Water Transport authority was set up, and in 1961 the central government joined with the Joint Steamer companies (two long-established sterling companies) in forming a new rupee operating company, Pakistan River Steamers, Ltd.

Priority was to be given to development of all three forms of transport during the period of the second five-year plan. Even though it was not proposed to make any significant extension of the mileage of the railways, development of the order of Rs. 960,000,000 was required as a minimum, mainly for replacement of rolling stock and rehabilitation and improvement of equipment. With all this, the railways still had to retain in service a great deal of overage rolling stock, and it was not possible to complete the change over from steam to diesel-electric locomotives. The inland water transport development program provided for expenditure of Rs. 95,000,000 in the private sector and Rs. 80,000,000 in the semipublic sector. The most important items in the program were modernization of craft and fleet replacements, developments of inland ports and dredging of navigational channels. Road development called for expenditure of Rs. 569,000,000. Road transport is however regarded as a field particularly suited to private enterprise, and government-sponsored services operate only where private enterprise is not forthcoming or, in a few instances, to serve as a model for private services.

2. Air Transport.—The geographical position of Karachi makes it an important air junction, and the runway is suitable for heavy jet aircraft. Medium jets can be accommodated at Lahore, Rawalpindi, Dacca and Chittagong. Pakistan International Airlines corporation, formed as a government concern in 1954, operates regular services to the middle east, Europe and the U.S. and performs an indispensable function in linking the two wings of Pakistan. An air link with Communist China was established in 1963. There are also regular Air Bus services within each wing.

3. Shipping.—The Pakistani merchant shipping fleet in the mid-1960s was small and in need of modernization. This fleet was sufficient for the handling of the zonal traffic, but a large part of the foreign trade was still carried by foreign companies; the freight earnings remitted by these constituted a drain of foreign exchange, and it was the government's policy to enlarge the Pakistani fleet. Pakistan is fairly well served by ports. Both the major ports, Karachi and Chittagong, have been greatly improved and developed; Karachi handles more than 5,000,000 tons of cargo a year, while Chittagong deals with more than 3,000,000 tons. The strain on Chittagong, formerly the only port for ocean-going vessels in East Pakistan, has been relieved by the construction of an anchorage, with some port facilities, at Chalna on the Pusur river, not far from the railhead at Khulna. Chalna handles about 1,000,000 tons of cargo a year, mostly in the form of jute exports.

4. Postal Services and Telecommunications.—The posts and telegraphs department runs at a profit and makes a substantial contribution to general revenues. Public demand for telephone services was unsatisfied in spite of considerable expansion but the need for telephone equipment is to some extent met internally by a factory at Haripur. The maintenance of satisfactory communications between East and West Pakistan presents a difficult problem; the two wings are linked by high-frequency radio telephone channels, but it has been found impossible to provide a sufficient number of circuits to bear the growing load. There is also a voice frequency telegraph system for working teleprinters between the two wings, and teleprinter exchanges at Karachi, Lahore and Dacca. Within East Pakistan, where the terrain is difficult for land line communications, the main centres are linked by a very high-frequency radio network radiating from Dacca.

International communications have been established by direct telephone with many important centres in Europe, the middle east and the far east. The international telegraph terminal at Karachi was taken over by the government. International radio telegraph circuits link Karachi with capital cities and commercial centres in most parts of the world, and a telex service is available for many of them. With the aid of CENTO a 600-channel microwave telephone system between Karachi, Teheran, Iran and Ankara, Turk., was being established. Broadcasting facilities in the mid-1960s were somewhat inadequate. The development program for broadcasting included in the second five-year plan was estimated to cost Rs. 40,000,000, and by the end of the period there were to be 13 transmitting stations in the country with 29 transmitters.

See the regional articles BALUCHISTAN; GILGIT; LADAKH; NORTHWEST FRONTIER; SIND; WAZIRISTAN; *see* also references under "Pakistan" in the Index. (F. M. I.)

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PAKOKKU, a district in the Magwe division in the heart of Burma, lies west of the Irrawaddy river and southwest of Mandalay, with the line of the Chin hills as a general boundary on the west. Area 5,345 sq.mi.; pop. (1962 est.) 711,616. The part of the district along the Irrawaddy and Chindwin rivers is partly alluvial and partly the undulating gravelly and sandy land typical of the Dry Belt of Burma. Beyond this, however, the country rises gradually to the low infertile Shinmataung and Tangyi ridges. Westward there is a rapid drop to the well-watered valley of the Yaw river, then a rise over broken, dry country before the valley of the Myittha river is reached. The principal products are peanuts, millet, sesamum and sugar produced from toddy palms in the riverain districts, which also grow rice, gram, peas and beans. Tobacco and vegetables are also cultivated in some quantity, and maize (corn) is grown largely for the sake of the husk, which is used for local cheroot wrappers, under the name of *yawpet*. The Yenangyat oil field is in the south of the district, and in the 1930s a remarkable new field, Lanywa, was developed by embanking a sandbank bordering the Irrawaddy. There are large areas of reserved forests in the west of the district where a good deal of teak is extracted. The cutch—a yellow dye obtained from a small tree (*Acacia catechu*) in the drier parts of the Yaw country—is particularly esteemed. The heat in May and June rises considerably above 38° C. (100° F.) in the shade.

The population is mostly Burmese, but in the Yaw valley there is a peculiar race called Taungthas, who claim to be distinct from both Burmese and Chins. The headquarters town, Pakokku, stands on the right bank of the Irrawaddy, and grew into impor-

tance after the British occupation. The population (1962 est.) was 156,960. It is the market for the trade of the Chindwin and Yaw river valleys.

PAKOKKU HILL TRACTS, formerly a district in the Magwe division to the west of the Pakokku district, now forms part of the Chin Hills Special Division (*q.v.*). It included Mt. Victoria (10,018 ft.), one of the highest peaks of the Arakan Yoma. The headquarters village was Kanpetlet. (L. D. S.)

PAKTIA (formerly SAMT-I-JUNUBI or SOUTHERN PROVINCE), a major province of Afghanistan, is bounded on the east by the Pakistan frontier and on the west by the province of Ghazni. Area *c.* 5,000 sq.mi. It extends from the Safed Koh range in the north to the Gumal River in the south. It contains the upper drainage basins of the Kurram, Kaitu, and Tochi rivers which flow east into Pakistan. Most of the province is mountainous and forested. The climate is pleasant in summer but cold in winter.

Few of the rulers of Afghanistan or northern India have exercised effective control over the Pathan tribes in this region. Khost, the central part of the province, has always been a trouble spot and *lashgars* (armed bands) of tribes gathered in this area have threatened both Kabul and the Indus Valley several times even during the 20th century. Armies have, however, used the Kurram-Khost route to cross the frontier. Lieut. Gen. Frederick (later Field Marshal Earl) Roberts marched to Kabul by this route in 1878 during the Second Afghan War, and during the Third Afghan War the Afghan Sardar Mohammad Nadir Khan (later King Nadir Khan) used the same route to attack the British fort at Thal.

Paktia is sparsely populated. Pop. (1962 est.) 729,763. The capital town of Gardez (*q.v.*) lies about 7,500 ft. above sea level in the west of the province. It is a garrison town in a strategic position guarding routes to Pakistan, to the east via Matun (or Khost) to the Batai Pass and to the south via Urgun to the Khand Pass. Both roads are little more than tracks. The people are almost all Pashto-speaking. The province is the home of a number of small but warlike and independent tribes: the Jajis in the north, the Mangals, Muqbils, Chakmanis, Jadrans, Tanis, and Khostwals in the Khost area, and, in the Birmal area round Urgun in the south, the only Wazirs in Afghanistan. Ghilzais live in the west of the province.

Agriculture, chiefly stock raising, is the main industry, but the land is poor and the tribes depend largely on subsidies. Lumbering is mainly of local importance, but some timber and charcoal are exported. Although Gardez is connected by road to Ghazni and to Kabul (via the Logar Valley) Paktia lies off the main routes in Afghanistan and is rarely visited. There are airfields at Gardez, Matun, and Urgun, mainly for military purposes. (X.)

PALA, the name of an important dynasty ruling in Bihar and Bengal, India, from the 8th to the 12th century. Its founder, Gopala, was a local chieftain who rose to power in the mid-8th century, during a period of anarchy. His successor Dharmapala (*c.* 770–810) greatly expanded the kingdom and was for a while in control of Kannauj. Pala power was maintained under Devapala (*c.* 810–850), who carried out raids in the north, the Deccan, and the peninsula, but after Devapala the dynasty declined in power and Mahendrapala, the Gurjara-Pratihara emperor of Kannauj, penetrated as far as northern Bengal. Pala strength was restored by Mahipala I (*c.* 988–1038), whose influence reached as far as Varanasi (Benares), but on his death the kingdom again weakened. Ramapala (*c.* 1077–1120), the last important Pala king, did much to strengthen the dynasty in Bengal and expanded its power in Assam and Orissa. He is the hero of a Sanskrit historical poem, the *Ramacharita* of Sandhyakara. On his death, however, the dynasty was virtually eclipsed by the rising power of the Senas, though Pala kings continued to rule in south Bihar for 40 years. The main capital of the Palas appears to have been Mudgagiri (Monghyr) in east Bihar.

The Palas were supporters of Buddhism and it was through missionaries from their kingdom that Buddhism was finally established in Tibet. Under Pala patronage a distinctive school of art arose, of which many noteworthy sculptures in stone and metal survive. *See* also BENGAL.

See R. C. Majumdar, *History of Bengal,* vol. i (1943). (A. L. BA.)

PALACIO VALDÉS, ARMANDO (1853–1938), one of the most popular 19th-century Spanish novelists, is distinguished by his optimism, his charming heroines, his realism and also his rather un-Spanish qualities of moderation and simplicity. He was born at Entralgo, Asturias, in 1853, and was educated at Oviedo and Madrid, where he died in Feb. 1938. His novels provide his best autobiography, particularly *Riverita* (1886), *Maximina* (1887; Eng. trans., 1888) and *La Novela de un novelista* (1921). He experienced an early predilection for science and his work reveals a temporary phase of Naturalism, notably *La Espuma* (1890; Eng. trans., *The Froth,* 1891) and *La fe* (1892; Eng. trans., *Faith,* 1892). *Marta y María* (1883), with its Biblical Martha and Mary theme, has perhaps a greater claim to profundity than most of his work. Local colour abounds, as it does also in his other Asturian novels, *José* (1885; Eng. trans., 1901), a realistic picture of the sea, whose epic note seems an echo of Pereda's *Sotileza,* and *La Aldea perdida* (1903). Not a marked regionalist like Pereda, his novels are set in different parts of Spain: *Riverita* in Madrid, *La Alegría del capitán Ribot* (1899; Eng. trans., *The Joy of Captain Ribot,* 1900) in Valencia, and his most popular work, *La Hermana San Sulpicio* (1889; Eng. trans., *Sister Saint Sulpice,* 1890) in Andalusia. The courtship of the Galician and the young Sevillian nun is set against a striking background of local colour and gaiety. Excessive sentimentality in his novels is mitigated by sincerity and humour. An impression is left of a sensitive and warm-hearted writer who is ever seeking beauty and truth.

See A. Cruz Rueda, *Armando Palacio Valdés* (1925); R. Narbona, *Palacio Valdés o la Armonía* (1941). (JH. M.)

PALACKY, FRANTISEK (1798–1876), the founder of modern Czech historiography and a leading figure in the political life of 19th-century Bohemia, was born at Hodslavice, Moravia, on June 14, 1798. Of Protestant upbringing, he was educated mainly in Slovakia where he came into contact with the resurgence of national feeling that had begun to influence Czech and Slovak intellectuals. His early writings were concerned with aesthetics. In 1823 he settled in Prague where he was enabled by noble patronage and by his marriage to the daughter of a well-to-do lawyer to devote himself to his scholarly and patriotic interests. In 1827 he became editor of the journal of the Bohemian museum in which he published articles on aesthetics (on Kantian idealistic lines) and on the Czech language (advocating a moderate traditionalism against attempts to make far-reaching changes).

In 1832 he began his magnum opus, a history of the Czech nation in Bohemia and Moravia, to 1526. The first volume, written in German, appeared in 1836; the later volumes were written in Czech. It was published as *Geschichte von Böhmen,* 5 vol. (1836–67), and *Dějiny národu českého* (1848–76). The work shows a clear conception of the nature of Czech history, which Palacky held to consist in "the constant contact and conflict between the Slavs on the one hand and Rome and the Germans on the other." Thus the Hussite period became the central episode of Czech history, epitomizing the national and the religious struggle.

As a politician, Palacky supported the Austro-Slavonic conception of a federal Austria, composed of nationalities with equal rights. He defended this conception in his letter to the Frankfurt *Vorparlament* of 1848 ("If the Austrian state did not exist we should have to create it in the interests of Europe and of humanity"), as chairman of the Prague Slavonic congress in the same year and at the diet of Kromeriz (Kremsier). After the failure of the 1848 revolutionary movements Palacky retired from active politics until 1861 when he became a deputy in the *Reichsrat.* In his *Idea státu rakouského* ("Idea of the Austrian State," 1865; German trans., 1869) he propounded a federalism based not on nationalities but on the historic provinces of the Habsburg empire ("We were before Austria, we shall still exist when she has disappeared"). His influence on Czech political thought and historiography was immense. The liberal nationalism of T. G. Masaryk and his generation owed much to Palacky.

Palacky died in Prague, May 26, 1876.

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PALAEOLOGUS, the name of a Byzantine family that became prominent in the 11th century and whose members married into the imperial houses of Comnenus, Ducas, and Angelus. Michael VIII Palaeologus became emperor at Nicaea in 1259 and founded the dynasty of the Palaeologi in Constantinople (1261–1453). He was succeeded by his son Andronicus II (1282–1328), with his grandson, Michael IX (d. 1320), as co-emperor. Michael's son Andronicus III (1328–41) left the throne to his infant son John V (1341–91), whose rule was disputed by John VI Cantacuzenus (1347–54), and later by his own son Andronicus IV (1376–79) and his grandson John VII (1390); but he was succeeded by his second son Manuel II (1391–1425). John VIII (1425–48) was a son of Manuel II, and his brother Constantine XI (1449–53) became the last Byzantine emperor. Other brothers were Demetrius and Thomas, despots of the Morea until 1460. Thomas died at Rome in 1465; his daughter Zoe married Ivan III of Russia. Another branch of the family, descended from Theodore, son of Andronicus II, held the marquisate of Montferrat from 1305 to 1533. *See* also BYZANTINE EMPIRE.

See V. Laurent, "La généalogie des premiers Paléologues," *Byzantion*, 8:125–149 (1933); A. T. Papadopulos, *Versuch einer Genealogie der Palaiologen, 1259–1453* (1938). (D. M. N.)

PALAFOX Y MENDOZA, JUAN DE (1600–1659), Spanish bishop whose name is connected prominently in Mexican history with conflict, was born June 26, 1600, at Fitero in Navarre, the natural son of the Marqués Jaime Palafox y Mendoza. Recognized by his father at the age of ten, the young man had the advantage of education at the Universities of Alcalá and Salamanca. Instead of life at the court, he chose the priesthood. After acting as chaplain to Princess Maria, he was in 1639 consecrated bishop for the see of Puebla in Mexico. During his first years he served in several official capacities for the crown and in 1642 was appointed interim viceroy and also named for the archbishopric of Mexico, which post he refused in order to return to Puebla. Early he had challenged some of the privileges and exemptions enjoyed by the older religious orders; then in 1647, over similar questions, he tangled with the Jesuits. At one point in the dispute he put the Jesuits of Puebla under interdict. Though Innocent X upheld him on most disputed points, Palafox returned to Spain in 1649. He was transferred to the Spanish see of Osma in 1653 and there died on Oct. 1, 1659. (J. F. BN.)

PALAMAS, SAINT GREGORY (1296–1359), archbishop of Thessalonica and chief defender of hesychasm (*q.v.*), was born of a noble family in Constantinople in 1296. He became a monk on Mt. Athos at the age of 20 and was soon the spiritual and intellectual leader of the hesychast monks. A few years later he left Athos, together with several companions, because of Turkish raids (*c.* 1525), and after some months in Thessalonica settled in a monastery at Beroea (mod. Veroia), in Macedonia, where he was ordained priest (1326). After Serbian invasions he left Beroea to return to Athos (1331). In 1336 he began a long controversy with a Calabrian "philosopher" and monk named Barlaam, who had violently criticized the hesychast method of prayer and denied the possibility of a real vision of God.

The hesychasts, who practised the uninterrupted "Jesus prayer" by linking it to breathing, affirmed that true spiritual life would lead to the vision of the divine uncreated light, which had appeared on Mt. Tabor at the transfiguration of Christ. Palamas' main argument against Barlaam was based upon the patristic doctrine of the deification of man: God became man and man therefore received access to divine life. Both the human soul and the body are sanctified by the grace of the incarnation through the sacraments of the church, and the body, together with the soul, can participate in the act of prayer and receive life divine. God, however, remains inaccessible in his essence: he reveals himself through his acts (or "energies") by his own free will. These energies, though distinct from divine essence, are still God himself and not a diminished deity. In Palamas' thought, the being of God cannot, therefore, be identified with the philosophical concept of "essence." What he defended against Barlaam is the biblical conception of a living God, both transcendent and revealed. Barlaam was condemned at the council held in Constantinople in 1341.

During the civil war from 1341 to 1347, Palamas faced renewed opposition to his theology, for his doctrinal opponents, notably Gregory Akindynos, were supported by the political faction then in power in Constantinople. Palamas himself was imprisoned and excommunicated, but when the war ended his orthodoxy was upheld in a council in 1347. In the same year he was appointed archbishop of Thessalonica, though he was not able to take up residence there before 1350. A further council in 1351 again supported Palamas. He was captured by the Turks while on a journey to Constantinople in 1354 and kept prisoner in Asia Minor, where he traveled about, being finally ransomed by Serbian gold in 1355. During the last years of his life he continued to write polemical treatises, notably against the humanist Nicephorus Gregoras. Palamas died in Thessalonica on Nov. 14, 1359. He was canonized in the Orthodox Church in 1368 and his feast day is Nov. 14.

Palamas' writings, some of which are unedited, include letters, 63 homilies, ascetical treatises on prayer, and polemical works: the nine books *Hyper ton hieros hesychazonton* ("In Defense of the Holy Hesychasts") against Barlaam, seven books against Akindynos, four against Gregoras, and two against the Latins defending the Orthodox doctrine of the procession of the Holy Spirit from the Father. He is also the compiler of the *Tomos hagioritikos*, a theological manifesto of the Athonite monks against Barlaam (1340).

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PALAMAS, KOSTIS (1859–1943), Greek poet, played an important part in the evolution of modern Greek literature. Born at Patras in the Peloponnese on Jan. 13 (old style; Jan. 25, new style), 1859, he was educated at Mesolongion and at Athens. He was the central figure in the demotic movement of the 1880s which sought to shake off traditionalism and draw inspiration for a new literary and artistic style from the life and language of the people, and became the founder of the "new school of Athens" which condemned romantic exuberance and reverted to a purer and more restrained type of poetry. In 1886 Palamas published his first collection of poems, the *Tragoudia tes Patridos mou* ("Songs of My Country"), followed by the *Iamboi kai Anapaestoi* ("Iambs and Anapaests"; 1897), the *Asalefte Zoe* (1904; Eng. trans. by A. E. Phoutrides, *Life Immovable*, 1904), the *Dodecalogos tou Gyftou* ("The Twelve Lays of the Gipsy"; 1907) and the *I flogera tou Vasilia* ("The King's Flute"; 1910). Palamas was the first poet to express the national sufferings and aspirations of the Greeks, and with his lyricism, metrical variety and robust language he remolded a great deal of Greek history, mythology and philosophy, fusing it with many Western European and even Eastern ideas. His play, the *Trisevgene* ("The Thrice Noble"; 1903) has lyric rather than dramatic merits. He also wrote short stories and his criticism raised the standard of modern Greek literary criticism. He died at Athens on Feb. 27, 1943.

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PALAMAU, a district in the Chota Nagpur division of Bihar, India. Area 4,925 sq.mi. Pop. (1961) 1,187,789. It consists of the lower spurs of the Chota Nagpur Plateau and is largely drained northward by the North Koel River, a tributary of the Son. In the extreme south is the elevated *pat* (flat) region, about 3,600 ft. high, on which stands the picturesque hill station, Netarhat. About 2,000 sq.mi. of the district are cultivated, mainly with rice; the remainder is sal (*Shorea robusta*) jungle. The district produces coal, bauxite, and limestone, and supplies bamboo for paper manufacture. There is a cement factory at Japla. The administrative headquarters are at Daltonganj (pop. [1961] 25,270). Near Palamau Village are two ruined forts of the Chero chiefs, who ruled Palamau before the Mogul conquest in 1660. (E. AH.)

PALAMCOTTAH (Palayamcottai), a town in the Tirunelveli district of Madras, India, lies 85 mi. SSW of Madura. Pop. (1961) 51,002. It stands on the Tambraparni River opposite the town of Tirunelveli (*q.v.*), the headquarters of the district, with which it forms a twin town. Palamcottah was formerly the district headquarters. It is an important centre for higher education, with five colleges of arts, science, and teachers' training, of which two are managed by the Protestant mission and three by the Roman Catholics. The town is on the Southern Railway and is well linked by road. (G. Kn.)

PALAMEDES, in Greek legend, the son of Nauplius, king of Euboea, one of the heroes of the Trojan War, belonging to the post-Homeric cycle of legends. Before the war he exposed the trickery of Odysseus, who had feigned madness to avoid military service; by placing the baby Telemachus in the path of Odysseus' plow in the field, he forced the king to admit his sanity. During the siege of Troy he alternated with Odysseus and Diomedes in leading the army in the field, but his capacity aroused their envy. In the epic version they drowned him while fishing, or persuaded him to seek treasure in a well, which they thereupon filled with stones. In the tragic version (thus Euripides' lost *Palamedes*) Agamemnon, Diomedes, and Odysseus caused a letter containing money and purporting to come from Priam to be concealed in his tent. They then accused Palamedes of treasonable correspondence with the enemy, and he was stoned to death. His father exacted vengeance from the Greeks on their way home, by placing false lights on the promontory of Caphareus.

Palamedes had a reputation for sagacity which attributed to him the invention of (among other things) the alphabet, numbers, weights and measures, coinage, and eating at regular intervals. These abilities may reflect his name (Greek *palame*, "hand"), but he is now generally understood to be a personification of Phoenician culture. (T. V. B.)

PALATE, the roof of the mouth in man and vertebrate animals. It consists of the anterior bony "hard palate" (*see* Mouth) and the posterior fleshy "soft palate" (*see* Throat). It is the partition between the mouth and nasal passages and the nasal pharynx. The name is popularly applied to the uvula or teatlike process of the soft palate. For information about cleft palate, *see* Speech Disorders.

PALATINATE (Ger. Pfalz), as a territorial name in German history, means primarily the lands of the Countship Palatine of the Rhine, that is of the Electoral Palatinate, which extended left and right of the middle Rhine over country now divided between Baden-Württemberg, Hesse, and Rhineland-Palatinate. Palatinate-Simmern and Palatinate-Zweibrücken were offshoots of this area; and the Palatinate of the 19th–20th century comprised parts of it. On the other hand the Upper Palatinate (*Oberpfalz*), Palatinate-Neuburg and Palatinate-Sulzbach, so named because of dynastic relationship, were in what is now Bavaria.

The Rhenish Palatinate grew out of the jurisdiction of the count palatine of Lotharingia (Lorraine) (*see* Palatine). The German kings of the Salian dynasty (1024–1125) had family possessions on the Rhine, with centres near Worms and Speyer and lands to the east on the Neckar and to the west on the Nahe. After these possessions had passed to the Hohenstaufens, the emperor Frederick I Barbarossa in 1155 granted the office of count palatine to his half brother Conrad, who proceeded to link that office with the inherited lands. Heidelberg on the Neckar became the capital of the territorial Palatinate, to which moreover the dignity of archsteward of the *Reich* was attached. Conrad's heiress Agnes brought the countship to the Welfs through her marriage to Henry, son of Henry the Lion, duke of Saxony; but their son Henry II died childless in 1214, whereupon the emperor Frederick II enfiefed Louis I, duke of Bavaria, of the house of Wittelsbach (*q.v.*), with the palatine office and territory; and the marriage (1225) of Otto II of Bavaria to Henry II's sister Agnes brought the hereditary lands also to the Wittelsbachs.

The count palatine of the Rhine was the foremost secular prince of the *Reich* and the supreme judge in lawsuits affecting the royal domain; and he exercised electoral rights (*see* Electors) as early as 1198. Partitions of the Wittelsbach lands led to disputes between Palatinate and Bavaria over the electoral dignity till it was settled on the former by the Golden Bull of 1356. Meanwhile the Wittelsbachs' Treaty of Pavia (1329) had assigned the Palatinate, together with the Bavarian North Mark (on the Nab River), thereafter known as the Upper Palatinate, to the senior branch of the family, the duchy of Bavaria to the junior.

Rupert I, elector from 1353 to 1390, acquired Oppenheim on the Rhine north of Worms, Kaiserslautern and Zweibrücken west of Speyer, Simmern to the northwest beyond the Nahe, and Mosbach on the Neckar east of Heidelberg; and Rupert III, elector from 1318 to 1410, was German king as Rupert I from 1400, further enhancing the dynasty's prestige. On his death, however, his four sons divided their inheritance as follows: (1) the Electoral Palatinate (first male line extinct 1559); (2) the Upper Palatinate (line extinct 1448); (3) Simmern-Zweibrücken, the latter being subdivided from 1569 between Neuburg, Zweibrücken, and Birkenfeld branches; and (4) Mosbach (line extinct 1499). As one line or branch died out, its possessions reverted to one or more of the survivors.

The Electoral Palatinate became a focus of German national feeling against papal and imperial universalism. Frederick I the Victorious, elector from 1449 to 1476, asserted himself against hostile coalitions (the archbishops of Mainz were his most persistent enemies) and won lands to the north right of the Rhine and to the south in Alsace. The War of the Landshut Succession (1503–05; *see* Bavaria) cost the Palatinate some of its acquisitions but secured Neuburg for a junior branch of the electoral line. The peasants' revolt of 1525 affected the Rhenish area.

Frederick III (*q.v.*), the first of the Simmern line to succeed to the electorate, established Calvinism in 1563. Thereafter French Huguenots and Calvinist refugees from the Netherlands were made welcome. Adherence to the Protestant Union of 1608 and the Bohemian enterprise of Frederick V (*q.v.*) led to the Thirty Years' War, which was disastrous for the Palatinate. Though by the Peace of Westphalia (1648) the dynasty was restored in the person of Frederick V's son Charles Louis (d. 1680), the ancient electorship, the archsteward ship of the *Reich* and what the senior line had held of the Upper Palatinate were transferred to Bavaria. A new electorship, however, with the dignity of archtreasurer, was created for Charles Louis. In 1685, the Electoral Palatinate passed to the Neuburg branch, which had reverted to Catholicism in 1612 to promote its succession to Jülich and Berg (*qq.v.*). Louis XIV of France, however, advanced claims in the name of his sister-in-law, Elizabeth Charlotte, duchesse d'Orléans. Invading the Palatinate in 1688, the French committed appalling devastations during the War of the Grand Alliance (*q.v.*); and under the Treaty of Rijswijk (1697) the elector John William had to impose Catholicism on his subjects. In 1705 a declaration granted equal rights to Calvinists and Catholics.

Charles Philip, elector from 1716 to 1742, transferred his seat in 1720 from Heidelberg to Mannheim (*q.v.*), which was considerably developed by his successor Charles Theodore. The latter belonged to the Sulzbach branch of the Neuburgs, for which a separate principality had been created in 1614. In the Palatinate he set up a third electoral residence at Frankenthal and generally promoted industry, road building, the arts, and the sciences. He betook himself to Munich on inheriting Bavaria in 1777.

When Maximilian Joseph became elector in 1799 (*see* Maximilian I Joseph, king of Bavaria), the lands west of the Rhine were occupied by the French; and they were formally ceded to France in 1801 (*see* French Revolutionary Wars; Napoleonic Wars), to be merged with the *département* of Mont-Tonnerre. In 1803 the lands on the right bank of the Rhine were assigned to Baden (which got the greater part, including Heidelberg and Mannheim), to Hesse-Darmstadt, and to the house of Leiningen. After Napoleon's downfall Bavaria in 1816 obtained a large part of the old territory on the left bank of the Rhine, with some new lands adjacent. This "Bavarian circle of the Rhine" was renamed as the Palatinate in 1838. Radicalism found expression in demonstrations at the Hambach festival in May 1832 and in revolutionary insurrection in summer 1849.

After World War I the Palatinate was occupied by the French

till 1930. Under the Nazis it was merged with the Saar district to form a region or a *Gau*, Westmark. Included in the French zone of occupied Germany after World War II, the Palatinate in 1946 was taken into the new *Land* Rhineland-Palatinate (*q.v.*), part of the Federal Republic of Germany from 1949. (H. V. J.)

PALATINE (Lat. *palatinus*, belonging to the *palatium* or palace). Under the Roman Empire the chamberlains of the emperor and the troops guarding his palace were alike described as *palatini;* and in Constantine I's time the same designation was used for the senior field force of the army, which might accompany the emperor on his campaigns. Among the Germanic peoples, however, from Frankish times onward, the word was revived to have a longer currency and to assume various meanings. The German word *Pfalz* (likewise from Lat. *palatium*) originally meant a castle of the *Reich* at which the king might reside in the course of his travels; consequently a major administrative centre. Thence arose the expression *Pfalzgraf* or count palatine (Lat. *comes palatinus; see* COUNT).

In Merovingian and in Carolingian times the count palatine was an official of the sovereign's entourage or household (*Hof*), in particular of his court of law. Under the German kings of the Saxon and of the Salian dynasties (918–1125), on the other hand, there were counts palatine with functions corresponding to those of the earlier *missi dominici* (*q.v.*), responsible for the administration of the royal domain and for the dispensation of justice in certain duchies of the *Reich; e.g.*, Saxony, Bavaria, Carinthia, Swabia, and, in particular, Lotharingia (Lorraine). Whereas the other countships palatine were subsequently either absorbed by the ducal dynasties or acquired as hereditary dignities by local families with little or no actual authority, the count palatine of Lotharingia, whose office had been attached to the royal palace at Aachen from the 10th century onward, was the real successor of the Carolingian count palatine; and from his office there grew up the Countship Palatine of the Rhine, otherwise known simply as the Palatinate (*q.v.*), which from the emperor Frederick I Barbarossa's time became a great territorial power. In the 14th century the emperor Charles IV instituted a further body of court or household counts palatine (*Hofpfalzgrafen*), but they had only voluntary jurisdiction and some honorific functions.

In post-Carolingian France the term *paladin* was early applied in literature to designate a companion of Charlemagne (*see* CHARLEMAGNE LEGENDS). For the connection between the 12 *paladins* or peers of the romances and the 12 peers of France *see* PEERAGE.

In England the term palatinate or county palatine was applied in the Middle Ages to counties whose lord—an earl or a bishop—exercised powers which were normally reserved to the crown. Cheshire, Lancashire, Pembrokeshire, and, in Ireland, Tipperary (*qq.v.*) constitute examples under secular lordship, Durham and Ely (*qq.v.*) under ecclesiastical; and in Tudor times Hexham is also cited as a county palatine. Likewise there were palatine provinces among the English colonies in North America: Cecil Calvert, 2nd Lord Baltimore, was granted palatine rights in Maryland in 1632; Sir Ferdinando Gorges, lord of Maine, was granted such prerogatives as were enjoyed by the bishop of Durham in 1639; and the proprietors of Carolina received similar rights in 1663.

Palatinus or its derivatives are also to translate the titles of certain great functionaries in eastern Europe: for example the Hungarian *nádor*, a dignitary whose office was instituted by St. Stephen and who was the second person in the kingdom; and the Polish *wojewoda* (voivode), the military governor of a province of a kingdom.

PALAUNG (also PALÈ), Burmese terms for such hill people of the Burmese Shan States as the Katurr, Kunloi, Kwanhai, Manloi, Rumai, Tawngma, and Ta-ang. They were estimated to number about 150,000 in the 1960s and speak various dialects of a common Mon-Khmer language (*see* AUSTROASIATIC LANGUAGES) quite distinct from the Thai speech of the Shan (*q.v.*), with whom they live closely intermingled. Their main centre is Tawngpeng, which is in form a Shan State (*q.v.*) although the bulk of the population, including the ruling family, is Palaung. This area has a long history as a centre of tea production. Some Palaung groups are organized in patrilineal lineages similar to those of their Kachin (*q.v.*) neighbours to the north; elsewhere their organization is more like that of the Shan. Shan-type Buddhism coexists with various local cults based on ancestor worship. The Palaung language resembles that of the head-hunting Wa (*q.v.*) farther east but there is otherwise no close cultural connection between the two groups.

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(E. R. L.)

PALAWAN, most southwestern and most remote province and island, Republic of the Philippines, is one of the frontier areas of the country. Pop. (1960) province and island 162,669. The province (5,693 sq.mi.) comprises the main island, fifth largest in the country (4,550 sq.mi.), and about 1,700 smaller islands and islets, of which the principal groups are the Calamian Islands (*q.v.*) to the north between Palawan and Mindoro, the Dumaran-Cuyo group off the northeastern coast and the Balabac-Bugsuk group off the southern coast. Culion Island (*q.v.*) is a leper colony. A mountain chain runs the entire length of the 270-mi. main island and divides the area into western and eastern Palawan. Mt. Mantalingajan (6,841 ft.) is the highest peak.

The narrow, discontinuous coastal plain extends from 1 to 6 mi. inland. It is best developed in the vicinity of Puerto Princesa, the capital and principal port. Pop. (1960) 23,125. This plain, which has the only all-weather road, is the principal agricultural area and the site of the Iwahig penal colony. The animal life and vegetation on Palawan bears a striking resemblance to that of Borneo, more so than to that of other islands of the Philippines—a result of the land bridge that connected these two islands in recent geological times. Most of Palawan is forest, the home area of primitive tribes of Batahs, Palawanes and Tagbanuas. The kaingin (shifting) system of agriculture is widely practised where rice, corn, beans and sweet potatoes are grown. Christian migrants (Visayans, Tagalogs, Ilocanos and Bikols) are settling on the north and east coast and pushing into the interior. There are some Moro settlements in the south. Scattered settlement predominates. Everywhere rice is the principal crop. Much of the mineral development is recent. A mercury mine was opened near Puerto Princesa in 1955; manganese has been mined on Busuanga and there is also guano in the Calamian group. Chromite has been discovered northwest of Puerto Princesa. Minerals, lumber and fish are the principal exports. (AN. C.)

PALAZZOLO ACREIDE, a town and holiday resort in Siracusa Province, Sicily, 2,250 ft. above sea level and 21 mi. W of Syracuse. Pop. (1961) 10,589 (commune). It was largely destroyed by earthquake in 1693. The church of S. Sebastiano (1609) survives. The Palazzo Iudica houses objects from the ruins of the nearby Syracusan colony of Acrae (founded 664 B.C.). On this site are a Greek concert hall and theatre; rock "temples of the dead"; and roughly carved life-size figures of deities, including Demeter, known as the Santoni ("big holy ones"). The modern town is on a railway and has a hydroelectric plant. Oil, grain, oranges, lemons, and almonds are grown. Ravaged by the Saracens in the mid-9th century, the town was ruled during the Middle Ages by a succession of families, was absorbed in the Kingdom of the Two Sicilies, and eventually passed to the kingdom of united Italy. (M. T. A. N.)

PALE (Lat. *palus*, "a stake"), a historical term denoting a district marked off from the surrounding country by definite boundaries or distinguished by a different legal and administrative system. An example was the English pale in Ireland, an enclave which existed from the time of Henry II's expedition of 1171–72, although it was not called "the Pale" until the late 14th century. The term was much used in the 16th century and is the origin of the expression "beyond the pale." The extent of the pale in Ireland varied considerably according to the strength or weakness of the English authorities. In the time of Henry VIII it was bounded by a line running from Dundalk to Kells, thence to Naas eastward to Dalkey, and comprised parts of the modern counties of Dublin, Louth, Meath, and Kildare. The pale existed until the

entire country was subjugated under Elizabeth I.

There was an English pale, or Calais pale, in France from 1347 to 1558. It extended from Gravelines to Wissant on the coast and stretched inland from six to nine miles.

In imperial Russia the Pale of Settlement was the internal line of demarcation drawn behind the western frontier to bound the zone east or north of which Jews were forbidden to settle. The pale was first established, by the empress Catherine II's *ukaz* of Jan. 3, 1792 (new style; Dec. 23, 1791, old style), along the northern and eastern border of the territory annexed from Poland in 1772; it was extended southeastward in 1794 to run along the eastern border of the provinces of Chernigov, Poltava, and Yekaterinoslav to the Sea of Azov; and after the annexation of Courland (1795) it was extended westward along Courland's southern frontier to the Baltic Sea. Thus in the 19th century all Russian Poland, Lithuania, Belorussia, most of the Ukraine, the Crimea, and Bessarabia were permitted areas of settlement for Jews. The right to cross the pale and to settle in any part of the empire except Finland was accorded to the following classes of Jews: (1) members of the first or highest of the three guilds of merchants (with a capital of 10,000 rubles), from 1859; (2) persons possessing a higher education, from 1861; (3) persons who had completed their term of military service, from 1867; and (4) some categories of artisans, from 1817 to 1826 and again from 1865 (but, from 1891, not in the city or province of Moscow). According to the census of 1897, there were 4,874,636 Jews (11.76% of the population) in the zone of permitted settlement, but only 207,706 (0.34%) in European Russia outside it.

PALEARIO, AONIO (also Antonio della Paglia or degli Pagliaricci; Aonius Palearius) (*c.* 1500–1570), Italian humanist and reformer, was born at Veroli in the Roman Campagna. In 1520 he went to Rome and he entered the brilliant literary circle of Leo X. When Charles of Bourbon stormed Rome in 1527 Paleario went first to Perugia and then to Siena, where he settled as a teacher. In 1536 his didactic poem in Latin hexameters, *De immortalitate animarum*, was published at Lyons.

In 1542 a tract by Paleario, commonly known as *Libellus de morte Christi*, was made by the Inquisition the basis of a charge of heresy, from which, however, he successfully defended himself. In Siena he wrote his *Actio in pontifices romanos et eorum asseclas* (posthumously published in 1606), attacking the substitution of traditional for scriptural authority, and certain doctrines, especially that of purgatory. Professor first at Lucca and then at Milan, he was denounced by the inquisitor of Milan in 1567, sent to Rome for trial, condemned in October 1569, and executed in July 1570.

An edition of his works, including four books of *Epistolae* and 12 *Orationes* besides the *De immortalitate*, was published at Lyons in 1552; others followed, the fullest being that of Amsterdam in 1696.

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PALEMBANG, a river port and the capital of South Sumatra Province, Indonesia, is situated amid marshy ground on both banks of the Musi River about 50 mi. from the sea. Pop. (1961) 474,971, including a substantial Chinese minority. The capital of the Hindu-Sumatran kingdom of Sri Vijaya from the 7th century, Palembang was for long the chief town of Palembang Sultanate. In 1617 the Dutch East India Company set up a trading post, and in 1659 a fort was built. In 1811, when the sultanate was temporarily under British suzerainty during the British occupation of the Dutch East Indies, the sultan massacred many Dutch settlers, whereupon a British force landed, drove the sultan from his capital, and installed his brother in his place. In 1825 the Dutch abolished the sultanate, and it became a residency, which was incorporated in the Republic of Indonesia after World War II.

Many buildings of modern design have been erected along broad new roads, often built on filled-in canals, but there are still traditional floating houses and houses on piles. Important ancient buildings and monuments include the Great Mosque (1740; minaret 1753), the tombs of several sultans, one of which is still a place of pilgrimage, and a museum. More modern are the town hall, with a reservoir on top, the Sukarno General Hospital (1959), a sports hall, a training centre of public administration, Seriwidjaja University (1955), with faculties of economics, law, technology, medicine, teacher training, and agriculture, and a school of business administration, a Methodist school (1959), and the provincial parliament building. Races between *bidars* (boats with 20 oarsmen) take place on Independence Day (Aug. 17). There are thousands of sampans on the river, and in the streets tricycle taxis (*betjaks*) are a familiar sight, together with small buses that carry seven people. Ferries connect both banks of the river.

The width and depth of the Musi River (more than 300 yd. and 60 ft. respectively at Palembang) make the town accessible to large ocean steamers, but the bar at the mouth can be crossed only at flood tide. The port is the terminus of the main line of the railway system of South Sumatra. Palembang has a considerable trade with eastern ports in the Malay Peninsula, Thailand, and China, and there is also much traffic by road and river with the hinterland and regular communication with other ports in Sumatra and Java. Industries include many rubber plants, a huge fertilizer factory, and smaller factories producing such products as textiles, bricks, and processed foods. There are large oil refineries in the suburbs of Sungaigerong and Pladju, to the east. Rubber and petroleum constitute a large part of the value of exports, others being coffee and coal; the chief imports are textiles and building materials. The airport at Talangbetutu, 9 mi. NW, provides services to a number of Indonesian towns. (K. Su.)

PALENCIA, a city and episcopal see of north central Spain and chief town of the province of Palencia, lies on the Carrión river in the plain of the Tierra de Campos, 47 km. (29 mi.) NNE of Valladolid by road. The city was the ancient Roman Pallantia. Pop. (1960) 48,216 (mun.). The cathedral, in a florid Gothic style, was begun by Alfonso XI in 1321 and is dedicated to San Antolín, whose festival is celebrated in the city in September. Other churches are San Pablo (13th century, restored in the 15th) and San Miguel (13th century). The city has been modernized, with new houses and hotels and a park by the river. The Calle Mayor is the principal street and the commercial centre. The Estudio General, founded at Palencia in 1208 by Alfonso VIII, was the first university in Spain; it was later moved and its heritage is contested by the universities of Valladolid and Salamanca. Palencia is the centre of a network of roads and railways. Industries include the making of Palencia woolen blankets and cloth.

Palencia Province has an area of 3,096 sq.mi. and a population (1960) of 231,977 (about half the average national density). Three regions may be distinguished: the mountainous Valdivia in the north; the wheat-growing plain of Tierra de Campos; and the inhospitable desert of the Valles de Cerrato. The main river system is provided by the Pisuerga and Carrión. The province is also crossed by the 129-mi.-long Canal de Castilla, constructed in 1751–1849 and leading to Valladolid province. The canal is used for transporting wheat and flour, for irrigation, and for the generation of electricity. The province contains attractive medieval towns, but its population is predominantly rural, and the Tierra de Campos is one of the granaries of Spain. After World War II a start was made in modernizing the agriculture and overcoming the problem of drought by irrigation. Much sugar beet is grown and the province supports a substantial number of sheep—the basis of the traditional textile industry. There are coal mines (bituminous and anthracite) in the north. The main towns beside Palencia include Baños de Cerrato (7,539), Baltanás (3,009), Dueñas (4,176), and Carrión de los Condes (3,058). (M. B. F.)

PALENQUE, a Classic Period city of the Maya Indians (*q.v.*) in Chiapas, Mex., about 80 mi. S of the port of Carmen. Its original name having been lost, it was named after the neighbouring village of Santo Domingo del Palenque. The ruins were discovered overgrown by jungle, but by the 1960s could be visited by tourists.

Although most Maya architecture was of tooled limestone, the Palenque builders were unusual in using plaster to obtain smooth surfaces. There is, however, considerable carving on the interior walls, the best specimens being on tablets, affixed to the walls with

plaster. Modeling in stucco was extensively used, and terra-cotta images have been found.

The plan of the so-called Great Palace shows three parallel walls enclosing two corridors covered with peculiar pointed arches or vaults characteristic of Palenque. A square tower rises to a height of about 40 ft. The Temple of Inscriptions, one of the largest and best preserved, is distinguished for its hieroglyphic tablets. In 1952 this temple was found to have been built over an elaborately jewelled crypt containing the remains of what may have been an ancient (*c.* A.D. 700) ruler-priest. The small Temple of Beau Relief features a large stucco bas-relief of a beautifully modeled figure seated on a throne.

See also ARCHAEOLOGY: *Mesoamerica: Central Maya Area.*

See M. H. Saville, *Bibliographic Notes on Palenque; Chiapas* (1928); M. B. Davidson (ed.), text by L. Cottrell, *The Horizon Book of Lost Worlds* (1962).

PALEO-ASIATIC LANGUAGES (better PALEO-SIBERIAN) are spoken in the extreme northeast of Siberia: Yukaghir, Chukchi, Koryak, Kamchatkan, and Gilyak. They contain features reminiscent of many American Indian languages. The phonetic system is rich and is marked by a scheme of vocalic alternation; weak, strong, and neutral. The grammatical processes are very complex (Koryak has a dual), and the relation between subject and predicate is conceived differently in transitive and intransitive verbs. Prefixes and suffixes are numerous, number, location, size being thus indicated. The numbers are derived from manual concepts, 5 being a hand and 20 being a man. Higher numbers are composed with the word for man, and numbers higher than 400 are called "limit of knowledge." Sentence structure is of the so-called polysynthetic type. Chukchi and Koryak have borrowed some words from Russian, but they also possess the power to form new words for new ideas. Kamchatkan has been much modified by Russian.

See R. Jakobson in *American Anthropologist*, vol. 45 (1942), and in A. Meillet and M. Cohen, *Les Langues du Monde*, 2nd ed., pp. 403–431 (1952). (J. WH.)

PALEOBOTANY (PLANT PALEONTOLOGY), a subdivision of botany that deals with the study of fossil plants. Although the organisms studied in paleontology include the remains of both plants and animals, it is customary to restrict the study of fossil plants to paleobotany. The importance of fossils is considered in the articles FOSSIL; PALEONTOLOGY; and EVOLUTION, ORGANIC. Since paleobotany is both a biological and a geological science, the relationship is surveyed primarily in GEOLOGY. Factors pertaining to living plants can also be applied to plants of past eras; these factors are reviewed in PLANTS AND PLANT SCIENCE.

An outline of the subjects discussed in this article is as follows:

I. General
  1. Introduction
  2. History
II. Fossil Evidence
  1. Means of Preservation
  2. Time-Space Relations
  3. Methods of Classification
III. Appearance of Major Plant Groups
  A. Nonvascular Plants
    1. Algae
    2. Fungi
    3. Bryophytes
  B. Vascular Plants
    1. Psilopsids
    2. Lycopsids
    3. Sphenopsids
    4. Pteropsids
IV. Geologic Distribution and Ecology
  A. Precambrian Time
  B. Paleozoic Era
    1. Devonian
    2. Carboniferous
    3. Permian
  C. Mesozoic Era
    1. Triassic
    2. Jurassic
    3. Cretaceous
  D. Cenozoic Era
    1. Tertiary
    2. Quaternary

I. GENERAL

1. Introduction.—The documents on which the history of the plant kingdom is founded are plant fossils, the debris of vegetation preserved in the rocks: leaves, twigs, seeds, fruits, flowers, spores, and pieces of wood representing trunks, branches, and roots. These fossils record the presence of aquatic plants upon the earth as far back as Precambrian time; the earliest land plants are known from Cambrian rocks laid down during the Paleozoic Era. While these earliest records are incomplete, there is sufficient evidence to show that the oldest known plants were small and simple as compared with modern trees. The evolutionary development of plants to their present high level of organization is a phase of paleobotany most closely related to the science of botany, as is the consideration of their structures. The stratigraphic occurrence of fossil plants falls in the field of geology; if the time of appearance, dominance, and extinction of a plant or of a group of plants (a flora) can be associated with rocks of known age, the geologist is thereafter able to correlate other rocks containing the same plants and to establish their age as approximately the same. Fossil plants may also supply the geologist with reliable evidence regarding ancient climate and topography; by comparison with related living forms, whose temperature and moisture requirements may readily be determined and whose topographic occurrence is also a matter of observation, the plants of the past may be judged to have lived in similar environments. With the combined viewpoint of the botanist and geologist, plant fossils may indicate the lines of evolution and relationship of the principal groups, the approximate dates when they lived, and the nature of the lands they occupied.

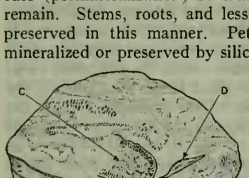
2. History.—As in the case of animal remains, fossil plants have long attracted attention. Early scientists generally subscribed to the idea of spontaneous production of fossils from inorganic matter, involving the operation of stone-making spirits or cosmic forces. This was an accepted doctrine as late as the 17th century; even in the 20th century the people of a small village in Shantung, China, believed that imprints of leaves on thin layers of shale in nearby hills represented the early efforts of gods of art and writing. Some appreciation of the organic nature of fossils was shown by the Pythagorean School and by Aristotle, but there was no general understanding of their significance in the record of earth history until many centuries later. In the 13th century, Albertus Magnus made the first written mention of a fossil plant. In a commentary on Genesis in about the year 1534, Martin Luther suggested that fossil wood might be expected to occur near mines, from which timbers had been washed by the deluge. Actually it was the extensive mining of coal following the destruction of forests in western Europe that first uncovered the abundant record of Carboniferous plants and provided a basis several centuries later for a scientific interpretation of fossil plants. But the diluvial theory flourished long after the day of Luther, with its Christian compromise that although plant fossils were of organic origin they represented the remains of vegetation washed away during the Noachian flood. The idea that fossils represent the accumulation of plants and animals over long periods of geologic time gained impetus after the discovery by William Smith (England) in 1798 that certain fossil shells always occurred in a given rock layer, while other beds above and below contained other shells. The founder of the science of paleobotany was Adolphe T. Brongniart (France), who during the 19th century established a sound classification for fossil plants and formulated several of the principles that govern their study. Other pioneers were H. Witham (England), who made the first anatomical study of petrified plants; H. R. Goeppert (Germany), whose voluminous works cover a wide range of interests; Oswald Heer (Switzerland), whose studies include a seven-volume discussion of Arctic floras; J. W. Dawson (Canada) and Leo Lesquereux (United States), who founded paleobotany in North America. In later years W. C. Williamson, D. H. Scott, and A. C. Seward (England), A. G. Nathorst (Sweden), and F. H. Knowlton and E. W. Berry (United States) made extensive contributions. Since about 1800 it has gradually been realized that plants in older rocks are relatively simple in organization and that they show a progressive trend toward com-

plex structure in successively younger layers. With this understanding of the significance of time in the history of life, paleobotany became a science in which the disorganized and mystical interpretations of earlier centuries gave way to a developmental point of view based upon comparisons with the morphology, distribution, and behaviour of living plants.

II. FOSSIL EVIDENCE

1. Means of Preservation.—Most of the plants that lived in past ages were subjected to decay and disintegration, and no trace of them remains; but under certain favourable conditions their more resistant structures were preserved, commonly as dissociated organs. Rapid burial in fine-grained sediments or volcanic ash greatly facilitated the formation of impressions of leaves and seeds or an occasional flower. If they imprint their margins and nervation on the sediments which bury them, these impressions will remain after the sediments have been compacted into solid rock, even though all the original plant tissues have then disappeared.

Circulation of ground water may add minerals carried in solution (commonly silica and calcium carbonate) to buried plant tissues (permineralization) so that all the details of cell structure remain. Stems, roots, and less commonly cones and seeds are preserved in this manner. Petrified wood that has been permineralized or preserved by silica is said to be silicified. Concretionary masses known as coal balls (fig. 1) contain well-preserved plant fragments that have been petrified by solutions of calcium and magnesium carbonates. Coal balls have been found only in Carboniferous coals. They range from one inch to several feet in diameter and are slightly flattened from the pressure of the surrounding sediments. Important coal ball discoveries have been made in the states of Illinois, Iowa, Indiana, and Kansas, as well as in England, Belgium, the Netherlands, and central Europe. Deeply buried plants may be subjected to pressure and heat until their volatile constituents are distilled away, leaving a residual film of carbon in the case of leaves or carbonized logs in the case of stems.



REDRAWN FROM PHOTOGRAPH BY COURTESY OF C. A. ARNOLD

FIG. 1.—SECTION OF COAL BALL From Conemaugh series, Ind., showing: (A) *Stigmaria* root; (B) *Lepidocarpon* seed; (C) petiole of *Medullosa*; (D) cross section of undetermined leaf, natural size

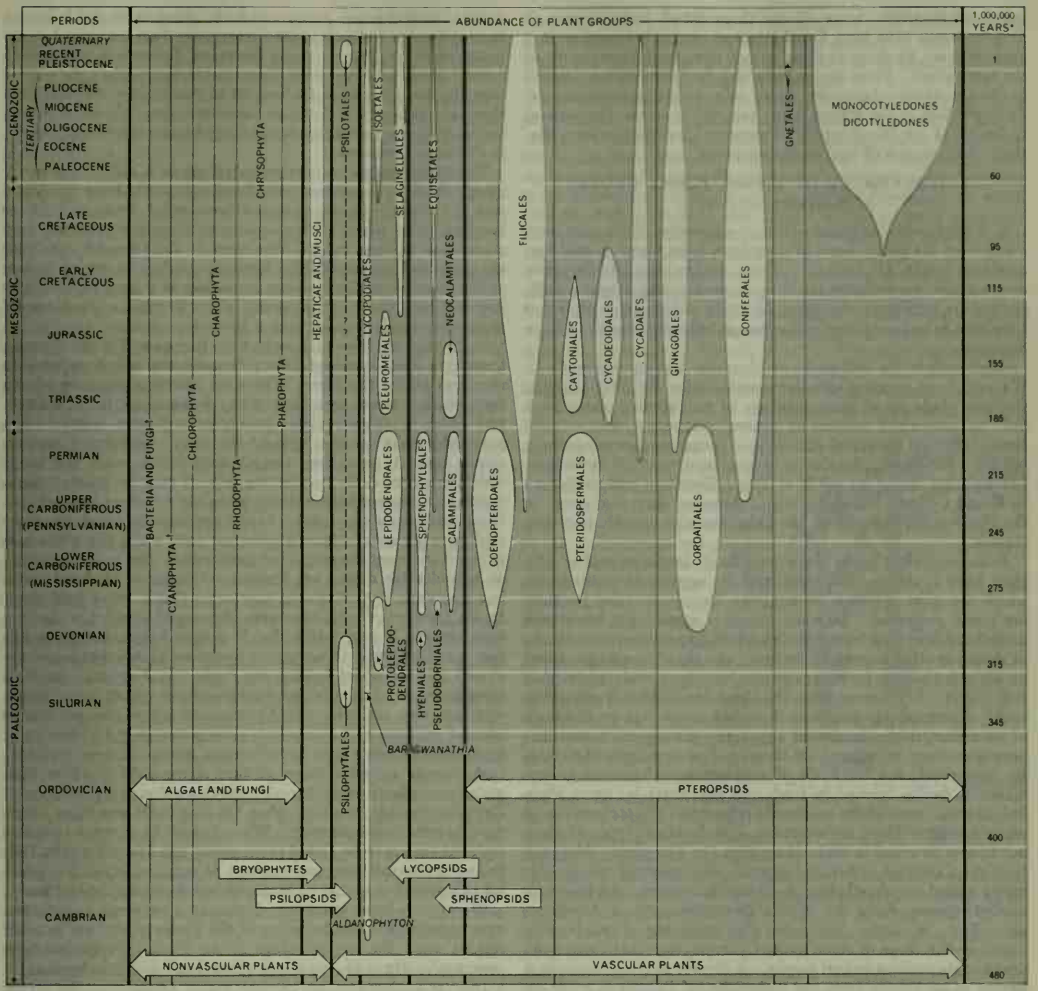
A third method of preservation is involved in certain rare situations where bacterial action is inhibited and plants are preserved in essentially their original state. At Rancho LaBrea and other California localities, great numbers of cones, seeds, leaves, and wood fragments, together with the bones of mammals and birds, have been enclosed in asphalt which has seeped out and impregnated the sands and clays in which they were buried. In the frozen muck of boreal regions, plant remains have been placed in natural cold storage for thousands of years without decay. The wood of some trees, of which *Sequoia* is a common example, contains substances such as tannin which protect it from bacterial action, and the only apparent change after burial for millions of years may be a slight crushing of the woody tissues. The dried and hardened resin of gum-bearing trees, especially conifers, may be preserved as amber in coal beds or other carbonaceous deposits. Amber from Oligocene sediments along the Baltic coast of Germany contains many flowers and other plant fragments, as well as insects, which became entrapped when the gum was soft. The original substance of these organisms has ordinarily disappeared, but the details of their form have been retained as molds. Pollen grains are of common occurrence in peat and carbonaceous shale, where resistant outer shells or exines are preserved in an essentially unaltered state.

Conditions that favour the preservation of plants may be found in valleys, lake basins, and estuaries where sediments are accumulating. Volcanic ash is an especially favourable medium for impression of plant remains and for rapidly enclosing logs and fruits that may later be petrified by the action of associated ground and magmatic waters. Since accumulation of sediments and ash is most permanent at low elevations where erosion is least active, it follows that the fossil record is limited largely to forests of the lowlands; trees of the highlands are ordinarily represented only by fragments that have been transported long distances or by pollen and winged seeds that are readily transported by wind. The tissues of herbs are less substantial than those of trees and shrubs, and even though they may have been numerous in the vegetation of the past, these smaller plants are seldom represented in fossil floras. Rare plants have less opportunity to enter the fossil record than abundant forms whose leaves, fruits, and stems may be deposited in large numbers. It may be concluded that the plants making up the fossil record are largely of common lowland types that have woody structures and substantial leaves. Knowledge of forests of the highlands is relatively incomplete, as is the record of herbs and structures such as flowers, which are often too delicate to be preserved.

2. Time-Space Relations.—Use of fossils as indicators of the age of rocks in which they occur is based upon observations made in many parts of the world that a given sedimentary layer or formation contains certain characteristic types of life (index fossils) and that the fossils in lower and higher formations are of different kinds. The basic concept that there has been a trend from simple structures in ancient organisms to progressively more complex structures in those of later age has already been mentioned; coming up through the rock layers from the beginnings of life, plants and animals of increasing complexity enter the fossil record. Thus in its simplest form, a general determination of age may be based upon the presence or absence of certain major groups. For example, angiosperms, an advanced type, were very scarce at a period earlier than the Cretaceous, while the more primitive pteridosperms (seed ferns) became extinct during the Jurassic. No rocks have been found to contain members of both these plant groups; thus the age of a formation containing angiosperms is likely to be Cretaceous or younger, while rocks with pteridosperms are Jurassic or older. Certain groups such as algae have only slight value in age determination since they have survived long ages with relatively little change.

Closer age determinations must depend upon occurrence of genera or species, for their span of life in earth history is shorter than that of the larger plant groups. Plants that evolved rapidly and lived for only a short segment of geologic time before they became extinct constitute the best index fossils. The pteridosperms of the Carboniferous Period are among the most valuable horizon markers, since in addition to living through a brief time range many of their species were abundant and broadly distributed geographically.

Presence of index fossils in rocks of unknown age, together with certain geologic criteria, makes possible their correlation in age with those in regions where the age of the rocks is well known. Plants of the Carboniferous Period show a marked similarity in Europe, Asia, and North America, providing a basis for age correlations across these continents. A much younger flora of the Miocene containing redwood (*Sequoia*), oak (*Quercus*), and other living tree genera was found across Eurasia from Japan to western Europe and in western North America; a closely similar flora is known in Arctic regions from northern Siberia to Spitsbergen, Greenland, and Alaska. Originally correlated with the Miocene of Switzerland because of similarity in composition, this northern flora is now known to be of Eocene Age from its geologic relations and associated faunas. The discrepancy in age from Miocene to Eocene represents the time required for migration of the redwood-oak flora southward from high to middle latitudes under the influence of cooling climate. Such similar floras, occurring in different areas at different times, are said to be homotaxial rather than synchronous. The redwood-oak floras of Greenland and Switzerland or of Alaska and Oregon may readily be correlated within the limits of the Tertiary Period, which includes both the Eocene and Miocene epochs and covers a span of about 60,000,000 years; but such wide differences in latitude must be considered to indicate a considerable difference in age, for at any one time in the past, as today, the plants of Greenland and Alaska differed



*The time spans shown may differ with those given in related articles elsewhere in the encyclopaedia, these differences reflect the opinions of the various authors concerned.
†Indications of bacteria, fungi, and cyanophyte have been found in Precambrian rocks.

THE OCCURRENCE OF THE MAJOR PLANT GROUPS IN GEOLOGIC TIME (AGES INCREASE FROM TOP DOWNWARD, AS IN A SEQUENCE OF SEDIMENTARY ROCKS)

greatly from those of Switzerland and Oregon. While it is doubtless true that at some past times climatic zones may have been less distinct than at present, there is no basis for supposing that at any time in the earth's history has the influence of latitude on land climate and vegetation been negligible. Marine faunas and to some extent the animals of the land may be somewhat less affected by climatic zones, since many of them are not fixed in position like land plants and can migrate as individuals. But any correlation of terrestrial floras must take into consideration the factor of latitude. The cosmopolitan flora of the Jurassic was contemporaneous from Greenland to Antarctica only within the time limits of this period, some 40,000,000 years in duration. There is no basis for supposing that the vegetation of England was identical at any one portion of the Jurassic with that of the poles, for conditions responsible for the growth of plants could never have been uniform over so wide a range in latitude. Having in mind the interrelations of time and space in the history of vegetation, correlations of similar plants may be made in approximate latitudes, or differences in age may be established if homotaxial floras occur at different latitudes.

3. Methods of Classification.—Fossil plants are classified by the system used for living plants (*see* PLANTS AND PLANT SCIENCE: *Classification of Plants*), but special problems arise because of the dissociated occurrence of most plant organs; for example, it is unusual to find leaves or fruiting structures attached to stems. It is therefore convenient to constitute form genera, each including a different part of what may be the same plant or a group of related plants. In a common Paleozoic lycopsid genus, the stems are placed in the form genus *Lepidodendron* (scale tree), the detached leaves in *Lepidophyllum* (scale leaf), and the cones in *Lepidostrobus* (scale cone); the root-bearing parts, which are indistinguishable from those of an allied genus *Sigillaria*, are grouped with those of the latter genus in the form genus *Stigmaria*. In some cases genera have been independently described for separate organs which are later found in association. A Carboniferous stem described as *Medullosa* is now known to have borne fronds

called *Alethopteris;* some of the three-ribbed fruits known as *Trigonocarpus* have been found attached to *Alethopteris;* so it is apparent that all three of these names refer to different parts of the same plant. Form names may also be appropriately applied to plants whose characters show only a family resemblance. *Laurophyllum* is the generic name assigned to leaves that appear to belong to the laurel family (Lauraceae) but do not show distinctive characters of any particular genus.

III. APPEARANCE OF MAJOR PLANT GROUPS

A. Nonvascular Plants

1. Algae.—*Precambrian.*—Objects suggestive of the gelatinous colonies of the living genus *Nostoc* have been found in the Precambrian rocks of Finland. These bodies, named *Corycium enigmaticum,* are probably the oldest known fossils. About equally ancient are structures resembling filaments of blue-green algae and fungi that have been found in the Precambrian flints north of Lake Superior.

Algal reefs in the Belt series of Montana, first studied by C. D. Walcott, have received detailed consideration by later authors. Colonies made up of great numbers of microscopic plants have built up masses and columns of calcium carbonate with concentric laminations, but the actual structures of the plants themselves have not been preserved. Similar reefs have been reported in rocks of Precambrian age as far north as Yukon Territory and southward to Grand Canyon National Park in Arizona; they also occur in the iron-bearing deposits of the Lake Superior and Hudson Bay regions.

Paleozoic.—As a group algae are difficult fossils to study. The plant body is soft in most cases, and the reproductive structures, which are most useful in determining their systematic position, are rarely preserved. In many instances fossil algae have been named and described from material which may represent the tracks of worms or other animals in the mud; also the rill marks produced on the ocean bottom by water currents have been misinterpreted as fossil algae. *Cryptozoon* from the Cambrian of New York and in rocks of younger age has been described as an alga on the basis of its concentrically laminated structure. Its organic nature has been questioned because of the absence of any evidence of a cellular framework, but its mode of occurrence and general resemblance to bodies formed in fresh and salt water by living algae indicate that most of the specimens referred to *Cryptozoon* are of organic origin. There are a number of well-defined types of algae not known to occur in rocks older than the Paleozoic. *Marpolia* from the Cambrian of British Columbia shows several cellular filaments united in a sheath, like the living *Schizothrix. Archaeothrix oscillatoriformis* from the Middle Devonian chert of Aberdeenshire, Scot., is another blue-green alga consisting of cellular filaments so like those of some living Cyanophyceae that there is no doubt of its position in that family. A deposit of bituminous shale known as kuckersite from the Ordovician of Estonia is made up of countless millions of minute bodies resembling the living *Gloeocapsa;* the name *Gloeocapsomorpha* has been applied to these cell aggregates.

Several fossil algae of the Paleozoic appear to be referable to a more advanced type, the green algae (Chlorophyceae). An Ordovician genus, *Dimorphosiphon,* is remarkably like the living genus *Codium* but differs in having a secretion of lime on its surface; in this respect it seems related to *Halimeda,* a reef-forming, calcareous seaweed in the tropical seas of today. In the Ordovician limestone of the Girvan district in Scotland is another related alga named *Girvanella;* this tangled mass of minute tubes may be a blue-green rather than a green alga. The family name Protophyceae has been suggested for those ancient fossils that seem to be algae but are not readily assignable to a definite systematic position. Certain bituminous shales and cannel coals of the Carboniferous and Permian are made up largely of *Pila* and *Reinschia.* A similar living genus, *Botryococcus,* stores up oil in its cells, and a like origin may be suggested for the combustible deposits containing *Pila* and *Reinschia.*

The red algae of Rhodophyceae include many of the more important reef-building algae of today. The most characteristic genus, *Lithothamnion,* has a worldwide distribution and is known to have lived as far back as the Cretaceous. It had an allied representative in the Paleozoic seas known as *Solenopora,* which with related forms built layers of limestone in seas widely distributed over the earth from the Ordovician to the Jurassic Period. Red algae are generally difficult to determine from these calcareous reefs, and it is possible that many other Rhodophyceae are present in Paleozoic limestones.

The Charophyceae (stoneworts) represent a highly specialized group which are sometimes considered as separate from the Algae. A well-known living example is *Chara,* which lives in fresh or brackish water where its lime-encrusted stem and branches may accumulate to form marl. The parts of the Charophyceae that are preserved are usually the female reproductive organs known as the form genus *Gyrogonites,* consisting of a large egg cell surrounded by five or more spiral cells. A similar plant named *Algites* has been recorded from a Devonian swamp.

In Silurian and Devonian rocks from Europe and North America there is a large-stemmed plant, *Prototaxites,* which appears to represent one of the Algae. The stem reaches a diameter of two feet, which is larger than that of any living alga. It has a structure which is typically algal: loosely packed tubes without cross partitions make up the bulk of the stem, following a sinuous course along its axis; their smooth walls lack the pits and bands which characterize the conducting cells of vascular plants. Associated with these relatively thick tubes are narrower tubes resembling the filaments of fungi. In one specimen in which the outer surface is preserved, there is a narrow zone where the tubes turn outward and meet the surface at right angles. No roots, branches, or reproductive organs are known. Occurrence of *Prototaxites* in a peat deposit confirms the suggestion that it was a land plant. In the absence of any structures that could support so large a stem upright, it is probable that it sprawled upon the ground in swampy situations. Other simply organized plants that may have shared this terrestrial habitat are *Parka* and *Foerstia. Parka* is represented by circular impressions on whose surface occur groups of spores with resistant walls like those of plants now growing in contact with the air. *Foerstia* is represented only by the tips of branches containing cutinized spores in groups of four (tetrads) that likewise resemble those of land plants. All of these little understood plants occur in rocks laid down during the Silurian or Devonian periods, at a time when the land habit was being developed by plants and animals. When known from more complete material they may be found to represent the first plants that left the relatively sheltered environment of seas and lakes and established themselves on the more diversified shores of the continents.

Mesozoic.—Reefs made up of calcareous seaweeds are of common occurrence in the dolomites of the Tyrolese Alps and in other regions where the marine record of the Triassic Period has been preserved. These seaweeds are green algae (Chlorophyceae) of a type now abundant in tropical seas. *Diplopora,* one of the common genera, had a stalk several centimetres long with clusters of small branches. Its distribution northward to Siberia suggests either that this Triassic seaweed was less tropical than its modern descendants or that warm currents in the seas extended its environment far to the north. A reef-building family of the red algae (Rhodophyceae), the coralline algae, is represented in marine deposits of Cretaceous Age by *Lithothamnion,* a genus still living. Well-defined stoneworts (*Chara*) are also known from the Cretaceous. The diatoms (Bacillariophyceae) first appeared during the Jurassic Period.

Cenozoic.—Blue-green algae (Cyanophyceae) appear to have played a major role in the accumulation of oil shales such as the 2,000-ft. deposits in the Green River Basin of the central northern Rocky Mountains in the United States. Lime-secreting types of green (Chlorophyceae) and red (Rhodophyceae) algae closely similar to living species contributed to the building of marine limestones in many parts of the world. Brown algae (Phaeophyceae) are seldom recorded in the fossil record because of their lack of hard parts. Charophyceae (stoneworts) continue to the present as one of the most persistent types of plants, forming beds of freshwater limestone. Diatoms (Bacillariophyceae) were abun-

dant especially during the Miocene, forming thick layers of shale (diatomaceous earth) from their siliceous shells; they are considered to have been an important source material for petroleum in California and elsewhere in later geologic time.

2. Fungi.—*Precambrian.*—The only indications of Precambrian fungi are minute bodies interpreted as bacteria from the iron ore of Michigan; their resemblance to the living *Chlamydothrix* has been suggested.

Paleozoic.—Fungi of the Early Paleozoic are largely limited to infrequent records of bacteria that are so poorly preserved as to have little scientific value. But in the later rocks of the Paleozoic there are many examples of other fungi that lived as parasites in the tissues of trees and shrubs. These fall largely in the group known as Phycomycetes because of their nonseptate hyphae. While some of the parasitic types of fungi doubtless had harmful effects on their hosts, as do their modern descendants, there appear to have been others that had established a symbiotic relationship. There are several later Paleozoic records of the roots of trees in which the distribution of fungal hyphae suggests such a beneficial parasitism.

Mesozoic.—The evidence of Mesozoic fungi is scarce. However, Cretaceous leaves showed characteristic disease areas.

Cenozoic.—Various types of fungi have been encountered on leaves and in wood of the Cenozoic, with a few records of the woody bracket fungus (*Fomes*).

3. Bryophytes.—Mosses and liverworts are found widely over the world at the present day; they are terrestrial in habit, commonly living in moist situations. If, as seems probable, their ancestors in past ages were likewise small and lacking in woody tissues, it is not surprising that they have so infrequently entered the fossil record. On structural grounds they must be considered a simple and probably primitive type of plant. It has been suggested that the problematical *Prototaxites, Parka,* and *Foerstia* may represent a stage of development intermediate between the thallophytes (algae and fungi) and the bryophytes.

Paleozoic.—Fossil liverworts from the Upper Carboniferous of England have been referred by J. Walton to the genus *Hepaticites.* These were small plants, in some species branching dichotomously and with parallel rows of leaves. Ancient equivalents of the mosses from the Upper Carboniferous of France are assigned to *Muscites.* The principal value of these rare and incomplete fossil members of the bryophytes is that they demonstrate the existence during the Paleozoic Era of an ancestral group of plants which affords, as Seward has stated, "an impressive instance of the persistence through a long succession of ages, of a delicate organism undisturbed by the influences which transformed again and again the character of the world's vegetation." (A. C. Seward, *Plant Life Through the Ages* [1931], by permission of the Cambridge University Press.)

Mesozoic.—Liverworts resembling modern *Marchantia* and *Jungermannia* occur in the Early Jurassic rocks of Sweden. One of the most interesting fossil bryophytes is *Naiadita* from the Late Jurassic of England. The small branched leafy stems bore lateral archegonia from which in some instances short-stalked spore cases had developed. True mosses have been found in Mesozoic rocks, but they were seldom abundant.

Cenozoic.—Bryophytes, never common in the fossil record, are represented in Cenozoic deposits by an occasional liverwort of modern appearance and by various types of mosses, especially in deposits of the Pleistocene.

B. Vascular Plants

The plants with vascular tissues are divided into four major divisions (psilopsids, lycopsids, sphenopsids, and pteropsids), all of which made their first appearance during the Paleozoic and became numerous and highly diversified before its close. The vascular tissues of the stem comprise: (1) phloem, made up of sieve tubes and other cells through which food is transferred from one part of the plant to the other; and (2) xylem, made up of elongated cells (tracheids) or groups of cells fused end to end (tracheae) to form vessels that conduct water and mineral nutrients. The cells of the xylem, including fibre cells, become thickened (lignified) by addition of lignin, giving them added strength and hardness. Without the mechanical support of such tissues it would not be possible for land plants to rise as trees for tens or even hundreds of feet above the ground.

1. Psilopsids.—*Paleozoic.*—Among the psilopsids are the Psilophytales, the most primitive vascular plants and among the first to establish themselves on the land. This group appears to be ancestral to the living Psilotales, represented by two simple genera of the tropics and Southern Hemisphere. It is noteworthy that there is no intermediate record from the Middle Devonian, at which time the Psilophytales became extinct, to the present; so it may be supposed that since Devonian times the ancestors of the modern Psilotales must have been small and few in number.

The Psilophytales are defined as simple plants with dichotomously branching stems bearing terminal sporangia and lacking true roots and leaves. Their resemblance to the living *Psilotum* was first noted by J. W. Dawson when he described *Psilophyton* from the Devonian of Canada in 1859. The most significant occurrence of this group was made known by R. Kidston and W. H. Lang in 1917 when they described the Middle Devonian flora from the Rhynie chert (a rock of fine-grained quartz found in Rhynie, Scot.). The genus *Rhynia* (fig. 2B) had a horizontal rhizome from which rose cylindrical, sparsely branching shoots, 8–20 in. in height, with sporangia at their tips. The internal structure of the shoots shows the simplest type of vascular tissue, a protostele made up of a single strand of xylem (wood) enclosed in a sheath of phloem (bast), with a broad zone of surrounding cortex, and an epidermis made up of a single layer of cutinized cells; there are a few simple stomata on the epidermis. *Horneophyton* was a similar plant, differing in its swollen base which lacked vascular tissues and in having columellate sporangia resembling those of certain bryophytes. *Asteroxylon* (fig. 2A) had longer shoots clothed with leaflike scales, becoming naked at their tips where some of them bore sporangia. The cross section of the stem shows a stellate protostele with small vascular strands extending up to but not into the bases of the scales; in true leaves there is a vascular connection from the wood into the leaves.

AFTER KIDSTON AND LANG BY COURTESY OF THE ROYAL SOCIETY OF EDINBURGH

FIG. 2.—TWO TYPES OF LAND PLANTS FROM THE DEVONIAN OF SCOTLAND: (A) ASTEROXYLON, (B) RHYNIA

Greater complexity of reproductive structures is apparent in *Zosterophyllum,* a widely distributed Early Devonian genus, and in *Bucheria,* which occurs in beds of the same age in Wyoming, in which genera the sporangia were borne in terminal spikes. These plants and the genera above mentioned show many resemblances to algae and bryophytes. But in spite of their simplicity, there are advances over these lower plants which place the Psilophytales at a higher level of development. The psilopsids may be considered ancestral to the other groups of vascular plants, which like them were becoming established on the land during the Paleozoic Era.

2. Lycopsids.—*Paleozoic.*—The lycopsid group includes among its fossil members some of the largest and most abundant trees of the Late Paleozoic forests. Surviving examples such as *Lycopodium* and *Selaginella* are small and inconspicuous and largely confined to low latitudes. In their vegetative characters certain members of this group, both fossil and modern, show sufficient resemblance to the spiny types of psilopsids to suggest that the latter bear an ancestral relationship. An important difference is the position of the sporangia at the end of the axis in the psilopsids, while in the lycopsids they are situated on the upper side of the leaves or at the leaf bases. Two primitive lycopsid genera appear to stand in an intermediate position with the psilopsids. *Drepanophycus,* known from the Early Devonian of Canada,

northwestern Europe, China, and Australia, had the vegetative appearance of *Psilophyton*, but it was a typical lycopsid in having sporangia attached on the upper side of the spines near their bases, as shown by R. Kraüsel and H. Weyland. In 1935 W. H. Lang and I. C. Cookson described a second genus, *Baragwanathia*, from the Late Silurian of Australia, which also shows a combination of lycopsid and psilopsid characters. The stems of this plant were similar to those of *Asteroxylon* in their structure but with a direct connection by leaf traces between the woody axis and the foliar organs, making them true leaves. Sporangia occurred along the upper end of the stem among and possibly attached to the leaves, instead of on naked tips as in *Asteroxylon* and related psilopsids. In 1954 A. N. Kryshtofovich gave the name *Aldanophyton* to a fossil from the Middle Cambrian of the U.S.S.R. that bears a striking resemblance to the living *Lycopodium*. If correctly interpreted this plant is not only the oldest known vascular plant but shows the existence of lycopsids several million years before any other known vascular plants. The trunk of *Archaeosigillaria*, a second widely distributed Devonian genus, shows vertically placed leaf scars near the base like *Sigillaria* and spiral scars above like *Lepidodendron*.

Lepidodendron, the scale tree, ranged from Late Devonian to Middle Permian, and its stems are among the most abundant fossils of the Carboniferous. Its slender trunk reached a height of more than 100 ft., while above the crown of forking branches it rose a further 20 ft. At the base were rootlike divisions of the trunk, dichotomously branched and spreading; these basal appendages, known as *Stigmaria*, sometimes extended from the trunks down into sandstone or shale underlying the coal seam, giving evidence that the coal was formed in the actual place of growth of the trees from whose remains it was accumulated. Covering the smaller branches of the crown were spirally placed, lanceolate leaves a few inches to nearly three feet in length; they were shed when the part of the plant bearing them reached a certain age, leaving a diamond-shaped scar on the leaf base. The stem was made up of a slender cylinder of primary wood, with or without pith inside, surrounded in most species by a broader cylinder of secondary wood with no indication of growth rings. Unlike the stems of conifers and angiosperms, in which the woody portion makes up 80–90% of the cross section, the stele of *Lepidodendron* made up only 9–14%. It would have been impossible for such tall trees to have been supported by so slender a core of wood alone; the development of a thick periderm made up of fibrous tissue in the outer part of the stem gave it the necessary mechanical strength. The cones (*Lepidostrobus* and other cone genera) were like those of *Selaginella*, only much larger; most of them produced two types of spores (heterospory), with the sporophylls bearing megasporangia at the base of the cones; sporangia of both types were borne on the upper surface of the sporophylls. Vast numbers of spores were produced, as indicated by the fact that some coals of Carboniferous Age consist largely of the compressed spores of *Lepidodendron* and its closely related but less branched associate, *Sigillaria*. Other distinguishing characters of *Sigillaria* are its longer leaves with once-forked veins and the vertical arrangement of the leaf scars, which are rounded or hexagonal in shape.

Certain isolated cones and sporophylls have been found with attached megasporangia containing only one large megaspore. At maturity an integument formed by an outgrowth from the sides of the sporophyll stalk enclosed the megasporangium except for a narrow opening along the top that may have served as a micropyle. The structure thus simulates a seed. The sporophyll with its attached sporangium and megaspore broke away from the parent plant and functioned as a seed. Unlike a true seed, however, no embryo has ever been seen in one of these fossils. These "seed" fossils are known as *Lepidocarpon*.

Miadesmia represents the fructification of a herbaceous lycopsid in which the seed habit was even more fully developed. Here the integument was prolonged in the form of a sheath beyond the top of the sporangium, with the micropyle a rounded pore at the top. Like *Lepidocarpon*, this seed differs from those of all other groups in having the entire sporophyll shed with it.

In addition to *Miadesmia* there were several other lycopsids (*Lycopodites* and *Selaginellites*) which appear to have had a herbaceous habit like that of living club mosses. Such plants are much less common than the tree types and less completely preserved.

Mesozoic.—The lycopsid group Lepidodendrales, which included the largest and most abundant trees of the Paleozoic forests, lost its dominant position at the close of the Paleozoic when *Lepidodendron* and *Sigillaria* became extinct. A genus surviving into the Late Triassic of Sweden, Greenland, and Arizona was *Lycostrobus*, represented by cones and spores which resemble those of *Lepidodendron*. The Arizona cone had oval seedlike bodies near its base. *Pleuromeia* was a widespread Triassic form that shows resemblance to *Sigillaria* in the leaf scars on its stem, but it is placed in a distinct group, the Pleuromeiales, because of its seedlike reproductive organs; it was a short unbranched shrub with needlelike leaves and with numerous rootlets growing from its swollen base, as in modern *Isoetes*. *Nathorstiana* from the Cretaceous of Germany, a small plant with tuberous stems, has also been considered to represent a possible ancestor of *Isoetes*. *Lycopodites* and *Selaginellites* both occur in Mesozoic rocks and may be considered ancestors of the common modern herbaceous lycopsids, *Lycopodium* and *Selaginella*.

Cenozoic.—The once abundant lycopsids make up an even less important part of the Cenozoic vegetation than during the Mesozoic Era. They are most numerous and diversified in the tropical regions at the present time, ranging also into high latitudes. Occasional remains of the club moss (*Lycopodium*) have been found.

3. Sphenopsids.—These plants are characterized by jointed stems with whorls of leaves and in some cases cones attached at the nodes.

Paleozoic.—Most abundant during the Paleozoic was the genus *Calamites*, which resembled the modern horsetail (*Equisetum*) in general appearance but formed tall trees instead of herbs. Other extinct types of sphenopsids show relationship to the ancestral psilopsids and will be considered first.

The oldest known articulate plant is *Calamophyton* from the Middle Devonian of Germany. Shrublike in habit, it bore slender dichotomous leaves on the nodes of its stem and branches that were less regularly jointed than in later forms. Sporangia were borne in pairs on fertile branchlets that were grouped into a loose terminal cone; these branchlets appear to correspond to the sporangiophores of more advanced types of sphenopsids. The terminal position of the sporangia on branchlets suggests a relationship to the psilopsids. *Hyenia* was generally similar in appearance to *Calamophyton* but showed no evidence of a jointed stem and had leaves more deeply cleft. In both these genera the leaves and fertile branchlets were homologous, and it has been suggested by A. J. Eames that the same relationship holds for the Equisetales group (*Equisetum, Calamites*, etc.), in which these structures have developed greater outward dissimilarity.

Sphenophyllum, a genus common in the Carboniferous, ranged from the Late Devonian through the Permian. The plant grew in the form of a slender shrub that may have supported its branches by scrambling over other plants. The jointed stems bore whorls of small wedge-shaped leaves that were often deeply dissected. The leaves of one whorl lay immediately above those of the whorl below and were usually in multiples of three. This arrangement is related to the structure of the stele, which was triangular in section and had a central column of xylem with no pith; at the nodes two vascular strands extended from each corner to supply the leaves. The stems and roots had a considerable amount of secondary vascular tissue. The slender terminal cones were built up of whorls of leaflike bracts and were relatively complex as compared with other sphenopsids. Sporophylls were divided into an adaxial and abaxial lobe, the latter usually sterile but in some species fertile. All known sphenophylls were homosporous. Heterospory has been reported in some forms, but subsequent investigations have shown that the plants were erroneously identified.

Equisetales was the most abundant group of sphenopsids during the Paleozoic Era and the only group that has survived to the present. The oldest known genera, *Asterocalamites* and *Pseudobornia*, are recorded from the Late Devonian; these were small

trees with jointed stems and whorls of large forked leaves. They showed a lack of alternation of the ribs along the stem from node to node that characterized later members of Equisetales. The cones resembled those of *Equisetum* in being without bracts.

During the Carboniferous the trees referred to the genus *Calamites* reached a height of more than 30 ft. and a diameter of 2–3 ft. They rose from huge rhizomes. The straight shaftlike trunks were jointed or segmented like bamboo stems. Some species bore branches at each of the nodes; others bore them only at certain nodes, and in still others the branching was irregular. The mature stem possessed a large central hollow caused by the breakdown of the pith tissue when the stem reached its ultimate size. When the trees fell into the swampy soil, the hollow became filled with mud or wet sand that ultimately hardened, and when the surrounding tissue decayed, the cast of the pith cavity was freed, bearing on its surface the imprints of the nodes and the vertical strands of primary wood that originally surrounded the pith. The pith casts of *Calamites* are common fossils in quarries and coal mines. The jointed branches bore whorls of linear leaves distinct at their bases (*Asterophyllites*) or leaves more broadly rounded and fused into a sheath around the stem (*Annularia*). The cones showed a considerable range in form and structure, indicating that several distinct types of plants may be included in *Calamites*. *Calamostachys* was a terminal cone with whorls of sporangiophores similar to those of *Equisetum* but with alternating whorls of sterile bracts. Two types of spores (heterospory) have been found in some species, but the difference in size was less marked than in most of the lycopsids. *Calamites* differed from *Equisetum* in becoming a tree with a cambium that produced secondary wood, in having leaves containing larger quantities of chlorophyll, and in having more complex cones.

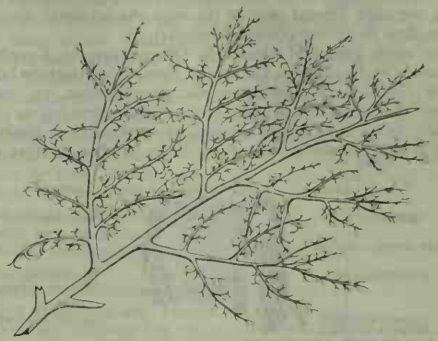
Mesozoic.—Unlike the scale trees, horsetails continued as abundant members of Mesozoic floras, though they were reduced in number. *Schizoneura*, which first appeared in the Antarctic flora of Permian time, was widespread throughout the world in the Early Triassic; both *Schizoneura* and the somewhat younger *Neocalamites* appear to be descendants of the Paleozoic *Calamites*. Another common Mesozoic genus was *Equisetites*, which resembled the living *Equisetum* in many ways but was larger.

Cenozoic.—Like the lycopsids, the sphenopsids declined in importance in the Cenozoic. Stems of horsetails (*Equisetum*) are common Cenozoic fossils.

4. Pteropsids.—In placing the ferns and the seed plants in the same division, recognition is given to fundamental resemblances of leaf and stem, which seem more significant than the presence or absence of seeds. Development of seeds by certain Paleozoic scale trees and possibly by one of the horsetails and the abundant occurrence of seeds in association and contact with leaves of the pteridosperms all point to the unimportance of the seed habit as a basis for major grouping. As further pointed out by Eames, ferns are more closely related to gymnosperms and angiosperms than to the "fern allies" of the old classifications, the scale trees and the horsetails. Spore-bearing ferns are designated here as Filicineae, a division of the pteropsids, along with Gymnospermae and Angiospermae. Seed-bearing ferns are designated as Pteridospermae, the most ancient and primitive of gymnosperms.

Paleozoic.—Filicineae are plants with relatively large complex fronds connected by large leaf traces with a simple stem that rarely produces secondary wood; sporangia are commonly borne on the margins or undersurface of the leaf and have a dehiscent mechanism known as an annulus. Heterospory is limited to two living families and to two or three Paleozoic ferns. Many of these older members of the Filicineae are preserved as stems; they were dichotomously branched with their upper ends serving as leaves. Most of these foliar organs did not have wide blades; sporangia characteristic of the ferns were borne on the fronds singly or in terminal clusters. The general appearance of these ancient ferns must have been wholly different from most modern members of the Filicineae. The Filicineae include the modern fern groups and the Coenopteridales, which became extinct at about the close of the Paleozoic Era.

The Coenopteridales form a group of ancient plants that ranged from the Middle Devonian to the Permian. Though fernlike in some respects, they also showed features indicative of affinity with the Psilophytales. Knowledge of them is based mostly on small



FROM KRAUSEL UND WEYLAND, "DEVONFLORA" (SENCKENBERGISCHE NATURFORSCHENDE GESELLSCHAFT)

FIG. 3.—ANEUROPHYTON, ONE OF THE MOST ANCIENT FRONDS KNOWN, FROM THE MIDDLE DEVONIAN OF GERMANY

portions of petrified stems and leaf stalks found in coal balls and other petrifactions.

Most of the Coenopteridales had upright stems, though a few had horizontally growing rhizomes resembling that of a modern bracken. The vascular system of the stem was a rather simple round or angled xylem strand surrounded by phloem. In the upright members the fronds were arranged in spiral sequence around the axis; in the prostrate forms they arose from the upper side. The vascular strands of the leaf stalks were variously shaped and were characteristic of different genera.

The fronds were large, and some were divided into pinnae and pinnules, as in modern ferns, but in some the frond ramifications terminated as naked unexpanded axes reminiscent of the branch systems of the Psilophytales.

The sporangia were not borne in sori on the pinnule surfaces as in Recent ferns, but in clusters resembling bunches of grapes at the ends of frond branches. Each sporangium had an annulus that opened the sporangium when the spores were released.

A related group, the Cladoxylales, had stems with several separate vascular strands, each of which was encircled by a layer of secondary wood, a phenomenon extremely rare in ferns.

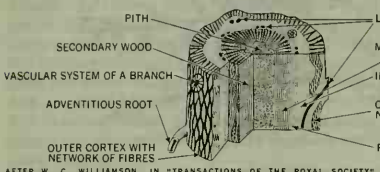
Several ferns in addition to the early members of the Coenopteridales have been found in the Devonian. One of these is *Archaeopteris*, which is sometimes used as an index fossil of the Late Devonian. Another ancient plant that was fernlike in some respects but of unknown position in the plant kingdom was *Aneurophyton* from the Middle Devonian of Germany and New York. Its stem shows a cylinder of secondary wood surrounding a three-angled core of primary xylem. Its leaves represent the most primitive type of frond, triply branched with the smallest branches bearing short forked appendages and with no development of leaf blades.

Aneurophyton shows a general resemblance to *Eospermatopteris*, described by W. Goldring from the Middle Devonian of New York. The stems of *Eospermatopteris* occur largely as casts with little structure preserved; the bases of the stumps were bulbous, narrowing upward to trunks with an estimated height of 30–40 ft. and a maximum diameter of 2–3 ft. Like *Aneurophyton* the fronds were compoundly tripinnate with slender bilobed pinnules, and larger specimens indicate a total length of 6–9 ft.

Specimens of the genus *Pecopteris*, a fernlike frond that is very common in shales associated with Carboniferous coal seams, are sometimes found bearing sporangial clusters very similar to those of the modern Marattiaceae, a widely distributed family of tropical ferns. There is some evidence that *Pecopteris* fronds were borne on tall trunks, which when found in the petrified condition are known as *Psaronius*.

Three other living fern families that appear to have been in existence during the latter part of the Paleozoic Era were the Schizaeaceae, the Gleicheniaceae, and the Osmundaceae. The latter is represented in the Permian by several petrified stems built along the same general plan as the very characteristic stems of the modern royal fern (*Osmunda regalis*).

The seven groups of pteropsids (Pteridospermae, Cycadales, Bennettitales, Cordaitales, Ginkgoales, Coniferales, Gnetales) commonly regarded as constituting the gymnosperms, or "naked seeded" plants, are now believed to have had diverse origins. The whole complex is no longer regarded as constituting a closely related group. However, they may still be handled together as a

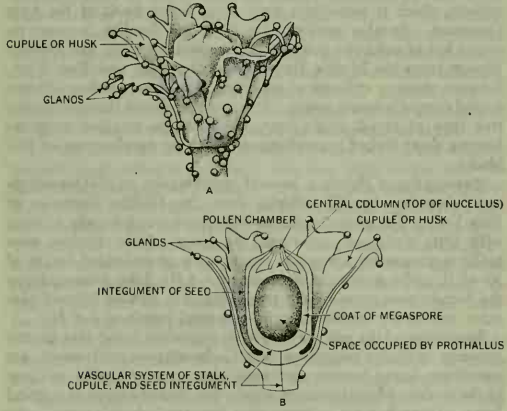


AFTER W. C. WILLIAMSON, IN "TRANSACTIONS OF THE ROYAL SOCIETY"

FIG. 4.—DIAGRAMMATIC RECONSTRUCTION OF THE STEM OF LYGINOPTERIS

matter of convenience. Some of the groups probably represent taxa higher than orders.

The seed ferns (pteridosperms) were among the most abundant plants of Late Paleozoic time and continued in reduced numbers into the middle of the Jurassic Period of the Mesozoic Era. Their stems show resemblance to both ferns and cycads. Fronds of seed ferns are abundant in rocks of Carboniferous Age and were interpreted as true ferns until 1903, when seeds were found attached to *Sphenopteris*. Since then most of the form genera of fernlike leaves in Paleozoic rocks have been found to bear seeds. Several common types, notably *Pecopteris*, appear to represent the foliage of both seed ferns and true ferns, and their systematic position can be established only when reproductive bodies are attached to them. When detached it may be impossible to distinguish the flattened type of pteridosperm seeds from those of the Cordaitales, but radiospermic seeds all seem referable to the Pteridospermae. The wood of Pteridospermae differs from that of the Filicineae in its secondary thickening. *Lyginopteris oldhamia*, the most completely known pteridosperm, was of Late Carboniferous Age and is of common occurrence in the coal measures around Oldham and other parts of Lancashire, Eng. It is found petrified in the coal balls and also as impressions in the shales forming the roofs of the seams. The frond, by an equal forking of the leaf stalk, was



BY COURTESY OF THE COUNCIL OF THE ROYAL SOCIETY AND OF PROF. OLIVER

FIG. 5.—SEED AND HUSK OF LYGINOPTERIS

(A) Reconstruction of the seed in its husk; (B) seed and husk cut longitudinally

divided into two equal divisions. The stem (fig. 4) varied from two mm. to four cm. in diameter. There was a pith forming the core of the stem surrounded by a ring of scattered xylem strands that were connected with the leaf supply system. In older stems the ring of strands was surrounded by a considerable quantity of secondary wood and bast. The outer cortex contained long anastomosing bands of fibres that formed a reticulum just inside the epidermis. In *Heterangium*, a closely allied genus, the centre of the stem was occupied by a solid core of primary xylem and the strands of the leaf-trace system were incorporated in the outer part of the primary xylem. F. W. Oliver and D. H. Scott in 1903 were able to identify a petrified seed found in a coal ball as the seed of *Lyginopteris* by the presence on its husk of glandular spines exactly like those on the frond and stems of *Lyginopteris*. The seed, *Lagenostoma lomaxi* (fig. 5), was enclosed in a lobed husk or cupule; it was barrel shaped and its integument was furnished with a vascular system. One part of the nucellus (sporangium wall) was modified to form a complicated pollen chamber or cavity in which the pollen became lodged. In structure the seed was similar to those of the living cycads or ginkgo, but the pollen chamber was rather more complicated than that of any of these living plants. Kidston described some tassels of microsporangia (fig. 6) attached to small pieces of fronds that bore leaflets of the same shape as those of *Lyginopteris*, and there is no doubt that they represent the pollen-producing organs of this plant. In most seed-bearing plants the microsporangia are borne on highly modified structures (stamens) that are quite unlike leaves in appearance; but in many pteridosperms the fronds which bear the microsporangia are like the sterile foliage fronds, and in this respect the pteridosperms are primitive.

FROM SCOTT, "STUDIES IN FOSSIL BOTANY" (A & C BLACK)

FIG. 6.—CROSSOTHECA HOENINGHAUSI

Male fructification of *Lyginopteris*

Another important group of pteridosperms, the Medullosaceae of Carboniferous and Permian Age, had fernlike foliage belonging to the form genera *Neuropteris* and *Alethopteris*. The stems (form genus *Medullosa*) were peculiarly complicated in structure; in place of the usual single vascular column they had several. Each vascular column was in structure like that of *Heterangium*, and the stem could be briefly described as a polystelic *Heterangium*. The spirally arranged leaf stalks were of large size and contained a large number of small collateral vascular strands. Seeds have been found attached to fronds of *Neuropteris* (fig. 7B) and *Alethopteris*. *Trigonocarpus* is a genus of seeds that were borne on some species of *Alethopteris;* it resembled the seeds of living cycads in having a testa consisting of both soft and stony layers. The micropyle was of very considerable length. The pollen-producing organs of these plants (fig. 7A and 7C) are still imperfectly known. *Potoniea* (fig. 7C) very probably represents the pollen-bearing flower of a *Neuropteris*. The structures with toothed margins were originally cup-shaped, with microsporangia placed on the inner surface of the cup. *Linopteris*, an allied frond genus, had similar microsporangiate fructifications. Another form genus, *Whittleseya*, had large cups more than an inch deep from which large pollen grains have been isolated.

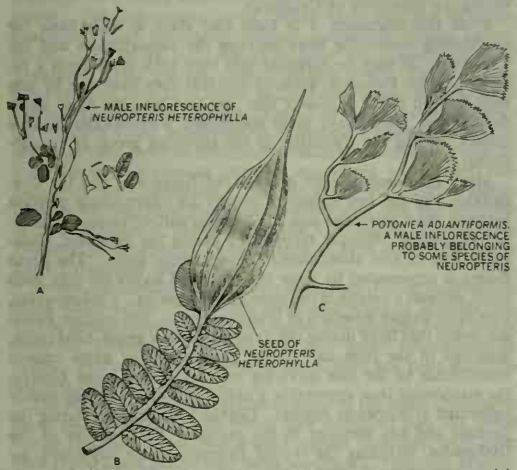
Several genera of seed ferns based on fronds, such as *Gigantopteris*, *Taeniopteris* (in part), *Glossopteris*, *Gangamopteris*, and *Gondwanidium*, add significant data regarding Late Paleozoic climate and distribution and will be considered in the section on geologic distribution and ecology.

Unlike the pteridosperms, the Cordaitales had little in common with the ferns and may be regarded as typical gymnosperms. *Cordaites*, which lived during the Carboniferous and Permian, was a lofty tree, unbranched except near the summit (fig. 8). The stem resembled that of conifers, especially *Araucaria*, except that the pith was much larger; but like most other Paleozoic woody plants from the Northern Hemisphere, no evidence of seasonal periodicity is indicated by growth rings.

The wood of some cordaitalean genera has features in common with pteridosperms. The vascular supply to the leaf is represented

by two of the primary strands surrounding the pith, which at higher levels pass outward and, on reaching the base of the leaf, fork repeatedly and link up with the numerous veins of the leaf blade. This double vascular connection with the axis is also found in *Ginkgo* (maidenhair tree) and in the pteridosperms. The leaves of *Cordaites* were large, linear, or spatulate in shape and traversed by numerous parallel veins. Seeds occurred in cones but were borne on short branches rather than on cone scales as in the conifers. Pollen grains were contained in microsporangia attached to long slender stems rising from between small crowded scale leaves.

Several types of gymnospermous wood from Devonian and Carboniferous beds may be referable to the Cordaitales, although in absence of associated leaves and fruiting organs their relationship is at present uncertain. *Callixylon* and *Pitys*, of doubtful taxonomic status, are stem genera that show a striking resemblance to the living conifer, *Araucaria*, as do such definitely cordaitalean genera as *Cordaites* and *Mesoxylon*. There is no certain evidence



BY COURTESY OF (A) THE ROYAL SOCIETY AND PROF. OLIVER, (B) THE DIRECTOR OF THE SOCIÉTÉ GÉOLOGIQUE DU NORD, (C) THE SOCIÉTÉ GÉOLOGIQUE DE FRANCE: COPYRIGHT H. BONNAIRE

FIG. 7.—PTERIDOSPERM FRUCTIFICATIONS

of the persistence of *Cordaites* and its allies after the end of the Permian Period, although the occurrence of large leaves of similar appearance as late as Jurassic time suggests such survival. The living coniferous family, Araucariaceae, whose first certain appearance is recorded in the Triassic and which may be represented by the genus *Araucarites* from the Permian of France, may trace its ancestry to the Cordaitales.

Several leaf genera from the Devonian, such as *Psygmophyllum* and *Ginkgophyllum*, have been doubtfully referred to the division Ginkgoales, but nothing is known of their stems or fructifications. The wedge-shaped leaves of *Psygmophyllum* also are found in Carboniferous and Permian rocks, where their variation in form suggests that they may belong to several groups of plants. *Trichopitys*, from the Permian of France, is regarded as the oldest unquestioned member of the Ginkgoales. It had spirally arranged leaves that divided dichotomously into four to eight linear tapering segments. The seeds were borne on branched axillary fertile shoots. The genus *Sapartaea* from the Early Permian of West Virginia and north China is represented by leaves that closely resemble those of the living *Ginkgo*. In the flora from China, T. G. Halle also recognizes leaves of *Baiera* and *Rhipidopteris*, two common Mesozoic genera. These leaves may well represent the Late Paleozoic ancestors of the Ginkgoales that became abundant during the Mesozoic Era, but in absence of other than foliar structures the presence of this order in Paleozoic time is not fully established.

Cycadlike plants (Bennettitales) are represented in Late Paleozoic rocks by fronds belonging to several genera that continued into the Mesozoic, when they had their widest development. *Pterophyllum* appeared in the Upper Carboniferous of Europe, becoming more widespread in rocks of later age. *Dioonites* is first recorded from the Permian of north China. *Sphenozamites* occurs in beds of that age in France. While little is known of these plants, their presence over a wide area at the end of the Paleozoic Era indicates that the cycadophytes had a long antecedent history before their period of first abundance, the Triassic.

There are relatively few representatives of the now abundant conifers until near the end of the Paleozoic Era. Stems with typical araucarian structure in their secondary wood (*Pitys* and *Callixylon*) suggest that the remote ancestors of the Araucariaceae may have been in existence as early as Middle Devonian time. However, these seem more on the line of cordaitalean or seed fern stocks, and no true conifers are known from rocks older than Upper Carboniferous.

AFTER GRAND EURY IN SCOTT, "STUDIES OF FOSSIL BOTANY" (A B C BLACK)

FIG. 8.—RESTORATION OF A CORDAITES TREE, SHOWING ROOTS, TRUNK AND BRANCHES BEARING LONG LANCEOLATE LEAVES AND FRUCTIFICATIONS

Walchia appeared during the Upper Carboniferous and was commonest during the Early Permian, after which it became extinct. It was a tree with foliage shoots resembling *Araucaria excelsa*. It had male and female cones, the latter differing in mode of seed attachment and in other details from living conifers and bearing a resemblance to *Cordaites*. *Lecrosia* had needle-shaped leaves and oval cones with winged seeds. *Ullmannia* and *Voltzia* were two of the common Permian genera, and the latter continued to live through the Triassic Period of the following era. A possibly related form, *Paleotaxites*, is represented by leafy twigs with attached fruits that resemble those of the modern *Juniperus*. Genera confined to the Southern Hemisphere were *Paranocladus* and *Walkomia*.

Voltzia is an example of an ancient and generalized type that shows resemblances to at least two major lines of living conifers. In its habit, in the form and spiral arrangement of its leaves, and in the structure of its wood, *Voltzia* shows a resemblance to the Araucariaceae, a family widely distributed in both hemispheres during the Mesozoic Era and now limited to southern latitudes; its cone scales suggest relationship to certain of the Pinaceae, plants well represented during the Late Mesozoic and now most abundant in North Temperate regions. In the occurrence of three seeds on its cone scales, *Voltzia* differs from all living conifers.

Mesozoic.—Pteropsids predominated in the Mesozoic Era, which is often termed the age of cycads because of the abundance of the cycadean orders Bennettitales and Cycadales. Ferns, ginkgoids, and conifers were also numerous, and by the end of the era the Angiospermae became well established.

Mesozoic rocks are rich in remains of ferns, one of the lower groups of vascular plants that survived the Paleozoic Era in relatively large numbers. Most of the Mesozoic ferns, however, can be attributed to modern families. The Osmundaceae, which appeared in the Permian, is represented throughout the Mesozoic by petrified stems (*Osmundites*) and foliage (*Cladophlebis*, *Todites*). The Pteridaceae is represented by *Onychiopsis* and *Coniopteris*. The wide occurrence of *Phlebopteris* shows that the family Matoniaceae once ranged far beyond its present-day tropical habits. The Middle Cretaceous tree fern *Tempskya*, of which there are about a dozen species, was very common in the western

United States and at places in western Europe.

Of the pteridosperms, plants with leaves resembling the southern genus *Glossopteris* became widely distributed over the world during the Triassic, with their last known occurrence in the Late Triassic of Greenland. *Callipteridium* was another Paleozoic genus that persisted into the Triassic but is known only from Africa and Madagascar. *Thinnfeldia,* considered to be a derivative of the Permian genus *Supaia,* was worldwide in distribution and continued into the Cretaceous, but it is probable that some of the younger fronds so identified were ferns rather than seed ferns. *Neuropteridium,* which is related to *Gondwanidium* of the Antarctic Carboniferous flora, is recorded as late as the Late Triassic but at this level may represent a true fern.

There is some question of the occurrence of members of Cordaitales beyond the Permian, though typical cordaitalean wood assigned to the stem genus *Dadoxylon* has been found as late as the Late Triassic, and leaves known as *Pelourdea* (*Yuccites*) may be related to *Cordaites.*

Rare in Late Paleozoic and Early Triassic time, fronds representing cycadean plants became common at the end of the Triassic. Although the cone structure and mode of attachment in the Bennettitales (the extinct group) show marked differences from the Cycadales (the group still living), it is difficult to distinguish the fronds of the two groups. Therefore the general term cycadophytes will be used here for all detached fronds, and the names of particular groups will be used only when other structures are represented.

The most primitive genus of the Bennettitales is *Wielandiella* from the Late Triassic. Its shrubby stem was dichotomously forked and bore small leaves. Between the forking branches were budlike shoots bearing sterile and fertile scales; the latter formed a circle of small male organs (stamens) around the base of the shoot, with several stalked female organs (ovules) surrounded by sterile scales above. This type of reproductive structure, which may be termed either a bisporangiate strobilus or a bisexual flower, shows a marked difference from those of modern Cycadales, in which the female and male elements are borne terminally in separate cones (monosporangiate strobili or unisexual flowers). It differs from a true flower in having the ovule naked, while in such a similar structure as the flower of a buttercup (*Ranunculus*) the ovules are enclosed. *Williamsoniella,* a Jurassic genus with similar stem and reproductive structures, is known to have borne scattered leaves of the form genus *Taeniopteris.*

A more advanced genus of the Bennettitales appearing in the Triassic and becoming widespread in the Jurassic was *Williamsonia.* It resembled living cycads in general habit, a simple stem covered with leaf bases and with a crown of leaves at the summit. But the reproductive structures were of the bennettialean type, borne on the ends of short branches along the stem. Associated leaves indicate that the fronds of *Williamsonia* were those assigned to the form genera *Zamites, Otozamites,* and *Ptilophyllum. Cycadeoidea,* a genus that reached its greatest abundance in the Early Cretaceous, also had the general habit of modern cycads, a short thick stem enclosed in leaf bases and a fluffy mass of scales resembling the ramentum of ferns. Along the axis of the stem were short lateral branches bearing flowers largely enclosed in the armour of leaf bases and scales; most of the flowers were bisexual, aligning this genus with the Bennettitales. Another difference between *Cycadeoidea* and the living Cycadales is its relatively small seeds.

Among the common form generic names assigned to cycadophyte fronds are *Pterophyllum, Nilssonia, Sphenozamites, Otozamites,* and *Pseudoctenis,* most of which had wide distribution during the Triassic Period; *Ptilophyllum* is added to several of the above genera in widespread Jurassic floras and also is recorded in rocks of Cretaceous age along with certain genera suggesting relationships to modern cycads (*Zamites, Zamiophyllum,* and *Pseudocycas*). Leaves of a number of these form genera have been found in attachment with the stems of Bennettitales, but none of them is certainly known to be referable to the Cycadales.

True Cycadales were abundant throughout the Mesozoic Era except at the beginning and the close, but due to the fragile construction of the plants they were less well preserved than the Bennettitales (the cycadeoids). It is difficult to distinguish between the fossilized foliage of Cycadales and that of the other group. However, *Bjuvia* from the Late Triassic of Sweden resembles the Recent genus *Cycas* to some extent, and cones known as *Beania* from the Middle Triassic of Yorkshire, Eng., resemble the modern *Zamia. Dioonitocarpidium* from the Late Triassic of Germany is interpreted as a fertile leaf or megasporophyll; its axis bore two rows of small leaflets and at the base were two oval bodies interpreted as seeds. *Cycadospadix* represents a somewhat similar structure of Triassic and Jurassic age. Both these fertile leaves show a resemblance to the megasporophylls of the living *Cycas,* whose strobili are less compactly organized and presumably more primitive than those of other living Cycadales. As above indicated there were Cretaceous fronds, *Pseudocycas,* that closely resembled the sterile leaves of *Cycas.* These and certain stems which appear to lack the armour of leaf bases and the axial cones characteristic of the Bennettitales may possibly represent the vegetative structures of Cycadales.

From this discussion it is clear that there is little basis for establishing connecting links between the Bennettitales and the Cycadales. It may be surmised that they both arose from a remote, perhaps Paleozoic, ancestor and that they lived side by side until the end of the Mesozoic Era. At that time the more abundant and in many ways more specialized Bennettitales became extinct, leaving the Cycadales as the surviving group of cycadophytes.

Many relationships exist between the Ginkgoales and the Cordaitales, and the two appear to occupy an intermediate position between the Coniferales and the more primitive groups of seed-bearing plants. Scantily represented during the Paleozoic, Ginkgoales had its first abundance in Late Triassic floras. The genus *Baiera* is represented by large wedge-shaped leaves cut into deep lobes, without a petiole in the more typical species. *Czekanowskia,* with more deeply dissected or branched leaves, was another Paleozoic genus that lived during the Triassic. A new genus, *Ginkgoites,* appeared in the later half of the period, and its name implies resemblance to the sole surviving member of the genus *Ginkgo,* the maidenhair tree, apparently a native of China and now widely cultivated in temperate regions. *Ginkgo* first appeared during the Jurassic and has survived to the present. Fossil leaves of the Ginkgoales, including the typical Paleozoic genus *Saportaea,* resemble the leaves of living *Ginkgo* in their cuticle. Little is known of the stems and reproductive structure of the extinct members of the group, though the discovery of male organs in the Jurassic of Siberia confirms the close relationship between *Ginkgoites* and *Ginkgo,* as suggested by their leaves. The wood may not in all cases be readily distinguishable from that of the conifers. Extinct members of Ginkgoales characterized by deeply incised leaves are particularly abundant in Mesozoic floras of Arctic regions. Many forms have been described from Alaska, Greenland, Spitsbergen, and northern Siberia.

During the Mesozoic Era representatives of the conifers were abundant and widely distributed, and they have continued to hold an important place in world vegetation to the present time. The Paleozoic genus *Voltzia* persisted into Late Triassic time. *Araucarites,* a form genus indicating relationship to the family Araucariaceae, ranged through the whole of the Mesozoic, grading into the genus *Araucaria* at the end of the era. In his study of remarkably preserved cones from the Middle Mesozoic beds of Argentina, G. R. Wieland in 1929 assigned a new generic name, *Proaraucaria,* to material previously called *Araucarites.* Leafy twigs, branches, and large trunks with araucarian type of wood occur with these cones. Other smaller cones associated with *Proaraucaria* are named *Pararaucaria,* now believed to be a member of the Taxodiaceae and not related to *Araucaria,* regardless of its name. Wood from the Late Triassic of Arizona is referred to the form genus *Araucarioxylon;* among all the giant logs in the Petrified Forest National Park in Arizona, not a single araucarian cone has been discovered. In this area and in many other localities scattered throughout the world occur leafy shoots or cone scales of another possibly araucarian type called *Podozamites;* certain cycadean

characters suggest that it may represent a generalized type related to conifers and cycads. *Rhexoxylon* from the Triassic of South Africa is represented by a stem that appears to be coniferous but shows an arrangement of its woody tissues similar to that of certain climbing angiosperms living in the tropics. Representatives of the Podocarpaceae have been reported from many parts of the world, but the only well-defined Mesozoic records are from the Southern Hemisphere, to which this family is now largely restricted. The oldest *Sequoia* is from the Middle Jurassic of Manchuria. *Metasequoia* appeared in the Late Cretaceous, along with *Pinus* and several other modern types of conifers.

The group of plants known as Caytoniales was established by H. H. Thomas in 1925 to include fernlike foliage known as *Sagenopteris*, branched pollen-bearing shoots known as *Antholithus*, and a previously unknown seed-bearing inflorescence. The female shoots described by Thomas as *Gristhorpia* and *Caytonia* consisted of an axis bearing two rows of short branches, each of which carried a small fruit. These shoots differ from those of modern angiosperms in being modified leaflets, not formed from complete leaves. The male shoots are of similar form, and their branches bear clusters of four-lobed stamens containing winged pollen-grains. The fruits, first described from the Jurassic rocks of Yorkshire, Eng., contain closely packed seeds. Other similar plant remains have been found in the Late Triassic of Greenland and in the Jurassic of Sardinia. Leaves of the genus *Sagenopteris* are regularly found in association with these reproductive organs, and since they have an epidermal structure identical with that of *Caytonia* and *Gristhorpia* they are considered to represent the foliage of the Caytoniales. Nothing is known of their stems. Thomas has suggested that their general aspect and the structure of their seeds may indicate that the Caytoniales derived from Paleozoic pteridosperms. They appear to have become extinct in Early Cretaceous time.

Several problematical specimens have been found in Mesozoic rocks which suggest the leaves, seeds, and wood of angiosperms. To the genus *Sanmiquelia* R. W. Brown has assigned fossil leaves from the Triassic of Colorado that bear every resemblance to palms. Pollen resembling that of water lilies has been found in Jurassic coal from Scotland.

The abundance of angiosperms in some of the older Cretaceous floras and the rapidity with which they wandered over the world during the Early Cretaceous Period suggest that they must have been evolved long before they came to occupy the premier position in the vegetable kingdom. The primitive types of angiosperms probably differed widely in habit from those with which we are now familiar.

From the rocks of western Greenland come some early records of angiosperm leaves. *Magnolia, Diospyros* (persimmon), *Sassafras, Quercus* (oak), *Platanus* (plane tree), and other broad-leafed trees were living in the far north with older types of ferns, cycads, and gymnosperms during the Early Cretaceous. Farther south at middle latitudes the forests of this time were made up wholly of these older types, but in beds of Portugal and Virginia are found the remains of leaves and stems of the oldest true flowering plants. By Late Cretaceous time angiosperms had become established widely over the earth, including a sufficiently large number of common living families to give a decidedly modern aspect to the vegetation. In addition to *Magnolia* and *Liriodendron*, members of the primitive tree family Magnoliaceae, there were representatives of other primitive families such as Annonaceae (*Annona*), Cercidiphyllaceae (*Cercidiphyllum*), Dilleniaceae (*Dillenites*), and Lauraceae (*Cinnamomum, Laurus, Sassafras*). Cretaceous floras also included some of the more specialized families such as Caprifoliaceae (*Viburnum*), Ebenaceae (*Diospyros*), Juglandaceae (*Juglans*), Rhamnaceae (*Rhamnus*), together with many of intermediate position including Betulaceae (*Alnus, Betula*), Fagaceae (*Castanea, Fagus, Quercus*), Moraceae (*Ficus, Artocarpus*), and Ulmaceae (*Ulmus*). It is apparent that family differentiation had been largely accomplished during Mesozoic time and that many modern genera were already distinct. Most botanists believe that herbs are less primitive than trees and shrubs, but their general absence from the Cretaceous and later rocks cannot be considered confirmatory evidence since their habit and structure make entrance into the fossil record of any age unlikely. All paleobotanical evidence supports the idea that monocotyledons (one-seeded leaves) have long been a separate line from the dicotyledons (two-seeded leaves), since such diverse families as Alismaceae (*Alismacites*), Gramineae (*Grammaephloios*), Liliaceae (*Smilax*), and Palmaceae (*Sabal*) are recorded in rocks of Cretaceous Age.

Cenozoic.—Pteropsids continued as the dominant plants, with ferns (Filicineae) making up a subordinate group. Most of the larger types of ferns disappeared by the close of the Mesozoic, and while stems and fronds of tree ferns (Cyatheaceae) are occasionally encountered in Cenozoic floras, smaller and more fragile types of leaves make up most of the fern record. The Polypodiaceae, now the most abundant and widely distributed family, is represented by *Acrostichum, Adiantum, Asplenium, Dryopteris, Onoclea, Polypodium, Pteris,* and *Woodwardia;* their relative scarcity in the fossil record may have resulted from their herbaceous habit and thin fronds rather than actual rarity in the forests of the Cenozoic; the fact that the fronds are not regularly shed by abscission as in most conifers and dicotyledonous angiosperms makes their burial in sedimentary deposits more infrequent. One of the common Mesozoic families, the Schizaeaceae, is represented by *Lygodium*, a now largely tropical genus whose Cenozoic occurrence is also with plants of tropical types. *Osmunda* of the family Osmundaceae was widely distributed as it is today, but other genera of this abundant Mesozoic family had largely disappeared. Several prominent families of the preceding era, such as the Marattiaceae, Gleicheniaceae, Matoniaceae, and Dipteridaceae, are rarely represented in Cenozoic floras and are today limited to the tropics.

With Pteridospermae, Cordaitales, Bennettitales, and Caytoniales extinct, and with Cycadales and Ginkgoales greatly reduced in numbers, the Coniferales comprise the only abundant order of gymnosperms during the Cenozoic Era. Fronds of several modern genera of the Cycadales, *Cycas* (Japan), *Dioon* (Alaska), *Encephalartos* (Greece), and *Zamia* (Europe, North America, Puerto Rico) are of occasional occurrence in Cenozoic rocks, but this group may be said to have constituted an unimportant element of vegetation then as it does today. The only genus of the Ginkgoales surviving into the Cenozoic was *Ginkgo;* its leaves are widely distributed from Spitsbergen and Alaska into middle northern latitudes, where it lingered on into the Pliocene and has continued to the present in China, though perhaps no longer in the wild state. All of the modern families of the Coniferales and most of the modern genera were differentiated at the opening of the era. The Taxodiaceae (*Cryptomeria, Glyptostrobus, Sequoia, Metasequoia, Taxodium*), Taxaceae (*Taxus, Torreya*), Pinaceae (*Abies, Picea, Pinus, Pseudotsuga, Tsuga*), and Cupressaceae (*Chamaecyparis, Cupressus, Juniperus, Libocedrus, Thuja*) are the common families of the Northern Hemisphere, with the Araucariaceae (*Agathis, Araucaria*) and the Podocarpaceae (*Dacrydium, Podocarpus*) characteristic of the Southern Hemisphere.

The living members of the Gnetales, a group of gymnosperms, show vascular anatomy resembling that of the angiosperms in having true vessels; in certain characters of the reproductive structures a further relationship to the angiosperms is suggested. Twigs and pollen grains of *Ephedra* have been collected from several Cenozoic horizons. The history of the Gnetales is so meagrely recorded that there is little paleontologic evidence for supporting the opinion of certain botanists that this group holds a position intermediate between the gymnosperms and the angiosperms.

The angiosperms are represented by over 325 existing families, of which Magnoliaceae (magnolias) and Ranunculaceae (buttercups) appear to be the most primitive now living; the latter are herbaceous and like other plants of similar habit are rarely if ever represented in the fossil record. All of the common temperate families of trees and shrubs are represented in the Cenozoic record, as well as many of the tropical families of woody plants. As indicated in the Mesozoic floras, *Magnolia* was one of the first angiosperms to appear and was widely distributed by the end of the era. It was a common Eocene genus, along with other genera

listed from the Cretaceous and with new genera of primitive types (*Dillenia* and *Tetracera* of the Dilleniaceae, *Annonaspermum* of the Annonaceae, and many new members of the laurel family, Lauraceae). There are also many more specialized genera such as *Eopuntia* (Cactaceae), *Inga, Lonchocarpus, Sophora* (Leguminosae), *Ficus* (Moraceae), *Meliosma* (Sabiaceae), *Cordia* (Boraginaceae), and various members of the Euphorbiaceae. Representatives of such typically North Temperate families as Aceraceae, Betulaceae, Fagaceae, Juglandaceae, and Salicaceae became more widespread during Miocene time. Several families that may have had their origin in the Northern Hemisphere but show most of their Tertiary and modern distribution in low and southern latitudes are the Monimiaceae (*Laurelia*), Myrtaceae (*Eucalyptus, Myrcia*), Proteaceae (*Knightia, Lomatia*), Rubiaceae (*Coprosma*), and Winteraceae (*Drimys*). Monocotyledons, never as abundant in the fossil record as dicotyledons, were also present during the Tertiary period, with members of the grass family, Gramineae, first becoming numerous in the fossil record of the Miocene.

IV. GEOLOGIC DISTRIBUTION AND ECOLOGY

A. Precambrian Time

The existence of plants of any kind during this early era of the earth's history has been questioned by many competent authorities. However in recent years evidence has accumulated to show that lime-depositing algae and bacteria were abundant in some parts of the Precambrian seas and that certain beds of limestone and dolomite are largely composed of the calcareous structures that they secreted. It is significant that no plants with a higher degree of organization have been found in the Precambrian rocks.

B. Paleozoic Era

Any accurate understanding of the distribution, relative abundance, and environments of the ancient Paleozoic floras is made difficult by the incompleteness of the fossil record and by the fact that few Paleozoic types have survived to the present for comparison. However the vegetation of the past gives more reliable information than any other body of evidence for reconstructing past topography and climate; it is also useful in determining the general distribution of the continents and oceans. It is therefore desirable to go as far as the evidence permits in interpreting the physical indications of Paleozoic plants.

The development of the land habit is a subject that has long engaged the interest of botanists, and several possible types of plants have been suggested as those most likely to have made the transfer from water to a land environment. The simplest known land plants are *Rhynia* and *Horneophyton*, psilopsids of the Middle Devonian Rhynie chert. Their naked branching stems tipped by simple sporangia differ from those of certain filamentous algae only in having a vascular strand in the stem, stomata on the epidermis, and cutinized spores; there is little of the differentiation of body parts that characterizes all higher plants. Resemblance is apparent to *Foerstia*, whose branching tips bore sporangia containing resistant spores; no other parts of this algalike plant are known. *Foerstia* or some other unknown filamentous alga may have established itself along the shore, where recurrent changes in water level caused by tides and other factors brought it into frequent contact with the atmosphere. Although it is not an ancestral type, a living kelp known as the sea palm (*Postelsia*) suggests the sort of habit that might favour establishment upon the land; growing along the shore, this erect stout-stemmed seaweed is regularly exposed to the air at low tide. In such an environment, intermediate between sea and land, and from some unrecorded algal stock, it is likely that the first land plants developed their conducting and supporting stem tissues, their stomata, and other structures required by a terrestrial habitat.

The date of this major event in plant history could not have been as late as Middle Devonian, when *Rhynia* and *Hornea* lived. For in Late Silurian time there are records of the primitive lycopsid *Baragwanathia* in Australia; another lycopsid, *Drepanophycus*, is known from the Early Devonian of Canada, Europe, China, and Australia. If the psilopsids of the Rhynie chert represent the ancestral stock from which all higher vascular plants arose, there is implied a long antecedent history during which these relatively advanced, though still primitive, lycopsids branched off and developed such structures as leaves and stalked sporangia and which accounted for their wide distribution over four continents. The date of origin of their ancestors, the psilopsids, must have extended into Early Silurian or even Presilurian time. It is apparent that the earliest chapter in the history of land vegetation has not yet been uncovered.

1. Devonian.—The psilopsids were the most numerous and widely distributed plants in Early Devonian time. Their relatively undifferentiated plant body is consistent both with their ancestral status and with their semiaquatic environments; many of them are judged to have been swamp plants because of their occurrence in carbonaceous (peat) deposits; the association of *Psilophyton* and *Bucheria* with the remains of primitive fishes in Wyoming suggests a brackish-water habitat. The Psilophytales had disappeared by the close of the Middle Devonian, and in their place are found larger plants with root systems, stronger stems, and improved means of dispersing their spores or seeds. The Late Devonian record, like that of most of geologic time, is made up largely of lowland types, for plants growing along shores and valley bottoms are in the best situation to contribute their parts to sedimentary deposits. Club mosses (Lycopodiales), horsetails (Equisetales), *Sphenophyllum*, ferns (Filicineae), and seed ferns (Pteridospermae) all were represented; although they were for the most part smaller than their Carboniferous descendants and less adequately preserved, they provide a preview of the vegetation so widely developed along shores and valleys later in the era. Collections from Bear Island, at the south end of the Spitsbergen Archipelago, come nearer to constituting a flora than those from any comparable area. Lycopsids represented were *Lepidodendron, Protolepidodendron* and *Cyclostigma;* sphenopsids included *Pseudobornia* and *Sphenophyllum;* pteropsids included *Archaeopteris, Cephalopteris* and *Sphenopteridium*, the last two of which may have been seed ferns, and *Psygmophyllum*, which has a doubtful taxonomic status. *Archaeopteris* and *Sphenopteridium* have been recorded from Ellesmere Island in northern Canada. Devonian reef corals within the Arctic Circle confirm the suggestion of these northern plants that mild climate extended into polar regions during at least part of Late Devonian time. It seems probable that currents of warm water may have been largely responsible for the northward extension of mild climate in the Devonian and later periods of the earth's history.

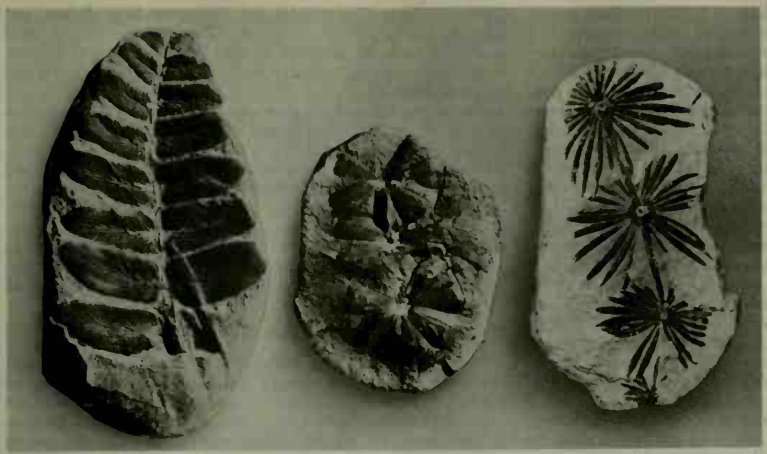
2. Carboniferous.—In most parts of the world, conditions for preservation of plants were less auspicious in Lower than in Upper Carboniferous time, for there were still widespread epicontinental seas in whose basins limestone was being deposited. Fossil plants have been found in Lower Carboniferous rocks of North America, Europe, and Australia; true ferns (Filicineae) were numerous, and new genera of club mosses and horsetails made their appearance; many of the seed ferns were represented by stems rather than fronds.

One of the largest floras of this age is recorded from Spitsbergen

BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM

FIG. 9.—RESTORATION OF PLANT LIFE OF THE CARBONIFEROUS PERIOD

(Left) trunks and cone-bearing branches of lepidodendrids; (right) calamite trees with whorled branches; sphenophylls and seed ferns growing on the forest floor



BY COURTESY OF ILLINOIS STATE GEOLOGICAL SURVEY

FIG. 10.—SPECIMENS OF PLANT FOSSILS OF THE PALEOZOIC ERA FROM ALLEGHANY SERIES, UPPER CARBONIFEROUS, ILLINOIS

(Left) *Neuropteris vermicularis*, portion of leaf; (centre) *Sphenophyllum emarginatum*, leafy stem; (right) *Annularia stellata*, leafy stem

and shows a close relationship to the Late Devonian vegetation of Bear Island. *Adiantites*, *Cardiopteris* and *Sphenopteris* were new genera of seed ferns to appear; the size of their fronds and of associated stems indicates an environment favourable for plant growth.

During the Upper Carboniferous an abundance of land plants together with ideal conditions for their preservation resulted in one of the most complete records of past vegetation in all earth history. Extensive mining of coal, with which most of the plant-bearing deposits are interbedded, has greatly facilitated the collection of these Upper Carboniferous fossils.

Lycopsids (*Lepidodendron*, *Sigillaria*) were the largest and most abundant trees, with sphenopsids (*Calamites*, *Sphenophyllum*) also numerous. The understory of this forest included the latter genus, which appears to have had a climbing habit in part, and an abundance of pteridosperms (*Alethopteris*, *Neuropteris*); some of the latter reached the size of small trees. True ferns (Filicineae) were represented in subordinate numbers by the fronds of *Pecopteris*. One of the most abundant groups of gymnosperms, the Cordaitales, was not so regularly represented in this swamp forest; it is considered to have lived on higher ground, from which its coarse leaves (*Cordaites*) were commonly washed or blown into the basins and mingled with the remains of plants growing there. Many of the seed ferns are also thought to have lived as trees above swamp level. Similar forests are known to have ranged over wide areas from the eastern United States to Europe and Asia Minor. The flora described by Halle from Shansi Province, China, is somewhat younger but includes many of the same genera as mentioned below.

Evidence of a frequently shifting position of the shore over wide areas of Eurasia and North America is afforded by the varying types of Carboniferous sediments. Fluctuations of level resulting from crustal instability had their effects upon the vegetation growing along swampy shores and estuaries, bringing marked changes in floral composition, especially among the pteridosperms. Their comparatively rapid modification from time to time under the influence of crustal movements is shown by the different species found in the sequence of plant-bearing beds, affording a basis for local and intercontinental correlations. The general aspect of the vegetation of this age leads to the conclusion that the climate was mild and humid, for most modern plants with similar stem and leaf development are found in regions with no frost and with ample rainfall.

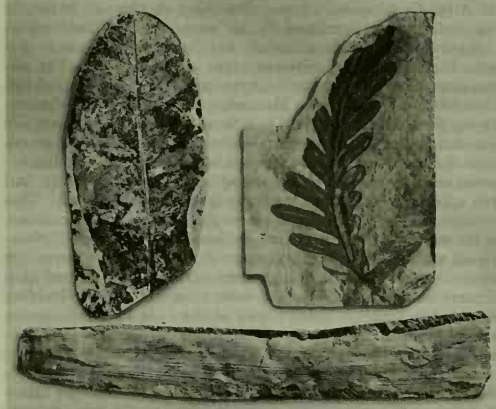
From several localities in the western United States, plant fossils have been collected which indicate other types of forests and different environments. The dominant members of the Garnett flora of Kansas are a conifer, *Walchia*, and a seed fern, *Taeniopteris*, both of which reached their greatest abundance during the succeeding Permian period, though they have also been recorded from the Upper Carboniferous of Europe. Associated with them were *Annularia*, several typically Carboniferous seed ferns, and *Cordaites*. This flora is considered to have lived in the relatively dry uplands, and its marked dissimilarity to the lowland swamp vegetation of the Carboniferous is a measure of this wide difference in environment. From sandy and shaley beds in Oregon other upland floras have been shown to include *Calamites*, conifers, and cordaitaleans, together with fronds of seed ferns. The smaller size of most of these Oregon plants and the absence of typical swamp types of seed ferns and lycopsids are in marked contrast to the Upper Carboniferous floras from the lowlands of the eastern United States and Europe. Remains of *Lepidodendron* and *Calamites* from Colorado are suggestive of a lowland forest that may have lived, as do certain modern club mosses and horsetails, under semiarid conditions less favourable to the growth of the seed ferns, few of which have been found with them. It seems clear that while most of the known forests of the Carboniferous lived on moist warm lowlands bordering inland seas, there were other less favourable environments in the western United States, and doubtless elsewhere, where a less luxuriant type of vegetation lived.

3. Permian.—Many of the plants of latest Carboniferous time resembled those of the Permian period and are commonly grouped with them under the transitional name Permo-Carboniferous. Because of their wide distribution and probable origin in the Northern Hemisphere, these Late Paleozoic plants are termed the Arcto-Carboniferous flora. The common types of horsetails and club mosses continued to be represented. *Odontopteris*, *Callipteris*, *Callipteridium*, *Supaia*, and *Taeniopteris* began to displace the typical Carboniferous types of seed ferns. The appearance of fronds of cycadophytes and the conifers *Walchia*, *Lebachia* and *Voltzia* gave a Mesozoic aspect to the Arcto-Carboniferous flora. It is significant that these northern conifers are not recorded south of the equator, where typically southern genera such as *Paranocladus* and *Walkomia* were dominant. Similar regional diversity may be noted among other groups of plants, and it is apparent that two major floras may be distinguished. This division of vegetation from north to south is in striking contrast to the worldwide occurrence of similar plants in earlier Carboniferous and Devonian time. It came about at a time when major physical events of earth history were taking place, the uplifting of some continents, the warping down of others, and the building of mountain ranges. These events of the Late Paleozoic appear to have brought about important climatic changes; gradual reduction of temperature and rainfall greatly modified the genial climate of Carboniferous time, especially in the Southern Hemisphere where the luxuriant forests of the Carboniferous swamps began to give way to types of plants better suited to the new environments.

The Permian flora of the Southern Hemisphere including peninsular India is termed the Antarcto-Carboniferous or Glossopteris flora. The latter name comes from one of its most characteristic genera of seed ferns, *Glossopteris*, which had a simple tongue-

shaped frond much thicker than those of typical northern genera. The name Gondwanaland has been applied to the southern land masses but need not be considered to indicate a continuous continental mass during Late Paleozoic and Early Mesozoic time. A common horsetail was *Schizoneura*, readily distinguishable from the northern *Calamites* by its more stocky habit and its larger leaves forming a sheath around the stem. With a single exception to be described below, none of these genera are recorded in the Paleozoic rocks of the northern continents. Certain of the northern plants were represented to the south, such as *Sigillaria, Lepidodendron, Sphenophyllum*, and *Psaronius*, along with heavy leaves resembling *Cordaites*. Stems of gymnosperms probably assignable to *Cordaites* showed well-defined growth rings. In this respect and in their shorter stems and thicker leaves, plants of the Antarcto-Carboniferous flora differed from those of earlier floras and are commonly interpreted as representing a response to an environment relatively unfavourable to plant life. Discovery of *Glossopteris* 300 mi. from the South Pole by the second Scott expedition suggests the possibility that this plant and its associates may have had their origin on Antarctica and ranged north into Australia, Africa, India, and South America.

The most northern Permian extension of the Antarcto-Carboniferous flora is recorded in Siberia, where several typical southern genera occurred with Arcto-Carboniferous forms; in addition there were a number of Mesozoic types of Bennettitales, Ginkgoales, and Coniferales. Represented in the Siberian (Kusnezk) flora was a thick-leafed seed fern, *Supaia*, which has been found in various other parts of the world and is common in an Early Permian flora from Arizona. This American flora contains a combination of Siberian and Arcto-Carboniferous elements, differing from floras of Permian age in the eastern United States and Europe in the reduced size of its stems and fronds and in other characters which suggest a relatively arid climate. In other parts of North America and in Europe the Arcto-Carboniferous flora was made up largely of Carboniferous types, some of which (*Calamites, Sphenophyllum, Lepidodendron, Sigillaria, Psaronius, Alethopteris, Neuropteris*, and most of the seed ferns) disappeared by the end of the era, with others (*Pecopteris, Cladophlebis, Neuropteridium, Taeniopteris* among the seed ferns, and certain members of the Bennettitales, Ginkgoales, and Coniferales) continuing on into the Mesozoic. The Permo-Carboniferous flora from Shansi, China, was Arcto-Carboniferous in composition; it included such distinctive genera as *Lobatannularia* and *Gigantopteris* (now also known from North America) and a considerable number of Mesozoic types, the ferns *Cladophlebis* and *Neuropteridium, Baiera*, and other ginkgoids and cycadophytes. This Chinese flora differed materially from the Kusnezk flora of Siberia, partly as a result of age differences but probably also due to migration barriers and unlike environments.



BY COURTESY OF (LEFT, BOTTOM) NATIONAL GEOLOGICAL SURVEY OF CHINA; (RIGHT) CARNEGIE INSTITUTION OF WASHINGTON

FIG. 11.—PERMO-CARBONIFEROUS PLANT FOSSILS

(Left) *Taeniopteris norinii*, leaf specimen from Shansi, China; (right) *Supaia compacta* leaf from Hermit shale of Arizona; (bottom) *Cordaites*, leaf specimen from Shansi, China

The closing days of the Paleozoic witnessed the disappearance of most of the older plants and the introduction of many new types. Continental uplift was draining the swampy lowlands; climatic changes involving greater extremes of temperature and precipitation were becoming more pronounced; other factors not fully understood may also have contributed to this major modification of vegetation. An outstanding feature was the development of floral provinces, with the Antarcto-Carboniferous flora in the Southern Hemisphere and India, the Arcto-Carboniferous flora in much of the Northern Hemisphere, and with a mixture of the two in Siberia.

C. Mesozoic Era

At the beginning of the Mesozoic Era the prevalence of desert conditions over a wide area in North America and in the Old World was highly unfavourable to the further development or the continued existence of many members of the rich Permo-Carboniferous flora. By far the greater number of Paleozoic species failed to survive; a few new forms were evolved, and some plants such as *Schizoneura* and *Glossopteris* were immigrants from Gondwanaland. A comparison of Late Paleozoic and Early Mesozoic floras reveals a sharp contrast that furnishes an interesting illustration of the interdependence of organic and inorganic evolution and of the effect of changing geographical conditions on the evolution of the plant world. One of the more important aims of the student of evolution is to discover connecting links in the plant world, particularly at epochs of widespread crustal disturbances. Attention has already been called to the presence in Late Permian floras of genera that are characteristic of Mesozoic floras: types that became prominent in the latter part of the Triassic Period and persisted through the several stages of the Jurassic Period were already in existence, though in a subordinate position, before the close of the Permian Period. The greatest contrast between the two eras is the marked difference in the general facies of the vegetation consequent to the disappearance of most of the commoner members of the older forests; but there is also a considerable difference which is due to the relative abundance in the Mesozoic floras of plants of more modern aspect, plants that were closely akin to living species as contrasted with the more archaic and much less familiar types in the Paleozoic floras.

1. Triassic.—At the beginning of the Triassic Period environments favouring the growth of forests appear to have been limited in extent. Land-laid sediments in Eurasia and North America include saline deposits and show other evidences of an arid climate during most of the period. Certain plants that survived the closing events of the Paleozoic, such as *Pleuromeia* and *Schizoneura*, were of smaller stature than their lycopsid and sphenopsid allies of the Arcto-Carboniferous flora. These and a few surviving seed ferns and conifers, together with new types of ferns, horsetails, and cycadophytes, made up the rather xerophytic population as the Mesozoic Era began.

By contrast, the vegetation in Late Triassic time was characterized by a greater variety of plants distributed over many parts of the world. These appear to have lived in valleys and swamps under relatively favourable climatic conditions. The immense trunks of araucarians in the Petrified Forest of Arizona indicate a forest comparable in density of growth with those of today in Queensland, Austr., and elsewhere in the Southern Hemisphere; thick growth rings of the fossil logs indicate an adequate supply of moisture and a relatively short season of drought or cold. Associated ferns were of types now living in moist tropical regions, and numerous large horsetails also suggest locally humid habitats. L. H. Daugherty has reconstructed an environment like that found in the savannas at low latitudes today, where dense forests fringe the streams and valley swamps; such a setting is in marked contrast to the variable climate of Arizona today, where sparse vegetation is a reflection of aridity and seasonal cold. Many of the same

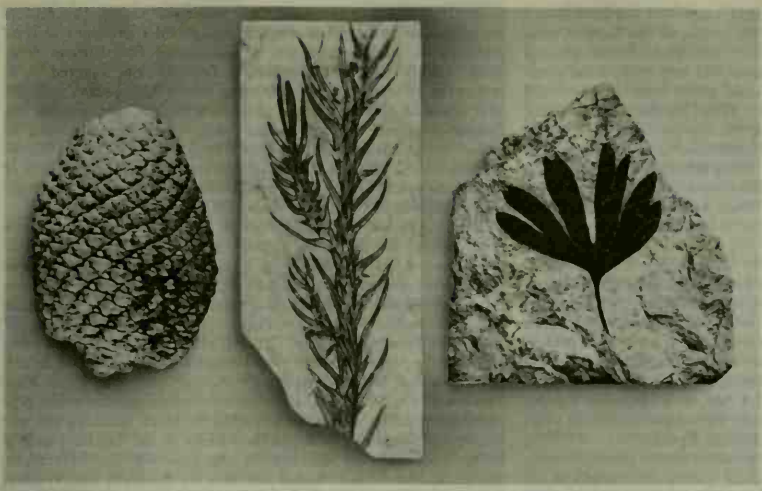


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FIG. 12.—PLANT FOSSILS OF THE MESOZOIC ERA

(Left) *Proaraucaria mirabilis*, cone specimen from Triassic of Argentina; (centre) *Araucarites longifolia*, branchlet specimen from Late Cretaceous of Wyoming; (right) *Ginkgo*, leaf specimen from Jurassic of Oregon

types of Late Triassic plants are found in the eastern United States and Europe. In the Late Triassic floras of Europe, ferns of now-tropical types, cycadophytes, conifers, and members of the Ginkgoales became numerous and diversified. Related types are also found in as widely distant localities as Greenland and Indochina, though at the latter locality there is indication of an intermediate relationship with floras of the Southern Hemisphere. During the Mesozoic, as in Permo-Carboniferous time, there were marked differences in character between the floras on opposite sides of the Equator.

2. Jurassic.—The Jurassic Period is generally considered to have witnessed the most widespread uniformity in living conditions of any time in earth history. The degree of this uniformity has probably been overemphasized; in the course of a period lasting about 40,000,000 years, migrations between lands as distant as Greenland and England may have brought certain plants from one area to the other, and similar extensions in range doubtless occurred in other areas in the Northern Hemisphere. But the picture of a worldwide cosmopolitan flora during the Jurassic does not meet the evidence presented by the fossil conifers of the Southern Hemisphere, which have been found by R. Florin to differ as much from those to the north as they did in Permo-Carboniferous time and as they do today. Fuller acquaintance with plants of the past may be expected to bring about certain changes in our major concepts, and in this case it is not surprising that marked differences in vegetation should be demonstrable over such wide distances in latitude.

In both hemispheres cycadophytes became a dominant part of the vegetation during Jurassic time, with more specialized Bennettitales apparently more numerous than the Cycadales. The habitat of these plants is difficult to reconstruct, since the Bennettitales are now extinct and the Cycadales live in both dry and humid situations; it may be supposed that they were commonest in regions of mild temperature, which brings up certain questions of past climate when it is realized that stems and fronds have been found as far south as Antarctica, and fronds have been found in northern Alaska and Siberia. There seems to be little question that broad submergence of the continents during Middle Mesozoic time resulted in more general circulation of ocean currents and winds than is found in the world today and that the effects of latitude were reduced. It may also be possible that some cycadophytes developed an ability to live under lower temperature conditions than others, as is the case with certain living conifers and angiosperms. Such changes in climate and tolerance appear more readily explainable than the assumption that the continents themselves have moved widely over the surface of the earth.

Abundance of ferns related to living types of the tropics confirms the indication of a frostless environment in many parts of the Jurassic world; the rarity of most of these in floras from high latitudes is in accord with the suggestion that the climate at high latitudes was less mild. The last of the seed ferns, characterized by thick leaves, are recorded at this time. All known lycopods were of small size, and the horsetails, while larger than any now living, had much shorter stems than those of the Paleozoic.

Several genera of the ginkgoids reached their greatest abundance and widest distribution in the Middle Jurassic. Conifers were also numerous and widespread, especially *Araucarites*, which is the only conifer whose distribution in both the Northern and Southern Hemispheres seems accurately established. Living members of the Araucariaceae are confined to southern latitudes, as are most of the Podocarpaceae. It is significant that podocarps are widely recorded at southern localities during the Mesozoic but are not certainly known to have lived north of the equator (except in peninsular India, which was on the south side of the Tethys Sea). The absence to the south of representatives of such typically northern families as Taxodiaceae, Cupressaceae, and Pinaceae further emphasizes the provincial character of the coniferous elements of Mesozoic floras in the two hemispheres.

Summarizing the general aspect of vegetation during Triassic and Jurassic time, there is evidence of widespread forests of humid lowland type in which large-leafed ferns were conspicuous, with conifers and ginkgoids making up the common trees, and with horsetails moderately abundant. The upland forests appear to have been largely coniferous, with araucarians the most numerous type in the Northern Hemisphere and with podocarps in the Southern Hemisphere. Cycadophytes may have been largely restricted to the more open savannas, though they were doubtless mingled with ferns in the understory of the lowland forests. A rich flora from the Triassic of Virginia, including horsetails, ferns, cycadophytes, ginkgoids, and conifers, is associated with coal deposits and appears to represent the vegetation in and adjacent to a swamp.

3. Cretaceous.—There is no sharp break between the Late Jurassic and the Early Cretaceous floras. The diversity of the earliest known flowering plants strongly implies a long antecedent history, of which only obscure fragments have been found in older rocks. A tendency toward the development of structures comparable in complexity with the angiosperm flower has been noted in such earlier groups as the Bennettitales and the Caytoniales. It may be assumed that during the earlier periods of the Mesozoic, the actual ancestors of the Cretaceous angiosperms may have been living in upland habitats that were not suited to the preservation of their remains. The appearance of highly diversified insects in the Jurassic doubtlessly accentuated the rate of evolution of angiosperms, since it added the possibility of insect pollination to the earlier and less effective method of pollination by wind. With the mountain-making and continental uplifts at the end of the Jurassic, the environments of the older plants were modified, and flowering plants were in a position to migrate down from the uplands and enter into successful competition with

them. Their first record in Greenland suggests a northern origin for the angiosperms, and during later stages of the Early Cretaceous they appeared at more southerly latitudes in North America and Europe. By Late Cretaceous time they had crossed the equator and were displacing the Mesozoic ferns, cycadophytes, and ginkgoids over most of the earth. With the conifers evolving many of their living genera during the closing days of the era, angiosperms also were becoming differentiated into their principal existing families and many of their living genera. Their complete invasion of the lowlands seems to have been finally achieved during Late Cretaceous time, and the stage was set for the development of modern vegetation in the era that followed.

D. Cenozoic Era

No new major groups of plants have appeared since the first record of the angiosperms in Early Cretaceous time. At the dawn of Cenozoic time the earth was covered with plants of modern aspect, but their distribution differed greatly from that of today. With reference to the time divisions of the Cenozoic Era, in the Tertiary Period are included the four epochs (Eocene, Oligocene, Miocene, Pliocene) preceding the Ice Age, or Pleistocene Epoch; this latter is assigned to the Quaternary Period and continues without floristic break to the present (Recent Epoch).

The outstanding feature of the vegetation of this latest era is its modern aspect. Many older Cenozoic plants are assignable to living genera, and before the middle of the era close relationships to living species were apparent. These relationships make it possible to recognize well-defined zones of vegetation during the Cenozoic, especially in the Northern Hemisphere, where the fossil record is more complete than in the Southern Hemisphere. Similar zones were doubtless in existence at some earlier times in earth history, but this is the only era in which the distribution and habitats of past vegetation can be so fully reconstructed.

Cretaceous uplifts temporarily removed many of the barriers to land migration, and numerous family and generic resemblances may be noted not only between Cretaceous floras of northern continents but with those of the Southern Hemisphere. During Early Tertiary time the Tethys Sea of the Old World and the Caribbean-Mediterranean of the New World once again set up barriers to north-south migrations, and since then vegetation in the Northern and Southern Hemispheres has shown marked differences. Worldwide moderation in temperature during Early Tertiary time is indicated by major plant migrations away from the Equator. The subtropical forests that migrated northward into Eurasia and southward into Africa and Australia may be termed the Paleotropical-Tertiary flora; they differed in many respects from those that invaded middle latitudes of North and South America (the Neotropical-Tertiary flora). Temperate forests that became established in high northern latitudes have long been assigned to the Arcto-Tertiary flora, and those that occupied a corresponding position to the south may be termed the Antarcto-Tertiary flora. The distribution and composition of these four floras during the Cenozoic Era throw light on the climate and topography of much of the earth in the immediate past and help to explain many problems of modern vegetation.

1. Tertiary.—*Paleotropical-Tertiary Flora.*—The largest and best-known unit of this flora has been described by E. M. Reid and M. E. J. Chandler from abundant fruits and seeds collected in the London clay. Growing in this forest at latitude 50° N were trees whose modern equivalents live in the tropical rain forest of the Indonesia-Malaysia region. One of the most significant of these was *Nipa*, a tropical palm now limited to tidal flats of the Indian Ocean and adjacent shores; its occurrence at many localities southeastward across Eurasia is considered to mark the shores of the Tethys Sea, along which the London clay and other floras of Eocene Age migrated from Indonesia-Malaysia into the Ukraine and western Europe. Among these were the floras from the Paris basin and from Huppaye and Gelinden in Belgium, which show a general resemblance to the London clay flora. Palms, figs, laurels, and other common members of these floras show their closest resemblance to living plants of the Old World.

Progressive uplift of the Alps, Caucasus, and Himalayas and the gradual withdrawal of the Tethys Sea were among the factors bringing new living conditions, especially wider extremes in temperature, to middle latitudes in Eurasia in Post-Eocene time. Many members of the Paleotropical-Tertiary flora lingered on as late as the Pliocene in western Europe, where inland seas continued over reduced areas. To the east such typical members of the Eocene floras as figs and laurels were restricted southward to Indochina and Burma during Late Tertiary time. In the middle latitude belt across Eurasia there appeared increasing numbers of temperate species from the Arcto-Tertiary flora, whose migration southward will be more fully discussed below.

The Paleotropical-Tertiary flora in lower latitudes shows some resemblances to that of the European Eocene. Along the southern shore of the Tethys Sea in Egypt, seeds of nipa palm have been collected, along with figs, laurels, legumes, and other northern types. B. Sahni has described a flora including *Nipa* and other palms from the Eocene Deccan traps on the south shore of Tethys in peninsular India. Wood and leaves of the Dipterocarpaceae, a tropical family now confined to Africa and Asia and most abundant in India and the Philippines, are found in the East Indies and also in Burma. The family Proteaceae had a few representatives such as *Lomatia* in middle northern latitudes but was largely restricted southward in the forests of the Tertiary, as it is today. Similar past distribution characterized the Myrtaceae, whose centres of distribution are now in Australia and tropical America but which may have been represented by the now southern genus *Eucalyptus* in Europe during the Tertiary and Cretaceous Periods. Little recent work has been done in the East Indies and Australia, and the older Tertiary vegetation of Africa is almost completely unknown. Leaves figured by H. R. Goeppert (1854) from the Eocene of Java are strongly suggestive of laurels, legumes, figs, and persimmon. The most reliable records from Australia and New Zealand are those summarized by R. Florin for the conifers; the occurrence of *Agathis*, *Dacrydium*, *Phyllocladus* and *Podocarpus* in the Eocene of New Zealand, of these genera and *Callitris* in the Miocene of Australia at latitude 35° S, and of *Podocarpus* and *Widdringtonia* in the Tertiary of South Africa, suggests generally distributed warm-temperate to subtropical conditions over middle southern latitudes. These genera all have their centres of distribution in the Southern Hemisphere today and are considered to have had a southern origin. A small flora of Pliocene Age has been described from Uganda, in equatorial Africa, all of whose members resemble species now living on this continent at low latitudes.

Neotropical-Tertiary Flora.—This forest spread north into middle latitudes in North America during Eocene time. Fossil leaves are of relatively large size, with texture, nervation, and shapes resembling the foliage of trees and shrubs of many tropical families; fruits and wood confirm these relationships, although wood is comparatively rare as might be expected by reference to modern forests of the tropics where fungi, termites, and other organisms rapidly destroy the trunks of fallen trees. The commoner families of the Paleotropical-Tertiary are well represented in North America, but many of the genera and most of the species are of New-World types. Palms, figs, legumes, laurels, and euphorbs were numerous. *Nipa* has been recorded and several other palms were well represented. No record has been found of the Dipterocarpaceae, a family now confined to the Old World, and Proteaceae and Myrtaceae were not common.

The Wilcox flora of the southeastern United States gives a rather complete picture of the vegetation that lived along the deltas and swampy shores of the Mississippi embayment during Eocene time. Angiosperms predominated, with a few ferns, cycads, and conifers. The immediate ancestors of some of these plants lived in this region during Cretaceous time, when the climate appears to have been more temperate, but most of them came northward from northern South America and the West Indies in response to the same moderating climatic influences that brought the London clay flora from Indonesia-Malaysia to England. Similarity of Eocene mollusks from Colombia to the southern United States supports the idea that a uniformly mild climate characterized this region as far north as latitude 37°. What is known of the Eocene vegeta-

tion of northern South America also indicates climatic uniformity along the Antillean route of migration to the Mississippi embayment. It has been suggested that the migration route followed by the plants to the west shore of the embayment in Texas may have been northward through Central America and Mexico.

Warm humid conditions persisted in the southeastern United States until Oligocene time, but in the Miocene Epoch there is evidence of a reversal in direction of migration. The Calvert flora of this age in Virginia is made up largely of typically temperate Arcto-Tertiary trees such as pine (*Pinus*), oak (*Quercus*), and elm (*Ulmus*), with a small representation of plants suggesting warmer conditions. Miocene and Pliocene vegetation in Florida was essentially like that found there today, with comparatively few relicts of the Neotropical-Tertiary flora surviving.

Northwestward in New Mexico and Colorado the Raton flora, somewhat older than the Wilcox, was also largely composed of angiosperms. Although nearly one-half of these fall into genera which range today into lower latitudes, the general aspect of the Raton flora was more temperate than the Wilcox. Northward along the Rocky Mountains and on their eastern border, the Denver and Fort Union floras indicate progressively more temperate climates consistent with their latitudes. Like the Eocene floras from higher middle latitudes in the interior of Europe, they included many angiosperms of typically northern types that were characteristic of the Arcto-Tertiary flora and such northern conifers as *Sequoia*. Still farther north in Saskatchewan, the Upper Ravenscrag and other Eocene floras were predominantly temperate in aspect, with only a few warm-temperate genera. Cooler and dryer living conditions are shown by the Green River flora from the Middle Eocene of the Rocky Mountain interior. Here evaporation products (such as gypsum) are conspicuous at certain horizons, while at others the leaves of angiosperms indicate a warm-temperate climate, probably with a marked dry season. Pollen described by R. P. Wodehouse is referable to many upland genera. From the Pacific coast eastward into the Columbia Plateau, a coastal type of forest indicates that the mild climate along the shore extended inland with no such topographic barriers as the Cascades and Sierra Nevada Mountains of today. The Goshen flora of western Oregon, the Chalk Bluffs flora of central California, and many others were made up largely of plants whose modern equivalents are found living in a climate with higher rainfall and less frost than now prevails in the western United States. To the north in Alberta and on Kupreanof Island in southeastern Alaska, several subtropical to warm-temperate trees were present in reduced numbers in floras made up largely of temperate plants, which may be more properly considered with the Arcto-Tertiary flora. The trend toward cooling climates in Post-Eocene time is first shown by the gradual withdrawal of the Neotropical-Tertiary flora from the continental interior coastward. Only a few warm-temperate trees may be noted in such Oligocene and Miocene floras as the Florissant (Colorado), Latah (eastern Washington), Bridge Creek, and Mascall (eastern Oregon), which are predominantly Arcto-Tertiary in origin and composition. In the belt of marine climate adjacent to the Pacific shore, they were more numerous; the Oligocene Weaverville flora of California is typically warm-temperate in aspect, with large-leafed angiosperms such as *Tetracera* and *Calyptranthes* and the conifer *Taxodium*. By the end of the Miocene even the hardy avocado (*Persea*) was restricted to central California, where it survived into the Pliocene. *Umbellularia* is the only western North American survivor of the Lauraceae, a family characteristic of both the Neo- and Paleotropical floras. Living palms do not range north of the Colorado Desert in southern California, and members of other typical Neotropical families such as the Euphorbiaceae and Leguminosae are today represented in western North America only by herbs or shrubs rather than by trees as in the Eocene. While there are some plants living in the Old World tropics that show a general resemblance to the Neotropical-Tertiary flora of western North America, the great majority of the modern descendants of this flora are to be found in Mexico and Central America.

The Neotropical-Tertiary flora of low and southern latitudes is not as well known as that of the United States. Judging from the available fossil material from the equatorial zone in Panama, Colombia, Venezuela, and Ecuador, the vegetation there has been tropical from Eocene time to the present, with none of the marked changes that resulted from climatic trends at higher latitudes. Resemblance of the Eocene flora of Venezuela to the Wilcox of the United States suggests that northern South America may have been a centre from which forests migrated over the Antillean land bridge. No floras of this age are known from Brazil, but a southward movement of vegetation under the influence of moderating climate is shown in Eocene floras of Patagonia and central Chile at latitude 37° to 45° S. They were made up largely of angiosperms, as in the case of the corresponding Neotropical-Tertiary flora at middle latitudes in the Northern Hemisphere, with Lauraceae a common family. Certain families now more characteristic of the Southern Hemisphere assumed importance, such as Apocynaceae, Bignoniaceae, Myrtaceae and Rubiaceae. The more abundant conifers, *Araucaria* and *Podocarpus*, are likewise largely southern in their modern distribution. In fact these Eocene floras were as typically South American in composition as the modern vegetation. They appear to have lived under climatic conditions involving no frost and heavy rainfall. Coupled with the world-wide amelioration in climate, other factors responsible for this southward extension of subtropical conditions may have been the broad marine transgression from the east and the absence of the Andes Mountains (shown by the similarity of floras in Patagonia and Chile on opposite sides of their present axis). With gradual Post-Eocene cooling, most of the members of the Neotropical-Tertiary flora moved northward 5° to 15° to their present ranges in South America. Peruvian floras of Oligocene and Miocene Age appear to have extended across the present Andean axis into Brazil, where the somewhat younger Bahia flora is tropical in aspect. The Pliocene Potosi flora from high altitudes in Bolivia includes plants whose living relatives occupy lower regions with higher rainfall and temperature; E. W. Berry concluded that this part of the Andes has been uplifted 5,000 ft. or more in Post-Pliocene time. Lowland Miocene floras in Ecuador, Colombia, Venezuela, and Trinidad resembled the modern forests of the upper Amazon Basin, and may be readily distinguished from floras of this age in Costa Rica and southern Mexico. This confirms an assumption based on faunal evidence that the land connections which characterized the Cretaceous and Early Tertiary had been broken before Miocene time.

In summary, the ameliorating climate at the outset of the Tertiary period resulted in an extension of subtropical vegetation to latitude 49° N on the western shore of North America and to 50° N on the equally favoured coast of western Europe. Inland these floras did not extend so far north, as is consistent with their more continental climates. Such distribution seems to establish the northern continents and ocean basins in essentially their present positions during the Tertiary Period and serves as a strong argument against continental drift in later geologic time. Similar distributional relations in earlier periods may also be considered to indicate the permanence of ocean basins and continental platforms through that portion of earth history in which land plants have lived. Families common to the Old World (Paleotropical-Tertiary) flora and that of the New World (Neotropical-Tertiary) suggest a common origin for much of the vegetation of the Northern Hemisphere during Cretaceous time or earlier; generic and specific differences serve to distinguish the Eocene floras of middle latitudes on the two continents, and these differences are still apparent in modern Paleotropical and Neotropical floras.

Lowered temperature and rainfall at the close of the Eocene Epoch resulted in a gradual movement of vegetation southward, although subtropical and warm temperate trees and shrubs lingered on into Miocene and Pliocene time along the westward shores of the continents, especially in Europe. Unlike the north-south ranges in North and Central America, which permitted migration to more favourable latitudes, the transverse Alps served as a barrier to southward movement into Africa, as did the Tethys-Mediterranean Sea.

Migrations of vegetation southward from the Equator carried

the Tropical-Tertiary floras into middle southern latitudes of South America and Australia during the Eocene, where they gradually withdrew as climatic conditions became more rigorous. A considerable part of these Southern Hemisphere forests, both in the Old and New worlds, appears to have developed south of the Equator; differences with floras of corresponding age north of the Equator are especially apparent when the conifers are compared, perhaps because they are better known and more accurately determined than most Tertiary angiosperms from the Southern Hemisphere. Increments have been progressively added to the forests of the equatorial belt by movements of vegetation from middle to lower latitudes in Post-Eocene time, which may account in part for the high degree of diversity now to be found in forests of the tropics.

Arcto-Tertiary Flora.—The northward extension of forests dominated by angiosperms during Eocene time had its parallel during the Devonian period in the predominance of ferns and in the Jurassic occurrence of ferns, cycadophytes, ginkgoids, and conifers, at high northern and southern latitudes. In all three cases wide submergence tended to equalize water and air temperatures, and it is probable that polar icecaps completely disappeared. Many students of past climates believe that increases in solar radiation may have brought a rise in temperature throughout the world. As stated earlier, the Tropical-Tertiary flora extended into middle latitudes in Eocene time, especially along the windward shores of the continents. A corresponding movement of temperate vegetation brought diversified forests into Greenland, Spitsbergen, central Siberia, and Alaska, and to southern Chile, Seymour Island in Antarctica, and the Kerguelen Archipelago. These latter are assigned to the Antarcto-Tertiary flora. At still higher northern latitudes on New Siberian Islands, in northern Siberia and Canada, in Banks Island, Bathurst Islands, Ellesmere Island, and up to Grinnell Land at latitude 83° N, Eocene floras of cold-temperate character included pine and spruce (Pinaceae), sedges (Cyperaceae), poplar and willow (Salicaceae), and birch (Corylaceae).

Like the Tropical-Tertiary floras of the Eocene, the Arcto-Tertiary ranged farther north on the windward sides of the continents than in their interiors. Alder (*Alnus*), birch (*Betula*), beech (*Fagus*), hornbeam (*Carpinus*), elm (*Ulmus*), maple (*Acer*), oak (*Quercus*) and katsura tree (*Cercidiphyllum*) were among the most common angiosperms; among the gymnosperms, *Sequoia, Metasequoia, Taxodium* (bald cypress), and *Ginkgo* were characteristic. There is no basis for differentiating what A. N. Kryshtofovitch has called the Turgayan flora of northeastern Asia from other Eocene floras in the Greenland region and in Alaska. During the Oligocene Epoch which followed, these temperate forests appear to have largely disappeared from high latitudes and to have migrated southward over about 12° of latitude. Bridge Creek flora from the John Day Basin of eastern Oregon includes species of *Metasequoia* and *Quercus* (also called *Lithocarpus*), which have similar living relatives in western North America; species of *Ostrya* and *Fagus*, whose living equivalents are now restricted to the eastern United States; and species of *Cercidiphyllum* and *Ulmus*, whose most nearly related equivalents live in eastern Asia. These and other common genera of the Arcto-Tertiary flora are represented in the Oligocene floras of France, Germany, Austria, Croatia, Manchuria, Korea, southeastern Siberia, Sakhalin, British Columbia, and Colorado, and it is clear that regional differentiation such as characterizes the forests of the Northern Hemisphere today had not yet been attained. Many of the mountain ranges that now serve as climatic and migrational barriers were not then in existence, and both temperature and rainfall must have been more uniformly distributed than they are today.

By Miocene time the Arcto-Tertiary flora had ranged south into China and Japan, into Spain, Switzerland, and southern Russia and into central California and Nevada. Extensive mountain-making and volcanism during this and the following epoch produced a topographic setting and a resultant climate unfavourable to the survival of many tree genera. With a change from rainfall uniformly distributed areally and seasonally to large areas of rain shadow and summer-dry climate, vegetation began to show greater regional differentiation. The Shanwang flora from the Miocene of northeastern China contains several genera such as *Broussonetia, Eriobotrya, Firmiana, Hovenia, Kalopanax,* and *Pueraria* which have not been recorded from Miocene floras in Europe and North America and which are limited to Asia in their modern distribution. The Mascall flora of Oregon and other Miocene floras from western North America include several species of black oak, a division of the genus *Quercus* which has not been found in fossil floras from Eurasia and is not represented on that continent today. Many Pliocene floras show smaller numbers of tree species, and the size of their leaves is much reduced in the case of aspen (*Populus*), oak (*Quercus*), and other trees. Such genera as *Ginkgo, Metasequoia, Glyptostrobus, Cercidiphyllum,* and *Zelkova* were rare or absent in North America, where none of them is known to have survived the Tertiary Period; in Europe most of these now-Asiatic genera lived later, but none of them lasted beyond the end of the Pliocene. In North America such deciduous genera as *Fagus, Carpinus, Castanea, Carya,* and *Ulmus* disappeared from the west during the Pliocene and have survived on this continent only in the east, where a summer-wet climate has persisted. The redwood (*Sequoia*) became restricted to the immediate borders of the Pacific, where it lives today in a marine-controlled environment. It became extinct in Eurasia before the end of the Pliocene Epoch. The Early Pliocene flora of the Dutch-Prussian border, which includes many well-preserved seeds, still showed a strong Asiatic alliance, but by the end of the epoch the vegetation of this age from western Europe was essentially like that of today.

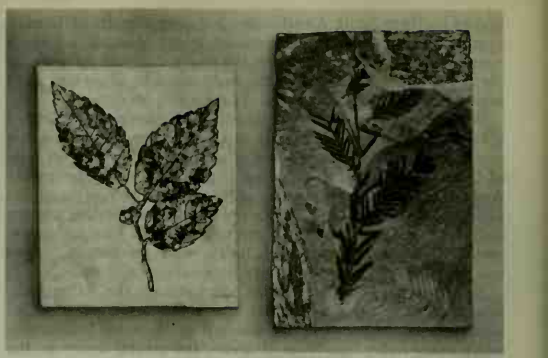

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FIG. 13.—PLANT FOSSILS OF THE CENOZOIC ERA

(Left) *Zelkova ungeri*, twig with leaves and fruit from Middle Tertiary of Shantung, China; (right) *Metasequoia occidentalis*, branchlet specimens from Middle Tertiary of Oregon

The changing climate of Late Tertiary time placed grasslands in a favourable position for competition with forests in the interiors of the northern continents. Fossil grasses are not of common occurrence, presumably because of conditions unsuited to their preservation. Occasional remains of the Gramineae have been found in rocks of Cretaceous Age and younger, but it is not until the Miocene Epoch that grasses are known to have become abundant. The silicified remains of their seeds have been described by M. K. Elias from a wide area in the high plains of North America. The abundance of grazing types of mammals indicates the extent of grasslands over a still more extensive region of North America and other northern continents. Few other plant remains are found associated with them, but occasional leaves, fruit, and stems indicate that trees such as *Celtis* (hackberry), *Platanus,* and *Populus* lived on the stream borders and in other favoured situations in the high plains of interior North America. In central Asia, in Kansu and Sinkiang provinces of China, stems and leaves believed to represent grass are associated with leaves of poplar (*Populus*), willow (*Salix*), and other stream-border plants.

Madro-Tertiary Flora.—Another result of the more rigorous cli-

mate following the Eocene Epoch was the appearance in the western United States of a small-leafed arid type of vegetation from the south. Its exact time and place of origin have not been established by fossil evidence, but its relations with living plants suggest that it became differentiated in Early Tertiary time on the arid uplands of Mexico and that it later migrated northward along mountain ranges. Its representation in the Green River flora of Eocene age is indicated by the occurrence of a nut pine (*Pinus*), a cactus (*Opuntia*), and small-leafed legumes. The Oligocene flora from Florissant, Colo., also includes plants that may have had their origin in the Sierra Madre. The Tehachapi flora from the Miocene of southern California is made up predominantly of Madro-Tertiary species, which are likewise well represented in Pliocene floras extending across Nevada into Oregon, and in central Colorado. Small-leafed oaks (*Quercus*) were characteristic members of the Madro-Tertiary flora, together with *Ceanothus*, *Arctostaphylos*, and other chaparral plants. A small flora of Oligocene Age from Turkestan is made up of steppe plants, which suggest that an Old-World flora corresponding to the Madro-Tertiary may have developed in Asia and ranged northward.

Antarcto-Tertiary Flora.—While there is a wide divergence of opinion regarding the place of origin of vegetation which occupied high and middle latitudes of the Southern Hemisphere in later geologic time, there seems to be little question that much of it has had a separate development there during the Tertiary Period and that it became established in high southern latitudes during Late Cretaceous time. Evidence of a broader extent of Antarctica has been presented in the discussion of Permo-Carboniferous and Jurassic floras. Northward connections from this polar continent to South America, to Australia and New Zealand, and probably to Africa seem also to have been in existence at the beginning of the Tertiary Period and to have provided routes for migration between the southern continents.

The Eocene flora of Seymour Island, Antarctica, in latitude 64° S contained three genera of conifers, *Acmopyle*, *Araucaria* and *Podocarpus*, all of which are now southern in distribution; the angiosperms were also of southern types, *Drimys*, *Knightia*, *Laurelia*, *Lomatia* and *Nothofagus*. To the north on the southern tip of South America (Strait of Magellan in Chile and Tierra del Fuego in Argentina), an Early Tertiary flora included the conifers *Araucaria* and *Podocarpus*, and the angiosperms *Nothofagus* (most abundant), *Knightia*, *Laurelia*, and others not generically determined. All of these plants ranged northward to latitude 45° S during older Tertiary time; several of them occurred in ecotonal relationship with the Neotropical-Tertiary flora at latitude 41° S in Patagonia and are considered to be of Eocene Age. Their present centres of distribution are at still lower latitudes in the southern continents other than Africa.

A small flora including *Araucaria*, *Podocarpus*, and fragmentary angiosperm leaves, of which the best-preserved resembles *Coprosma*, has been recorded from the Kerguelen Islands at latitude 49° S below Africa and Australia in beds of older Tertiary Age. Little is known of the temperate vegetation of South Africa. An Eocene flora from New South Wales (latitude 35° S) includes laurels, *Magnolia*, *Eucalyptus*, legumes, *Pittosporum*, and other subtropical genera, together with such typically temperate forms as *Nothofagus* and *Knightia;* most of the Miocene plants were typically temperate, including *Nothofagus*, *Araucaria*, *Lomatia*, and *Coprosma;* the majority of these plants were characteristic of the Southern Hemisphere, and many of their living equivalents are Australian. A significant flora of Late Tertiary Age has been described by F. W. Oliver from South Island, New Zealand (45° S). Along with *Podocarpus* were numerous angiosperms, some of which (*Nothofagus*, *Knightia*, *Laurelia*) appear to have had their origin to the south, while others were of Malayan origin and doubtless entered this region during the southward extension of the Paleotropical-Tertiary flora.

The discontinuous distribution that now characterizes so many genera in the Southern Hemisphere seems to have resulted from the breaking of land bridges between Antarctica and continents to the north during Tertiary time and to climatic changes that made the higher latitudes uninhabitable for trees. Resultant migrations brought Antarcto-Tertiary conifers and angiosperms northward from Antarctica into middle latitudes of South America, Australia, and New Zealand, and to a lesser extent into Africa during Tertiary time, and certain genera have spread into still lower latitudes along mountain ranges to become mingled with the descendants of the Tropical-Tertiary floras. There has been some intermingling with vegetation north of the Equator, where similar migrations were shifting the Arcto-Tertiary flora southward, but the forests of the Southern Hemisphere have continued largely distinct from those of the Northern Hemisphere to the present day.

2. Quaternary.—The vegetation of the Pleistocene Epoch, which with the Recent makes up the Quaternary Period, grades imperceptibly into that of today. Fossil plants preserved in river and glacial clays and in peat and asphalt deposits seem in most cases to represent species now living. But their distribution may show marked discrepancies with that of today because of the relatively rapid changes in climate which characterized the Pleistocene. The southward extension of continental glaciers in the Northern Hemisphere brought Arctic birch and willow into England during colder and moister stages. The occurrence of white spruce (*Picea glauca*) in Louisiana, more than 800 mi. south of its present southern limit, is indicative of corresponding glacial climate in North America. On the Pacific Coast, where glaciers are not known to have come down out of the mountains to the coastal plain, the redwood (*Sequoia*) appears to have lived in the regions it now occupies; but it also ranged down into southern California, where the

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FIG. 14.—MODERN FORESTS RESEMBLING CENOZOIC FLORAS
(Left) subtropical forest in Panama; (right) redwood forest in California

present warm, dry climate is unsuited to it. Fossil cones of Monterey pine (*Pinus radiata*), Bishop pine (*P. muricata*), and other northern species also indicate a cooler and more humid climate than is now found there. Manzanita (*Arctostaphylos glauca*) and other shrubs lived in the adjacent hills. During an interglacial stage of the Pleistocene, Monterey pine ranged north along the Pacific Coast beyond its present limits. In the North American interior, *Asimina triloba*, *Robinia pseudoacacia*, and other species with more southerly modern ranges occur with northern trees in an interglacial deposit in Ontario, Can. A similar flora in western Austria includes a *Rhododendron* and other species now living under milder conditions. Remains of *Libocedrus* and *Podocarpus* in Pleistocene deposits of the Falkland Islands indicate a milder climate at southern latitudes during part of this epoch than that of today, for trees no longer live there. Alternations of cold with mild climate brought the final elimination of many plants from middle latitudes, especially in Europe, where the Alps served as a barrier to north-south or south-north migrations. Pollen records in post-glacial peat deposits indicate several fluctuations in precipitation and temperature during past millennia. Vegetation of today is doubtless responding to climatic changes, but its migrations are ordinarily too slow to be perceptible.

During the present era there has been a worldwide movement of forests from higher to lower latitudes under compulsion of climatic change. The sequence of fossil floras in the John Day basin of eastern Oregon provides one of the most complete known records of plant migrations. It is a region of low rainfall and of wide temperature extremes, with willow (*Salix*), cherry (*Prunus*), hackberry (*Celtis*), and other small trees largely limited to the river borders. But in the Middle Tertiary time this region was inhabited by redwoods like those now living on the humid coast of northern California. Their leaves and petrified stems are found preserved in rocks of eastern Oregon underlying flows of Columbia lava that poured out across this region during the Miocene Epoch. With these redwoods grew beech (*Fagus*), hornbeam (*Carpinus*), and other deciduous hardwoods now restricted in North America to its eastern half, where a summer-wet climate prevails; certain trees of the Oligocene and Miocene forests of the John Day Basin have their nearest living equivalents in northeastern Asia. During a still earlier stage of Cenozoic history, a subtropical forest occupied this part of Oregon. Its presence is recorded by large, thick, fossil leaves of trees and vines now living in the humid, frostless environment of Central America. In the course of the 60,000,000 years represented by these fossil floras, the John Day Basin has been covered successively by the Neotropical-Tertiary flora, the Arcto-Tertiary flora, and modern steppe vegetation. During the ages since the Eocene, the Neotropical-Tertiary flora has retreated southward, with the Arcto-Tertiary flora moving in from Alaska and British Columbia to take over the area it occupied. Subsequent uplift of the Cascades has cut off most of the rainfall from eastern Oregon, and the moderating influence of the ocean on its temperature is no longer felt in the interior of the continent. The redwood and many of its moisture-requiring associates have been confined to the Pacific shores, while other trees that flourish during rainy summers and shed their leaves during the winter have survived in the eastern part of North America and in eastern Asia.

In other parts of the world similar changes in plant distribution have been taking place; forests have been forced equatorward by temperature reduction or have given way to grasslands and deserts in regions of lessened rainfall. Present-day vegetation is the product of all of the floras of the past. It has been modified through the ages by changing environments that have shifted forests widely across the earth. During these journeys some elements have become extinct, others have developed into more specialized types, while a few have survived with little change to illustrate the nature of yesterday.

See also references under "Paleobotany" in the Index.

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PALEOCENE: *see* EOCENE AND PALEOCENE.

PALEOENTOMOLOGY, the science that deals with fossil insects. Although insects are not ordinarily found in the fossil state as frequently as other invertebrates, several hundred thousand specimens are contained in museums and university collections in Europe and North America. Only a small part of these collections have been systematically studied, but despite this about 13,000 species have been described. Pioneer work in the subject was done by Oswald Heer, whose publications on Tertiary insects of central Europe (1847–58) set the pattern for subsequent studies. S. H. Scudder, who wrote extensively on fossil insects from 1865 to 1903, published several comprehensive monographs and the first review of the whole field of paleoentomology. A. Handlirsch published an extensive treatise on the subject (1906–08), and included an account of insect evolution which has formed the basis of more recent studies of insect phylogeny and classification. (The classifications described here may differ with arrangements given in related articles elsewhere in the encyclopaedia; these differences reflect the viewpoints of the various authors concerned.)

The process by which insects became preserved as fossils was

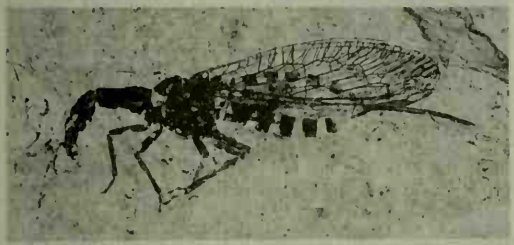

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FIG. 1.—SNAKE FLY (RAPHIDIA MORTUA) FROM THE FLORISSANT SHALES OF COLORADO

similar to the process that created other fossil animals: the insects fell into a body of water and were subsequently buried by the sediments; later, the deposit became lithified. Since most insects spend a large part of their adult life in the air, unusual conditions —most commonly high winds and falling volcanic ash—were necessary to bring them into the water. One of the best examples of a deposit containing large numbers of fossil insects is the Florissant shales, near Pikes Peak in Colorado. The shale was formed mainly by the deposition of volcanic ash in the bottom of a lake; as the ash fell into the lake it forced into and beneath the water the insects that were flying over the lake at the time. In this way the insects' bodies were covered by ash and other lake sediments and

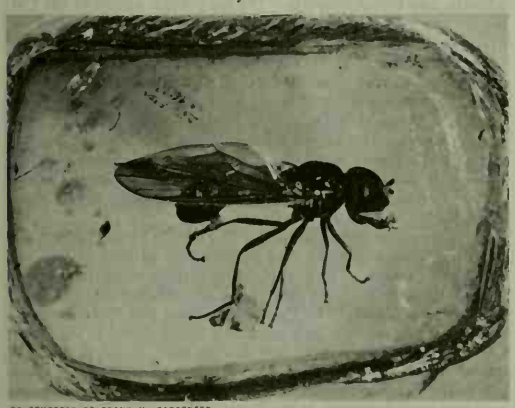

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FIG. 2.—SYRPHID FLY (PSEUDOSPHEGINA CARPENTERI) IN BALTIC AMBER

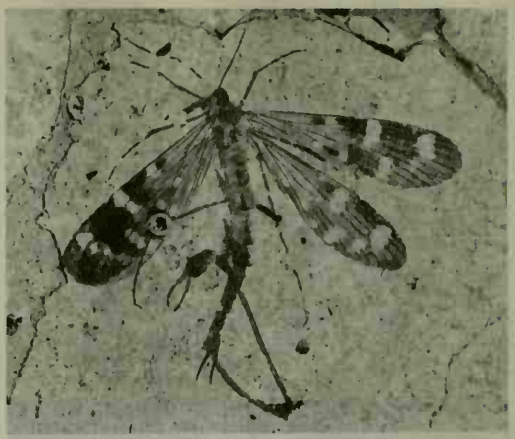

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FIG. 3.—SCORPION FLY (HOLCORPA MACULOSA) FROM THE FLORISSANT SHALES, COLORADO

protected from disintegration. When the layers of the shale are separated, remains of the insects are exposed, many of them in an excellent state of preservation; even the hairs on the bodies and coloration of the wings may be seen. The commonest type of preservation is that occurring in the Baltic amber, which is itself the fossil resin of extinct pine trees. Insects and other small arthropods living at the time were caught in the sticky resin that dropped from the branches or tree trunks and were eventually preserved within the amber itself. Many of these insect specimens in amber can be seen as clearly as existing insects mounted in balsam.

Fossil insects have been found in about 150 individual geologi-

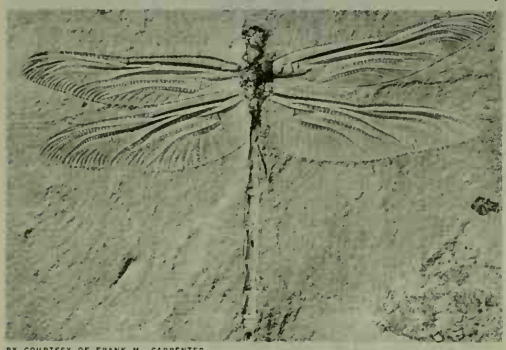
Geologic Column and Scale of Time

(Ages increase from top downward, as in a sequence of sedimentary rocks)

System and Period	Series and Epoch	Distinctive Records of Life	1000 Years*
		CENOZOIC ERA	
Quaternary	Recent	Modern man	*11*
			>*44*
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	(21,000)
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	(58,000)
	Paleocene	First placental mammals	70,000
		MESOZOIC ERA	
Cretaceous		Extinction of dinosaurs, floras with modern aspects	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
		PALEOZOIC ERA	
Permian		Conifers abundant, reptiles developed	(230,000) 235,000
Carboniferous			
Upper (Pennsylvanian)		First reptiles, great coal forests	260,000
Lower (Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000 (380,000)
Ordovician		First primitive fishes	400,000
Cambrian		Large faunas of marine invertebrates	(440,000) 500,000
		PRECAMBRIAN TIME	
No known basis for systematic division		Plants and animals with soft tissues, few fossils	(620,000) (1,420,000) (1,800,000) (2,680,000) (3,310,000) 3,500,000-4,000,000

*Italicized figures are from radiocarbon analyses; figures in parentheses are reliable values from radioactive minerals found in rocks that belong in time divisions indicated; plain figures give estimated dates at start of corresponding time units.

cal deposits. Although there is no way of predicting the occurrence of fossil insects in a formation, the presence of plant remains indicates the previous existence of the kind of environment in which insects might have lived; in most cases, fossil insects are found in close association with plant remains. About four-fifths of all the specimens of fossil insects that have been collected were obtained in about 20 deposits. The most important of the Carboniferous deposits containing insects is at Commentry, France; other significant deposits of that period are the ironstone nodules in the vicinity of Mazon Creek in Illinois, various shales associated with coal beds in Pennsylvania and eastern Ohio, and similar shales in England and in the Saar Basin in Europe. Insect remains of Permian Age have been found in Kansas and Oklahoma, in New South Wales, Austr., and in many parts of European U.S.S.R. and Siberia. Triassic deposits containing insects are few in number; the only important ones are in New South Wales and Queensland, Austr. Jurassic insects are known from the lithographic limestone of Solnhofen, Bavaria, and from limestones of southern England, the Mecklenburg region in Germany, and Turkestan in the U.S.S.R. Cretaceous insects have been very



BY COURTESY OF FRANK M. CARPENTER

FIG. 4.—DRAGONFLY (PROTOLINDENIA WITTEI) FROM THE JURASSIC SHALES OF SOLNHOFEN, BAVARIA

rarely found; the only source of many specimens is an amber (apparently of Cretaceous Age) found along the shores of Cedar Lake in Manitoba and along certain shores in northern Alaska (Beaufort Sea).

Tertiary rocks have produced by far the majority of fossil insects. The most prolific Eocene deposits are the oil shales of the Green River Formation, exposed extensively in parts of Colorado, Wyoming, and Utah. Insects of a somewhat younger age, perhaps Late Eocene or Early Oligocene, are found in the Baltic amber; well over 100,000 amber insects, contained in the Albertus University of Kalinigrad (Königsberg) before World War II, were apparently destroyed during the war. Somewhat younger insects, of Late Oligocene or Miocene Age, have been found in numerous lake deposits formed mainly of volcanic ash; these include the shales at Florissant and Creede, Colo., and at Oeningen, Ger. Pleistocene insects are found in peat deposits in many parts of the world, such as the northern part of the United States and Europe, as well as in some of the subfossil gums on the east and west coasts of Africa. *See* also FOSSIL.

EVOLUTION OF INSECTS

Origins.—The study of fossil insects has contributed much to understanding the evolution of this extensive group of arthropods. Fossil evidence and study of the comparative morphology and development of living species have shown that insects began as wingless creatures, resembling in general form the silverfish, which belong to the living order Thysanura. Such primitively wingless insects comprise the subclass known as the Apterygota.

The winged insects, forming the subclass Pterygota, have gone through three stages in the course of their geological history. The earliest and most primitive of them, making up the division Palaeoptera, had a wing articulation that restricted the movements of the wings so that they could not be folded back over the abdomen at rest. The orders of mayflies (Ephemeroptera) and dragonflies (Odonata) are the only living representatives of this division. The other two stages of winged insects, belonging to the division Neoptera, are able to fold their wings back over the abdomen in the resting state, a device that enables them to crawl among foliage, to hide under logs and stones, and even to burrow in the ground. The most generalized forms of the Neoptera, called Exopterygota, have a direct type of development, the wings forming on the outside of the body and the immature stages (nymphs) resembling the adult in general form, living in the same environment as the adult and feeding on the same types of food.

The Exopterygota include living types like the stone flies (Plecoptera, or Perlaria), cockroaches (Blattaria), grasshoppers and allies (Orthoptera), and true bugs (Hemiptera), as well as several other smaller orders. The more highly specialized members of the Neoptera and of all known insects have a more complicated life history, the wings developing beneath the integument in the immature stages. The Neoptera, called Endopterygota, are characterized by early immature stages (larvae) that appear very different from the adults, occupy different environments, and feed upon different types of food. To this series belong about 88% of the living species of insects, including beetles, true flies, butterflies, moths, ants, bees, and wasps, as well as other smaller orders.

The earliest known Apterygota are found in the Upper Carboniferous strata of France; the same type of insect is also found in Permian deposits of the U.S.S.R. These fossil insects resemble silverfish but have less specialized appendages and body structures. The presence of such apterygotes in the Carboniferous strata shows that the insect line had obviously been in existence well before the Upper Carboniferous, certainly well into the Lower Carboniferous, and perhaps even in the Devonian. The earliest remains of the Pterygota have been found in lower strata of the Upper Carboniferous. Since the species found there, although few in number, belong to two orders (one of them being neopterous), the record clearly supports the previous conclusion that the insects had already gone through considerable development before the Upper Carboniferous Age.

Distribution in the Geologic Past.—The fossil record shows that insects developed many specializations and differentiated into several ordinal lines early in their geological history.

Carboniferous.—The insect faunas of the Upper Carboniferous Period were fundamentally primitive. It was unique in two respects: (1) it included many more extinct orders than living ones; and (2) the palaeopterous orders were more numerous than the neopterous. Five of the extinct palaeopterous orders listed below (see *Extinct Orders*) were included in the Carboniferous faunas: the Palaeodictyoptera, Protephemerida, Megasecoptera, Protodonata, and Protohemiptera. The neopterous orders of the Carboniferous were the Protorthoptera, the Caloneurodea, and the living order Blattaria (cockroaches). The presence of the latter in the Carboniferous strata is especially interesting, since its members were the most abundant of all the Carboniferous insects. These Carboniferous cockroaches were remarkably similar to the types now living, differing only in having a more primitive venational pattern. The known Carboniferous fossils show that the insects had acquired surprising diversity, the full degree of which is probably not fully recognized, by the end of the Upper Carboniferous Period; additional records will doubtlessly reveal many other extinct orders and lines of evolution.

Permian.—The insects of the Early Permian Period present distinctive faunas, consisting of a combination of nine extinct and seven living orders. The extinct orders include all of those known from Carboniferous strata (except the Protephemerida) and in addition several others. The Palaeodictyoptera and Protohemiptera had apparently reached their maximum development in the Upper Carboniferous, only a very few having been found in Permian strata. In contrast, the Megasecoptera showed even greater diversity in the Permian than in the Carboniferous. The Protodonata were also more numerous in the Permian than in the Carboniferous Period and included more species of the very large forms. Since

no flying vertebrates were then in existence, these large predatory insects presumably ruled the air for many millions of years. The Permian Protorthoptera continued to show marked diversity of structure. The additional extinct orders which made their first appearance in the Early Permian were the Protelytroptera, the Protoperlaria, and the Glosselytrodea. The living insects of the Early Permian included, in addition to the cockroaches, the orders consisting of the mayflies, dragonflies, bark lice (Psocoptera), true bugs, scorpion flies (Mecoptera), and Dobson flies (Neuroptera). All of these Permian representatives were more generalized in most respects than the living members of their orders. The Permian mayflies, for example, had front and hind wings similar to those in living species, although in the living species the hind pair are much reduced in size and venation. This type of evidence indicates that the Early Permian was apparently close to the time of origin of most of these orders.

Before the end of the Permian Period, three more living orders of insects appeared in the strata. One of these, the stone flies, included a species found in the Late Permian of Australia which can be assigned to the living family Estheniidae. The other two orders comprise the thrips (Thysanoptera) and the beetles (Coleoptera). The dominant insects of the Late Permian Age were the true bugs (Hemiptera, specifically of the suborder Homoptera), which were clearly adapted for feeding on juices of plants.

Mesozoic.—The insects of the Triassic Period presented a striking contrast to those of the Permian; with the exception of the Protodonata and the Glosselytrodea all extinct orders had disappeared, so that the faunas as a whole assumed a semblance of those now living. True Orthoptera first appear in Triassic strata, including species having well-developed stridulatory structures on the fore wing of the males. By the beginning of the Jurassic Period, the Protodonata apparently became extinct, perhaps because of the advent of flying reptiles and primitive birds. Additional living orders, the earwigs (Dermaptera), caddis flies (Trichoptera), true flies (Diptera), and ants, bees, and wasps (Hymenoptera) appeared before the end of the Jurassic. Many of the Jurassic insects belonged to living families, but by far the majority represented extinct ones. Notably absent were some of the dominant families of the present time—certain families of Hymenoptera and the numerous families of the more specialized Diptera. Cretaceous insects were so few in number that they do not provide even a suggestion of the degree of development of the insect faunas of the time. This gap is unfortunate, for it was that period which saw the rapid development of the flowering plants.

Tertiary.—The insects of the Early Tertiary Period consisted almost exclusively of families and genera now living. The orders of the butterflies and moths (Lepidoptera) and the termites (Isoptera) first appear in Tertiary rocks, although it is highly probable that these groups arose earlier, in the Mesozoic Era. The insects preserved in Baltic amber have enabled more exact comparisons with living insects than ordinary preservation in rock deposits would permit. It is apparent that some of the Baltic amber insects, such as certain ants, were very close in structure to certain living species, perhaps the same species. The amber insects have also furnished proof of the existence of social habits among the insects of the Early Tertiary. For example, the amber ants included major and minor workers that took part in the complex social activities of the colonies. Not all of the families of insects had acquired this evolutionary stability by the Tertiary Period; all of the bees preserved in the amber belong to extinct genera.

The study of Tertiary insects has contributed a great deal to understanding the changes that have taken place in the geographical distribution of living families and genera. It has become clear that many living genera now found in Europe and Asia, but absent at present from North America, occurred in certain parts of North America during the Tertiary Period. One of the best known examples is the existence in Colorado during Tertiary times of tsetse flies (Diptera), a family now confined to Africa.

EXTINCT ORDERS

Many of the insects found in Carboniferous and Permian strata are excluded from living orders by the nature of their structure, especially wing venation, and are placed in extinct orders. Although over 40 extinct orders of insects have been established in the literature, only 11 of these are well enough known and seem to be sufficiently different from living groups to justify their recognition.

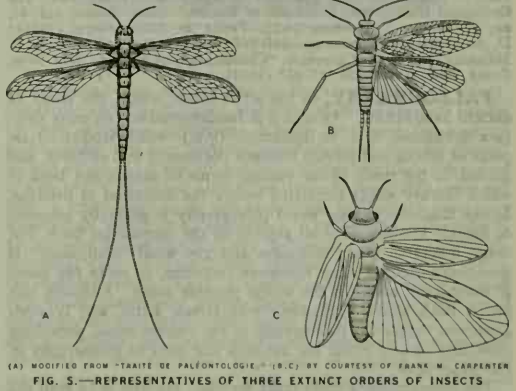
Apterygota.—The apterygote Monura represents an extinct order resembling silverfish but having less refined appendages and body structure. The earliest forms have been found in the Upper Carboniferous strata of France and in Permian deposits of the U.S.S.R.

Pterygota (Palaeoptera).—*Palaeodictyoptera.*—The Palaeodictyoptera were mayflylike insects found in Upper Carboniferous and Permian deposits of North America and Eurasia. They were small to medium-sized and had few specializations; the fore and hind wings were alike, or nearly so, in shape and venation; the legs were adapted for walking, and the slender abdomen terminated in a pair of conspicuous segmented processes, the cerci. Most of the Palaeodictyoptera possessed a pair of small membranous lobes on the first thoracic segment (prothorax). These lobes apparently were homologous with the true wings of the second and third segments. The immature stages of these insects are unknown, but their development was presumably of the exopterygote type. Twenty-five families have been described.

Megasecoptera.—The Megasecoptera, also known from the Upper Carboniferous and Permian strata of North America and Eurasia, were similar to the Palaeodictyoptera in many respects but had more specialized wings and wing venation, with frequent fusion of certain veins. The head and legs showed specializations of various types; the cerci were very long, usually as long as the whole body of the insect. The immature stages of one family are known and these are of the exopterygote type. The adults of some families were apparently able to flex their wings over the abdomen, although the mechanism for this was presumably developed independently of that of the true Neoptera. Eighteen families of Megasecoptera have been described.

Protephemerida.—The order Protephemerida is known only from one Upper Carboniferous deposit of France (Commentry) and includes species closely related to the existing mayflies but with a venational pattern more like that of the Palaeodictyoptera. A median caudal filament was present between the cerci, as in true mayflies. The immature stages are unknown.

Protodonata.—The order Protodonata, consisting of three families, includes large to very large insects related to the living dragonflies but differing in venational details. The large mandibles and spiny legs were apparently adaptations to a predaceous habit. Some of the species, having a wing expanse of about 30 in., were the largest insects known to have existed. The immature stages have not been found.



(A) MODIFIED FROM "TRAITÉ DE PALÉONTOLOGIE" (B,C) BY COURTESY OF FRANK M. CARPENTER

FIG. 5.—REPRESENTATIVES OF THREE EXTINCT ORDERS OF INSECTS

(A) Megasecoptera (*Mischoptera nigra*) from the Upper Carboniferous of France, (B) Protorthoptera (*Liomopterum ornatum*) from Permian of Kansas, only right wings shown, (C) Protelytroptera (*Protelytron permianum*) from Permian of Kansas

Protohemiptera.—The order Protohemiptera, consisting of three Upper Carboniferous and Permian families, includes medium-sized insects related to the Palaeodictyoptera, but the head and mouth parts are modified to form a beak, presumably used for sucking up liquid foods. The immature stages are unknown.

Pterygota (Neoptera).—The following orders all belong to the exopterygote series, there being no extinct orders in the endopterygote line.

Protoperlaria.—The Protoperlaria, known from Permian deposits of Europe and North America, were small or medium-sized insects related to the living stone flies. The first thoracic segment of the adult had prominent membranous lobes like those of the Palaeodictyoptera, but the hind wings were considerably broader than the fore wings and included an anal fan. The nymphs were aquatic, having swimming limbs as well as tracheal gills. Only a single family of this order is known.

Protorthoptera.—The Protorthoptera is an extinct order including small to large insects related to the grasshoppers, the cockroaches, and also to the stone flies. Representatives of the order have been found in Upper Carboniferous and Permian strata. This was a very large and perhaps artificial assemblage of species that had little in common except their orthopteroid features. The front wings were slender and usually somewhat thickened, forming tegmina; the hind wings were membranous, with a large anal area. The legs were variously modified for running or jumping or occasionally for predation. Fifty–seven families of this order have been described.

Caloneurodea.—The Caloneurodea is an order of small to large insects related to the Protorthoptera, but differ in possessing similar membranous fore and hind wings, with no enlarged anal area in the hind wing. The immature stages are unknown. The order has been found in Upper Carboniferous and Permian deposits, with six families included.

Glosselytrodea.—The Glosselytrodea were small species known from the Upper Permian to Jurassic strata and probably related to the Caloneurodea. Only two families have been described. The hind wings are unknown, but the fore wings had a precostal bulge and a submarginal vein that extended around almost the entire wing. Immature stages are unknown.

Protelytroptera.—The Protelytroptera were small insects found in Carboniferous and Permian strata, apparently related to the earwigs and to the cockroaches. The front wings were in the form of elytra, superficially resembling those of beetles but possessing true venation. The hind wings were broad and expanded like those of the earwigs. Only six families have been described; the immature stages are entirely unknown.

See also INSECT.

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PALEOGRAPHY, in the strict sense, means the study of ancient handwriting. As such it is fundamental to two more complex disciplines: first, to diplomatic (*q.v.*), which studies all aspects of official and private business documents and archives, and second, to the study of the various forms of manuscript book in which literary works circulated before the invention of printing. In the English-speaking world paleography is generally assumed to include knowledge of all aspects of the manuscript book, but usage differs in other languages and the word "codicology" is sometimes used, in some European countries, to mean the study of manuscript books in the widest possible sense. Although this article deals almost exclusively with Greek, Latin, and Western European vernacular paleography in the stricter sense, something must first be said about the methods and aims of paleography in the wider sense.

The paleographer's basic tasks are two: the first is to read the handwritings of the past correctly; the second—more interesting and more complex—is to date and localize manuscript books by examining their physical features, including the script, in the light of any internal evidence that may be supplied by their contents, and any external evidence—from documents, chronicles, and the like—that may be available. Like any other archaeologist, the paleographer works outward from a small core of securely dated and localized examples to the great majority of manuscripts for which style and technique furnish the only evidence. Besides handwriting, the paleographer considers the materials of books (papyrus, parchment; *qq.v.*, and paper) and their form (roll, codex), the writing implement (stylus, reed, quill), the binding (*see* BOOKBINDING), the decoration (*see* ILLUMINATED MANUSCRIPTS). All these physical features have to be examined as possible sources of information, and any one of them may furnish the key to the problem in hand.

Since knowledge of the provenance of a book may help to establish its place of origin, the student must be familiar with the histories of medieval libraries and of subsequent collections of manuscripts. He must also understand the practices followed by authors, scribes, booksellers, and others when composing, copying, or distributing books. He is also expected to deal with literary papers and correspondence, a field in which he may be occasionally asked to identify forgeries.

Paleography is commonly regarded as a subject for classicists and medievalists only, but it has no fixed limit and some 17th-century hands are difficult to read without paleographical training. If the development of writing is not followed down to the present, as it is in this article, the subject loses much of its interest as an index of the continuity of European civilization since Classical times. Although this article is confined to Western civilization, any ancient script may be the subject of paleographical inquiry, and paleography is closely related to epigraphy (*q.v.*), the study of inscriptions on durable materials such as stone or metal.

Paleography is in itself an absorbing subject, but its ultimate justification lies in the information which it alone can give about the development of literary and artistic culture. Illuminated manuscripts are among the richest and most accurately datable sources for medieval art, and their decoration and illustration are always intimately related to work in other media, from wall painting and architectural sculpture to ivory carving and metalwork. On the literary side, knowledge of how texts were transmitted from the remote past to the present, an important branch of the history of civilization, would be infinitely poorer without the evidence about the dates, origins, and subsequent histories of manuscript books which it is the paleographer's duty to discover.

This article is divided into the following sections and subsections.

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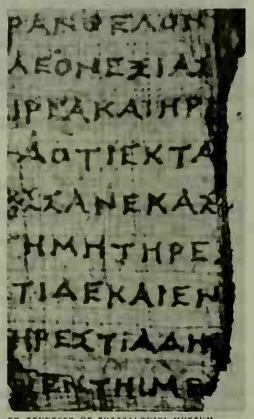
I. GREEK PALEOGRAPHY TO 8TH CENTURY A.D.

1. Materials for Study.—The oldest Greek writing, syllabic signs scratched with a stylus on sun-dried clay, is that of the Linear B tablets found in Knossos, Pylos, and Mycenae (1400–1200 B.C.; *see* MINOAN LINEAR SCRIPTS). Alphabetic writing, in use before the end of the 8th century B.C., is first found in a scratched inscription on a jug awarded as a prize in Athens. The consensus is that the Homeric poems were written down not later than this time; certainly from Archilochus onward (7th century B.C.) individuals committed their works to writing. But the vehicles of literary writing have perished. Scratchings on pottery or metal and then texts deliberately cut in bronze or marble or painted on vases are, until *c.* 350 B.C., the only immediate evidence for the way the Greeks wrote, and their study is normally treated as the province of epigraphy (*see* INSCRIPTIONS).



BY COURTESY OF THESSALONIKI MUSEUM

FIG. 1.—RELIGIOUS TEXT, 4TH CENTURY B.C.: PAPYRUS FROM DERVENI

A find in 1962 at Derveni in Macedonia of a carbonized roll of papyrus offers the oldest and only example of Greek handwriting preserved in the Greek peninsula (4th century B.C.). From then until the 4th century A.D. the paleographer's materials consist of the countless texts, especially on papyrus, found in and, with a few exceptions, written in Egypt, which have given a firm foundation for knowledge. From outside Egypt there is a Greek library buried in Herculaneum, 79 A.D.; and papyri and parchments from Avroman in Kurdistan, 1st century B.C.; Doura-Europus on the Euphrates, 3rd century B.C. to 3rd century A.D.; from Nessana, 6th century A.D., and from the Dead Sea area (Qumran, 1st centuries B.C. and A.D.; Murabbaat and Engedi, 2nd century A.D.). A number of original vellum manuscripts has survived from the 4th century A.D. onward, preserved in libraries such as the monastery of Mt. Sinai. These materials of diverse origin suggest that the forms and shape of Greek handwriting were remarkably constant throughout the Greek world, wherever writing was practised and whatever the material used; inside this consistent framework it is occasionally possible to distinguish local variations (as between the contract hands of 1st-century-A.D. Doura and of Egypt).

2. Writing Materials.—The principal vehicles for writing were wax tablets incised with a stylus, or a prepared surface of skin, such as leather and vellum, or of papyrus written on with a pen (*see* PAPYRUS; PARCHMENT). Other surfaces—*e.g.*, broken pieces of pottery, lead, wood, and even cloth—were also used. To some extent the forms of letters were affected by the resistance of the material to the writing instrument. It is likely that the use as a pen of a hard reed, split at the tip and cut into a nib (which must be constantly sharpened) is an invention of the Greeks. Egyptian scribes used a soft reed, with which ink was brushed on.

Till about A.D. 300 ink was normally made of a carbon such as lampblack, mixed with gum and water, which even today retains its black lustre. After that time, because of the increasing popularity of vellum, iron inks (*e.g.*, of oak galls), better suited to vellum, tended to replace carbon. The iron inks have faded with age, and often have eaten by chemical action into the vellum. Erasures could be made on wax with the blunt end of the stylus, on papyrus by wiping with a sponge; but on vellum written in iron ink erasures could be made only by rubbing with pumice or scraping with a knife. Texts from which a previous writing was deliberately erased to provide writing material are termed palimpsests; the earlier writing can often be read, especially with the help of ultraviolet or infrared rays.

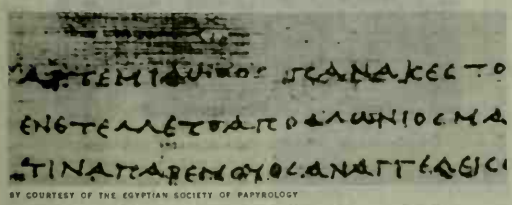


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FIG. 2.—PRIVATE LETTER, 257 B.C. (P. CAIRO ZENO 59816)

Papyrus was normally sold in rolls (*volumina*) made up of 20 or 50 glued sheets: the horizontal fibres of the papyrus are placed on the inside of the roll, on which side (the *recto*) each gummed sheet overlaps the next horizontally. Leather, similarly, was for long made into rolls (*cf.* the Dead Sea scrolls). Shortly after the beginning of the Christian era the custom began of folding a single sheet (or several superposed sheets, a quaternion or quire) down the middle and stitching the quires into a binding case to give a book of modern form (codex, originally a set of wax tablets coupled with a thong). Tradition associated this invention with Pergamum.

The decisive impetus to the use of this form came from the early Christians, who deliberately chose the commercial vellum notebook (*membranae*) in which to circulate the Christian Gospels in preference to the traditional Jewish roll. Almost without exception the earliest texts of the New Testament are in codex form, even though written on papyrus, which is less able than vellum to bear repeated bending. In the 2nd century A.D. pagan works of literature appeared in this format, which gained ground in the 3rd century, often in small or utility sizes. By the 4th century it became the predominant form, and codices with handsome margins, of dazzling white vellum, and sufficient size to contain the whole Bible (*e.g.*, the Codex Sinaiticus) were being produced.

3. Types of Handwriting.—The fundamental distinction is that between book hands and documentary hands. The former, used especially for the copying of literature, aimed at clarity, regularity, and impersonality, and often made an effect of beauty by their deliberate stylization. Usually they were the work of professionals, who may have multiplied copies to dictation, though ancient evidence on this subject is unreliable and the evidence of scribal errors equivocal (since the ancients invariably read out loud, a scribe copying by eye in solitude is likely to have pronounced the words of his exemplar). Outstanding calligraphy is not common among papyrus finds, perhaps because they are mainly provincial work. But the British Museum Bacchylides (fig. 8) or the Bodleian Homer (fig. 7) can stand comparison with any later vellum manuscript from outside Egypt. Book texts are written in separately made capitals (often called uncials, but in Greek paleography, except for the time-hallowed class of biblical uncials, the term is better avoided) in columns of writing, with ample spaces between columns and good margins at head and foot. Punctuation (usually by high dot) is minimal or completely absent; accents are inserted only in difficult poetic texts or as practice by schoolboys; and letters are not grouped into separate words.

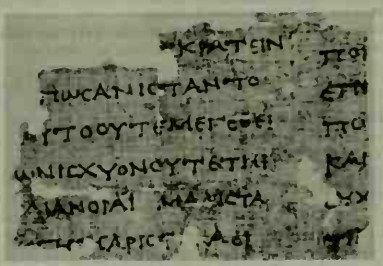

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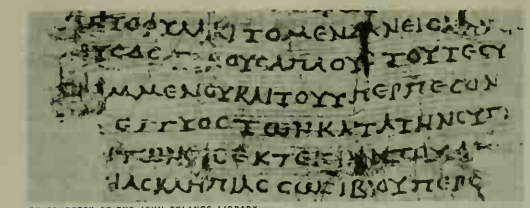
FIG. 3.—BOOK HAND: THUCYDIDES, 3RD CENTURY B.C. (P. HAMBURG 163)

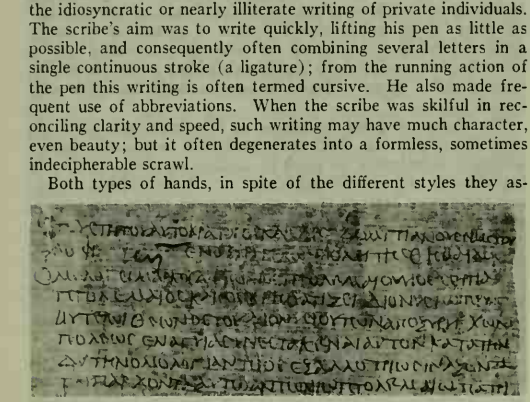


BY COURTESY OF THE JOHN RYLANDS LIBRARY

FIG. 4.—LEGAL TEXT, 99 B.C. (P. RYL.IV 586)

Documentary hands show a considerable range: stylized official "chancery" hands; the workaday writing of government clerks or of the street scribes who drew up wills or wrote letters to order; the idiosyncratic or nearly illiterate writing of private individuals. The scribe's aim was to write quickly, lifting his pen as little as possible, and consequently often combining several letters in a single continuous stroke (a ligature); from the running action of the pen this writing is often termed cursive. He also made frequent use of abbreviations. When the scribe was skilful in reconciling clarity and speed, such writing may have much character, even beauty; but it often degenerates into a formless, sometimes indecipherable scrawl.

Both types of hands, in spite of the different styles they assume at different periods, show remarkable uniformity and continuity in the shapes of letters. Behind both lies an unvarying basic alphabetic form taught in the schools. The more skilful a book hand scribe was, the harder it is to date his work. Documents in the ancient world carried a precise date; books never did. To assign dates to the latter, the paleographer takes account of their content, the archaeological context of their discovery, and technical points of book construction (*e.g.*, quires, rulings) or modes of abbreviation. But he finds of great service: (1) a stylistic comparison with those dated documentary hands which show resemblances to book hands; (2) those cases where a roll was reused—*i.e.*, has a literary text on its recto and a dated document on its verso (in which case there is a *terminus ante quem* for the literary text, often estimated at 50 years before the date of the verso), or has a dated document on the recto and a book hand on the verso (which gives a *terminus post quem* for the literary text, not more than 25 years after the document). Not much help is gained from illustrations in dating Greek manuscripts of this period; the number of illustrated manuscripts is small; their quality is varied; and there is no agreement between specialists about the sources from which illustrations were taken.



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 5.—AUTHORIZATION FOR SALE OF SLAVES, LATE 1ST CENTURY A.D. (P. OXY. 94)

4. Successive Epochs.—Any historical sketch is bound to be a simplification. At certain epochs several different styles of handwriting existed simultaneously, so that there is no straight line of development. Moreover, owing to the arbitrariness of finds, generalizations are based on mainly provincial work; and, even in that, examples of book hand belonging to the 2nd century B.C. and the 5th century A.D. are still relatively rare.

Ptolemaic Period.—In the roll from Derveni, Macedonia (fig. 1), dated on archaeological grounds to the 4th century B.C., lines and letters are well spaced and the letters carefully made in an epigraphic style, especially the square E, four-barred Σ, and arched Ω; the whole layout gives the effect of an inscription. In the Timotheus roll in Berlin (dated 350–330 B.C. on archaeological grounds) or the curse of Artèmisia in Vienna (4th century B.C.) the writing is cruder, and ω is in transition to the form which is afterward the invariable written form. Similar features can be seen in the earliest precisely dated document, a marriage contract of 311 B.C. It has indeed been argued that a documentary hand of cursive type had not yet been developed, and that it was a creation of the Alexandrian library. Plato, however (*Laws* 810), speaks of Athenian writing whose aim was speed; and later on, when a cursive hand had certainly been developed, documentary scribes often chose to use separate capitals; *e.g.*, fig. 2, a private letter of 257 B.C.

Characteristic of its period is the contrast of size between long letters (*e.g.*, Μ) and narrow letters (Ε Ϲ Θ or Θ, Ο or ο); and characteristic forms are to be seen in the letters Τ (with its long crossbar, often with initial stroke), Υ (upsilon) with long shallow bowl, Μ or Μ in three or four strokes, Ν in three strokes, α (alpha) raised off the line and its last vertical not finished, small round ο (with internal dot or tiny stroke), broad epigraphic Α and Η. These same features, written with more regularity, appear in the contemporary book hand of fig. 3, a fragment of Thucydides. In documentary cursive hands of this period letters seem to hang from an upper line; ⊬ (alpha) often turns into a mere wedge, ⊬ (nu) lifts its second vertical above the line. In the 2nd century B.C. the contrast between long letters and narrow letters disappears, the writing grows rounder, and letters are often linked by ligatures at the top of their last vertical (*e.g.*, ⊢ Μ Ν). In fig. 4, a contract of loan of 99 B.C., in which capitals and cursive are mixed, this irregular roundness is clearly seen. Note the ε with detached crossbar, and the exaggerated serifs (Τ Κ Υ Ρ), which have been elevated by some paleographers into a criterion of a special style, though in fact they are always liable to occur (figs. 1 and 2).

Roman Period.—Half a century or so passes after 30 B.C. before a definitely Roman manner is established. In documentary hands the tendency to roundness continues. Documentary cursive may be influenced in various ways (*e.g.*, by Latin forms such as those of *e* and *d*, or by the exaggeration of verticals practised by chancery scribes), may lean over in either direction, or may be reduced to tiny proportions. In the 2nd century the cursive hand tends to be round and sprawling, in the 3rd century to become more angular, in the 4th century to become characterless and to combine letters into ligatures that distort the forms of the letters concerned. A typical small late-1st-century-A.D. round cursive

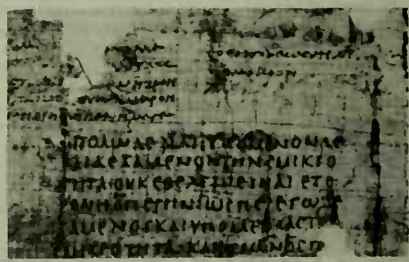


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FIG. 6.—PLATO, "PHAEDO," C. A.D. 100 (P. OXY. 1809)

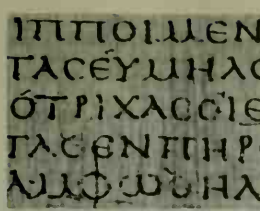

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FIG. 7.—HOMER, "ILIAD," 2ND CENTURY A.D. (OXFORD, BODLEIAN LIBRARY, MS. GR. CLASS.A.1. [P])

may be seen in fig. 5. The book hand of the Plato papyrus in fig. 6 shares its informality but regularizes the letter forms. Written on a larger scale and with more formality, this round hand can be very beautiful. In fig. 7, for example, found at Hawara (2nd century A.D.), almost every letter (even ρ, τ, ι) would go into an identical square: only ϕ and ψ cross it above and below, μ, ω, and π horizontally.

If this writing is made to lean to the right, and to revive the 3rd-century-B.C. distinction between narrow and broad letters, it takes on the aspect of the "severe" style, a technically admirable example of which is shown in fig. 8, the Bacchylides roll in the British Museum (2nd century A.D.). If, on the other hand, the scribe makes his verticals or obliques thicker, and his horizontals thinner, the hand is called biblical uncial, so named because this type of writing is employed in the three great early vellum codices of the Bible, Codex Vaticanus and Codex Sinaiticus of the 4th century and Codex Alexandrinus of the 5th century. It is now certain that this style goes back to the 2nd century A.D. But the example of it illustrated in fig. 9 is relatively late (the Dioscorides

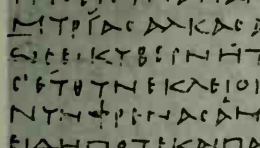

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FIG. 8.—BACCHYLIDES, 2ND CENTURY A.D. (P. BRITISH MUSEUM 733)

herbal in Vienna, written in A.D. 512), in which the writing has become rigid and lumbering; the thick strokes are overdone; and blobs of ink terminate the horizontals of, *e.g.*, δ, ϵ, σ, τ. Such heavy decoration is also a feature of the Coptic style, of which there are examples as early as the 2nd century A.D. This hand may be thought of as constituting a special case of biblical uncial.

Byzantine Period.—For the paleographer the significant division is not the founding of Constantinople in 330 but the 5th century, from which a few firmly dated texts survive. At its close a large-sized, exuberant, and florid cursive is found fully established for documents; in the 7th and 8th centuries it slopes to the right, becomes congested, and adopts some forms of letters which anticipate the minuscule hand (*e.g.*, the π and λ in fig. 12). No new book hand was invented. A favourite informal type of the 6th century is shown in fig. 11, an acrostic poem by Dioscorus of Aphrodito; it bears a clear relationship to the Menander *Dyskolos* hand of fig. 10, which was probably written in the later 3rd century A.D. Similar pairs could be found to illustrate the continuity in transformation of the biblical uncial and Coptic styles. The latest Greek papyrus from Egypt is not later than the 8th century. There is a considerable lapse of time before the history of Greek writing resumes at Byzantium. (E. G. T.)

II. GREEK PALEOGRAPHY, 8TH to 16TH CENTURIES A.D.

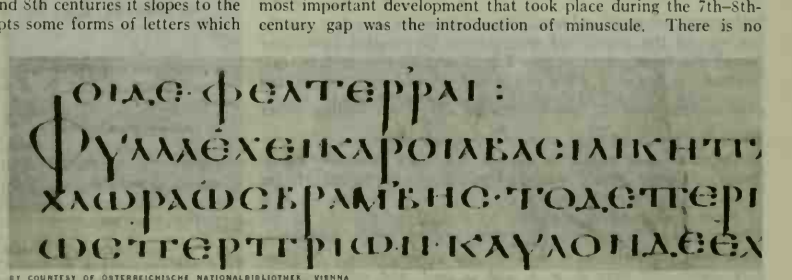
To judge when and where a Greek manuscript was written is as difficult in this as in the earlier period, but for different reasons. The material for study is admittedly more extensive; manuscripts produced in the Middle Ages and Renaissance have been preserved in very large numbers (more than 50,000 whole volumes survive, of which probably 4,000 or 5,000 are explicitly dated); and they include work from most parts of the Byzantine Empire as well as from Italy. The difficulty of the paleographer lies in the essential homogeneity of the material, which is largely the result of the conditions in which the manuscripts were produced.

The fully developed Byzantine Empire of the 8th to the mid-15th centuries was extraordinarily uniform in its culture. Its contraction in space after the Arab conquests of the 7th century, which cut off the more distant and ethnically differentiated provinces of Syria, Palestine, and Egypt, made it a relatively compact geographical entity. The continuity and comparative stability of a single empire not divided into distinct national states such as evolved in the West resulted in a strength and unity of tradition of which the Byzantines were always conscious and which shows in their habits of writing no less than in their literature and art. Distinct local styles and sharp breaks in ways of writing in different periods cannot, therefore, be looked for; characteristics which may be specially typical of one period come in gradually and disappear equally slowly. A more potent factor than date or place in producing divergencies in the style of writing is the purpose for which a manuscript was designed and what type of scribe wrote it.

1. Late "Uncial," 9th to 12th Centuries.—There is a gap in the evidence covering the 7th and 8th centuries, owing partly to the Arab conquest of Egypt, partly to the perpetual wars on all fronts in the 7th century, and partly to the iconoclastic struggle (*see* ICONOCLASTIC CONTROVERSY) during the 8th and early 9th centuries, so that no literary texts have survived (and very few others) which can actually be dated to this period.

During this time the evolution of writing in capitals (not very aptly named "uncial") probably continued along the lines one would expect—toward a greater formality and artificiality. But this natural tendency was hastened by the introduction and spread of minuscule as the normal way of writing, after which the purpose of "uncial" changed completely. From an everyday hand in which all books were naturally written, it became a ceremonial hand used only for special copies, and therefore grew increasingly stylized and artificial. In the 9th century a still elegant style was used for both patristic and classical works in splendid volumes destined for the imperial library or for presentation copies, such as the copy of Gregory of Nazianzus made for the emperor Basil I between 879 and 883 (fig. 13). By the 11th and 12th centuries, capitals were used only for liturgical books, mainly lectionaries, which had to be read in dimly lit churches; but the increasing tortuousness of the style must in the end have reduced its usefulness, and by about 1200 "uncial" was dead.

2. Earliest Minuscule, 8th to 10th Centuries.—By far the most important development that took place during the 7th–8th-century gap was the introduction of minuscule. There is no



BY COURTESY OF ÖSTERREICHISCHE NATIONALBIBLIOTHEK VIENNA

FIG. 9.—DIOSCORIDES HERBAL, A.D. 512 (VIENNA, ÖSTERREICHISCHE NATIONALBIBLIOTHEK, MED. GR. 1)

incontrovertible evidence of how this came about, or where. What scraps of evidence there are (a few documents from the gap, a few sentences in lives of the abbots of Stoudion of that time, and

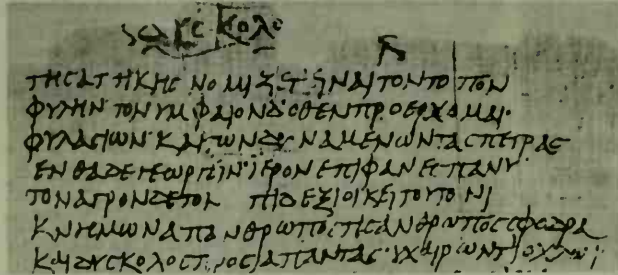


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FIG. 10.—MENANDER, "DYSKOLOS," PROBABLY LATE 3RD CENTURY A.D. (PAP. BODMER IV)

the first dated manuscript written in true minuscule) point to its development from a certain type of documentary hand used in the 8th century, and to the likelihood that the monastery of the Stoudion in Constantinople had a leading part in its early development. Though its origins are obscure, the reasons which led to its introduction and rapid spread are obvious: poverty induced by wars and persecutions coincided with a shortage of papyrus after the Arab conquest of Egypt in the middle of the 7th century to induce a search for a more economical use of the relatively expensive vellum; the polemics of the iconoclastic controversy demanded a speedy, informal style of writing; and finally, when peace was restored in the middle of the 9th century, the revival of learning, with the reorganization of the university, brought the need for multiplying plain workmanlike texts for scholarly purposes.

The earliest dated example of true minuscule (and it is probably one of the oldest extant examples altogether) is a copy of the Gospels written in 835 almost certainly in the monastery of the Stoudion (fig. 14). Here are found all the characteristics of the earliest minuscule, which is called pure minuscule because there is as yet no admixture of uncial forms, except occasionally at line ends. The letters are even and of a uniform size; letters are joined or not joined to each other according to strict rules, sometimes by ligatures in which part of each letter is merged in the other, but not to the extent of distorting the shape of either letter. There is no division between words, for the divisions are only those that arise from the rules for joining or otherwise of individual letters, and at this stage any letter that can be joined to the next one nearly always is joined to it. Breathings are square, either ⊢ ⊣ or ⌊ ⌋, and accents are small and neat; abbreviations are very few, usually confined to the established contractions for *nomina sacra* (the names and descriptions of the Trinity and certain derivatives), omitted *ν* at line ends, a few of the conventional signs for omitted case endings, and ⨍ sometimes for *και*. The writing either stands on the ruled lines or is merely guided by them.

Absolutely pure minuscule did not last long. Gradually uncial forms of those letters that had specifically minuscule forms began to be used alongside the minuscule forms: λ was the first to appear, followed very closely by ξ, both by the end of the 9th century. Then from about 900 onward ζ, κ, ν, π, and σ were used regularly, α, γ, δ, ε, η, and ψ sometimes. Not before about 950 were β, μ, υ, and ω used, and still comparatively rarely. But by the end of the 10th century the interchangeability of all uncial and minuscule forms was complete, though all the alternative forms are not necessarily found in any one manuscript. Perhaps the earliest dated manuscript with any uncial form in it is of 892/893 (Sinai, St. Catherine, MS. 375 + Leningrad, Bibl. Publ. MS. 343, Chrysostom, facsimile in L. T. Lefort and J. Cochez, *Palaeographisch album*, 1932, facsimile 8), but pure minuscule continued to be used, in probably the majority of manuscripts, up to 900, and thereafter in a rapidly decreasing number until the last dated example in 969 (Meteora, Metamorph. MS. 565, John Climacus; facsimile in K. and S. Lake, *Dated Greek Minuscule Manuscripts to the Year 1200*, 1939, plates 754, 757). Besides the intrusion of uncial letters, some other characteristics of the earliest minuscule were modified during the 10th century. Rounded breathings ‘ ’ are first found in manuscripts of the last half of the century, interspersed with square ones. From about 925 the practice of making the writing hang from the ruled lines began to prevail. Although in most manuscripts abbreviations were confined to a few forms used at line ends only, a few copies dated in the last part of the century used nearly all the conventional signs.

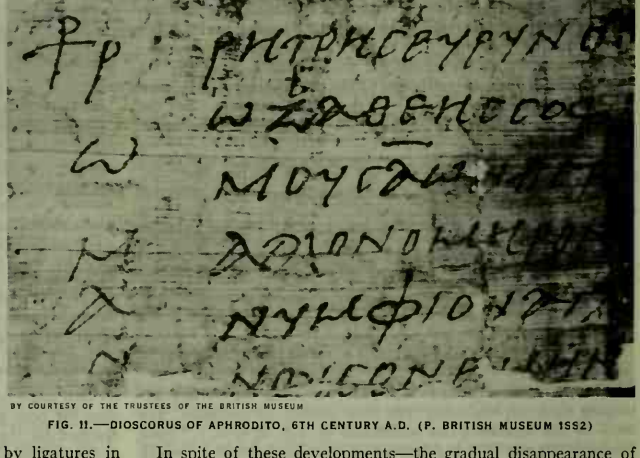

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FIG. 11.—DIOSCORUS OF APHRODITO, 6TH CENTURY A.D. (P. BRITISH MUSEUM 1582)

In spite of these developments—the gradual disappearance of pure minuscule and the other changes that accompanied it—the same general styles of writing persisted until about the end of the 10th century. Broadly considered, three styles can be distinguished. There is a rather primitive-looking angular, cramped style which may perhaps be associated with the Stoudion monastery, in which a certain number of mainly patristic texts was written *c.* 880–*c.* 980 (*e.g.*, Paris, Bibliothèque Nationale, MS. grec 1470, a menologion of 890, facsimile in Lefort and Cochez 7). Secondly, there is a plain, neat, workmanlike style (seen in a commentary on Gregory of Nazianzus copied in 986, fig. 15), which continued in use at least until the end of the 10th century. In it were written several of the important classical manuscripts which are now the oldest texts of some authors (*e.g.*, Aeschylus, Sophocles, Aristoph-

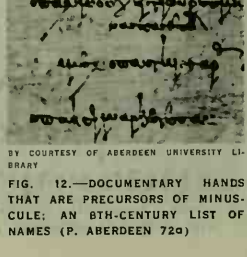

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FIG. 12.—DOCUMENTARY HANDS THAT ARE PRECURSORS OF MINUSCULE; AN 8TH-CENTURY LIST OF NAMES (P. ABERDEEN 72α)

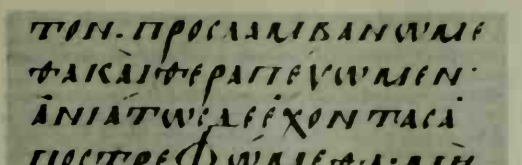

FIG. 13.—GREGORY OF NAZIANZUS. A.D. 879–883 (PARIS. BIBLIOTHÈQUE NATIONALE. MS. GR. S10 FOL. 61ᵛ)

anes) but are unfortunately not explicitly dated. Thirdly, a consciously elegant, even mannered, style was used in books made for the imperial library or for wealthy dignitaries, but is not found before the early years of the 10th century (seen in a copy of Basil on Isaiah made in 953, fig. 16). All these styles, which have many variations and are by no means always distinct from each other, are found at least till the end of the 10th century. Their one common characteristic is a crispness and individuality which distinguishes them from writing of the next period.

3. Formal Minuscule, 10th to 14th Centuries.—From about the middle of the 10th century a smoother, almost mechanical appearance can be noticed in an increasing number of manuscripts; the hands seem more stereotyped, less individual. They are not immediately distinguishable from the plainer styles of the earlier part of the century, and their evolution during the next four centuries was very gradual. A few distinct types can be singled out from time to time. A bold, round, heavy liturgical style, fully established in the 11th century, was one of the most enduring types (*e.g.*, London, British Museum Add. MS. 19,352, a psalter of 1066, facsimiles in the Palaeographical Society's *Facsimiles of Manuscripts and Inscriptions*, 1st series, ed. by E. A. Bond and E. Maunde Thompson, 1873–83, plate 53), which became more and more stereotyped and mechanical until in the 15th century a branch of it was transplanted to Italy.

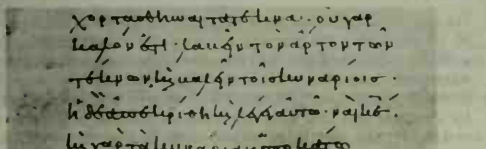

FIG. 14.—GOSPELS. A.D. 835 (LENINGRAD, BIBL. PUBL. MS. 219. FOL. 124)

The small, neat, happily named *Perlschrift*, which also had its flowering in the 11th century and is really a miniature version of the liturgical style, was used mainly for small copies of various parts of the Bible, most probably in monastic houses in Constantinople (*e.g.*, Milan, Biblioteca Ambrosiana F.12 sup., a psalter with catena of 961, facsimile in Lefort and Cochez 36). A very plain, businesslike, rather staccato style was used in manuscripts with musical notation, most commonly in the 12th and 13th centuries (*e.g.*, Leningrad, Bibl. Publ. MS. 789, a sticherarion of 1106, facsimile in Lake, plate 438).

Manuscripts written outside Constantinople are recognizable, if at all, usually by a rougher, provincial appearance. Only two styles can be assigned to a specific provincial centre: a small unpretentious hand used by St. Nilus, the founder of many monasteries in south Italy at the end of the 9th century, was used for a time by others in that part of the world (*e.g.*, a copy of the works of Dorotheus made by Nilus in 965, fig. 17). Later, in the heyday of the reorganized Greek monasteries there in the 12th century, an elegant, rather mannered style, which almost certainly had its origin in Constantinople, is nevertheless often found in manuscripts known to have been written in south Italy and Sicily (*e.g.*, Paris, Bibliothèque Nationale MS. grec 83; Gospels copied in Sicily in 1167, facsimile in Lake, plates 322–325, 330).

These particular styles, however, are not really as typical of the period as the less distinctive plain hands in which the majority of the manuscripts are written, at least in the 11th and 12th centuries (*e.g.*, a collection of canon law copied in 1042, fig. 18).

The comparatively uniform type of writing of which all these were minor variations was remarkably enduring and widely dispersed, but from the 11th century onward certain changes may be observed which help to date manuscripts written in all types of formal minuscule. One change in its general appearance may be noticed as the 12th century advances: an increasing lightness of touch and a lessening of the closely knit, rather thick appearance that is characteristic of the 11th century. But the most noticeable change in this period is the breakdown in the evenness and regularity of the writing, which is partly attributable to the influence of documentary and the later personal hands (*see* below). It is not, however, entirely so attributable, for a tendency to enlarge some letters out of proportion to the size of the rest is seen in a

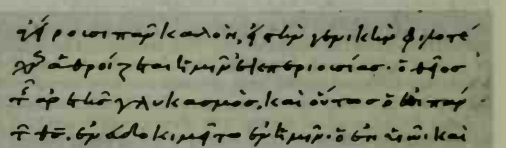

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FIG. 15.—COMMENTARY ON GREGORY OF NAZIANZUS. A.D. 986 (PARIS BIBLIOTHÈQUE NATIONALE, SUPPL. GR. 469ᴬ FOL. 7ᵛ)

small way in some of the more personal hands of the earliest period. But it is rare in formally written manuscripts, only gradually becoming more general until in the 12th and 13th centuries it is the most noticeable feature of even the most formal hands (*e.g.*, a synaxarion copied probably in 1329; fig. 19). In the 14th century and later there was a return to less flamboyant ways with the tendency to imitate earlier models more closely, but the habit of enlarging some and diminishing the size of other letters never died out.

In the actual forms of letters used in these formal styles there was practically no change; only occasionally from the end of the 12th century onward one of the "modern" forms of letter normally confined to personal hands found its way into a formal manuscript. Much the same holds good for ligatures. The tendency from the 11th century onward is to use ligatures and to join letters less automatically than in earlier times. The permissive rules and most of the forms remain unchanged, for already in the 10th century most of the distorting forms (notably those in which the ε is represented only by a *c*-shaped stroke; *e.g.*, ϲ for στ) were well established, and in formal manuscripts these, with the earlier

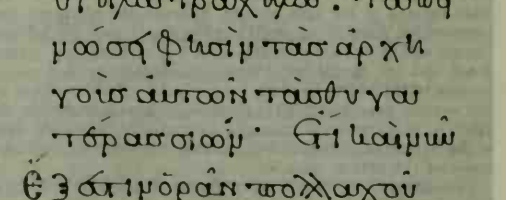

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FIG. 16.—BASIL'S COMMENTARY ON ISAIAH, A.D. 953 (OXFORD, BODLEIAN LIBRARY, MS. AUCT. E.2.12, FOL. 80)

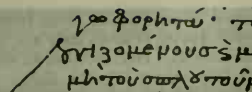

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FIG. 17.—DOROTHEUS, COPIED BY NILUS, A.D. 965 (GROTTAFERRATA MS. B. α 20) (FROM K. AND S. LAKE, "DATED GREEK MINUSCULE MANUSCRIPTS TO THE YEAR 1200")

forms, continued in use until they were illogically taken over by the first printers of Greek. Time did, however, gradually increase the tendency to join letters to each other by insetting them in or by superimposing them on each other. Abbreviations were even more conservatively used, only the oldest conventional forms being admitted, and often only a very few and those only at line ends.

The rule that the writing should hang from the ruled lines, already applied in most manuscripts by the mid-10th century, became invariable by the middle of the 11th. Square breathings (used indiscriminately among the round ones) were gradually eliminated, though they did not completely disappear from formal manuscripts until the middle of the 12th century. The practice of joining accents with breathings and also with the letters to which they belonged spread from personal hands to formal writing in the 13th century, but was far more often avoided altogether.

Apart from the actual writing, one development is common to all manuscripts written in this period: the use of paper instead of vellum, which occurred first perhaps in the late 11th century and was in regular use by the 13th century whenever economy was a major consideration.

These are the main criteria by which a formally written manuscript can be assigned to an earlier or a later part of this period. But the problem of distinguishing different styles and their dates, and still more their places of origin, remains more difficult for these than for any other Greek manuscripts.

4. Personal Hands, 12th to 14th Centuries.—From the be-

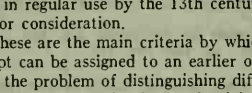

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FIG. 18.—CANON LAW, A.D. 1042 (OXFORD, BODLEIAN LIBRARY, MS. BAROCCI 196 FOL. 253)

ginning of minuscule there were obviously educated individuals who occasionally copied texts for their own use in a formal hand which nevertheless had a distinctive personal flavour; indeed, professional scribes occasionally used a less formal style than usual. Several dated examples of this type of hand survive from the 10th, 11th, and early 12th centuries, but they are rarities. Toward the end of the 12th century, however, the prosperity and comparative stability of the Comnenan age, with its brilliant literary and artistic achievements, gave way to increasing internal chaos and the hostile encirclement of Byzantium that was a prelude to the Fourth Crusade and the sack of Constantinople by the western powers in 1204. Scholars perhaps already felt the pinch of poverty, which naturally grew greater during the exile of the Byzantine court (1204–61) and culminated in the economic crises of the 14th century.

Certainly a change in writing habits began slowly to take place. Instead of commissioning professional scribes to copy manuscripts, some scholars began to make copies for themselves, and in place of the smooth, mechanical styles of the professionals they used the sort of writing that they presumably already used for personal notes. This was an adaptation (for greater clarity) of the type of writing that had been standardized in official documents from the beginning of the Byzantine period. Its chief characteristic was the greatly exaggerated size of certain letters or parts of letters, particularly letters with rounded bows such as $\beta, \epsilon, \zeta, \theta, \kappa, \xi, o, \upsilon, \phi$, and ω, and the excessive size of these letters is made to look even more unbalanced by some exceptionally small forms of (*e.g.*) η, ι, ν, or ρ. This essentially unbalanced, "wild" look was transplanted to literary manuscripts written by scholars for their own use.

Along with this exaggerated contrast in size between letters, they took from the documentary hands several new forms of letters that had gradually evolved from the originally common forms of both hands. In the 12th century the new scholarly hands began to use ε with separate small bows; ε, with a broken back; η, which had lost its high first stroke; and ν, which had dropped its

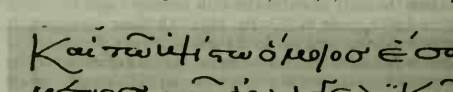

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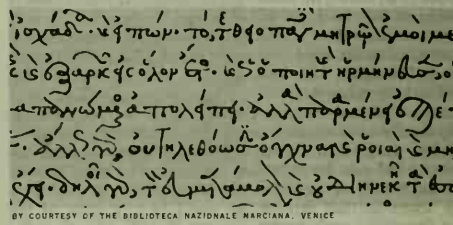
FIG. 19.—SYNAXARION, PROBABLY A.D. 1329 (OXFORD, BODLEIAN LIBRARY, MS. AUCT. E.S.10. FOL.73^{v})

first long down stroke; and by the end of the 13th century ς, with a short embryonic tail. The old forms of ligature were kept basically the same, but in some cases were reduced to a barely recognizable minimum (*e.g.*, $\varepsilon\iota$ for $\varepsilon\iota$) and in others distorted by the general flourishing tendency of the script (*e.g.*, $\varepsilon\pi$ for $\varepsilon\pi$). Abbreviations were naturally used with great frequency in all positions; the ancient conventional signs for suppressed syllables, which had acquired rounded and more flourished shapes, were used alongside a certain amount of "arbitrary" abbreviation in which a large part of a word was omitted and replaced simply by a general sign that some abbreviation had taken place.

Accents and breathings joined with each other, with letters, and with abbreviation marks are found earlier and more frequently in scholarly than in formal manuscripts. The only exception to the rule of round breathings in this type of manuscript is in cases of deliberate archaism such as Demetrius Triclinius (d. *c.* 1340) practised in his later years.

One of the earliest datable examples of these scholarly productions is the copy of his commentary on the *Odyssey* written *c.* 1150–70 by Eustathius, the scholar-archbishop of Thessalonica (fig. 20). In the 13th century the exaggeration of specially round



BY COURTESY OF THE BIBLIOTECA NAZIONALE MARCIANA, VENICE

FIG. 20.—EUSTATHIUS (AUTOGRAPH), COMMENTARY ON THE "ODYSSEY," *c.* A.D. 1150–70 (VENICE, BIBLIOTECA NAZIONALE MARCIANA, MS. GR. 460 FOL. 79)

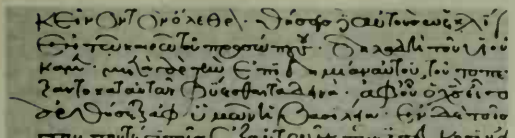


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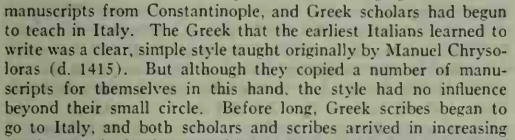
FIG. 21.—ZIGABENUS' COMMENTARY ON THE PSALMS, A.D. 1279 (OXFORD, BODLEIAN LIBRARY MS. ROE 7 FOL. 60v)

features reached its height (*e.g.*, in a copy of Euthymius Zigabenus on the Psalms, of 1279; fig. 21), while in the 14th century the tendency, as in the formal styles of writing, was toward less ebullience and exaggeration in all ways, and the writing of scholars such as Triclinius is compact and sober (*e.g.*, his copy of Aphthonius and other grammatical works, of 1308; fig. 22). For these hands the problem is not to discover centres of writing or styles for different uses, but to identify the hands of individual scholars.

5. The Italian Renaissance.—By the end of the 14th century, Italian scholars were learning Greek and bringing back Greek manuscripts from Constantinople, and Greek scholars had begun to teach in Italy. The Greek that the earliest Italians learned to write was a clear, simple style taught originally by Manuel Chrysoloras (d. 1415). But although they copied a number of manuscripts for themselves in this hand, the style had no influence beyond their small circle. Before long, Greek scribes began to go to Italy, and both scholars and scribes arrived in increasing numbers as the Turks pressed in round the Byzantine capital until it finally fell in 1453. They brought with them, naturally, the two styles of writing that had persisted throughout the history of the empire. On the one hand, professional scribes such as Joannes Rhosus (d. 1497–1500), the majority of them from Crete,



BY COURTESY OF NEW COLLEGE, OXFORD

FIG. 22.—GRAMMATICAL WORKS COPIED BY TRICLINIUS, A.D. 1308 (OXFORD, NEW COLLEGE MS. 258 FOL. 205)

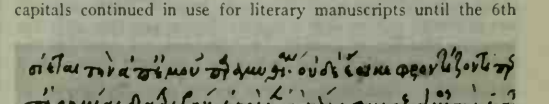
copied an astonishing number of manuscripts in the formal, now glib and stereotyped "liturgical" style of writing (*e.g.*, London, British Museum Harl. 5658, an *Odyssey* copied by Rhosus in Rome in 1479, facsimile in E. Maunde Thompson 81). On the other hand, scholars such as Janus Lascaris (*c.* 1445–*c.* 1535) continued to write in a mannered personal style (*e.g.*, a letter of Demetrius Chalcondyles of 1488; fig. 23).

It was on the scholarly hands that Aldus Manutius and other early Italian printers of Greek based their types. But perhaps the most enduring of all styles was that of a group of Cretan scribes who made their way to France and were employed by Francis I in his library at Fontainebleau. The writing of one in particular, Angelus Vergecius (*e.g.*, his copy of Manuel Philes made in 1564; fig. 24), was used as a model for the French Royal Greek type, which has influenced the form of Greek printing down to the present day. (RH. B.)

III. LATIN AND WESTERN EUROPEAN VERNACULAR

A. The Roman Hands

1. Rustic Capitals.—The Latin and vernacular handwriting of Western Europe descends in an unbroken line to the present day from the point at which we first catch a clear sight of it, in the 1st century A.D. The script used throughout the Roman Empire at that time for books, and occasionally for formal documents, is known as "rustic capitals" (fig. 25). The pen was cut with a broad end and held so that its thickest strokes fell at an oblique angle to the line of writing, and it was lifted several times in the formation of a single letter. The rustic capital alphabet is "majuscule," in that all the letters are contained between a single pair of horizontal lines. The use of this elaborate script, whose letter forms were the natural outcome of using a broad pen held obliquely, was extended to certain sorts of inscription on stone, etc., and it is called rustic only by comparison with the magnificent square capitals characteristic of Roman imperial inscriptions, whose forms were governed by the use of the chisel. Square capitals were seldom used in manuscripts except for titles. Rustic capitals continued in use for literary manuscripts until the 6th



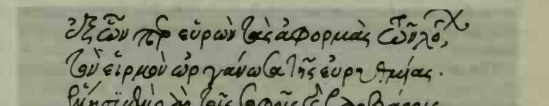
BY COURTESY OF THE BIBLIOTECA APOSTOLICA VATICANA

FIG. 23.—AUTOGRAPH LETTER OF DEMETRIUS CHALCONDYLES, A.D. 1488 (VATICAN LAT. 5641 FOL. 2)

century, especially for texts of Virgil, but thereafter appear only in titles, down to the 12th century.

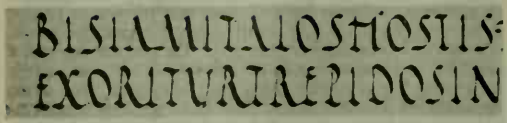
2. Cursive Capitals.—The business hand of the 1st century, used for correspondence and for most documents, private and official alike, is known as "cursive capitals" (fig. 26). Here the pen, cut to a sharp point, was held at the same oblique angle but was lifted less often, and this "cursive" handling automatically produced new and simpler letter forms such as δ (two strokes) for D (three strokes) and ϵ (two strokes) for E (four strokes). Some of these new letter forms are "minuscule" in that parts of them ascend or descend beyond the body of the letter (h, q) instead of being confined between a pair of lines, as in the majuscule rustic capitals (H, Q).

From the 2nd to the early 4th century, parchment was replacing papyrus as the standard writing material for books and the codex was replacing the roll as their standard form. The evidence that survives from this period, during which biblical and other Christian literature was beginning to be copied extensively, is fragmentary and its interpretation still controversial. The main line of development, however, is clear enough. The elaborate letter forms of rustic capitals, with their numerous pen lifts, began to be abandoned, and experiments were made with new book hands in which the simplified letter forms of cursive capitals were written with a broad pen, sometimes held obliquely in the traditional way and sometimes held "straight," so that its thickest strokes fell at right angles to the line of writing. It was probably the use of a straight pen that produced, for example, the conversion of cursive capital δ (axis oblique) into the fully minuscule d (axis vertical).



BY COURTESY OF BODLEIAN LIBRARY, OXFORD

FIG. 24.—MANUEL PHILES COPIED BY ANGELUS VERGECIUS, A.D. 1564 (OXFORD, BODLEIAN LIBRARY MS. AUCT. F.4.15 FOL. 2)

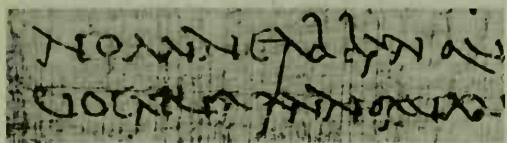


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 25.—RUSTIC CAPITALS, 4TH–5TH CENTURY; VIRGIL, CODEX PALATINUS (VATICAN, PAL. LAT. 1631)

3. Uncials, Half-Uncials, and Cursive Minuscule.—At the end of this period of transition, in the 4th and 5th centuries, when the evidence becomes more abundant, two new book hands and a new business hand are found in use. The older of the book hands, called "uncials" (the name dates only from the 18th century), was originally written with a slightly oblique pen (fig. 27); but from the 6th century onward a straight pen was used and the hand began to look rounder and more contrived. Although it incorporates several of the cursive letter forms (ɔ, ɛ, h) of cursive capitals and has two forms peculiar to itself (ɑ, ɯ), it also preserves certain forms, such as B, N, R, S, which differ only a little from the forms of rustic capitals; and all three kinds of letter are treated as majuscules, being confined as far as possible between one pair of lines.

From the 4th to the early 7th century most Christian books—biblical, patristic, and liturgical—were written in the uncial script,



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 26.—CURSIVE CAPITALS, A.D. 166; SALE OF A SLAVE (BRITISH MUSEUM, PAP. CCXXIX)

and even for pagan literature it almost entirely superseded rustic capitals. It survived the collapse of the Roman book trade, and after the 6th century, when the production of all books, pagan as well as Christian, was taken over by the Church—notably by the monasteries, such as Cassiodorus' foundation in southern Italy, the Vivarium, and the houses which observed the Rule of St. Benedict—it survived in many centres, especially for biblical and liturgical texts, down to the 9th century. Thereafter, like rustic capitals, uncials were used only for titles, and they too disappeared in the 12th century.

The younger of the two new book hands is called "half-uncial" (fig. 28). This script was less popular than uncials and never broke their monopoly of biblical and liturgical texts, although like them it was still being written in the 8th century and even, as a display script for certain purposes, in the 9th. The artificial name half-uncial tells nothing about the origin or nature of the script. It differs from early uncials in being written with a perfectly straight pen. One letter (N) remains more or less unchanged from the capital form, but the rest of the alphabet is cursive in origin. The letter forms which differ most from uncials are *a, b, d, g, m, r, s;* and the alphabet as a whole is frankly minuscule, since no attempt is made to confine it between a single pair of lines.

The new business hand of the 4th century and after is known as "cursive minuscule" (fig. 29). Like cursive capitals it was written with a pointed pen, but the pen was held more or less straight. It, too, is a frankly minuscule alphabet and uses basically the same letter forms as half-uncials, although the frequency in cursive minuscule of ligatures between letters tends to conceal the fundamental likeness between the two hands.

The letter forms which distinguish cursive minuscule and half-uncials from rustic and cursive capitals and from uncials were evolved during the obscure period between the 1st and 4th centuries. The question of whether these forms were evolved in the sphere of the book hands or of the business hands is still undecided, but whatever their origin, their importance for the subsequent history of European handwriting is paramount. They provided the material on which the Caroline (Carolingian) minuscule, first developed in the late 8th century, was based; and that script dominated Europe, in spite of severe modifications, until the end of the Middle Ages. Only in one other period were new letter forms evolved, between the 13th and the 15th centuries, in the group of scripts known as "Gothic cursives"; and the influence of these late innovations was ultimately canceled out, thanks to the revival of Caroline minuscule in a pure form by the Italian humanists at the beginning of the 15th century.

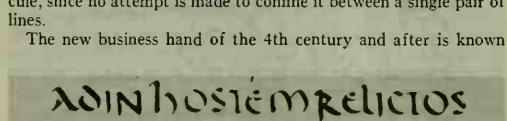


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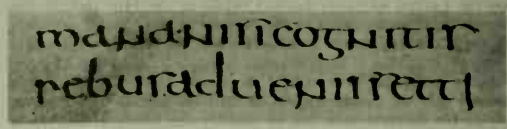
FIG. 27.—UNCIALS, 5TH CENTURY; LIVY (PARIS, BIBLIOTHÈQUE NATIONALE, LAT. 5730)

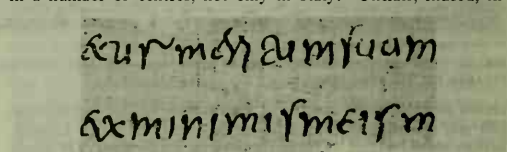


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 28.—HALF-UNCIALS, 5TH–6TH CENTURY; HEGESIPPUS, "DE BELLO JUDAICO" (MILAN, BIBLIOTECA AMBROSIANA, C. 105. INF.)

B. The "National" Hands

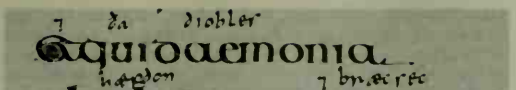
During the 6th to 8th centuries, when Western Europe had exchanged the unity of the Roman Empire for the diversity of smaller kingdoms under more or less barbarian rulers, the standard of handwriting in general declined and the new political divisions began to be reflected in the sphere of script. This was the period of the "national" hands. On the continent, cursive minuscule survived as the business hand of the successor states and was occasionally used for books. The uncial and even the half-uncial book hands were preserved, especially for Bibles and service books, in a number of centres, not only in Italy. Uncials, indeed, increased their range, since they were taken to England both by St. Augustine's mission to Canterbury (597) and again by Benedict Biscop, the founder of the romanizing monasteries at Wearmouth (674) and Jarrow (681) in Northumbria. In Kent uncials probably played an important part throughout the 7th century, but in Northumbria they never seriously challenged the ascendancy of the two Insular hands brought to Lindisfarne from Iona by Irish missionaries in 635.



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 29.—CURSIVE MINUSCULE, 6TH CENTURY; AVITUS OF VIENNE, "HOMILIES, ETC." (PARIS, BIBLIOTHÈQUE NATIONALE, LAT. 8913 + 8914)

1. The Insular Hands.—By the early 8th century these Insular hands, majuscule and minuscule, were dominant not only in their native Ireland, where no others were in use, but in all the Anglo-Saxon kingdoms. The handsome and formal Insular majuscule, written with a broad pen held straight, was a half-uncial script which allowed uncial D, G, N, R and S to be used as alternative forms (fig. 30). The Irish had presumably received it from

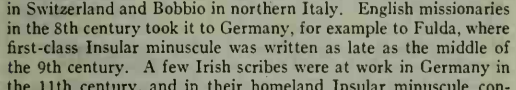


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 30.—INSULAR MAJUSCULE, BEFORE A.D. 698, THE LINDISFARNE GOSPELS; GLOSS, IN INSULAR MINUSCULE, 10TH CENTURY (BRITISH MUSEUM, COTTON NERO D. IV)

Gaul at the time of their conversion to Christianity. Insular minuscule, compressed and relatively informal, was produced by writing the majuscule somewhat cursively, with a narrower pen, held obliquely (fig. 31). It served as the only business hand of England until the middle of the 10th century. Anglo-Saxon writing, both majuscule and minuscule, can generally be distinguished from Irish by its greater precision and by the more orderly arrangement of the text on the page. Both the Insular hands are remarkable for the wedge-shaped serifs at the tops of ascenders and minims.

Irish missionaries in the late 6th and 7th centuries took Insular script to their continental foundations, among them Sankt Gallen in Switzerland and Bobbio in northern Italy. English missionaries in the 8th century took it to Germany, for example to Fulda, where first-class Insular minuscule was written as late as the middle of the 9th century. A few Irish scribes were at work in Germany in the 11th century, and in their homeland Insular minuscule con-



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

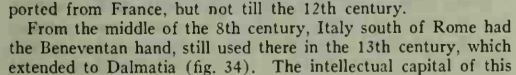
FIG. 31.—INSULAR MINUSCULE, 8TH CENTURY; BEDE, "HISTORIA ECCLESIASTICA" (BRITISH MUSEUM, COTTON TIBERIUS C.II)

tinued to be used for texts in Irish until long after the end of the Middle Ages. In England it began to give way to Caroline minuscule, for books as well as for documents, about the middle of the 10th century, but was used until the 12th century for texts in English (fig. 32) and bequeathed three of its letter forms, *g* and the borrowed runic letters for *th* and *w*, to English texts of the 13th to 15th centuries (in *ye* for *the*, *y* is a debased form of the *th*-rune, called *thorn*). Insular majuscule had virtually disappeared everywhere by the middle of the 9th century.

2. Other "National" Hands.—Nearly everywhere on the continent the longer texts, which in Britain and in some continental Irish or English foundations were written in Insular minuscule, were written in hands that, unlike the Insular hands, were based on the Roman cursive minuscule as it had survived to serve the legal and administrative needs of the barbarian kingdoms. From the late 7th century onward Spain had the Visigothic hand (fig. 33), which was finally dislodged by late Caroline minuscule imported from France, but not till the 12th century.

From the middle of the 8th century, Italy south of Rome had the Beneventan hand, still used there in the 13th century, which extended to Dalmatia (fig. 34). The intellectual capital of this area was St. Benedict's great foundation at Monte Cassino; Cassinese manuscripts in the Beneventan hand are important for the transmission of a number of classical and early Christian texts.

The 8th-century minuscules of northern Italy were subject to foreign influence, both from France and, via Bobbio near Pavia,



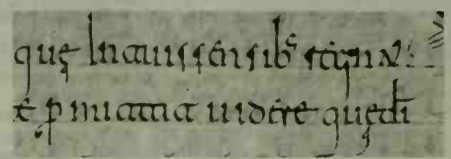
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 32.—INSULAR AND CAROLINE MINUSCULE, 11TH CENTURY; PSALTER IN LATIN AND ANGLO-SAXON (PARIS, BIBLIOTHÈQUE NATIONALE, LAT. 8824)

from Ireland. On French soil the earliest type of minuscule book hand that had any claim to be called decorative appeared toward the end of the 7th century, at the Irish foundation of Luxeuil, in the Vosges Mountains (fig. 35). This hand owed nothing to Ireland and was simply a formalized version of the sort of cursive minuscule that was then being practised in the Merovingian chancery. In the 8th century several other, more northerly centres, including Laon and Corbie, possessed hands of the same type which arose in the same way as the Luxeuil hand.

C. The Caroline Hands

Decorative though they were, these French minuscules were a poor vehicle for the diffusion of literature; they must have been

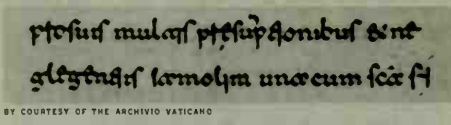


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 33.—VISIGOTHIC MINUSCULE, A.D. 919; PASSIONALE (BRITISH MUSEUM, ADD. 25,600)

slow to write and even to read outside the monasteries or areas in which they were at home. In the second half of the 8th century a number of religious foundations in northern France, Switzerland (notably at Sankt Gallen), and Germany began to experiment, in books and documents alike, with simpler minuscules in which letter forms were less stylized and fewer ligatures were used. The numerous modified minuscules of this period are generally known as "precaroline."

The monks of Corbie, at this time, were writing both a minuscule comparable to Luxeuil minuscule and excellent half-uncials, and to these hands they added a new type of minuscule, free of ligatures and thoroughly suitable for use as a book hand, which is known as Maurdramnus minuscule (fig. 36), after an abbot of Corbie for whom a Bible was written in that script before 781. Since it was written with a straight pen, the stylistic debt of Maurdramnus minuscule to half-uncials is more obvious than in other examples of Caroline minuscule, which elsewhere was written



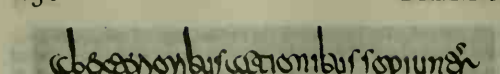
BY COURTESY OF THE ARCHIVIO VATICANO

FIG. 34.—BENEVENTAN MINUSCULE, 11TH CENTURY; REGISTER OF POPE JOHN VIII (ARCHIVIO VATICANO, REG. VAT.1)

with an obliquely held pen and was closer in style to the precaroline minuscules.

Caroline minuscule differs from half-uncials, in point of letter forms, chiefly in its use of a small uncial *a* and of a cursive looped *g* instead of the flat-topped form ȝ, and of cursive *n* (cursive open ⁊ and capital N occur in some early examples as alternative forms). Manuscripts in pure Caroline minuscules were written before the end of the 8th century for Charlemagne, after whom the script is named, and his family, but it was not until the second quarter of the 9th century, at Tours, that the script assumed its most impressive form (fig. 37).

With the exceptions already mentioned of Britain, Spain, and south Italy, Caroline minuscule had ousted the national and pre-Caroline book hands from Europe by the middle of the 9th century. The quick reception of this practical and beautiful script over such a wide area must have greatly eased the energetic revival of classical and Christian literature for which the monasteries of northern France and Germany in the time of Charlemagne and his immediate successors are famous. The oldest surviving manuscripts of Latin classical authors are, as a rule, copies in Caroline



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 35.—LUXEUIL MINUSCULE, EARLY 8TH CENTURY; GREGORY, "MORALIA" (BRITISH MUSEUM, ADD. 11,878)

minuscule that were made in that area during the 9th century. (*See* TEXTUAL CRITICISM.)

From the 9th to the 12th century Caroline minuscule was the only Western book hand, except on the Insular, Beneventan, and Visigothic fringes. By the end of the 9th century, the lightness and spontaneity of the early period was everywhere being exchanged for a certain monumental uniformity, and distinct national styles were beginning to evolve. The German style, down to the end of the 12th century, was the most conservative. In Italy, manuscripts of the 11th and 12th centuries are remarkable for the roundness of their script (fig. 38), which was handed on to the Italian Gothic book hand of later centuries. The English style, between its creation in the 10th century and the Norman Conquest, was of great beauty and purity (fig. 39). In the 12th century the English and north French book hands were very similar, and it was in that area that the Caroline minuscule evolved furthest and, in the end, was first transformed into Gothic book

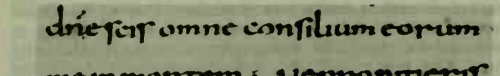
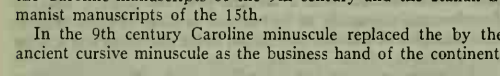


FIG. 36.—MAURDRAMNUS MINUSCULE, LATE 8TH CENTURY; LIBER COMITIS (LENINGRAD, SALTYKOV-SCHEDRIN LIBRARY, Q.V.I.16)

hand. The biblical and patristic manuscripts written in the 12th century by the clergy of the monasteries and cathedrals of Europe, aided latterly by lay scribes whom they engaged to assist them, are one of the finest groups of books ever made, comparable to the Caroline manuscripts of the 9th century and the Italian humanist manuscripts of the 15th.

In the 9th century Caroline minuscule replaced the by then ancient cursive minuscule as the business hand of the continental



BY COURTESY OF THE BIBLIOTHÈQUE NATIONALE

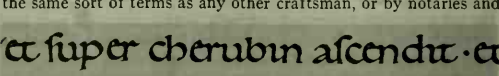
FIG. 37.—CAROLINE MINUSCULE (TOURS), A.D. 849–851; GOSPELS OF LOTHAIRE (PARIS, BIBLIOTHÈQUE NATIONALE, LAT. 266)

chanceries. But it was not adopted by the papal Curia until the early 12th century, and the notaries of southern Italy did not abandon the old script till the 13th. Many 12th-century documents concerning religious houses were written in book hands, but the standard business hand of the period was a version of Caroline minuscule written with a thin pen. Its ascenders and descenders were greatly lengthened in imitation of late cursive minuscule, and it could be written informally, sometimes even a little cursively, as in the writs of the English kings (fig. 40), or formally, as in papal bulls (fig. 41).

D. The Gothic Hands

At the end of the 12th century, when literacy was ceasing to be the virtual monopoly of the Church, Western Europe possessed only a limited repertory of handwritings. In spite of regional differences, the most formal of the book hands and the least formal of the business hands were only the opposite ends of a single scale, that of Caroline minuscule in its last phase. With the 13th century a new situation began to develop in response to major changes in the nature of society. On the one hand the masters and students of the newly founded universities needed an ever-increasing number of textbooks, and the rise of a literate middle class in the towns led to a demand for works of devotion and romances in the vernacular. On the other hand, the records and documents of government and commerce became far more complicated and numerous.

Books and documents continued to be written in religious houses, but the great majority of both were from now on written by laymen, either by scribes who could be hired to write books, etc., on the same sort of terms as any other craftsman, or by notaries and



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 38.—CAROLINE MINUSCULE (ITALY), 12TH CENTURY; SERMONS AND HOMILIES (BRITISH MUSEUM, HARLEY 7183)

official clerks who wrote documents as part of their legal and administrative duties. Most books and documents of the 13th to 15th centuries were still written on vellum, and paper was not extensively used before the beginning of the 15th century. It was manufactured in Spain, by the Arabs, as early as the 12th century and in Italy from the middle of the 13th, but it was not widely produced in northern Europe before the 15th century, and did not come into its own as a material for books until the invention of printing (*see* PAPER MANUFACTURE).

The so-called Gothic handwritings of the later Middle Ages present a far more varied picture than those of the preceding Caroline period. Service books, including the books of hours used for private prayer, were written in a variety of formal book hands which descend directly from the Caroline minuscule of the late 12th century. The hallmarks of these Gothic book hands are (1) the uniform treatment, following several distinct systems, of vertical strokes which end on the base line; (2) the use of angular

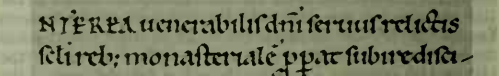


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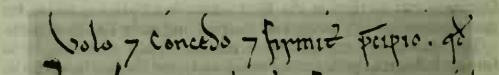
FIG. 39.—CAROLINE MINUSCULE (ENGLAND), 12TH CENTURY; BEDE, "LIFE OF ST. CUTHBERT" (OXFORD, UNIVERSITY COLLEGE, 165)

forms instead of smooth curves (for *o*); (3) the overlapping of convex forms which lie back to back (, , etc.). (*See* fig. 42.) The first of these three features appears in northern Europe before the end of the 11th century, perhaps under Insular influence; the other two appear in the last quarter of the 12th.

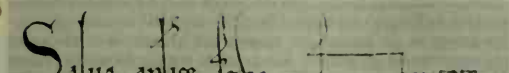
In the universities of Paris and Oxford, textbooks were written in a less formal Gothic book hand, and the scribes who wrote them used the same hand for romances, etc., in the vernacular (fig. 43). In the 13th and 14th centuries many university manuscripts were produced under the system of the *pecia* (piece), devised by the



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 40.—CAROLINE BUSINESS HAND (ENGLAND), A.D. 1156; WRIT OF HENRY II (WESTMINSTER ABBEY, CHARTER XLIV)

authorities in order to ensure the rapid and accurate diffusion of the numerous new textbooks, in all subjects from theology to law, which were composed during that period. An officially approved

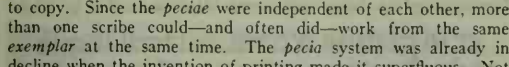


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 41.—CAROLINE BUSINESS HAND (PAPAL CURIA), A.D. 1147: BULL OF POPE EUGENIUS III (BRITISH MUSEUM, COTTON CLEOPATRA E.I.)

copy, or *exemplar*, of the new text was deposited by the university with a stationer. The separate *peciae* of which it consisted, *i.e.*, gatherings of four leaves (eight pages), were then hired out one at a time to a scribe engaged by a student, or to the student himself, to copy. Since the *peciae* were independent of each other, more than one scribe could—and often did—work from the same *exemplar* at the same time. The *pecia* system was already in decline when the invention of printing made it superfluous. Not unlike the Parisian university hand was the minute writing used in the innumerable "pocket" Bibles written in the 13th century in response to the revival of interest in the Scriptures that was brought about by the teaching of the new orders of friars.

In all the Gothic book hands the ascenders and descenders are



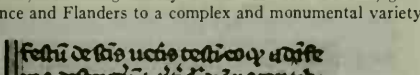
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 42.—GOTHIC BOOK HAND (ENGLAND), A.D. 1283–1300: PETRUS COMESTOR (BRITISH MUSEUM, ROYAL 3 D.VI)

shorter, the letters narrower, the words better separated from each other, and the lines generally closer together than in the 12th-century Caroline minuscule.

During the first half of the 13th century the same reduction in scale had become the rule in the business hands, and at the same time the ascenders began to be decorated with forks or hair-line loops or both (fig. 44). The letters were still formed on the Caroline model, but from the early 13th century onward the pen began to be handled more cursively (*i.e.*, with fewer lifts) and a certain number of new letter forms came into being as a result; of these, looped ꝺ and looped ſ were among the earliest (fig. 45).

The new Gothic cursive soon began to be used for books, other than service books, and a stylized version of it was evolved in northern Europe, originally in France, during the second half of the 14th century (fig. 46). During the early 15th century the northern kind, which is generally known as *lettre bâtarde*, gave rise in France and Flanders to a complex and monumental variety



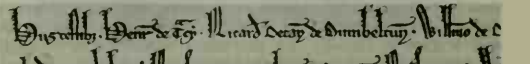
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 43.—GOTHIC BOOK HAND (PARIS), A.D. 1312: JACOBUS DE VORAGINE, LEGENDA AUREA (BRITISH MUSEUM, ADD. 11,882)

(fig. 47) used for books of all sorts but not for documents, which was strongly influenced by the contemporary Gothic book hands.

In the second quarter of the 15th century another type of script, to which the name *bastarda* is sometimes given (fig. 48) and which originated in the diocese of Cologne and the Low Countries, was evolved for use in nonliturgical books by modifying the contemporary book hand in the direction of the Gothic cursives (note the forms of *a*, *f*, *g*, long *s*). This was the last new Gothic hand to appear before the invention of printing and the spread of the humanist hands from Italy brought in a new era in the production of books.

In this brief summary of the Gothic hands little has been said about national differences. But the handwritings of France, England, Germany, the Low Countries, Spain, and Italy can as a rule be easily distinguished from one another. When they cannot, it is generally because French influence is particularly strong. From the 13th to the early 15th century Paris, with its university, was the intellectual capital of Europe and set the fashion for handwriting as for much else. Italy alone, which possessed in Bologna another major university and centre of the book trade, remained more or less completely aloof from French developments after the 13th century. By the middle of the 15th century French influence was no longer being felt even in northern Europe, and England and Germany, for instance, either went their own



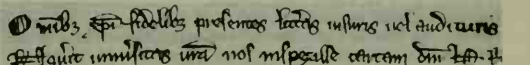
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 44.—GOTHIC BUSINESS HAND (ENGLAND), A.D. 1230: LEASE TO ABINGDON ABBEY (BRITISH MUSEUM, HARLEY CHARTER 75.F.36)

way or, like France itself, borrowed the new humanist hands from Italy.

E. The Humanist Hands

1. Humanistic Round Hand.—By the middle of the 14th century Italy possessed a Gothic cursive—ultimately of French origin—suitable for correspondence and informal documents, a formalized version of the same hand suitable for important documents and some books (fig. 49), and a type of Gothic book hand, often called *litera* (or *littera*) *rotunda* (fig. 50), which closely resembled the *litera Bononiensis* written from the 13th century onward by the scribes attached to the University of Bologna in their manuscripts of canon and civil law. *Litera rotunda*, which preserved much of the roundness of the Italian 12th-century book hand, was



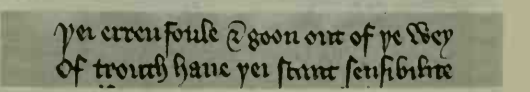
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 45.—GOTHIC CURSIVE MINUSCULE (ENGLAND), A.D. 1251: GRANT TO BIDDLESDEN ABBEY (BRITISH MUSEUM, HARLEY CHARTER 84.D.6)

used for service books until the 16th century and after, and was even borrowed, for the same purpose, by Flemish scribes at the end of the 15th.

By the second half of the 14th century, however, learned Italians such as Petrarch, Boccaccio, and the Florentine chancellor Coluccio Salutati were beginning—in their old age—to complain in their letters about the illegibility of *litera rotunda*. Petrarch (fig. 51) and Boccaccio both wrote simplified book hands of their own, and a variety of "prehumanistic" Gothic hands of the same general kind were in use by the end of the century.

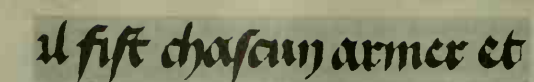
It was their preoccupation with classical Latin texts, most of the early manuscripts of which are written in more or less pure Caroline minuscule of the 9th to early 12th centuries, that suggested to the humanists the source of a major reform of the book hand by which the unsatisfactory *rotunda* could be banished once and for all. The inventors of Caroline minuscule in the late 8th century had drawn some of their inspiration from the by then ancient half-uncial. The humanists in turn went back to the



BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 46.—GOTHIC CURSIVE MINUSCULE (ENGLAND), EARLY 15TH CENTURY: HOCCLEVE, "DE REGIMINE PRINCIPUM" (BRITISH MUSEUM, HARLEY 4866)

Caroline minuscule, and in particular to the 12th-century variety. Salutati refers to a manuscript of Abelard (d. 1142) as written in *antiqua littera*.

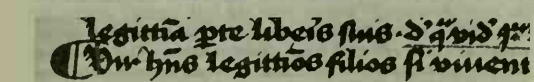


BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 47.—"LETTRE BÂTARDE" (FLANDERS), A.D. 1458; "CONQUÊTES DE CHARLEMAGNE" (BRUSSELS, BIBLIOTHÈQUE ROYALE, 9066–8)

Salutati himself seems, on more than one occasion, to have tried to imitate Caroline minuscule, but the credit for evolving a new calligraphic book hand on the basis of it almost certainly belongs to another great humanist, Poggio Bracciolini (1380–1459), in due course to be chancellor of Florence in his turn, who as a young man was employed by Salutati as a copyist (fig. 52). Poggio's earliest surviving manuscript in humanistic round hand was probably written in 1402–03; his first dated manuscript is of 1408. By 1420 a number of good scribes were writing books in the new hand at Florence. Within a generation it had spread in a pure form to other Italian cities and also had begun to influence writers of *rotunda*, producing a mongrel hand, or rather group of hands, known as "gothico-humanistic." By the end of the century humanistic round hand of a sort was being written here and there in most countries of Europe and was on the way to superseding the Gothic "black-letter" as the standard (Roman) type in printed books.

The capital letters of the earlier Florentine scribes were based on the rustic capitals which they found in the titles of their Caroline exemplars. Soon after the mid-15th century, square capitals, based on Roman imperial inscriptions, appeared in the manuscripts of Paduan scribes associated with the archaeologically minded painter Andrea Mantegna, and by 1500 they had been



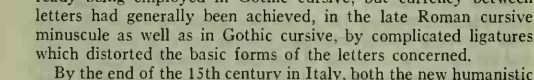
BY COURTESY OF THE BIBLIOTHÈQUE ROYALE, BRUSSELS

FIG. 48.—"LITERA BASTARDA" (FLANDERS), A.D. 1452; BARTHOLOMAEUS PISANUS, "DE CASIBUS CONSCIENTIAE" (BRUSSELS, BIBLIOTHÈQUE ROYALE, 8374–5)

adopted throughout Italy by scribes and printers alike.

2. Humanistic Cursive.—The other new Italian hand of the 15th century, "humanistic cursive," was no less influential than the round hand. It not only provided the printers with their italic type but ultimately it superseded the Gothic cursives as the medium for correspondence and, until the invention of the typewriter, for documents. The earliest-known examples are the work of Niccolò Niccoli (1364–1437), another Florentine humanist and a close friend of Poggio (fig. 53). The cursive was written with a thinner pen, held more obliquely, than the round hand, although the letter forms, except *a*, are the same. The most original feature of humanistic cursive is the allowance which it made, even in its earliest stages, for horizontal or slanting linkages between letters, a system which was developed in due course to produce the fully cursive handwriting of today. A few slanting linkages were already being employed in Gothic cursive, but currency between letters had generally been achieved, in the late Roman cursive minuscule as well as in Gothic cursive, by complicated ligatures which distorted the basic forms of the letters concerned.

By the end of the 15th century in Italy, both the new humanistic hands had undergone the formalization, involving loss of sponta-

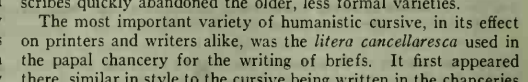


BY COURTESY OF BIBLIOTECA APOSTOLICA VATICANA

FIG. 49.—GOTHIC CURSIVE MINUSCULE (ITALY), 14TH CENTURY; PETRARCH (AUTOGRAPH), "SONNETS" (VATICAN, LAT. 3196)

neity, which sooner or later overtakes all forms of handwriting. The round hand of Pierantonio Sallando (*c.* 1460–*c.* 1540), for instance, was written with a straighter pen and shows smoother, more monumental forms than the script of the Florentine scribes working in Poggio's tradition (fig. 54). By 1501 an analogous development in the humanistic cursive had brought it to the point of formalization at which it was possible for the Venetian printer Aldus Manutius to adopt it as the type face now known as italic. These late forms of the humanistic hands were particularly influential with the printers, and once they had adopted them, the scribes quickly abandoned the older, less formal varieties.

The most important variety of humanistic cursive, in its effect on printers and writers alike, was the *litera cancellaresca* used in the papal chancery for the writing of briefs. It first appeared there, similar in style to the cursive being written in the chanceries of other Italian states, during the papacy of Pius II (1458–64). By the end of the century it had been raised to a high degree of formality and was being written with consummate skill by official



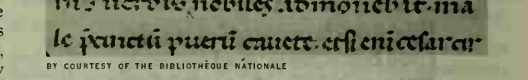
BY COURTESY OF THE PALAEOGRAPHICAL SOCIETY

FIG. 50.—"LITERA ROTUNDA" (ITALY), EARLY 14TH CENTURY; GUILLAUME DURAND, "RATIONALE DIVINORUM OFFICIORUM" (BRITISH MUSEUM, ADD. 31,032)

scrittori da brevi apostolici such as Lodovico Arrighi (fl. 1510–27), from Vicenza, the author of the first printed manual of handwriting (*La Operina*, 1522). (*See* fig. 55.) Since Arrighi's numerous imitators, in northern Europe and Spain as well as in Italy, followed him in recommending *cancellaresca* as the standard script for private, but not necessarily for official or commercial purposes, that hand must be regarded as the ancestor of the hands written today in Western Europe and, for European languages, in the countries overseas which have at one time or another belonged to any of the Western European powers.

F. Abbreviations in Medieval Manuscripts

The abbreviations found in vernacular texts are few and simple, but in the Latin texts of most of the Middle Ages they play a conspicuous part, so that some knowledge of them is essential to anyone who consults medieval manuscripts. The various dictionaries of abbreviations, especially A. Cappelli's, provide an adequate means of interpreting particular forms, but the system as a whole varied, like script itself, according to time and place, and a word or two on the significance of these variations must be said. To have recognized the existence and implications of the historical development of abbreviations was the achievement of Ludwig Traube (1861–1907), whose teaching—together with the new weapon of photographic facsimiles—put fresh life into Latin



BY COURTESY OF THE BIBLIOTHÈQUE NATIONALE

FIG. 51.—PREHUMANISTIC BOOK HAND (ITALY), 14TH CENTURY; PETRARCH (AUTOGRAPH), "LIFE OF CAESAR" (PARIS, BIBLIOTHÈQUE NATIONALE, LAT. 5784)

paleography after the relatively stagnant period which followed the codification, in the middle of the 18th century, of the pioneer work of Jean Mabillon and Scipione Maffei.

In suspensions the abbreviated word or its syllables are cut off short, as in *M* for *Marcus*, *Aug* for *Augustus*, *tm* for *tamen;* in contractions the ending of the word is preserved, as in *tn* for *tamen*, *nrm* for *nostrum*, *nro* for *nostro*. Suspensions were used in Roman inscriptions from the earliest times for names and titles and for words or groups of words which occurred often and allowed no misunderstanding. Suspensions such as these, with *-b* and *-q* followed by a point (standing for the common endings *-bus* and *-que*) and a horizontal line placed beside or above a vowel (standing for final *-m* or *-n*), are the only abbreviations found in normal literary manuscripts down to the 6th century. There do survive, however, some legal manuscripts and some informally written literary manuscripts (including sets of marginal notes to literary

texts) that date from the 4th–5th centuries and use a few contractions as part of their stock of *notae iuris* (*see* below).

From the 4th century onward a special group of contractions, known as *nomina sacra* and derived from Greek manuscripts, are used in Christian texts for the names of God ($\overline{DS}$, $\overline{DM}$, etc., for *Deus, Deum*, etc.; $\overline{IHS}$—the *H* represents the capital form of the Greek eta—for *Iesus*; $\overline{DNS}$ for *Dominus*). Some later contractions, such as *eps* for *episcopus*, were doubtless formed on the analogy of the *nomina sacra*, but a more important source of suspensions and contractions alike were the *notae iuris*, not confined to legal terms, used in the early manuscripts of Roman law. These included combinations of letters and conventional signs, such as *p* with a bar across the descender for *per*, and shorthand symbols, such as reversed *c* for the prefix *con-*, which came from the "Tironian" system of shorthand, invented by Cicero's freedman Tiro and subsequently much elaborated (*see* SHORTHAND). Some of these *notae iuris* were used by writers of the national hands on the continent in the 7th and 8th centuries; many more were known to the Irish at an early stage and handed on by them to the Anglo-Saxons, so that in the 8th century they reached all the Insular centres on the continent.

In the 9th century the diffusion of Caroline minuscule was accompanied by the formation and diffusion of a unified system of abbreviation which drew on all the above-named sources and which, by the 12th century, was common to most of Europe. From the 7th to the 10th century, however, abbreviations provide

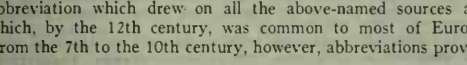


FIG. 52.—HUMANISTIC ROUND HAND, BY POGGIO BRACCIOLINI, A.D. 1425: CICERO, "DE ORATORE," ETC. (FLORENCE, BIBLIOTECA LAURENZIANA, 50.31)

an invaluable means of dating and localizing manuscripts. The use of *nm* instead of *nrm* for *nostrum* suggests a date before the 8th century; *t* followed by a sign like an arabic figure 2 for *-tur* first appears, on the continent, about 820; *p* with a tick on the bow for *per* is Insular; *nsrm* for *nostrum* is Spanish; the sign which meant *pro* on the French side of the Pyrenees meant *per* on the Spanish side. Again, misunderstandings by a French or German scribe of abbreviations in the manuscript that he was copying may show that it was written in, say, the Insular or the Visigothic hand.

In the 13th century the Caroline system was vastly extended by the scribes who copied the works of the scholastic theologians and philosophers, and many of the new abbreviations coined by them were current until the end of the Middle Ages. The Italian humanist scribes, however, tended to use only the abbreviations they found in their Caroline exemplars, and before long they were often writing whole manuscripts from which all but the simplest abbreviations were excluded. Before 1500 the printers, especially when they used Gothic fonts, cut type for many of the abbreviation symbols used by contemporary scribes.

G. The 16th to 20th Centuries

1. The Writing Masters.—After Arrighi published *La Operina* in 1522 the development of European handwriting followed, until very recently, the fashions set by writing masters whose primary source of income was the teaching of handwriting and the publication of manuals. Such men had existed in the 15th century, as is known from the surviving sheets of specimens they wrote to advertise their teaching, but their influence was not so great. If writing masters have a fault, it is their tendency to introduce new

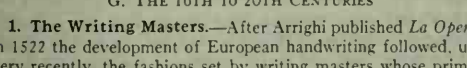
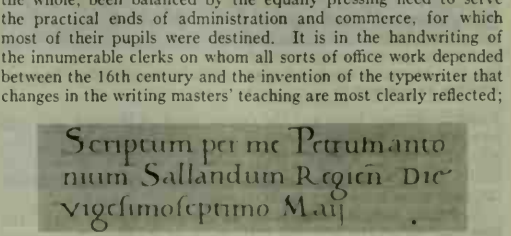


FIG. 53.—HUMANISTIC CURSIVE, BY NICCOLÒ NICCOLI, A.D. 1423 (?); CICERO, "ORATOR," ETC. (FLORENCE, BIBLIOTECA NAZIONALE, CONV. SOPPR., I.1.14)

styles and "systems" of handwriting merely in order to go one better than their competitors, but this desire for novelty has, on the whole, been balanced by the equally pressing need to serve the practical ends of administration and commerce, for which most of their pupils were destined. It is in the handwriting of the innumerable clerks on whom all sorts of office work depended between the 16th century and the invention of the typewriter that changes in the writing masters' teaching are most clearly reflected;



BY COURTESY OF BODLEIAN LIBRARY, OXFORD

FIG. 54.—HUMANISTIC ROUND HAND, BY PIERANTONIO SALLANDO, A.D. 1490; APICIUS (OXFORD, BODLEIAN LIBRARY, CANON. CLASS. LAT., 168)

the *literati* have always followed them less closely and their writing has at times been subject to fashions which have little to do with the world of the professionals.

2. English Hands.—Humanistic cursive triumphed in the long run, but in the 16th century it was still a minority script, except perhaps in Italy during the later years. In England a small, light, very cursive variety of Gothic minuscule (fig. 56), evolved during the first half of the century and known as "secretary hand," was still the normal handwriting in the reign of James I, although most well-educated men and women, from the mid-16th century onward, also wrote an elegant *cancellaresca* which derived from the models of Arrighi and his Italian contemporaries. During the second quarter of the 17th century the secretary hand was rapidly disappearing, and many Englishmen wrote a mixed hand, basically humanistic but with more or fewer secretary letter forms, of which curly $\mathcal{E}$ was the most tenacious; it can still be found occasionally toward the middle of the 18th century. An upright and enlarged version of secretary—the "engrossing hand"—survived in law offices well beyond the 18th century, and until 1731 documents issued by certain courts of law, including the Chancery and the Courts of Common Pleas and King's Bench, were still written in large Gothic hands, of the utmost complexity, which had begun to be differentiated from everyday Gothic cursive, and from each other, before the end of the 15th century.

3. Other European Hands.—In Holland a neat Gothic hand

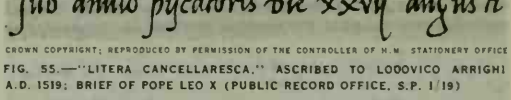


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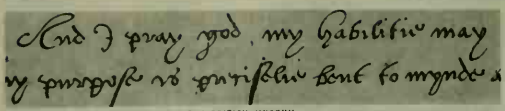
FIG. 55.—"LITERA CANCELLARESCA," ASCRIBED TO LODOVICO ARRIGHI A.D. 1519; BRIEF OF POPE LEO X (PUBLIC RECORD OFFICE, S.P. 1/19)

resembling English secretary was freely used, along with humanistic cursive, as late as the third quarter of the 17th century. Gothic cursive reached its nadir in the hands of French and Spanish lawyers of the 16th and 17th centuries, although less conservative writers in those countries adopted the humanistic style within a generation of Arrighi's first publication. When, in the middle of the 17th century, Colbert banished Gothic from government offices in France, it was replaced by the three varieties of a compromise hand called *ronde*, still sometimes taught in France today, all of which included a few Gothic letter forms, notably a peculiar form of final *s*. The variety called *écriture financière* was upright and Gothic in style, while *écriture italienne-bastarde* was sloping and humanistic in style (fig. 57).

In Germany and Austria a variety of Gothic cursive called *Kurrentschrift* was only superseded as the normal everyday handwriting after World War II. Its development can be traced back in an unbroken line to the early years of the 16th century, and during its first hundred years of life it was fairly close to the



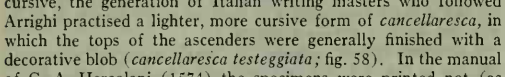
BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 56.—SECRETARY HAND, A.D. 1552; LETTER OF ROGER ASCHAM (BRITISH MUSEUM, LANSDOWNE 3)

English secretary hand and the Gothic hand of Holland, although from the 18th century onward it grew taller and narrower than ever they were. *Kanzleischrift,* used in the more formal documents, bore the same sort of relation to *Kurrent* as, in England, the engrossing hand bore to secretary.

Still more formal was *Fraktur,* an elongated Gothic book hand first used by a printer in the *Gebetbuch* of Emperor Maximilian (1512–13); it is the ancestor of what was until the mid-20th century the normal type face for books printed in the German language.

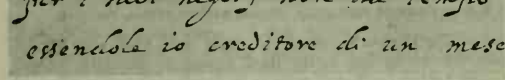
4. Later Manuals.—Returning to the tradition of humanistic cursive, the generation of Italian writing masters who followed Arrighi practised a lighter, more cursive form of *cancellaresca,* in which the tops of the ascenders were generally finished with a decorative blob (*cancellaresca testeggiata;* fig. 58). In the manual of G. A. Hercolani (1574) the specimens were printed not (as hitherto) from wooden blocks but from copper plates which allowed a meretricious contrast between the thinness of the ascenders and the thickness of the blobs; by the end of the century a flashy *testeggiata* had become the fashionable style throughout Europe, and it also furnished the humanistic component in the French *ronde* and in the mid-17th-century English mixed hand.



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 57.—RONDE, FROM LOUIS BARBEDOR, "LES ÉCRITURES FINANCIÈRE ET ITALIENNE BASTARDE"

The *testeggiata* style dominates the English manuals of Edward Cocker (1631–75), which included specimens of the "mixed" hand; but a reaction in favour of something plainer and more practical set in soon after his death, as may be seen in the manuals published in London by Colonel John Ayres between 1680 and 1700. In the anthology of English specimens issued by George Bickham as *The Universal Penman,* between 1733 and 1741, it is apparent that the result of Ayres's reform was the canonization of a style which, whatever its debt to certain French and Dutch masters of the early 17th century, was both profoundly original and admirably suited to the needs of the time in commercial as



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

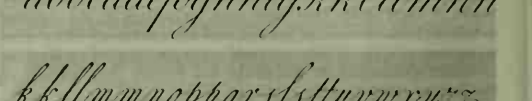
FIG. 58.—CANCELLARESCA TESTEGGIATA. JOHN FLORIO, LETTER TO SIR R. COTTON, A.D. 1600 OR 1601 (COTTON MS. JULIUS C.III)

well as private life (fig. 59). There were two varieties of this new "copperplate" style: "round hand," the bolder of the two, was considered appropriate for business use; "Italian," lighter and narrower, was the ladies' hand. Such was the success of copperplate that by the end of the 18th century it had been adopted in France (where it has coexisted with *ronde*), Spain, and Italy, in all of which countries it was known as "the English hand."

John Sealy's manual of about 1770, *The Running Hand,* recommends a sloping Italian with loops (not in regular use before), in which all the letters are linked (fig. 60); and it is apparently to the influence of running hand that we should attribute the change which came over English handwriting in general in the last years of the 18th century. Loops and links have been the general rule ever since.

From 1809 onward Joseph Carstairs taught a new "system" of writing in which the whole forearm was moved. The result was a hand which, unlike copperplate, tended to sprawl. Most English children today are taught to write after late-19th-century models which owe much to Carstairs. The adoption, during the 1820s, of steel pens allowed the ordinary writer to contrast his thick and thin strokes in a way which had previously been possible only for those, including the writing masters themselves, who were prepared to take considerable trouble over cutting the quill to a sharp and flexible point.

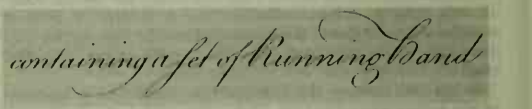
The partial break which has taken place in the English tradi-



FROM GEORGE BICKHAM, "THE UNIVERSAL PENMAN"; © 1941 BY PAUL A STRUCK. REPRODUCED BY PERMISSION OF DOVER PUBLICATIONS, INC.

FIG. 59.—ENGLISH COPPERPLATE: (TOP) ROUND HAND AND (BOTTOM) ITALIAN. FROM PHILIP HOFER (ED.), "THE UNIVERSAL PENMAN" ENGRAVED BY GEORGE BICKHAM, LONDON, 1743; FACSIMILE EDITION, 1941

tion, as it has existed between Ayres's time and the successors of Carstairs, is ultimately due to the influence of William Morris (1834–96). In about 1870 Morris began both to practise formal handwriting modeled on early humanistic round hand and to reform his own everyday handwriting in a manner which seems to imitate humanistic cursive of the same period. In 1898 Mrs. M. M. Bridges published models which frankly derive from Italian *cancellaresca* of the early 16th century. Edward Johnston (1872–1944), although his principal achievement was in the field of formal calligraphy, exerted a powerful influence on this movement for the reform of everyday writing through his championship of the

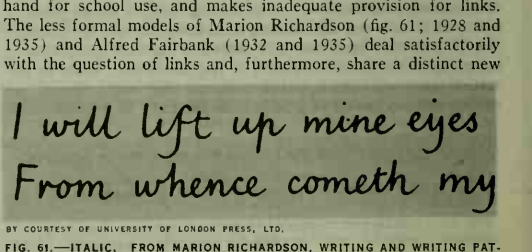


FROM SIR AMBROSE HEAL, "THE ENGLISH WRITING-MASTERS AND THEIR COPY-BOOKS, 1570–1800" (1931)

FIG. 60.—RUNNING HAND BY JOHN SEALLY, *c.* 1770

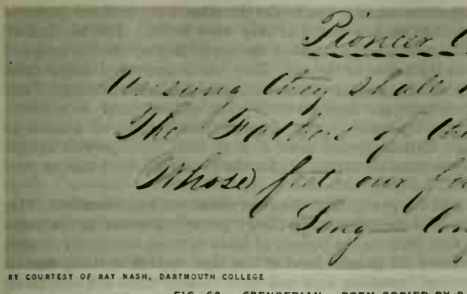
broad pen. An early and unfortunate consequence of a misunderstanding of Johnston's address to the Conference of Teachers in 1913 was the invention of "print script," a hand in which the letters are entirely separate from each other and imitate the forms of roman type. Children are supposed to go on from this to linking their letters, but do not always manage to make the change.

A handsome model, based on good *cancellaresca,* was published by Johnston's pupil Graily Hewitt in 1916, but it is too like a book hand for school use, and makes inadequate provision for links. The less formal models of Marion Richardson (fig. 61; 1928 and 1935) and Alfred Fairbank (1932 and 1935) deal satisfactorily with the question of links and, furthermore, share a distinct new



BY COURTESY OF UNIVERSITY OF LONDON PRESS, LTD.

FIG. 61.—ITALIC. FROM MARION RICHARDSON, WRITING AND WRITING PATTERNS



BY COURTESY OF RAY NASH, DARTMOUTH COLLEGE

FIG. 62.—SPENCERIAN. POEM COPIED BY P. R. SPENCER, 1850

style evolved (it is true) from careful study of the *cancellaresca* of Arrighi and his contemporaries, but as easily distinguishable from it as the copperplates of Ayres and his contemporaries. It remains to be seen whether it has the same success as its Italian and English predecessors, but under the aegis of the Society for Italic Handwriting, founded in 1954, the new style is steadily gaining ground in British schools, has established outposts in the British Commonwealth, Europe, and the United States.

5. United States.—The United States, as the first overseas dependency of European script to gain an undoubted independence, deserves a word to itself. Until the middle of the 18th century, North America relied on models brought from England; the colonists wrote secretary, humanist, or mixed hands which were indistinguishable from those of their contemporaries at home. Benjamin Franklin executed the first colonial models of the Italian, round, and secretary hands and published them in *The American Instructor* (Philadelphia, 1748). They scarcely diverged from standard English practice. Christoph Saur's *Hoch-Deutsch Americanische Calender* (Germantown, 1754) contains the second oldest colonial models, mostly of *Kurrent*, the national hand of the Pennsylvania Dutch, but with a line or two of English round hand thrown in.

The first genuinely American copybook was John Jenkins' *The Art of Writing* (Boston, 1791), which expounded a "system" of constructing the letters from a few basic strokes but still followed the style of contemporary English round hand. The "running hand," which goes back to Seally's English manual of about 1770, appeared in American copybooks soon after 1800 and was strongly recommended by B. H. Rand in his Philadelphia manual of 1814.

From 1830 onward, because of the advocacy of Benjamin Foster of New York, Joseph Carstairs' method and style became popular in the United States and inspired the "Spencerian" style of writing, an unquestionably native variety, never imitated in Britain, which was for many years supreme in North America. The credit for its invention was long and hotly disputed between two followers of Foster, A. R. Dunton and P. R. Spencer (fig. 62), who began to teach the style in the 1840s. Whoever was first in the field, it was the prosperous chain of business schools directed by Spencer's sons that gave the style its name and canonized the wide, swinging movement and the strong contrast between thick and thin strokes.

The later versions of "Spencerian" which dominated the United States from the 1890s and even spread to parts of South America, as a result of the success of the manuals still being published by the firms of Zaner-Bloser and Palmer, preserve the characteristic swing but use a line of constant, medium thickness.

The work of the English reformers was introduced into the United States by Ernst F. Detterer and by Frances M. Moore. The former studied under Johnston in 1913 and then began to teach formal calligraphy in Chicago. The latter, who taught writing in a New York school, worked under Graily Hewitt in 1923 and published her *Handwriting for the Broad-Edge Pen* in 1926. Both branches of the movement are flourishing, although the "Italic" branch seems to have made less progress in the schools than its British counterpart. The new style is basically Johnstonian, but American calligraphers show more sympathy than British with the freedom and eclecticism that mark the calligraphy of the German-speaking countries of Europe, in which the craft was revived, early in the 20th century, by Rudolf von Larisch and O. Hurm of Vienna.

See also references under "Paleography" in the Index.

(T. J. B.)

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PALEOLITHIC (OLD STONE AGE), as commonly used by archaeologists, refers to a prehistoric level of human cultural attainment, a type of technology, and a specific period of time.

Paleolithic people hunted game and collected plant food. During the earlier (Lower) Paleolithic, they probably wandered in groups of 5 to 20, though larger and relatively settled human concentrations were possible by the later (Upper) Paleolithic. In the Upper Paleolithic of central and western Europe, herds of reindeer, horses, and bison were hunted, permitting hundreds (perhaps thousands) of people to live close together in rock shelters or open encampments. The spectacular paintings and engravings at such sites as Lascaux Cave in France and Altamira Cave (*q.v.*) in Spain date from this time.

Technologically the Paleolithic marks the manufacture and use of bone and chipped-stone tools; no metals or pottery were used. Lower, Middle, and Upper Paleolithic are distinguished by specific types of tool. In general, tools became smaller and more specialized as men gained technical competence. Tools were somewhat standardized over much of Europe, the Near East, and Africa, but Asia and the Americas had very different stone-working technologies.

The Paleolithic Period begins with the earliest human remains found (in the 1960s these were estimated to be about 1,750,000 years old) and is generally said to end with the recession of the last of the Pleistocene glaciers about 8000 B.C. In northwestern Europe the Paleolithic is replaced by the Mesolithic (*q.v.*) but in most other parts of the world the way of life and technology continued virtually unchanged until agriculture was introduced. In a few places (*e.g.*, in remote parts of Africa, the Americas, Australia, and New Guinea), people who lived by hunting and who used no metal tools were to be found in the 20th century. *See*

also ARCHAEOLOGY: *Prehistory;* FLINT AND OTHER STONE TOOLS; and references under "Paleolithic" in the Index. (F. A. HE.)

PALEONTOLOGY, the science that deals with the remains of animals and plants found buried in the rocks. For convenience it is now customary to use the term only for the study of fossil animals and to deal with plants under the head of paleobotany (*q.v.*). In essence, however, the two form one science. Paleontology is distinguished from zoology and botany by the fact that the organisms with which it deals are not all of the same age but cover the history of life in the world from a time not long after its appearance, when organisms capable of being preserved first arose.

The following topics are discussed in this article:

I. Fossils
  1. Fossil Process
  2. Preparation for Study
  3. History
II. Geological Paleontology
  1. Classification of Stratified Rocks
  2. Zones
  3. Facies
  4. Establishment of Zones
  5. Paleogeography
  6. Fossils and Climate
III. The Succession of Faunas
  A. The Geologic Time Scale
  B. Precambrian Time
  C. Paleozoic Era
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    4. Devonian
    5. Carboniferous
    6. Permian
  D. Mesozoic Era
    1. Triassic
    2. Jurassic
    3. Cretaceous
  E. Cenozoic Era
IV. Evolutionary Evidence
  A. The Fact of Evolution
  B. Theories of Evolution
  C. Adaptation
  D. Parallelism
  E. Speed of Evolutionary Development
  F. Evolutionary Sterility: Extinction

I. FOSSILS

In most cases only the hard parts of animals are capable of preservation as fossils, but under especially favourable circumstances the soft parts may be represented either by an impression upon the surrounding rock, by stains, or even by a petrifaction that may preserve the microscopic structure of muscle and other tissues.

For convenience, fossils may be arranged into four general types on the basis of their mode of preservation: original soft parts; original hard parts; altered hard parts; and marks or traces. Soft parts are fossilized only under exceptionally favourable conditions, as in frozen soil, ice, amber, and petroleum-saturated soil. Hard parts are often fossilized in a virtually unaltered condition, but sometimes may be considerably changed by infiltration of chemical substances through a process called permineralization or petrifaction. The traces of organisms, which provide evidence of the structure or habits of such organisms, include chiefly molds of impressions, from which positive representations, or casts, are often derived by infiltration. Bodies or parts of bodies, tracks, trails, burrows, fecal pellets or castings all may occur as molds or casts.

1. Fossil Process.—The preservation of any animal as a fossil depends on its burial in a sediment that is not subsequently destroyed by denudation. In the sea the remains of marine animals are continually accumulating on the sea bottom. They may lie where they fall or be carried for considerable distances by the current. When the speed of the current becomes insufficient to move them, the remains may be laid down, often in association with many other objects of the same area and weight. Thus it is common to find great accumulations of fossil shells all of approximately the same size, which are not necessarily in the place where the organisms actually lived. On the other hand shells of burrowing mollusks may be found as they were in life. The remains of animals (even shells) are soon destroyed if they lie for long exposed to the action of the sea. They can be preserved only if they are deposited at a place where mud or sand is accumulating. Such accumulations are comparatively rare and of local occurrence. They may be found chiefly where the sea bottom off a coast is sinking. Certain special areas such as coral reefs provide exceptionally favourable conditions for the preservation of marine fossils.

On land the possibilities of preservation are much smaller. The remains of a land fauna are chiefly preserved either in the sediments that form on the bottom of lakes or more commonly in arid areas where the general level of the land surface is rising due to wind action depositing dust and sand. Under these circumstances the skeleton of a dead animal may become covered by blown sand and may remain buried for several geological periods.

One exceptional method of preservation, more important in the case of plants than animals, is in the detritus of forests growing on a coastal plain at or below high-water mark. If this plain is situated in a sinking area, great masses of deposits (now represented by coalfields) may be built up, and in them animals and plants will be abundantly preserved. The nature of the preservation of an individual fossil depends greatly on its own chemical and physical composition and on that of the surrounding sediments. The calcareous shells of mollusks and brachiopods, if buried in mud that becomes converted into a clay, may be preserved indefinitely in their original form. This clay hinders the passage of water, which could either dissolve the shell completely or bring about a rearrangement of the molecules, often into crystals. In some cases such clays, especially if they become impregnated with petroleum, may preserve traces of the soft parts of the animal in the form of a carbonaceous film made from its material.

The most remarkable of such fossils are those from the Middle Cambrian of Burgess Pass, B.C., described by C. D. Walcott. Here the external form of slender soft processes of worms has been perfectly preserved. Even something of their internal anatomy can be made out from colour differences in the carbonaceous films.

A shell buried in sand may be exposed to the action of percolating waters, which, if acidic, are capable of dissolving the shell. Its preservation is therefore dependent either on the sealing down of the sand by such a layer of clay as will prevent the circulation of water or on a solidification of the sand by a cementing together of the individual grains, usually by calcium carbonate. This forms a solid case round the shell, which may persist if the percolating water is completely saturated with calcium carbonate. It is altered only by the laying down of further calcite in its pores. In many cases, however, the shell itself is entirely removed in solution, and its former presence is shown by a cavity in the sandstone, which reproduces the surfaces of the shell often in a startlingly complete negative.

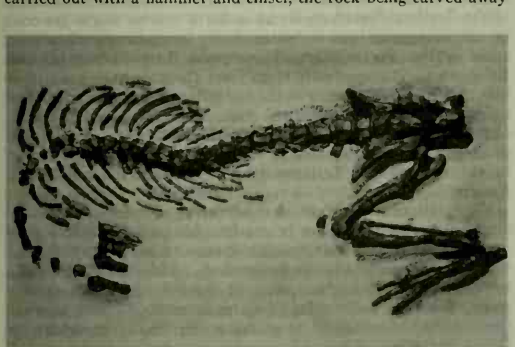
When buried in a calcareous mud such as that which accumulates in the lagoon behind a coral reef, a shell often remains unaltered. In a limestone that has been formed from such mud, a shell may be found in its original form or changed only by the addition of more calcite. Under exceptional circumstances the material of an animal's skeleton may be removed and replaced by silica, sometimes as opal, by iron pyrites or other minerals.

2. Preparation for Study.—Before it can be studied, any fossil must be freed as completely as possible from the surrounding matrix. The technique of this operation varies in each case. Bones and shells preserved in clays can often be entirely cleaned by washing. Fossils replaced by silica or consisting of chitin can be prepared chemically by removing the enclosing rock with hydrofluoric or hydrochloric acid; in recent years such preparation in brachiopods and other invertebrates has revealed delicate structures that had never been suspected from specimens prepared mechanically. For vertebrate skulls and similar objects it has been found that prolonged immersion in weaker chemicals (acetic or formic acid) will gradually dissolve the enclosing rock matrix if it contains a percentage of calcium carbonate. More commonly,

however, the rock surrounding the fossil must be removed by mechanical means. Hammer and chisel were earlier universally employed for chipping away the matrix and are still a major standby. Mechanical drills, delicately directed sandblasts, and other modern machines used for dental and industrial purposes enter prominently into the picture today. Where the fossil is represented by a cavity in which the walls preserve a mold of its surfaces, it is necessary to make casts; these were formerly made in plaster of paris, wax, or glue, but today latex or plastic compounds are generally used. For small complex objects, such as the skull of a fish, it is often preferable to remove the bone and rely on casts, rather than attempt to pick away the stone and preserve the actual bone substance.

Sometimes both rock and bone are too hard to be attacked by steel tools and too similar chemically to be prepared by solution in acid. In these cases it is possible to discover the structure by a method invented by W. J. Sollas. By this technique one surface of the specimen is ground to a flat face on which the fossil is shown in section. An enlarged photograph is then made of this ground surface. In a better method the surface is etched or softened with acid and a cellulose preparation is poured over it. When hardened, it is removed as a "peel" containing a thin layer of the original material. A layer of rock of definite thickness is then removed by further grinding, and another photograph is taken. The process is repeated until the whole fossil is ground away; but the appearance of the sections made across it at definite distances apart is preserved in the series of photographs or peels. Each section is reproduced by being cut out of a sheet of wax of appropriate thickness. These wax plates when piled up in correct order reproduce perfectly the shape of the original fossil at any magnification required. This method, though extremely laborious, leads to results that can be attained in no other way. In some cases it may be necessary to make a thousand sections and wax plates of a single object.

The preparation of the skeleton of a large vertebrate is usually carried out with a hammer and chisel, the rock being carved away



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

A MUSEUM PREPARATION OF JAW FRAGMENTS AND PARTIAL SKELETON OF AN EOCENE HORSE (HYRACOTHERIUM ANGUSTIDENS), FOUND AT BIG HORN, WYO., IN 1911

from the bones until these are free. The bones can then be mounted to form a skeleton.

3. History.—The fossil remains of animals have long attracted attention. In a Neolithic grave at Dunstable, Bedfordshire, Eng., a skeleton was found surrounded by fossil echinoderms, and a famous silicified tree trunk acted as a pedestal in an Etruscan tomb. Fossil shells were repeatedly observed during medieval times and are referred to in such works as Georgius Agricola's *De natura fossilium* (1546). During the 18th century many works containing illustrations of fossils were published, and some attempt was made to understand fossil structure and compare fossils with living forms. In one case a skeleton of *Megatherium* was actually set up in what was supposed to be its natural position in the museum at Madrid.

The whole concept of paleontology as a record in the rocks began with the work of two men. The first was William Smith (*q.v.*), a land surveyor, who in 1791 when supervising the construction of the Kennet and Avon Canal observed that each of the well-marked formations represented in the Jurassic rocks in the neighbourhood of Bath, Eng., was characterized by the presence of fossils that could not be found in the beds above or below. Smith was able to show that it was possible by the aid of the contained fossils to trace across the Midlands of England to the Yorkshire coast the formations he had recognized near Bath. These observations formed the basis of stratigraphic geology and showed that there had been a succession of different faunas living in the English region during geological time.

Secondly, Georges Cuvier (*q.v.*) applied to the skeletons of fossil vertebrates the methods of study already developed for recent animals. In his great work *Recherches sur les ossements fossiles de quadrupèdes* (1812), he gave accurate and detailed accounts of the teeth and bones of fossil mammals and reptiles.

By comparing many specimens and their anatomy he endeavoured to build up the complete skeleton of a number of forms and to determine their systematic position in the animal kingdom. By studying the skeleton he attempted to deduce something of the habits of prehistoric animals. His work was of great importance because it showed that many fossil animals were of types that no longer existed. Previously, when only extinct invertebrates had been studied, it was always possible to say that they still lived and would one day be found when the seas of the world had been completely explored. When not one but very many large extinct animals had been shown to have existed in France and elsewhere, this possibility became less plausible; even in 1824 the world had been explored well enough that it was most improbable that many large animals remained unknown to zoologists. (In fact only two completely new types of large animals have since been discovered, the giant panda and the okapi.)

From Smith and Cuvier two different lines of paleontological work have arisen. Until comparatively recently invertebrate fossils were studied chiefly by men whose interests lay in stratigraphic geology and who used them purely as time markers, or indices to certain strata. The type of work initiated by Cuvier has been carried on chiefly by zoologists and anatomists and has been concerned mainly with vertebrates.

II. GEOLOGICAL PALEONTOLOGY

The geological use of fossils as time markers rests primarily on observation of the actual occurrence of the remains of animal species in the rocks. Very extensive collections have shown that species of the genus *Productus* are found only in rocks of Late Devonian, Carboniferous, and Permian age, that the species *Productus giganteus* can be found only in a small part of Lower Carboniferous strata, and that the family Productidae lived from the Late Ordovician to the end of the Permian. These facts are a mere matter of observation; their accuracy depends upon a correct identification of fossils and on the extent of the collections which have been studied. The importance of stratigraphic geology for commercial purposes is so great that geological investigations have been conducted on an extensive scale all over the world, even in such difficult regions as Spitsbergen, Patagonia (in Argentina), central Africa, and Mongolia.

1. Classification of Stratified Rocks.—The divisions recognized by Smith were marked primarily in the mineral composition of the strata. The Early Jurassic strata in the Bath district showed successive stages of clay, sandstone, limestone, unconsolidated sand, and so on. It was in such formations, readily separable from one another by inspection, that Smith collected his fossils. From this collection he claimed that geological formations could be identified by the fossils they contained.

Later workers extended this concept and used it as a basis for the division of stratified rocks into systems. An example is the Silurian System, which resulted from the research of R. I. Murchison (*q.v.*), who separated a great series of formations containing certain fossils, trilobites, and graptolites that were rare or nonexistent in later geological time. The character of the basis on which

this system was formed was made clear by the famous long-continued discussion between Murchison and Adam Sedgwick. The latter had mapped North Wales, dividing up the rocks into formations and grouping the whole in the Cambrian System. After the establishment of the Silurian System by Murchison, the fossils collected by Sedgwick were examined, and it was discovered that the whole assemblage of Sedgwick's Cambrian fossils was that which characterized the Silurian System. Murchison claimed that the term Cambrian was synonymous with Silurian. Thus the two conceivable methods of dividing stratified rocks into groups on the basis of their lithology and of their paleontology were placed in opposition, and the true nature of the differences had to be considered.

It is certain that every change in the character of sediments depends on a modification of the geography of the region in which they were being laid down. Also, in those cases where successive rocks have an unconformable relationship to one another, there is an interval of time separating the two. It is evident that the faunal changes that distinguish one formation from another are to a great extent the result of the evolution that has proceeded during the time separating the deposition of the sediments involved. Thus the evidence from stratigraphy and from paleontology should lead to the same conclusions. But the changes in faunas, depending as they do on evolution, which proceeds with time, should occur whether or not the geography is so altered as to cause a modification in sedimentation. It should therefore be possible on paleontological grounds to divide the rocks of a single geological formation into smaller periods not necessarily recognizable by lithological differences but displayed by a change in faunas. The first geologist to do so was Albert Oppel, who divided the Early Jurassic into small periods that he called zones. Technically a zone consists of the sediments that were laid down during the existence of a particular species of animal. In practice it is usually found that they are most readily recognized not by the presence of a single species but by the coexistence of a group of forms, not one of which is necessarily present in each locality where the zone occurs.

2. Zones.—This process of dividing rocks into small divisions has been carried to an extreme length among Jurassic and Cretaceous sediments but has to some extent been applied to all systems. The Cambrian System, divided into groups primarily on the lithology of the sediments of that age in North Wales, has been subdivided into about 12 zones, chiefly on the evidence afforded by the range of different genera or species of trilobites. The succeeding Ordovician and Silurian systems were shown by Charles Lapworth to be divisible on the evidence of graptolites, and it has since been found that these graptolite zones can be recognized not only in the region of southern Scotland, where they were established, but throughout western Europe, North America, and even Australia. They are thus of worldwide significance.

3. Facies.—In the course of his work, Lapworth emphasized the fact that the Ordovician and Silurian rocks of southern Scotland existed in two different forms. One form consisted of sandstones, shales, and limestones containing trilobites, the shells of brachiopods and mollusks, and corals. The other form was composed of very thin-bedded, black shales often crowded with graptolites but yielding very few other fossils. He called these two rock types the shelly and the graptolite facies, respectively. With the occasional occurrence of graptolites in the shelly facies, he was able to show that the difference between the faunas of the two types did not depend on differences of time but could be completely explained by the assumption that the rocks of the shelly facies were laid down near the coast in shallow water where trilobites and shells were living. The graptolite shales, on the other hand, were deposited in relatively deep water, and the graptolites found in them were pelagic animals floating freely in the sea, their skeletons sinking to the bottom and becoming buried in the scanty sediments accumulating there. The idea that two faunas of identical age may differ completely because of such a difference of facies is a most important one. It should always be kept in mind in discussing the geological age of any rock.

Modern work on the distribution of animals on the floor of the Kattegat Strait, the North Sea, and the English Channel has shown conclusively that in very short distances (in some cases within a few hundred yards) totally different forms may be lying buried in the sea bottom. The character of the fauna is determined in part by the nature of the soil (whether gravel, sand, or mud), and in part by the depth of water.

The fact that graptolites are unattached forms floating in the surface layers of the water explains the occurrence of their skeletons in both the shelly and graptolitic facies. It also accounts for their wide distribution. Since they were undergoing a rapid evolution their time spans were relatively short. The graptolite zones of the Paleozoic Era probably cover longer periods of time in comparison with those recognized in Jurassic rocks. Throughout the Mesozoic, zones have been established on the basis of the ammonites. These fossil shells of cephalopod mollusks are often enormously abundant. They were undergoing very rapid evolution from their first appearance at the base of the Permian to their disappearance at the top of the Cretaceous. Many are found in sediments of all types, suggesting that, like the graptolites, most of them did not dwell on the sea bottom but swam freely in midwaters or near the surface. These habits would explain the wide geographical range that some ammonites are known to have covered. For example, the same or closely similar species of *Mortoniceras* occur in Texas, India, South Africa, and Europe.

Ammonite zones have been established in all marine sediments up to the Late Cretaceous, but in Tertiary formations there were found conditions in which no group of marine animals can be used for a worldwide division into zones. The difficulty of subdividing the Tertiary Period in all probability is explained by the absence of any group of highly developed pelagic forms undergoing a rapid evolution and capable of ready preservation as fossils. A survey of the present faunas of surface waters, especially of those not entirely coastal, suggests that the most valuable groups for zonal purposes in the Tertiary would be the whales, whose size and rarity render them unavailable, and the copepods, which are except in very special cases incapable of preservation. Thus the subdivision of the Tertiary Period, so far as rocks of marine origin are concerned, necessarily rests on bottom-living forms from shallow seas, such as the Foraminifera, Gastropoda, Lamellibranchia, and Echinoidea. It is perfectly clear from the present-day distribution that species belonging to the last three groups generally have a restricted geographical distribution. The fundamental nature of the shortcomings that such materials possess when used as time markers is vividly illustrated by the uncertainty that still exists as to the ages of the Tertiary deposits of Australia and South America.

Foraminifera and such other small fossils as Ostracoda have attained a special importance in stratigraphic geology because they can be determined in the fragments obtained from boreholes. The exploratory bores, made very extensively to locate oilfields, yield such material. The investigation of these fossils has become a special branch of paleontology (micropaleontology; *q.v.*), now actively pursued because of its economic importance, especially by U.S. workers.

4. Establishment of Zones.—The zones so far considered rest entirely on an observational basis. They have been defined by recording the distribution of particular species in a series of rocks where succession can be determined by mapping. Their validity depends entirely on the certain recognition of individual species and on the extent to which collections have been made. The business of a geologist intent on establishing zones is to collect as many fossils as possible from each bed of a well-exposed series and then in the presence of the whole material to draw the limit of his species as finely as he can: that is, to indicate by a name (to be regarded purely as a method of handling the facts) each type of organism which can be distinguished from all others by observable and constant morphological characters. Theoretically such groupings should be made without reference to the beds in which the individual fossils have occurred, but in practice it is usually found that recognition of the more minute differences in structure is much easier if the relative ages of the specimens are taken into account. This practice, universally and necessarily pursued, in-

troduces the danger of accepting, as permanent and characteristic, features that are not such in fact.

For full use of the information acquired by this process, it is necessary to compare the species of fossils that have been thus recognized with materials from other parts of the world. Since very few museums possess collections from all over the world and since these will in any case be inadequate, such a comparison can be made only with fossils previously described. It is therefore a primary duty of a paleontologist to publish detailed descriptions illustrated by accurate and clear figures of the forms he recognizes, but he may do so only after he has compared his own specimens with the whole of the published accounts of similar creatures. This process is extraordinarily laborious and tedious but is rendered far easier if there is a modern monograph of the whole group involved. After each fossil of the collection has been referred to a definite species, it is easy to discover if any of them are restricted to a definite bed or series of beds. It is then necessary to consider whether the absence of a given species at any particular horizon is due to the age of those rocks or to a change of facies, which will in most cases be indicated by a change in the lithology. Life zones are founded on the period of existence of a definite species of animal and should have a validity throughout the entire region in which the animal lived. Zones should not be established, although they may be tentatively put forward, until it can be shown that they are recognizable over some area that represents a fair sample of the probable space range of the species. Since it is known from present-day conditions that no individual species of sedentary animal that lives in shallow seas occurs uniformly distributed over any area even so small as the English Channel, it is clear that the nonoccurrence of the zone fossil at any place does not necessarily imply that deposits of its zone are absent there. Even in rocks not lithologically dissimilar, the same zone may contain different faunas in places only a few miles apart.

If the zonal fossil is a pelagic form that was buried only after it had sunk, then within wide limits its occurrence should be independent of the nature of the sediments, and its distribution, depending on the vagaries of the currents, may be expected to be uniform in periods of time exceeding a few years. The nonoccurrence of a pelagic zonal fossil in an area within which its remains are found, assuming that the collections are adequate, is good evidence that sediments laid down during its zone were either not deposited or have subsequently been removed. The very detailed zoning of Jurassic rocks in England by the work of S. S. Buckman and his successors has shown that such failures of sedimentation or local unconformities are exceedingly common in shallow water deposits and that they may be entirely unrecognizable by ordinary stratigraphic methods.

5. Paleogeography.—In addition to their value as time markers, fossils may throw light on the geographical conditions under which rocks were laid down and on the paleogeography of the world as a whole. Certain groups of animals are now, and always have been, restricted to salt water; no echinoderm, for example, is ever found in rivers or lakes. Although a few forms (none capable of preservation as fossils) do occur in fresh water, the Coelenterata is known as a marine group, and the occurrence of a coral is almost conclusive evidence that the rocks in which it was found were laid down under the sea. Brachiopods are equally marine, but *Lingula*, and presumably some of its allies, extends its range into brackish water. In most cases a phylum may have representatives both in the sea and in fresh water, but even in these cases it will usually be found that many of its larger divisions are restricted to one or the other habitat. Thus most molluscan groups are strictly marine, but among the gastropods the snails have emigrated into fresh water and onto land. A limited number of pelecypods (mussels and the like) live in fresh waters.

Among marine animals, contrasts in faunas of any given age may indicate the presence of land barriers between oceanic areas. Much evidence of former continental connections can be gained from the study of terrestrial fossils, particularly the vertebrates. The history of mammalian life shows clearly, for example, that South America was isolated from other continents during nearly the entire Tertiary. During this time a unique South American mammal fauna developed, only to disappear for the most part during the Pleistocene, when proof of reestablishment of connections is given by the presence of numerous animals of northern origin. That connection existed between Siberia and Alaska during various stages of the Tertiary is indicated by the fact that at various times Eurasian and North American faunas show marked similarity, only to diverge again when (it can be inferred) connections were broken. At one time various workers assumed the presence of a variety of Tertiary land bridges between one continental area and another to account for the presence in the two of some specific type of animal life. In general, however, such theoretical bridges raise more difficulties than they solve, and belief in them has been generally abandoned. In the Mesozoic and Paleozoic eras intercontinental relationships are less clear. Mainly on paleobotanical grounds many workers assume that in Pre-Jurassic times South America, Africa, peninsular India, and Australia formed a single continental mass, Gondwanaland; again, the theory of continental drift, of which Alfred Wegener was a major advocate, assumes that all the continents at an early geologic time formed a single mass that later separated into its present components, the American continents remaining long in contact with Europe and Africa before being separated by the Atlantic Ocean. Animal fossil distribution has been adduced both for and against this hypothesis, but the evidence is far from conclusive.

6. Fossils and Climate.—Appeal is often made to fossils in discussions of the temperature under which certain formations have been deposited. For example, it is stated that such an extensive development of corals as occurs in the coral rag of Mid-Jurassic age implies that this sea was tropical. This conclusion is based entirely on the fact that present-day coral reefs are found only in or near the tropics; there is nothing in the structure of the coral species to explain it. The coral *Lophohelia*, which forms great branching colonies two feet in height, lives in the cold deep waters of the Norwegian fjords and off the coasts of Scotland. This animal and others that occur with it differ in no consistent respects from allied tropical forms. Thus the mere occurrence of corals provides very unsubstantial evidence on which to found an interpretation of the temperature of past seas. If this doubt exists for Jurassic times, then the abundance of corals in Paleozoic rocks affords no evidence whatsoever as to the temperature, especially since the phylogenetic relationships between Paleozoic and Mesozoic corals are quite uncertain. In the case of rocks of Pleistocene and Late Tertiary age in which the remains of living species are found, it is possible to use their evidence in following the course of temperature changes during the period of their deposition.

Most living species of marine animals have a distribution limited by temperature. Such fish as the haddock can live and breed only in waters where upper and lower temperature limits are strictly defined, and it is reasonable to suppose that this disability has existed from the time of their origin. The discovery of such an animal as the abalone (*Haliotis*, whose present northern limit is the Channel Islands) in Late Tertiary rocks in England would imply that there has since been a fall in temperature in the sea surrounding the British Isles. It is clear that such evidence must be used with caution and that it becomes more fragile the further back the species be traced.

For continental areas, where greater temperature variations exist than in the sea and where differences in rainfall afford a second major variable, evidences of ancient climates are of greater potential value. Many major events in vertebrate evolution, including the origin of lung-bearing fishes and amphibians and the "invention" of the shelled egg definitive of amniotes, are best understood as being due to a widespread development in Late Paleozoic times of climates producing areas comparable to modern tropical savannas, with marked seasonal droughts. The abundance of aquatic amphibians in the Upper Carboniferous is in agreement with the conclusion from sedimentary and paleobotanic evidences that the period was one of equable temperatures and abundant rainfall. Animal as well as plant evidence indicates that in Early

Tertiary times temperature gradients from poles to tropics were less steep than at present, for fossil deposits of those times show not only an abundance of warmth-loving mammals, such as primates, far to the north but also numerous reptiles, which cannot in general withstand deeply cold winters. A harsher zonation for the Late Tertiary is indicated by the fact that of the bovids (the cattle-antelope group) only a few forms adapted to cold climates were able to reach North America from their place of origin in the Old World. *See* also Fossil; Marine Biology; Geology.

(D. M. S. W.)

III. THE SUCCESSION OF FAUNAS

A. The Geologic Time Scale

The history of the earth is measured by paleontologists not by years but in terms of major periods of time (eras) that are correlated with successive series of rock formations; eras, in turn, may be divided into periods, and periods into epochs. The earth is now believed to be several billion years old. The proper mode

Geologic Column and Scale of Time

(Ages increase from top downward, as in a sequence of sedimentary rocks)

System and Period	Series and Epoch	Distinctive Records of Life	1000 Years*
		CENOZOIC ERA	
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	>44 1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	(21,000)
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	(58,000)
	Paleocene	First placental mammals	70,000
		MESOZOIC ERA	
Cretaceous		Extinction of dinosaurs, floras with modern aspects	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
		PALEOZOIC ERA	
Permian		Conifers abundant, reptiles developed	(230,000) 235,000
Carboniferous			
Upper (Pennsylvanian)		First reptiles, great coal forests	260,000
Lower (Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000 (380,000)
Ordovician		First primitive fishes	400,000
Cambrian		Large faunas of marine invertebrates	(440,000) 500,000
		PRECAMBRIAN TIME	
		Plants and animals with soft tissues, few fossils	(620,000) (1,420,000)
No known basis for systematic division			(1,800,000) (2,680,000) (3,310,000) 3,500,000-4,000,000

*Italicized figures are from radiocarbon analyses; figures in parentheses are reliable values from radioactive minerals found in rocks that belong in time divisions indicated; plain figures give estimated dates at start of corresponding time units.

of division of the earlier portions of its history into eras is disputed since fossil animals (and indeed any sort of traces of life) are exceedingly rare except during the last half-billion years or so. There is general agreement that this final fraction of the earth's history can be regarded as constituting three eras: Paleozoic, Mesozoic, and Cenozoic.

Estimates of the age of the various periods were long made on the basis of the minimum amount of time necessary for the deposition of the sediments attributable to them. Since such figures allowed but a few million years for the whole Tertiary history of mammals, Charles Darwin and later workers were much concerned as to whether all the known evolutionary development of life could have been accomplished in the time allowed. Our present, vastly larger, figures are based on modern knowledge of radioactivity. At various points in the geologic sequence are found rocks which contained radioactive minerals. Since the rate of disintegration of these substances is known, the ratio of original materials to their disintegration products furnishes positive evidence of age (*see* also Radiocarbon Dating).

The geologic history of many major (and minor) animal groups is noted in a variety of other articles treating the specific types concerned; below is gathered material attempting to treat as a whole the nature of successive faunas period by period.

North American workers divide the Carboniferous into two periods, Mississippian (Lower) and Pennsylvanian (Upper). The Ordovician is considered by some European workers to be merely an earlier part of the Silurian; the latter term as used here may then be referred to as the Gotlandian. Some European writers further consider that the Tertiary should be divided into two periods, an older Eogene (or Nummulitic) and a later Neogene Period.

B. Precambrian Time

In the Cambrian, earliest of Paleozoic periods, there occurred numerous and varied forms representing full-fledged members of almost every major animal group in the fossil record. It is obvious that animal evolution was well advanced at this time. But in older deposits there are almost no animal fossils at all. There are trails and burrows attributed to worms, possible fragments of arthropods, a few very dubious sponges, foraminifers, and radiolarians, nothing more. Where are the ancestors of the highly evolved Cambrian animals? This major problem has puzzled students of fossils from the time of Charles Darwin to the present. There is no certain answer. Possibly there were Precambrian forms with hard skeletons, but these may have been destroyed by subsequent metamorphosis of the rocks containing them. Perhaps Precambrian strata are mainly freshwater deposits, rather than marine formations in which early shelled forms might be expected. A majority opinion holds that Precambrian organisms may have been already highly evolved but lacked hard parts. Some believe that this was due either to a paucity of calcium available for skeletal formation in the waters in which they lived or to acidity in these waters, thus preventing the formation of calcareous skeletons. A final suggestion is that ancestral types were mainly active forms, in which hard skeletons would be of little use or actually detrimental. It is possible that shells or hard external coverings appeared as the result of the adoption of a sessile or sluggish mode of existence.

C. Paleozoic Era

1. Cambrian.—Information regarding the faunas of the Cambrian and other Early Paleozoic periods is almost entirely derived from beds in Europe and North America, for little is known from other continents. In fact, few Early Paleozoic formations are present anywhere in the Southern Hemisphere. During the course of this first period of the Paleozoic, there appeared representatives of every animal phylum of importance except the chordates (the vertebrates and their relatives). But while this "sudden" outburst of fossil types is spectacular, the speed of their appearance should not be overemphasized, for the Cambrian covered a considerable period of time. The Early Cambrian faunas were relatively restricted in the variety of forms represented, and it was not until late in the period that the full Cambrian fauna was present. Although no land animals are known, two marine groups were particularly prominent, the trilobites and the brachiopods. The trilobites, archaic arthropods with broad flat bodies and numerous appendages, were exceedingly numerous, increasingly so in the Late Cambrian.

In the Early Cambrian the trilobites were diversified into four distinct orders, with a fifth order appearing in Middle Cambrian times. Most of these orders were of little importance later, but included are the Opisthoparia, longest lived and most successful of trilobite types. The brachiopods, or lamp shells, although relatively unimportant today, were extremely prominent in all Paleozoic marine faunas. In the Cambrian they constituted nearly a third of all reported genera. Brachiopods were of two main types: the articulates, in which the two shells are hinged together; and the inarticulates (such as the modern *Lingula*), in which the hinge is absent. Both types were present in the Cambrian, but inarticulates were dominant.

There is almost no indication of protozoan life in the Cambrian. On the other hand, sponges and possible sponge relatives

were widespread. Siliceous spicules and skeletons represented both the Hexactinellida (or Hyalospongea) and Demospongia. Much more common, however, were the Pleospongia (or Archaeocyatha), a group of reef-building organisms with a vase-shaped, porous skeleton surrounding a central cavity. Confined to the Cambrian, these forms are considered by some to be coelenterates, but are more probably a class of calcareous sponges. Of the phylum Coelenterata (or Cnidaria), only a fraction secrete a skeleton and hence are capable of fossilization under normal conditions. Corals, common in later periods, were unknown in the Cambrian, and the only common coelenterates were the Stromatoporoidea, an order of colonial polyps (extinct since the Cretaceous) that secreted massive calcareous deposits about themselves. Very doubtfully referred to the Scyphozoa (the jellyfish group) are the conulariids (Conulariida), known from four-sided pyramidal shells; they appear from the Early Cambrian to the Triassic.

Mollusks, highly important later, were relatively poorly represented at this time. Most of the known genera were gastropods. Although individual specimens are relatively rare, there were representatives of about nine families of these snail relatives, with shells varying from a simple cone to shells coiled in a single plane. Of especial interest was the presence of a class of primitive mollusks (Monoplacophora). Formerly included in the gastropods, they are known from small and simple shells, the markings on which suggest a primitive bilateral body symmetry and a possibly segmental arrangement of muscles and other organs. Fossils of this type were confined to the earlier Paleozoic periods, but the suggestions of primitiveness have been strikingly confirmed through the discovery of a living monoplacophoran (*Neopilina*) in the depths of the Pacific Ocean. The cephalopod mollusks, so important in later geologic periods, were relatively slow to make their appearance. Primitive curved-shell members of the nautiloid group (Nautiloidea) are found in Late Cambrian strata, but no earlier cephalopods are known. A puzzling exception was the appearance of tiny, slender, conical shells (*Volborthella*) in the Early Cambrian, which may represent early cephalopods of some sort. Possibly mollusks, but of very dubious relationships, were the extremely abundant little tubular or cone-shaped shells of the genus *Hyolithes* and its allies; relationship to the modern pteropods has been suggested.

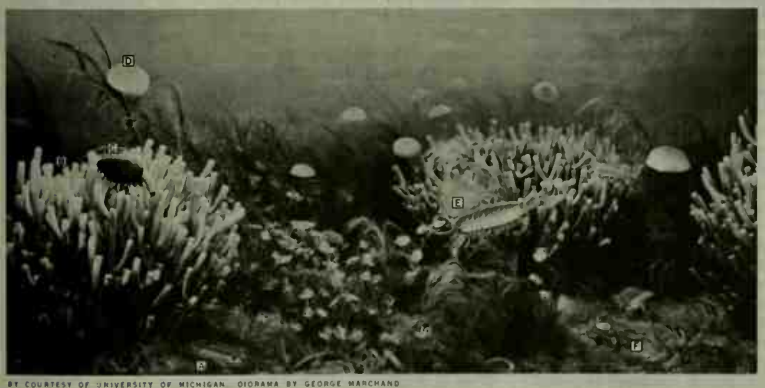
Although the trilobites were the dominant arthropods, two other groups were present. The living horseshoe crab (*Limulus*) is the sole survivor of the arthropod order Xiphosura, of which the oldest representatives occurred in Middle and Late Cambrian deposits. Crustaceans, important in later history, were poorly represented in the Cambrian. The only forms surely known are shelled representatives (Conchostraca) of the little branchiopods (fairy shrimps, water fleas, etc.) in the Middle and Late Cambrian and the first of another group of tiny shelled crustaceans, the phyllocarids, somewhat more advanced in structure but destined not to survive the Paleozoic.

A final major invertebrate group of the Cambrian was that of the echinoderms. Cambrian echinoderms were relatively uncommon, and types represented were for the most part archaic in nature, indicating that the phylum had evolved at a relatively late date. Study of living echinoderms suggests that stalked forms (Pelmatozoa), represented today by the crinoids (such as sea lilies), are more primitive than unattached types (Eleutherozoa, such as starfish, sea urchins, etc.). The fossil record appears to corroborate this belief, for apart from a possible ancestral sea cucumber, all known Cambrian echinoderms were attached types. There were as yet, however, no true crinoids, since the Cambrian forms pertained to groups (Edrioasteroidea, Eocrinoidea, Carpoidea) that were destined to become extinct well before the end of the Paleozoic.

Many living groups of invertebrates lack hard parts of any sort and hence can be found as fossils only under most unusual conditions. Moreover, there may have existed many types of shellless invertebrates that have left no mark of their existence at all.

A fortunate glimpse into the world of early invertebrate life is afforded by studying the exquisite impressions of numerous soft-bodied animals of Middle Cambrian age, such as those found in the Burgess shale of British Columbia. Many of them are puzzling forms difficult to assign to any known groups, living or extinct. But in addition to such puzzling forms and otherwise familiar types, the Burgess shale exposed such rare fossils as those of the most ancient jellyfishes, polychaete annelid worms, and somewhat doubtful sea cucumbers (*Holothuria*). This shale also contains the only known fossils of the wormlike Onychophora (represented today by *Peripatus*), of the Chaetognatha (arrow-worms), and, possibly, of the peculiar, living, wormlike group of the Gephyrea.

2. Ordovician.—Knowledge of animal life of the Ordovician Period is confined to the seas. In many regards the life of the period continues the picture seen in the Cambrian, but marine invertebrates were still more abundant and varied. Of the Protozoa, the shelled Foraminifera, of importance later, appeared for the first time but were as yet rare. Of spongelike organisms, the Pleospongia of the Cambrian were gone, but there appeared in the Ordovician (continuing to the Devonian) another problematical group, *Receptaculites*, characterized by globular or saucer-shaped calcareous structures. Notable was the appearance among the coelenterates of two major groups of corals, the tabulate and rugose corals (the latter also termed Tetracoralla). Now extinct, these corals played a prominent part in the formation of Paleozoic limestones. The stromatoporoids continued as important reef builders, and in the Ordovician there appeared the similar Labechiidae. In contrast to the Cambrian, the mollusks assumed a position of major importance.



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DIORAMA OF THE SEA FLOOR OF THE MIDDLE CAMBRIAN PERIOD. (A AND F) TRILOBITES, EXTINCT ARTHROPODS; (B) BRANCHING SPONGE; (C AND E) LARGE ARTHROPODS; (D) JELLYFISH

Most notable was a vast outburst in numbers and variety of nautiloid cephalopods. Ancestral Cambrian forms possessed curved shells; those of the Ordovician varied from the first properly coiled, true nautiloid types to a variety of types with conical shells. The gastropods increased greatly; there were more than a dozen new families, most of which, however, were destined not to outlive the Paleozoic. The Ordovician marked the first appearance of the Amphineura (represented today by chitons and their relatives); this group of relatively primitive mollusks was at no time of any great paleontological importance. Much more noteworthy is the fact that the first pelecypods occurred in the

Middle Ordovician and became abundant before the end of the period. Trilobites still were dominant among arthropods and were even more prominent than in the Cambrian. The first rare members of the scorpionlike Eurypterida appeared; many later eurypterids were apparently freshwater dwellers but the early representatives appear to have been marine.

There was an increase in variety of the groups of smaller crustaceans. There appeared the ostracods, whose tiny bivalved shells are common in many Late Paleozoic deposits, and the first certain representatives of the barnacles (Cirripedia). Brachiopods were again very prominent; from this period onward, however, the inarticulate forms became relatively rare, and the hinged forms became highly abundant. Prominent were the subfamilies Orthacea, Strophomenacea, and Rhynchonellacea. There appeared also several groups of brachiopods destined to become important in later periods.

Echinoderms had become much more prominent in the faunal picture. Attached forms still dominated. The three groups present in the Cambrian persisted, and others that appeared were blastoids and abundant cystoids. A more modern note was struck by the presence of crinoids, which increased greatly before the close of the period. In addition to stalked forms, there was a definite but modest representation of free-living groups, including representatives of the true starfishes (Asteroidea), brittle stars (Ophiuroidea), and sea urchins (Echinoidea).

The Ordovician is notable for the introduction of several major groups quite unknown in the Cambrian. As a relatively minor event, the conodonts (Conodontophoridia) first appeared. These are toothlike or jawlike little objects, useful in Paleozoic stratigraphy but extremely difficult to classify. In this period, too, were found the first of the moss animalcules or bryozoans, small colonial animals, most of which secreted hard skeletons of paleontological interest. Four of five known orders of this sort appeared in the Ordovician; particularly prominent in Paleozoic rocks are colonies formed by members of the order Trepostomata, the stony bryozoans.

Appearing at the Cambrian-Ordovician boundary and continuing as common fossils through much of the Paleozoic were the graptolites. Their remains commonly consist of small, branched, chitinous tubules that obviously sheathed small colonial animals of some sort. Some colonies appear to have been attached to the sea bottom, others were free floating. The nature of graptolites has been much debated; it has been seriously contended that they are comparable to the pterobranchs, small, living, marine forms related to the hemichordate acorn worms and hence remote vertebrate ancestors. Still, certain Ordovician forms are claimed to be actual pterobranchs.

But the Ordovician fossil record advances still further; there are definite traces of true vertebrates. A few toothlike structures of possible vertebrate type were long ago reported from the Ordovician of Russia, and a few possible vertebrate fragments were found more recently in the St. Lawrence region. Positive evidence of vertebrates, however, has long been known from an area extending from Colorado northward through Wyoming. Here in the Harding sandstone and equivalents are remains, generally quite fragmentary, of dermal plates of primitive jawless vertebrates (ostracoderms of the order Heterostraci). The deposits in which the remains are found are marine (apparently near-shore deposits), and it has been reasonably argued that the earliest vertebrates were freshwater forms; our sparse knowledge of early vertebrate history may be due to the paucity of continental deposits of this high antiquity.

3. Silurian.—Fossiliferous Silurian deposits continued to be primarily marine in nature, although toward the end of the period there appeared limited continental deposits, best known in northeastern North America and northern Europe. In the seas the aspect of the animal population was fairly similar to that of the older periods of the Early Paleozoic. There was little notable change regarding protozoan and sponge fossils. Among coelenterates, both tabulate and rugose coral groups continued in prominent fashion, and there were considerable additions to the variety of rugose forms; stromatoporoids continued to be common in this period and the Devonian as well. Of mollusks, nautiloids were still the only cephalopods; they remained abundant, although there was some slight reduction. Gastropods and pelecypods flourished from this period onward.

In the Silurian were found the first representatives of the Scaphopoda, the so-called elephant's-tusk shells; at no period, however, is the group of importance in the fossil record. Of arthropods, the trilobites were still abundant but had definitely passed the climax of their development. Of the xiphosurans, forms intermediate between ancestral types and the limuloids were present in the Silurian and Devonian. Knowledge of crustaceans is still confined (as is also true of Late Paleozoic periods) to small shelled forms and barnacles; ostracods were abundant then and in the Late Paleozoic. Some (but not all) of the rather numerous eurypterids appear to have been still marine in habitat. Brachiopods flourished greatly; the Orthacea were reduced; Rhynchonellacea and Strophomenacea continued to be plentiful; and Spiriferacea and Rostrospiracea were among new groups rapidly rising to prominence. Of echinoderms, there was some reduction of the more primitive sessile types, but the crinoids were more diversified than in the Ordovician. Eleutherozoans were of only modest importance. Graptolites, mostly of free-floating types, continued to be plentiful.

Particularly toward the close of the period and in the transition to the Devonian there was some development of continental deposits. In these deposits were found the first land and freshwater animals. Although some eurypterids of the Silurian appear to have persisted in salt waters, others in the Late Silurian appear to have invaded brackish or fresh waters. Vertebrate spines, scales, and plates are found in marine deposits of the Late Silurian to some extent, but the best-preserved fossils (almost entirely members of the armoured jawless fishes grouped as the ostracoderms) are found in red beds of a continental type. In such beds, too, are found the oldest known fossils of scorpions (related to the older aquatic xiphosurans and eurypterids) and the first millipedes (Diplopoda). There, then, were the beginnings of a continental animal fauna.

4. Devonian.—Although the Devonian witnessed a considerable increase in the faunas of continental areas, the greater wealth of animal life continued to be found in the oceans. Devonian marine beds are most numerous in Europe and North America; continental red beds are best preserved in northeastern North America and in northern Europe. Siliceous sponges were locally abundant. The last members of the problematical *Receptaculites* appeared in the Devonian. Both tabulate and rugose corals were prominent in the Early Devonian, but later the tabulates declined. Stromatoporoids were common elements in reef deposits. Conulariids are best known from this period. Nautiloids continued to dominate among cephalopod mollusks, but during the period there developed from them the first of the ammonoids (Ammonoidea), never too abundant during the rest of the Paleozoic but destined for Mesozoic prominence. Gastropods were highly diversified. The decline of the trilobites continued.

In the Devonian were the first "modernized" xiphosurans, approaching the modern *Limulus* in structure. Of the flourishing brachiopods, the Spiriferacea and Rostrospiracea were the most prominent groups. The trepostome bryozoans were common and varied. Except for the blastoids, which were increasing even more in numbers, the more primitive attached echinoderms were close to the vanishing point.

The Devonian is often termed the Age of Fishes because of the rapid expansion of water-dwelling vertebrates. Many fish groups of the period were primarily freshwater forms, but there was a continually expanding marine fish fauna as well. A majority of the members of the great order Arthrodira were marine forms, and typical armoured arthrodires swarmed the Late Devonian seas. Some, such as *Dinichthys*, attained a length of about 30 ft. In the latter half of the period there appeared the first primitive sharks represented by *Cladoselache*.

With abundant continental sediments, particularly of the Old Red Sandstone type, further advances occurred in the development of freshwater and terrestrial faunas. Among the arthropods,

the first wingless insectlike forms were added to the known land fauna. These ancient types are compared to the living Collembola (springtails). The eurypterids reached the peak of their development at about the Silurian-Devonian boundary; later forms, decreasing in abundance in the Late Paleozoic, appear to have been restricted to fresh or brackish waters. Fishes are numerous and varied in continental deposits. Like the eurypterids, the primitive jawless ostracoderms are most abundantly represented in deposits transitional from the Silurian; they then rapidly declined and became extinct by the end of the Devonian. Of the three prominent ostracoderm groups, the Osteostraci (Cephalaspida) and Anaspida appear to have been restricted to fresh waters; the Heterostraci are found in both continental and marine deposits. Of primitive jawed fishes (Placodermi), small acanthodians ("spiny sharks") were a modest element in fresh waters, as were a restricted series of arthrodires. Notable in the Late Devonian was the appearance and temporary prominence of the antiarchs, small, armoured arthrodire relatives with peculiar bony shoulder "flippers."

By Middle Devonian times freshwater streams were swarming with highly developed bony fishes. All three major groups were present, but in the Devonian, in contrast to later periods, crossopterygians and lungfishes were the prominent forms; ray-finned fishes, destined for later dominance, were rare. A further evolutionary step in the vertebrate story was the appearance (in the Late Devonian of Greenland) of *Ichthyostega* and its allies, the oldest known amphibians.

5. Carboniferous.—The Lower Carboniferous (Mississippian) was predominantly a time of deposition of limestones and other marine sediments; the Upper Carboniferous (Pennsylvanian) was notable for the deposition of the great coal deposits in swamps and lagoons of Europe and North America, giving their name to the period. Marine formations were more widespread than in earlier periods; apart from familiar areas of Europe and North America, there were notable marine beds along the course of the ancient Tethys Sea. This stretched eastward from the Alpine-Mediterranean area across southern Asia; the Tethys area furnished marine faunas at many stages, from the Late Paleozoic well on into the Tertiary. In the seas, Foraminifera, although present much earlier, first became of major stratigraphic importance as index fossils of the Late Carboniferous; particularly important were the large members of the family Fusulinidae. There were varied hexactinellid sponges and demospongians. Among corals, the tabulates continued to decline as contrasted with the continued abundance of rugose forms. Of the nautiloids, a number of groups declined; the majority in the Late Paleozoic pertained to the order Nautilida and were coiled types related to the Mesozoic and Cenozoic forms. *Goniatites* and its relatives were widespread representatives of the ammonoids, and a new note was struck by the appearance of a belemnoid, the most primitive of the group of dibranchiate cephalopods, which were much later to rise to prominence. There was a considerable development of pelecypod types comparable to the scallops and mussels of later times. Of marine arthropods, the trilobites became rare; xiphosurans were unimportant; and small ostracods were the only common crustaceans. Cryptostome bryozoans such as *Fenestella* were common in the Carboniferous and Permian. *Productus* and related types were the brachiopods most typical of the period. In early phases there were also abundant representatives of the Spiriferacea, Rostrospiracea, Rhynchonellacea, and other groups, but in general there was a gradual decline in Late Carboniferous horizons. Crinoids still flourished greatly and blastoids reached the peak of their development, but all other attached echinoderms disappeared except a few relicts of the edrioasteroids.

Then, as in other Late Paleozoic periods, the starfish groups were but modestly represented. The echinoids, however, assumed a temporary importance in the Lower Carboniferous, and the first definitely identifiable holothurians were found in the Lower Carboniferous. The period saw the last rare representatives of the graptolites, and, although the problematical conodonts persisted into the Mesozoic, they were abundant there for the last time. Of marine fishes, the varied arthrodire groups disappeared at a point close to the Devonian-Carboniferous boundary, but there were numerous cartilaginous fishes (Chondrichthyes), mainly represented by teeth and spine fossils. There were typical predaceous sharks of the general *Hybodus* type, and varied mollusk-eating forms grouped as the Bradyodonti.

On the continental areas, a notable molluscan advance was in the appearance of air-breathing snails (Pulmonata); pelecypods had invaded fresh waters. The greatest terrestrial development, however, was among the arthropods. In addition to scorpions and millipedes (both fairly common) there had been added a wide variety of spiders. Most important was the development in the Upper Carboniferous of a great variety of winged insects. Some seven orders were present. Although all were primitive in nature, they were so diversified that a more complete fossil record could probably trace the insects back into the Lower Carboniferous and probably into the Devonian. Only one Carboniferous group, that of the cockroaches, is represented in the modern fauna; of the other groups the Palaeodictyoptera were the most prominent. The Carboniferous insects were, on the average, of large size; one type had a wingspread of 2½ ft. All had four wings; the two pairs were generally identical and in many species could not be folded over the back; most were surely weak fliers. Some certainly represented sterile side lines, but others appear to have been ancestral to dragonflies, orthopterans, and others of the more primitive existing groups.

In fresh waters, along with a restricted series of mollusks, crustaceans, and rare eurypterids, was a wealth of fish faunas. Ostracoderms and placoderms had vanished, except for a few acanthodians; there had appeared a group of large freshwater predaceous sharks, usually termed pleuracanths, but bony fishes were dominant. Crossopterygians and lungfishes continued to be moderately abundant, but they were far outnumbered by primitive ray-finned fishes, the palaeoniscoids. These forms, mostly of modest size, had spread out into a considerable number of genera. Amphibians are numerous in coal swamp deposits. Most pertained to the main line of older amphibian evolution, the Labyrinthodontia. Some were of modest size; others reached the proportions of alligators. A majority pertained to the Rhachitomi subdivision of the labyrinthodonts; the Embolomeri were slenderly built fish eaters. In addition to the labyrinthodonts there were numerous small Lepospondyli, generally slimly built, with reduced limbs and in some cases a snakelike (or eellike) appearance. Although fossils of most Carboniferous land vertebrates come from the coal swamps and little is known of what went on in higher and drier lands, a limited number of specimens show that the evolution of reptiles had already begun. There are a number of Cotylosauria (stem reptiles) known, and there are even a number of forms pertaining to the Pelycosauria, most ancient of mammalian ancestors.

6. Permian.—In addition to plentiful marine sediments, well developed in Texas and Russia, there are broad areas of continental beds such as the "red beds" of western North America and central Europe and highly fossiliferous deposits in the pre-Ural region of Russia and the Karroo of southern Africa. The marine life of the Permian, at least in the earlier part of the period, was essentially a continuation of that of the Upper Carboniferous. Fusulinid foraminifers, for example, continued to be important horizon markers; rugose corals were close to extinction, but tabulate forms continued; nautiloids, although still gradually declining were still the typical cephalopods, although goniatite ammonoids were common. Brachiopods of the *Productus* type were persistently abundant, but other typical Carboniferous groups declined. Blastoids and especially crinoids were the abundant echinoderms, with but a moderate representation of the free-living orders. Of fishes, the Early Permian seas showed a continuation of both the predaceous and mollusk-eating sharklike types. But while the Early Permian showed little change from the Carboniferous in the life of the sea, there occurred by its end a marked change, notably a great reduction in the abundance of animal life generally and the extinction of many characteristic Paleozoic groups. It is true that the relative sparsity of known deposits of Late Permian and Early Triassic age may tend to exaggerate the phenomenon, but even so the Paleozoic-Mesozoic

boundary certainly marks the sharpest change in marine life in the whole extent of known fossil history. Numerous extinctions can be timed definitely to the final phases of the Paleozoic. Many of the older invertebrate forms had vanished before the beginning of the Triassic. These included the stratigraphically useful and abundant fusulinid foraminifers; the labechiid order of polyps; the rugose corals; the goniatite type of ammonoids; the last lingering trilobites; two of the four Paleozoic bryozoan orders (Trepostomata and Cryptostomata); the Productacea, Delmanellacea, and Rhynchoporacea among the brachiopods; and the blastoid group of echinoderms. In addition, further impoverishment of the faunas was due to reduction in members and variety in other groups that survived. For example, ostracods (flourishing in the Late Paleozoic) came close to extinction; among brachiopods, the Spiriferacea, Rostrospiracea, and Strophomenacea were sharply reduced; few crinoids survived. Fish life in the seas was also reduced, for the bradyodonts disappeared before the Permian closed; a few hybodont sharks survived. No such catastrophic events as those that marked marine life are apparent in the continental faunas. Among invertebrates, the insects continued their deployment. There was a persistence of many of the Carboniferous groups, but many further orders made their appearance, including two now extinct orders, and the first representatives of the Odonata (dragonflies), Mecoptera (scorpion flies), Neuroptera (lacewings), Corrodentia (bark lice), Hemiptera (true bugs), Ephemeroptera (mayflies), Thysanoptera (thrips), Perlaria or Plecoptera (stone flies), and, late in the period, the first Coleoptera (beetles). In fresh waters, the early part of the period sees the last of the eurypterids, pleuracanth sharks (except in Australia), acanthodians, older lungfish types, and typical crossopterygians. However, progressive types of the more advanced lungfish survived, as did coelacanth crossopterygians, and palaeoniscoid ray-finned fishes continued to flourish on a large scale. The last of the ancient groups of lepospondylous amphibians were found in the Early Permian. Labyrinthodonts remained abundant in Early Permian deposits, with numerous rhachitomes, such as *Eryops*, and the last embolomeres. Later in the period, however, labyrinthodonts were less common and confined to rhachitomes of an advanced nature. With regard to reptiles, there was a marked contrast between the Early Permian and later phases of the period. In the Early Permian red beds the faunas are essentially continuations of those which had arisen in the Upper Carboniferous, consisting almost entirely of cotylosaurs and numerous pelycosaurs, the latter evolving into such bizarre types as the long-spined *Edaphosaurus* and *Dimetrodon*. In Middle and Late Permian times there were persistent cotylosaurs, notably the ungainly plant-eating *Pareiasaurus*, but the greater part of the fauna consisted of Therapsida, the order of mammal-like reptiles descended from the pelycosaurs. These included a large variety of carnivores that show features suggestive of later mammals. Flesh-eating therapsids were far outnumbered by the Dicynodontia. These were herbivorous therapsids in which the dentition was reduced, except for the frequent presence of upper-jaw tusks, and the jaws resembled turtlelike bills. Few reptiles of other groups were known. In the Late Permian there were a few forms with a two-arched (diapsid) skull, whose descendants were to dominate the Late Mesozoic. The oldest known reptile of the Southern Hemisphere is *Mesosaurus*, a small, slenderly built, aquatic animal of uncertain relationships, known from the Early Permian in southern Africa and Brazil.

D. Mesozoic Era

1. Triassic.—Marine faunas of Early Triassic were limited, but for later parts of the period they were abundant; Middle Triassic exposures are widespread in the Muschelkalk deposits of Germany and France and in western North America. Middle and Late Triassic marine faunas were plentiful in the region of the ancient Tethys Sea. Continental fossiliferous deposits of the Early Triassic are best exposed in southern Africa; those of the Middle Triassic, in Brazil, Argentina, and eastern Africa. Of the Late Triassic there are widespread continental red beds, such as the European Keuper and the American Newark and Chinle formations. Marine faunas had become greatly impoverished by the end of the Permian, and marine invertebrates were still limited in the Early Triassic. By the end of the period, however, characteristic Mesozoic faunal assemblages of a much more modern aspect had become well founded. Foraminifera, rare at the beginning of the period, began to flourish again before its end. The prominent coral types of the Paleozoic were reduced or extinct but were replaced by the scleractinian hexacorals, which were abundant by the end of the period. In the Triassic were the first Pennatulacea (sea pens). The nautiloids continued their steady decline; in contrast, the ammonoids rapidly expanded to become the dominant cephalopods of the Mesozoic. Modern cephalopods (except the pearly *Nautilus*) all belong to the group of Dibranchia (or Coleoidea); some members of the primitive belemnoid group of this order had appeared before the close of the Paleozoic; during the Triassic belemnoids increased in numbers, and from them arose the first squids (Teuthoidea). From the Triassic onward pelecypod and gastropod mollusks were very common, displacing the brachiopods from their previously outstanding position. Among this last group, there was a minor recrudescence of the Spiriferacea and Rostrospiracea during the course of the Triassic, but these forms and a few other "holdovers" were inconspicuous in the Mesozoic. Almost the entire Mesozoic assemblage of brachiopods was made up of members of the *Terebratula* and *Rhynchonella* groups, of ancient lineage but not previously of such great importance. There was a rapid increase in both during the Triassic period. Apart from rare limuloid xiphosurans, the marine arthropods were confined to the crustaceans; these are not too common in Triassic deposits, although there appeared the first of the advanced Decapoda, the group to which the lobsters and crabs pertain. Of the echinoderms, attached forms were restricted to crinoids, and these were not very common at that time. Starfishes and brittle stars continued from the Paleozoic into the Triassic and Late Mesozoic periods with relatively little change in nature and abundance; on the other hand, there was a major expansion of the sea urchins during the Triassic. Of marine fishes, only a few hybodont sharks had survived from

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LANDSCAPE OF THE MESOZOIC ERA. (LEFT) TRICERATOPS AND (RIGHT) AN ARMOURED ANKYLOSAUR, HERBIVOROUS REPTILES; (CENTRE) TYRANNOSAURUS, A CARNIVOROUS REPTILE

the Paleozoic; they became moderately abundant before the end of the period. The dentition of these sharks enabled them to feed on hard-bodied animals as well as softer types. There is little evidence of any major invasion of the seas by bony fishes during the Late Paleozoic. In the Triassic, however, large numbers of actinopterygians had become inhabitants of salt waters; palaeoniscoids were still abundant, but many ray-finned forms were of a more progressive nature. By the end of the period there were various Holostei (related to the living garpike and *Amia*). It may have been at this time that coelacanths adopted the marine mode of life that is still followed by the surviving *Latimeria*. Early Triassic salt waters show the only known invasion of the seas by amphibians, the long-snouted fish-eating *Trematosaurus*.

Although the main trend in reptilian evolution was toward a purely terrestrial existence, there was a strong countertendency toward a marine life. In the Middle Triassic of western North America, Europe, and Spitsbergen, there appeared ichthyosaurs, some of very large size, already well adapted to marine life although somewhat more primitive than their later Mesozoic descendants. Characteristic of the marine Middle Triassic of Europe were two related groups of reptiles that were less highly adapted for aquatic life: the Nothosauria, structurally ancestral to the plesiosaurs, and the Placodontia, mollusk eaters with crushing tooth plates. There were further amphibious to aquatic forms of obscure relationships.

Our picture of Triassic invertebrate life in fresh waters and on land is very fragmentary. Freshwater fishes consist almost entirely of actinopterygians paralleling their marine relatives in evolutionary status; in deposits suggestive of seasonal aridity, remains of a fish similar to the living Australian lungfish are not uncommon. The Triassic witnessed a final chapter in labyrinthodont history. Throughout the period there were numerous representatives of a degenerate end group, the Stereospondyli. These were water dwellers, generally of large size, with broad, flattened heads and bodies and tiny limbs. In the Triassic of Madagascar is found the first hint of the development of the more modern types of amphibians in *Protobatrachus*, with a skull already froglike but with more normal limbs and tail. In the Triassic, as in the Permian, there was a sharp contrast between the reptilian life of the early part of the period and that of its close. In the Early Triassic (best seen in southern Africa) the therapsids, including such carnivores as the Cynodontia and herbivorous dicynodonts as well, constitute much of the faunas. Therapsids still abounded in southern continental faunas of Middle Triassic age (eastern Africa, Brazil, Argentina), but in the Late Triassic very few remained, except a few forms structurally close to mammals. On the other hand, there was a great increase in two-arched (diapsid) reptiles during the period. At its beginning there were some primitive diapsid types (Eosuchia) and the first of the Archosauria ("ruling reptiles") in the form of primitive members of the Thecodontia, a purely Triassic order from which dinosaurs, crocodilians, flying reptiles, and birds appear to have originated. From the primitive diapsids, the Triassic saw the development of lizardlike forms and the first Rhynchocephalia (represented today by *Sphenodon* of New Zealand). Characteristic of the middle part of the period was the appearance of highly numerous rhynchosaurs, rather ponderous plant-eating rhynchocephalians. During the Triassic the thecodonts increased in number and variety and threw off as a side branch the short-lived phytosaurs, which paralleled the crocodilians in the Late Triassic of Eurasia and North America. From the thecodonts there likewise developed true crocodile ancestors and, more important, the first dinosaurs, which flourished in Late Triassic days. Of the Ornithischia (birdlike dinosaurs) there is but sparse evidence. But there were abundant Saurischia (reptilelike dinosaurs) in the Late Triassic red beds. All saurischians (like typical thecodonts) were bipeds; many were already of large size; and there was a distinct cleavage into lightly built Coelurosauria, flesh-eating Carnosauria, and ponderous Prosauropoda, ancestral to the amphibious dinosaurs of the Jurassic. In the Late Triassic, too, appeared the first Chelonia (turtles and tortoises), of unknown ancestry.

BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM, FROM A MURAL BY CHARLES R. KNIGHT

SCENE FROM THE LATE JURASSIC PERIOD SHOWING BIRDS AND FLYING REPTILES DESCENDED FROM A COMMON ANCESTRAL GROUP. (TOP) RHAMPHORHYNCHUS, WEB-WINGED FLYING REPTILES; (BOTTOM) ARCHAEOPTERYX, EARLIEST KNOWN BIRDS

2. Jurassic.—During much of this middle period of the Mesozoic, shallow seas covered great areas of the continents, and marine faunas were hence abundant; on the other hand, relatively little is known of freshwater and land dwellers except in such Late Jurassic formations as the Morrison of western North America and the Tendaguru of eastern Africa. In the oceans, Foraminifera had again become so plentiful and characteristic that they are highly useful as zone markers in this and the following period. Sponge spicules and skeletons are often prominent in Jurassic and Cretaceous deposits, and in the Late Jurassic sponges were important reef builders in central Europe. The last gasp of the ancient tabulate corals was witnessed in the Jurassic, the scleractinians taking their former role. Of cephalopod mollusks, the *Belemnites* were in a flourishing condition; the teuthoids increased considerably; the first Sepioidea (cuttlefishes) appeared. Nautiloids were of little importance in geologic history from this time on; there were a number of Jurassic forms, but they are rare as fossils. Ammonoids, on the other hand, proliferated immensely, with about 600 Jurassic genera, including many useful horizon markers. Gastropods and pelecypods abounded, and during the Jurassic and Cretaceous there was a gradual modernization within these groups. Of crustaceans, there was a modest reexpansion of the ostracods and some increase in decapods, with the first appearance of crablike forms. Bryozoans, which had approached extinction at the end of the Paleozoic, showed a revival, with a recrudescence of the order Cyclostomata and the appearance of the Cheilostomata. The brachiopods of the *Terebratula* and *Rhynchonella* groups reached the peak of their development in the Jurassic; other brachiopod types were unimportant. Crinoid

echinoderms, reduced in the Triassic, were again common, although far from reaching their Paleozoic abundance. Most notable of events in the phylum Echinodermata was the continued expansion of the echinoid class, of which some seven orders were already present. Fishes swarmed the Jurassic seas in great numbers and great variety. From the ancestral hybodonts there branched off before the close of the period representatives of a number of shark families and even a primitive skate.

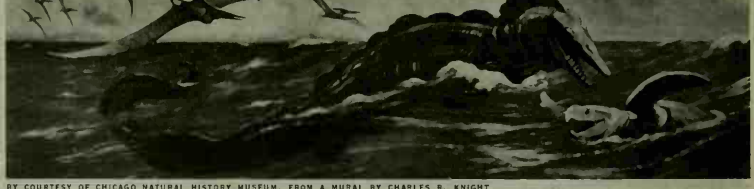
In the Jurassic, too, appeared the first Chimaerae, cartilaginous fishes of uncertain ancestry that appeared in restricted numbers in various later horizons. Among the bony fishes there were surviving palaeoniscoids and the oldest sturgeons, but the characteristic fishes of the period were members of the middle "grade" of actinopterygian development, the holosteans, including semionotids (Semionotidae), pycnodonts (Pycnodontidae), and many other types. In addition, toward the end of the period there were swarms of small fishes, such as *Leptolepis,* which had attained the final major stage of ray-finned evolution as primitive Teleostei. Marine reptiles were abundant. Some chelonians were already taking up an aquatic existence, and in the Late Jurassic there was a short-lived development of marine crocodiles. The major types, however, were ichthyosaurs and plesiosaurs. The former group reached the peak of their development, it would seem, in the Early Jurassic. Plesiosaurs of various sorts (long-necked and short-necked types) flourished throughout the period. Insects were none too common in most Mesozoic horizons. In the Jurassic, however, appeared the first known members of the Trichoptera (caddis flies), Dermaptera (earwigs), Diptera (true flies) and Hymenoptera (ants, bees, wasps). Coleoptera (beetles) appear to have been the most common insects of the Mesozoic, as later, orthopterans were common.

The life of Jurassic fresh waters is incompletely known, but there were freshwater bony fishes of holostean types and a varied series of turtles of the "old-fashioned" Amphichelydia suborder which could not withdraw their heads. Crocodilians of several families flourished. As noted, terrestrial vertebrates were for the most part confined to Late Jurassic beds. Amphibians were unknown except for rare frog remains. Of older reptilian groups, cotylosaurs were extinct; therapsids were represented by a lone small survivor; rhynchocephalians and lizards were poorly represented. It was the dinosaurs that dominated the scene. The saurischians were abundant; there were lightly built, little coelurosaurs such as *Ornitholestes* and *Compsognathus,* large flesh eaters such as *Allosaurus,* and, most impressive, a great array of enormous quadrupedal amphibious dinosaurs (Sauropoda) such as *Brontosaurus, Diplodocus,* and *Brachiosaurus.* Ornithischians were relatively rare but included primitive bipeds (*Camptosaurus*) and quadrupedal "plated" forms (*Stegosaurus*). Flying vertebrates had developed from bipedal archosaur ancestors. Pterosauria (flying reptiles) appeared early in the period in such genera as *Rhamphorhynchus;* in the Late Jurassic *Pterodactylus* represented a more advanced type. The lithographic stone deposits of the Late Jurassic of Bavaria have further yielded several fossils of the first archaic bird, *Archaeopteryx,* with reptilian affinities.

A final evolutionary event in the Jurassic was the appearance of the oldest known mammals, represented by teeth, jaws, and other fragments from a limited series of Middle and Late Jurassic localities.

3. Cretaceous.—Known fossil-bearing rocks of Early and Middle Cretaceous age are almost exclusively marine in nature, and early continental faunas are confined to a few formations such as the Wealden of southern England, northern France, and Belgium. Of the Late Cretaceous, however, there are great areas of continental sediments, notably in the western United States and Canada and in central and eastern Asia. The marine faunas of the Cretaceous continued for the most part the pattern seen in the Jurassic, although there was a gradual modernization in various groups. The Foraminifera continued to be well represented. The last rare stromatoporoids occurred in this period; scleractinian corals were still abundant; and several coelenterate orders appeared for the first time. Ammonoids were still extremely plentiful but were destined for complete extinction by the end of the period. Belemnoids and cuttlefish were not uncommon; squids were abundant; nautiloids survived in lingering fashion; and there appeared the first octopods. As in the Jurassic, pelecypods and gastropods abounded. There were great numbers of thick-shelled pelecypods, such as *Ostrea* and *Gryphaea,* and characteristic of the period were reefs and banks formed mainly by corallike rudistid pelecypods. Bryozoans of both cyclostome and cheilostome orders were very numerous. Again as in the Jurassic, the common brachiopods were terebratulids and rhynchonellaceans. Crinoids were fairly plentiful; echinoids were even more numerous and varied than in the Jurassic. In the fish faunas the radiation of sharks had continued. By the end of the period all common modern types were present, and there appeared most groups of skates and rays. Among the bony fishes the teleosts developed rapidly during the Cretaceous; the holosteans and the last surviving palaeoniscoids were reduced to insignificance. Aquatic reptiles continued to be abundant. Ichthyosaurs declined and may have become extinct well before the end of the Cretaceous, but there were varied plesiosaurs. During the period lizards took to the water, the mosasaurs becoming plentiful in the chalk deposits of the Late Cretaceous. There were large sea turtles of several families. Freshwater fishes were poorly known. The sparse amphibian faunas were increased by the appearance of the first urodeles (salamanders). Turtle evolution in general had progressed; there appeared species in which the head could be pulled directly back into the shell (Cryptodira) and rarer "side-necked" forms (Pleurodira). As in the Jurassic, there were numerous crocodilians.

For the first time, in the Late Cretaceous, lizards became abundant, and there appeared the first primitive snakes, of lizard ancestry. Although pterosaurs were seldom found, there had developed giant types, such as *Pteranodon.* As in all faunas since the Late Triassic, dinosaurs dominated the terrestrial scene. The great sauropods were of lesser importance and may have disappeared before the close of the period. Other saurischians were numerous, with surviving coelurosaurs and carnosaurs, which culminated in the Late Cretaceous in such giants as *Tyrannosaurus.* There were numerous bipedal ornithischians. *Iguanodon* was a well-known form in the European Early Cretaceous. In the Late Cretaceous there was a great radiation of large bipeds, the hadrosaurs or duck-billed dinosaurs, many of which developed peculiar head crests. The stegosaurs had vanished, but there were present instead the heavily armoured ankylosaurs and, late in the period, the Ceratopsia, dinosaurs with cranial horns and a great bony neck frill. In the late Cretaceous there were a few oceanic birds, such as the flightless diver *Hesperornis,* which retained



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REPTILES THAT LIVED IN THE SEA COVERING PARTS OF THE PRESENT NORTH AMERICAN CONTINENT DURING THE LATE CRETACEOUS PERIOD. (LEFT) PTERANODON, FLYING REPTILES; (CENTRE) TYLOSAURUS, GIANT, FISH-EATING LIZARD; (RIGHT) PROTOSTEGA, SEA TURTLE

BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM. FROM A MURAL BY CHARLES R. KNIGHT

PROTOCERATOPS, SMALL HORNLESS DINOSAURS OF THE LATE CRETACEOUS PERIOD

teeth, and *Ichthyornis*, with a modern, highly developed type of wing. Mammals were still rare. In the Early Cretaceous there were survivors of archaic orders; late in the period were found the first representatives of the modern marsupials and placentals. A notable feature of vertebrate history is the major extinction of reptiles which occurred at the end of the Cretaceous. Most dinosaur groups persisted into the final phases of the Cretaceous, but not a single one survived into even the earliest Cenozoic deposits. The pterosaurs disappeared as well, and in addition there vanished the marine reptiles (plesiosaurs and mosasaurs), which had abounded in Late Cretaceous seas. The reasons for this sudden disappearance of Mesozoic groups are far from clear, although orogenic and climatic factors have been thought to supply at least a partial explanation.

E. Cenozoic Era

Various stages of this last, relatively short era of the earth's history are represented by widespread fossil-bearing formations. In such areas as central to western Europe and the Mississippi embayment of North America, marine Cenozoic beds cover broad areas of the modern continents, and the Tethys Sea belt continued to be an area of deposition during the Early Tertiary. In most other regions, marine deposits are confined to coastal belts. For earlier geologic periods, long-continued erosion generally resulted in the destruction of continental deposits other than those of lowland coastal areas; for the Cenozoic, in contrast, there are numerous beds representing inland and upland areas. The most productive terrestrial beds are those of the western United States, but there are numerous continental deposits in Europe, central, eastern, and southern Asia, Patagonia, etc.

The greater part of the Cenozoic is formed of the Tertiary Period; the Ice Age, geologically more recent, initiated the Quaternary Period. The marine invertebrate faunas of even the earliest Tertiary had already a somewhat modern aspect, and modernization of the faunas progressively continued during the course of the Cenozoic. Foraminifera, still plentiful, are readily recovered from the generally soft Tertiary sediments. They are frequently useful for stratigraphic purposes. The genus *Nummulites*, for example, is so characteristic of the Early Tertiary, particularly in the Mediterranean region, that French workers often consider this span of time to constitute a Nummulitic Period. Most of the older types of scleractinian corals became extinct in the Early Tertiary, but more modern corals were effective reef builders. Such reefs were developed well into the present subtropical regions in the older Tertiary subdivisions. Among the mollusks, both pelecypods and gastropods continued to be abundant. The rudistid pelecypods, prominent in the Cretaceous, had become extinct. There developed large series of advanced types of marine snails with complexly built and highly coiled shells. Nautiloids were very limited in numbers in the Tertiary (only a single genus survives), and the ammonoids, so abundant in the Mesozoic, had been completely wiped out. The last belemnoids were found in the Early Tertiary, but of other dibranchiate cephalopods there was a fair representation of cuttlefishes, octopuses and numerous squids. Decapod crustaceans attained a modest abundance in the Late Cenozoic; ostracod shells were common; other crustacean types were rare. *Limulus* continued the xiphosuran line. Although the brachiopods were far less important than in most earlier periods, the terebratulids and, to a lesser degree, the *Rhynchonella* group were well represented. Both surviving bryozoan orders were present in abundance. Holothurians were relatively rare; starfish, brittle stars, and crinoids were moderately abundant. The echinoids were the most common echinoderms, with a wealth of sea urchins, sand dollars, and other forms. Skates and rays, already essentially modernized by the beginning of the Tertiary, made up a fairly substantial fraction of the marine fish faunas, and rare chimaeras and a single coelacanth survived. The dominant fishes throughout were the teleosts, of which many hundreds of fossil forms are known, representing a variety of teleost orders.

Throughout the Tertiary the continental invertebrate faunas appear to have been similar to those present today, including various snails and a limited number of freshwater pelecypods and crustaceans. Outstanding were the insects, of which a fair representation is had in a variety of localities, notably in the amber of the Baltic. Of freshwater fishes, the most common Tertiary fossils were those pertaining (as do existing forms) to the order Ostariophysi (including the catfish, carp, and minnows). Finds of frogs, toads, and salamanders belonging to a variety of modern families represent a variety of times and places during the Tertiary. Cenozoic fossil reptiles consisted of three orders. Chelonians of modern types are very abundant in many Cenozoic deposits. Crocodilians were common in the earlier phases of the era and were then present much farther from the tropics than at present, a situation presumably due to climatic conditions of a more equable nature. Of the order Squamata, Early Tertiary beds give a fair representation of most major lizard groups, but they were relatively rare in later phases of the Tertiary, presumably due to climatic changes. Snakes appear to have undergone most of their evolutionary development during the Tertiary, but their fossil record is poor. Avian fossils are generally poorly preserved because of the delicate nature of their skeletons, but it appears that all, or nearly all, major groups had developed by an early stage of the Tertiary. Notable is the occasional appearance of giant flightless types, such as *Diatryma* in the Early Tertiary of North America, *Phororhacos* and other forms in South America at a rather later date, and both the moa of New Zealand and *Aepyornis* of Madagascar in the Quaternary.

Most notable of Cenozoic events has been the rise and spectacular distribution of the mammals. In order to be able to refer to these evolutionary events in proper chronological sequence, subdivisions of the era must be referred to (*see* Chart). The Ceno-

zoic can be divided into a series of epochs, named in accordance with the relative modernization of their faunas.

Geographic factors must further be kept in mind. The northern continents were the major centers of mammalian evolution; Eurasia was more important, but North America was a center of development of many stocks. The two regions were in connection at various stages of the Tertiary, allowing an interchange of faunal elements. Of the southern continents, Africa appears to have been in open communication with northern regions for much of the Cenozoic but may have been at least partially isolated in early times. The present land connection between North and South America was not established until very late Tertiary times, and earlier communications were difficult. Australia appears to have been isolated, as at present, throughout the era.

When the Cenozoic opened, the more archaic types of mammals were extinct (except for some peculiar forms of the order Multituberculata, paralleling the rodents). With the extinction of the dinosaurs, the lands lay open for mammalian conquest, and two progressive groups were on the scene to take advantage of the opportunity. For the most part the evolutionary story is that of the placental mammals (Eutheria); but the pouched mammals (Marsupialia) likewise expanded, if to a more modest degree. The most ancient marsupials were omnivorous types much like the smaller living opossums. These survived for a time in northern areas but marsupial success was obtained only in the isolation of southern continents. In South America some placental mammals were present in the oldest known beds, but no eutherian carnivores were present.

In the Tertiary there developed a considerable series of marsupial flesh eaters, paralleling such placental animals of other continents as the wolves, felids, and weasels. At the end of the Tertiary and in the Pleistocene, however, there arrived from the northern continents placental carnivores, and most South American marsupials became extinct. In the isolation of Australia the marsupials were more successful. No placental mammals of any sort appear to have entered that continent before the relatively recent arrival of man. The Tertiary fossil story of Australia is nearly a complete blank, but Pleistocene and Recent faunas show that there had developed in that continent a wide radiation of marsupial types that paralleled many of the placental orders.

In the main Tertiary history is a history of placental evolution. The Cretaceous placentals were small forms, apparently rather omnivorous in habits, which can be classed broadly with the modern forms included in the order Insectivora. In the Paleocene and Eocene there was a broad spread of little animals of the same general category. Some appear to be transitional to the order Primates, and by Late Paleocene and Eocene times there were present types clearly comparable to existing lemurs. From them further primate evolution appears to have developed in two distinct lines. The ancestors of the South American monkeys had invaded that continent, presumably from the north, by the Miocene; on the other hand, fragmentary remains from the Late Eocene of Egypt show the beginnings of a line of higher primates from which in the Eastern Hemisphere developed the Old World monkeys and great apes, with the final development in the Pleistocene, of subhuman and human types. From omnivorous insectivores to flesh eaters was an easy transition, and members of the order Carnivora appeared at an early date. The older, more archaic carnivores of the Paleocene and Eocene are commonly termed creodonts; by the Oligocene, however, there appeared representatives of the civet, cat, dog, and weasel families. At a later Tertiary date appeared the pinnipeds (seals and walruses), raccoons, bears, and hyenas. Again from insectivores, a shift toward a plant-eating diet resulted in the development of numerous herbivores with grinding molars and, generally, hoofed limbs (the varied ungulate orders). Some early ungulates, the Condylarthra of the Paleocene and Eocene, were of a rather generalized nature. Other early ungulate types such as the amblypods and uintatheres tended to grow prematurely to large size and ungainly form and were destined for early extinction. Africa may have been a minor centre of ungulate evolution, for the oldest conies (Hyracoidea) and proboscideans are found there.

The conies are unimportant in later history, never spreading beyond Africa and the eastern Mediterranean region. The proboscideans, however, spread widely as varied mastodons in Miocene times. In the Pleistocene, mastodons and mammoths were common in every continent except Australia, only to approach extinction in Recent times. Sirenians (manatees and dugongs) may be offshoots of the coney-proboscidean stock, for the earliest remains of these aquatic herbivores, which appeared in the Eocene, are for the most part found in Egypt and the Mediterranean region.

In the Eocene appear the first of the two most progressive orders of hoofed mammals, the Perissodactyla and Artiodactyla (the odd-toed and even-toed ungulates). *Eohippus*, the little "dawn horse," is close to the stem of the perissodactyls; before the close of the Eocene there had developed a variety of odd-toed forms including not only ancestors of the surviving horses, tapirs, and rhinoceroses but ancestors of the now extinct horned titanothere and clawed chalicothere families of the order. In the Late Tertiary perissodactyls became reduced in variety and importance in the ungulate world. The artiodactyls, on the contrary, were relatively rare in the Early Eocene but later became increasingly important. Since the Miocene one artiodactyl family, the Bovidae (cattle, antelopes, and their kin), has risen to a dominating position in the ungulate world, but there are numerous other successful artiodactyls, such as the pigs and camels, which date from the older Tertiary, and others, such as hippopotamuses, giraffes, deer, and American prongbucks, which are of later origin. The Middle

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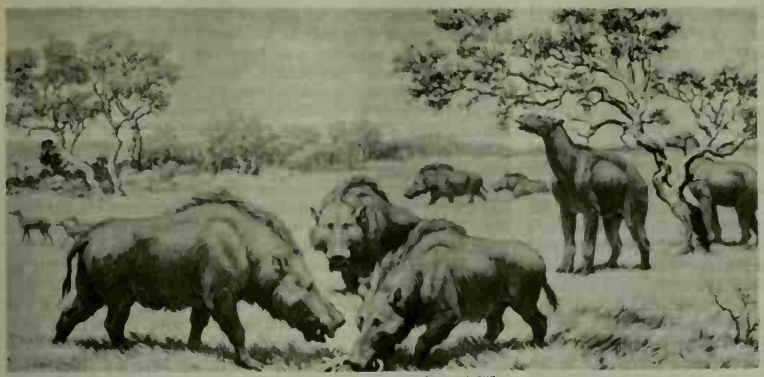
ANIMALS OF THE NORTH AMERICAN MIDDLE EOCENE EPOCH. (LEFT) OROHIPPUS, A PRIMITIVE HORSE THAT WAS NO LARGER THAN A COLLIE DOG; (RIGHT) HORNED UINTATHERIUM, ABOUT THE SIZE OF A RHINOCEROS



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PLAINS MAMMALS OF THE MIOCENE EPOCH. (FOREGROUND) PIG-LIKE DINOHYUS; (RIGHT) MOROPUS, AN ANIMAL WITH CLAWS INSTEAD OF HOOFS

Tertiary further saw the rise of other temporarily successful artiodactyl types which were destined for later extinction, of which the most prominent were the oreodonts, which are the commonest North American fossils of the Oligocene and Early Miocene.

The isolation of South America was responsible for the development there of peculiar types of ungulates such as the Litopterna (with forms analogous to horses and camels), the elephantlike Pyrotheria, and most especially the order Notoungulata, which developed an amazing series of ungulates not readily comparable to those of other continents. This entire assemblage became extinct in the Pleistocene, with invasion of South America by placental predators and competing herbivores of other groups. A second peculiar South American Tertiary development was that of the Edentata (or Xenarthra), the so-called edentates. Of the group, the armadillos, anteaters, and little tree sloths have survived, but the giant ground sloths and armoured glyptodonts have, like their native ungulate neighbors, disappeared, despite some temporary success they assumed in the Pleistocene in a counterinvasion of North America. The Cetacea (whales and porpoises) first appeared in the Eocene as the archaic *Zeuglodon* (or *Basilosaurus*); by Miocene times there were present toothed whales and numerous porpoises of the suborder Odontoceti; a first whalebone whale (suborder Mysticeti) appeared in the Oligocene, and this more specialized type was fully extended by Miocene days. The major group of gnawing animals, the Rodentia, were relatively slow to develop, for there was no trace of them until the end of the Paleocene, and it was not until considerably later that they attained their present prominence. The rat-mouse group (Muridae and Cricetidae), ubiquitous and highly flourishing today, was relatively insignificant until the Pliocene. South American isolation was responsible for the development there from the Oligocene onward of what some authorities classify as a special suborder, the Caviamorpha (of which the guinea pig is typical), which constitute the entire Tertiary rodent fauna of that continent and of which the North American porcupines are an emigrant branch. Of minor mammalian orders it is noted that full-fledged bats are known from complete skeletons as early as the Eocene and that the Lagomorpha (hares and rabbits, except for a seemingly aberrant form in the Paleocene of Asia) first occurred in the Eocene and were not abundant until Oligocene and Miocene days.

Although many instances of extinction and reduction of older groups occurred during various stages of the Tertiary, the story of mammalian evolution when broadly viewed is one of constantly increasing diversity of forms and increase in size in various lines to reach a climax in the faunas of the Pleistocene. But during and especially toward the close of that epoch there occurred a major reduction in the world's mammal faunas; numerous forms, particularly of larger mammals, and even whole groups that had flourished a short time before, geologically speaking, vanished. The mammal assemblage of modern times is a relatively impoverished one. The causes of this sharp decline are not clear.

See also ORNITHOLOGY; MAMMAL; ANIMALS, PHYLOGENY OF.

IV. EVOLUTIONARY EVIDENCE

The fossil record is of the utmost importance in the study of evolution. It provides the best possible answers to two major questions: "Has evolution actually occurred?" and "By what modes has this process taken place?"

A. The Fact of Evolution

That living animals have presumably descended, with modification, from preexisting forms was demonstrated to the satisfaction of most scientists by Charles Darwin and other workers with little or no recourse to fossil evidence. That evolutionary change is not only possible but probable was indicated by a study of the similarities found to varying degrees among living animals and plants and by a study of the variability that living forms may exhibit. There is, however, nothing in the study of living forms alone definitely to exclude the possibility that (as indicated by a strict interpretation of the Book of Genesis) man is part of a special direct creation and that, although modification of the animals thus created may occur, these modifications have been only of a minor nature, not meriting the designation of a major evolutionary process.

With the development during the 19th century of a connected paleontological story much light was shed on this situation. It was discovered that in the past history of the earth there existed many animals that differed in varying degrees from those now living. It was found too that these animals constituted a series of successive faunas that followed one another in time. The members of each fauna show in general the broad structural pattern characteristic of the major groups of animals still living but differ to a variable degree from the modern representatives of these groups. It became gradually clear that the degree of difference from modern forms was in general correlated with the amount of time involved and that the successive faunas exhibit a pattern of progressive change. The older faunas differ most from animals now living; members of more recent faunas gradually come to resemble more and more closely the modern animal types.

All these facts are quite in harmony with the doctrine of evolution, but they by no means prove its truth. Indeed, such great figures in the early history of paleontology as Georges Cuvier and Louis Agassiz held no evolutionary beliefs and claimed that these successive faunas were the results of successive creations. Cuvier maintained that the world had undergone a series of "revolutions," each cycle corresponding in time essentially to what we now term a geological period. At the end of each cycle the existing fauna was overwhelmed by some catastrophe of nature. The next cycle introduced a new fauna; some of its members may have been already in existence in areas not affected by catastrophe, but most are assumed to have been created *de novo*. The resemblances between successive faunas were held to exist because of the tendency of nature or the deity to reproduce the earlier creations with successive modifications of each type toward greater perfection.

But with increasing knowledge of fossils it became more and more difficult to adhere to a belief in a series of revolutions and creations. The breaks between successive faunas are actually not sharp. Faunas intermediate in nature and containing some old, some new, forms are frequently found. In many instances there are series of beds that appear to extend without break from one period into another and show series of forms transitional between those of supposedly distinct creations.

Obviously, there have been no major catastrophes or violent revolutions leading to complete extinction of faunas. Changes have been continuous and seemingly gradual. There were no major times of new creation; if successive creations occurred, they must have been of almost constant occurrence. Today, the evidence for continuity of life and change in the fossil record is so great that lack of belief in the evolutionary story is almost impossible to any competent person familiar with the facts of paleontology.

It is difficult to interpret the general story of faunal succession, as outlined elsewhere in this article, in any fashion other than that of a progressive evolutionary story. Not only do the faunas as a whole show a steady drift toward modern conditions, but numerous lines that can be traced through successive faunas give every evidence of being evolutionary in their nature. In many instances (the horses are a familiar example) are had well-documented family histories, covering scores of millions of years, which are inexplicable in other than evolutionary fashion. In numerous other cases the story is less clear (a relatively small percentage of the animals of the past is known), but the facts are never inconsistent with an evolutionary explanation.

Is evolution "true"? The answer to this question depends upon what is considered by the questioner as valid evidence. Obviously no one can go back through the ages and furnish birth certificates for each of the countless generations of individuals in every animal series. But it can be said that all the known facts of paleontology are consistent with the theory of evolution and impossible of rational interpretation on any other basis. Few accepted truths of any sort rest on firmer grounds.

B. Theories of Evolution

Most modern students of evolution are adherents of a "synthetic" theory. The conclusions derived from studies of modern populations and from actual evolutionary happenings preserved in the fossil record are combined results derived from the study of population genetics. Still basic, however, is the Darwinian concept of natural selection. It is agreed by most that the variations upon which selection acts are due to genetic mutations, which are essentially random as regards their potential selective value. There are adherents of other general theories of evolutionary change: those holding the Lamarckian concept of inheritance of acquired characteristics; and those adhering to more "vitalistic" types of speculation who hold that evolution is a response to some inner urge of the organism or due to some mystic force of "nature" or a deity carrying out a predestined design.

Most of the facts of the fossil record can be interpreted in accordance with the current concepts of the synthetic theory, and a majority of the paleontologists currently interested in evolutionary problems accept this theory as a working hypothesis. However, paleontologists in the past have been prone to subscribe to the doctrine of orthogenesis (*q.v.*). It is held under this theory that much of evolution has taken the form of an "undeviating straight line" from the original ancestor to the terminal member of a phyletic series and that this orthogenetic trend is because of some vitalistic principle working within the animals concerned, a sort of evolutionary predestination. This concept gained its hold on paleontologists through the fact that many evolutionary lines seemed to be of this nature. The changes witnessed in the successive members of evolutionary phyla all tended, it seemed, in the same direction; in many cases the evolutionary tree appeared to be branchless.

Belief in this concept has decreased in recent decades. With increasing knowledge it is now seen that there are actually few examples of undeviating and unbranched evolutionary lines. The horses, for example, were once thought to exemplify orthogenesis, but it is now known that in both the Eocene and Miocene there were various side branches of the horse stock; and the rhinoceroses, related to the horse group, branch so wildly that they form not an evolutionary tree but a bush, with a wild tangle of stems, branches, and twigs. And even where there still appears to be some semblance of a single stem, the condition requires no vitalistic explanation. If the main evolutionary line represents the direction in which change was of an adaptive nature and hence of selective value, the single stem may be accounted for on a neo-Darwinian basis: the side branches may have begun but were eliminated as inadaptive before they became visible in the fossil record. The single stem is a tree rigorously pruned by selection.

Closely related to the doctrine of orthogenesis is that of the irreversibility of evolution, formerly held by many paleontologists. In its broadest literal sense this implies that evolution, once it has taken up a given direction, never changes its course; that structures once acquired are never lost; that structures once lost are not regained. When carried to this extreme (as has been done by many workers in the past), adherence to this doctrine leads to absurdity. The course of evolution does change. For example, reptiles and mammals, many of whose ancestors left an aquatic environment for dry land, have returned to the sea; some birds whose ancestors had become flying types have lost this power and have descended again to earth. Structures once gained are often lost: the snake has abandoned the four terrestrial limbs acquired by his ancestors; mammals have lost the armour of scales that covered the body of their piscine ancestors.

However, Louis Dollo, the distinguished paleontologist to whom the doctrine of irreversibility is attributed, was more modest in his beliefs. He claimed only that structures once reduced to an essentially functionless state seldom redevelop to or toward their original condition and that when organs are lost in the course of phylogeny they do not reappear, although some effective substitute may develop if a need for such a structure should arise. This limited thesis of irreversibility is reasonable from the point of view of genetic theory and appears to be borne out by the known history of fossil lines. If for example a reptile or mammal returns to an aquatic life, it never redevelops the gills lost by its ancestors when they left the water, although they would be highly useful if present; a tail fin may redevelop in an ichthyosaur or whale, but it is not the original type of fin, rather, an effective substitute built on a different pattern.

C. Adaptation

Evolution is change; changes that persist in a stock are generally indicative of closer adaptation of the animal to its environment. Whereas unfavourable changes tend to be weeded out by selection, favourable changes lead to survival of the individual and its progeny. Most of the structures (and functions) of living animals are readily interpretable in terms of adaptative utility; others, not in themselves useful, may in the pattern of inheritance be tied in with useful structures or functions.

The examination of the fossil record reveals a constantly changing structural pattern that may be interpreted in terms of useful adaptation. Some of the structures seen are of a familiar sort, and their utility is fairly obvious. Others, however, are widely different from any seen in living animals, and their function (if any) is difficult to interpret; some structures would appear to have been definitely detrimental. It is difficult to imagine a function for the great sail, supported by long spines, that sprang from the back of certain Permian reptiles; the enormous antlers of the extinct Irish elk would seem to have been an almost insupportable burden. But it is not impossible that the sail of the Permian reptiles was an effective heat-regulating device; it is possible (although incapable of proof) that the presence of gigantic antlers may have been of advantage to their bearer in the annual fights of the deer for mates and progeny.

In many instances students of adaptation in modern animals have found it difficult to imagine that any utility could have been found for a complex structure during the stages in its evolutionary development; it is frequently assumed that there has been a condition of "preadaptation"; structures were developed and became incorporated into the normal members of a species or group before any utility was found for them. In a limited sense this is perhaps true, for genetic theory implies that single mutations are random events, occurring without reference to necessity for them. But it seems highly improbable that the complex of mutations necessary for the development of a major structure should become established in the absence of any action

of selection because of utility. And a consideration of paleontological evidence indicates that many supposed cases of preadaptation are not of that nature.

For example, a land animal such as a reptile differs basically from its fish ancestors in possessing (1) lungs for air breathing, (2) four land limbs, and (3) a shelled amniote egg that can be laid on land. All these adaptations for land life would appear at first sight to be useless to a fish and hence to have developed as preadaptations before they became useful. But the study of the fossil record combined with the evidence of living forms shows that this is not the case. It appears that in Late Paleozoic days many fishes living in fresh waters were subject to conditions of marked seasonal drought. Lungs would be extremely useful in supplementing the meagre oxygen supply in stagnant or failing waters. Limbs even if feebly developed would have been of use in enabling a stranded fish to seek another pool. And although amphibians normally lay their eggs in fish fashion in the water, many forms today (particularly those living in tropical regions where rainfall is seasonal) have more or less effective adaptations, paralleling those of the amniotes, for the development of the young without deposition of the eggs in the pond. Thus all the major features that make land animals successful could have been and apparently were developed in earlier, prereptilian stages as immediately useful and adaptive structures; there was no preadaptive lag.

Emphasized particularly by the late Henry Fairfield Osborn was the principle of adaptive radiation. Given the opportunity, the descendants of a "generalized" ancestral form may spread out widely, with a striking variety of adaptive features, into a number of different environments and modes of life. On a large scale the development of the higher placental mammals illustrates this principle. Their ancestors were present in the shape of small, insect-eating forms at the close of the Age of Reptiles. With the extinction of the dinosaurs the world lay before them, and there began a rapid adaptive radiation into types ancestral to such diverse mammals as men, bats, whales, cows, and lions. On a somewhat more modest scale is the adaptive radiation of the marsupials, or pouched mammals, in Australia. The placental mammals never reached that continent in the early days of their expansion, but apparently there were present primitive opossumlike marsupials from which has descended the native mammal fauna of that continent. This adaptive radiation of marsupials produced pouched flesh eaters such as the marsupial (Tasmanian) wolf, some anteaters, and moles, all of which resembled placental forms of other continents, and a variety of herbivores such as the kangaroos, the wombats and pouched "squirrels."

From what has just been said, it is obvious that two adaptive radiations may overlap one another and produce end forms that have similar habits and adaptive structural features but are quite unrelated, having descended from ancestors remote from one another. This is the phenomenon of convergence. As an example may be cited the case of the Tasmanian wolf just mentioned and the true wolf of other continental areas. The two lead similar lives as terrestrial, running predators and are strikingly similar in adaptive features of the jaws, teeth, limbs, etc. They are however, quite unrelated, having come from very different ancestral stocks. Their dissimilar pedigrees can be determined by examining not the superficial features readily modified in adaptive ways but the more basic, internal structural features (of the brain case, etc.).

D. Parallelism

To be distinguished carefully from convergence is the phenomenon of parallelism, which in recent decades has been realized to have been a very common and important feature in evolutionary history. In convergence is seen the attainment of similar features by unrelated animals; parallelism is a situation in which two end forms similar to one another have evolved from related ancestral types. The end forms may possess many characteristics which their common ancestors lacked and may have acquired them step by step in parallel fashion.

This type of phenomenon is readily interpretable in terms of modern genetics. Numerous examples of parallel mutations are known in different species of the common fruit fly *Drosophila*. If such parallel mutations should prove to have selective value, there would be evidence of their incorporation in the general population of the various species in which they occur and the beginning of a process of parallel evolution such as that actually witnessed in the fossil forms.

The Tasmanian wolf and the true wolf are to be considered as convergent, for their ancestors were of quite different stocks. As an example of parallelism there is the case of the same Tasmanian wolf with certain South American marsupial flesh eaters, the borhyaenids. Now extinct, these forms were the typical carnivores of the Tertiary Period in that continent. The borhyaenids were exceedingly similar to the Tasmanian wolf in almost every feature, and some have argued that there must have been a Tertiary land bridge between South America and Australia to account for this fact. This is improbable. The borhyaenids appear to have been a group that originated, like the Tasmanian wolf, from opossumlike ancestors and that adopted a flesh-eating mode of life like their Australian cousins. Given a similar basic structural pattern in the two cases and a similar change in habits, it is reasonable that similar adaptive changes should have occurred in these two related stocks, providing an example of true parallelism.

In such a case as this a parallelism exists in almost the entire structure of the organism. In other instances related forms may diverge in certain features but exhibit parallel advances in other regards. Thus the mammallike reptiles of the Permian and Triassic are quite diverse in many regards; but all later members of the group tended to develop a secondary palate in the mouth and tended to reduce the count of toe joints from the higher reptilian number to that characteristic of primitive mammals and man. These developments appear to have taken place independently at about the same time in several distinct but related groups of mammallike reptiles, thereby exemplifying parallelism of a sort.

Such illustrations of partial parallelism may best be considered under another term, that of phyletic drift. Phyletic drift is the general tendency for a group of animals to move in a certain evolutionary direction as regards certain of their structures, although diversifying in other ways. For example, the labyrinthodont amphibians of the Triassic varied greatly in numerous features (heads were long or short, snouts broad or narrow, etc.), but all tended to drift in common toward the development of very low skulls, feebly ossified, with enormous openings present in the palate. Again, early land vertebrates almost uniformly retained a third median eye in the centre of the forehead. But in Triassic days the drift in land vertebrates as a whole was away from this structure, and at about this time the opening that housed it disappeared in group after group.

The evolution of the mammalian brain likewise illustrates the phenomenon of phyletic drift. The brains of modern progressive mammals (not only man and the primates, but various ungulates, carnivores, etc.) exhibit in common a variety of advanced characters not present in primitive mammals. It has been assumed that these characters were present in the common ancestors of the modern forms. But recent studies of casts of the brain cavity in a series of fossil horses by Tilly Edinger show that these advanced characters, as seen in the living horses, appeared at a fairly late date in the history of the equids and that therefore there was a parallel drift in brain structure in the various higher mammal groups.

The most widespread example of phyletic drift seen in fossil lines is the almost universal tendency toward increase in size. In following through any well-known evolutionary series, almost invariably it is found that it commences with forms of modest size whose descendants tend steadily to increase in bulk with the passage of time. Indeed, the general impression from the fossil record is that the present world should be filled with giant forms of life. But actually it is not; today, as always, there is still a host of small as well as large animals. Bulk has its advantages. It is in itself a partial protection against enemies; for warm-blooded animals, heat conservation is simpler because of the relatively small surface in proportion to bulk. But size also appears

to have disadvantages: large animals appear to be able to adapt themselves less readily to changing environments. The survivors tend to be forms of smaller size which in turn generate new series of bulky and temporarily successful descendants.

Among mammals the Pleistocene Epoch represented the climax of development in size. There existed during the Ice Age numerous large animals such as the various mammoths, mastodons, ground sloths, etc. Most have since become extinct. The wiping out of many of the larger animal types is most noticeable in the Americas; the reasons for this depopulation are not clear. Also noticeable to a minor degree in the Pleistocene was the rarer opposite trend, the development of dwarf types, of which the most curious was the occurrence on Mediterranean islands of pygmy hippopotamuses and tiny elephants (one no larger than a collie). The trend toward dwarfism appears to be particularly associated with adaptation to island life.

E. Speed of Evolutionary Development

The neo-Darwinian concept generally assumes a relatively slow evolutionary development, the gradual appearance and spread through a species of numerous small mutations which only after countless generations cumulate to produce a markedly different descendant. Until recently it seemed difficult to account for such a leisurely process of evolutionary change, for the times computed by the geologists for the various eras and periods were far too short. Recent work on the age of radioactive rocks has indicated a much longer sweep of time. The Cambrian Period, when most of the major animal groups were already established, was approximately 500,000,000 years ago; for the time of development of the modern mammals, since the extinction of the dinosaurs, there appears now to have been about 70,000,000 years available instead of the 5,000,000 once thought to be the extent of the Cenozoic Era.

To visualize the relatively slow type of evolutionary change that may have been characteristic of much of phylogenetic development there have been suggested the concepts of adaptive hillocks (Sewall Wright) or adaptive zones (G. G. Simpson). The former concept would picture the face of nature as a plain in which there rise here and there elevations, each representing a specific type of environment. Within a group of animals each form would be found occupying one of these adaptive hillocks, and in great measure the changes that each animal would undergo would be the gradual development of features adapting it more perfectly to its own small area. But in this concept these hillocks are not fixed; they change position gradually, much like slowly moving waves in a swelling sea. As the hillock moves, the animals must move with it and change with it. Simpson's concept of adaptive zones is an attempt to restate this picture with more emphasis on time as a dimension. On a graphic plot with time moving horizontally from left to right may be substituted for the concept of hillocks the concept of bands or zones following the time axis across the field and separated by untenantable intermediate belts (the bare plain of the Wright concept). These bands may be placed essentially horizontally, in which case little or no evolutionary change is required in the animals which inhabit them. But if the band is tilted, the inhabitants of the zone must gradually change adaptively to maintain themselves within it.

It has been argued that not all evolution follows such a course of slow, adaptive change. Many have contended that at least part of the evolutionary process has consisted of major changes accomplished in a short period of time or even in one single step (saltation). The mutations of the geneticist were originally conceived to be of this nature; but most mutations, as now known, are changes of a very modest sort, and those of larger proportions are generally markedly deleterious, if not lethal. In plants, abrupt changes are positively known in certain instances, caused by the phenomenon of polyploidy (a multiplication of the chromosomes present in ancestral generations), but it is doubtful if this phenomenon has been at all common in animals. Thus there is little reason to believe, on the basis of observation of living forms, that there have been abrupt single-step evolutionary changes in the phylogeny of animals.

In many cases where evolutionary series are known, evolution appears quite surely to have been a gradual and orderly process. In many cases where the record is imperfect and many forms are missing, there is nevertheless a sufficient time interval between the known representatives of the group for gradual development to have taken place. But there are still many instances where it is reasonable to believe that rapid evolution has occurred. It may be noted that the origin of numerous major groups is obscure, no matter how common their later representatives may be or how well known may be the general nature of the ancestral stocks from which these groups sprang. Further, it is often certain that the time interval between deviation from the ancestral stock and the appearance of the new type in the fossil record must have been short.

The lack of connecting links in such cases might have been caused by a saltation, but in all probability the explanation lies in other directions. Presumably the population of animals making the transition was relatively small in number (a feature conducive to rapid evolutionary change); this, with the fact that the time interval was short, makes the chances of finding specimens of transitional forms very poor indeed; there are many missing links that are destined to remain missing. These relatively sudden shifts may have taken place by the normal mechanisms of mutation and selection, but a selection that proceeded at a very rapid rate.

The reasons for this rapid selection and consequently rapid evolutionary change may be understood in the light of the concept of adaptive hillocks or zones. As long as an animal clings to the slopes of its own hillock, it will change but little or but slowly. If, however, in the gradual shifting of these hillocks, two approach one another, it may be possible for the dwellers on one to cross the ground between them and to take up life in this new area. When the animal does this it must rapidly adjust itself structurally and functionally to a new environment. In terms of adaptive zones, an animal may "jump" from one zone to another, passing rapidly through the intervening area where life is impossible for it. In the old zone changes would have been gradual; in the new zone the newly evolved type may soon settle down to a leisurely evolutionary pace; but in transition the pressure of selection would be very strong and change in adaptive features rapid.

F. Evolutionary Sterility: Extinction

With evolution may be compared antithetical processes also seen in geologic history: the stability of type seen in some lines over long periods of time and the extinction of various animal groups.

While the fossil record shows most groups of animals to have continuously undergone change, whether fast or slow, there are cases in which there has been little modification over long periods of time. Brachiopods of the *Lingula* group are frequently cited in this connection; they appear to have persisted with relatively little change since Paleozoic days. Evaluating this condition can be difficult. Such stability could indicate that the animal group has attained a nearly perfect adjustment to its environment, or it may be exhibiting evolutionary sterility.

In evolutionary sequences it is frequently found that terminal members are more simplified, less complex in structure, than their ancestors. The process of simplification is frequently referred to as one of degeneration, with the moral overtones (or undertones) associated with that word when applied to human beings. But nature is unaware of human moral values; survival is success, and simplification may be as effectual an evolutionary process as progress by increase in complexity.

Many major animal groups evolve, but most of the species and genera of past ages (even many families and higher categories) have become extinct without leaving progeny. Extinction is thus the common fate, evolutionary progress the exception.

The reasons for extinction have been often pondered, with little result in reaching any general principles. In certain instances specific causes for extinction have been reasonably claimed: disappearance of an appropriate food supply, appearance of predatory enemies, successful competition for available food by rivals with more progressive adaptations, etc. Frequently there has been

a recourse to a hypothesis of "racial senility" leading to extinction (Alpheus Hyatt and others); a condition of spininess sometimes seen in terminal members of a group is cited as a manifestation of this senescence. But a comparison between somatic tissues of the body of an individual animal and a species or group as a whole seems unjustified. An individual body and its specialized tissues may be young or old, but it is obvious that (unless one believes in special creation) every animal in existence at a given time in the earth's history has exactly the same number of millions of years in its pedigree as every other.

Specialization is frequently cited as a major cause of extinction. The term refers to the presence of adaptations fitting an animal to a special type of environment; a generalized type is, on the contrary, one defined as lacking such specializations. These terms should be used with caution. After all, every animal must be adapted to its environment in order to live at all; an animal lacking adaptive specializations of some sort could hardly survive. Too frequently cause and effect are confused in the use of these terms. If an animal of the past has given rise to descendants, it is admired as a generalized type; if it became extinct, it was *ipso facto* specialized. The dinosaurs became extinct; therefore they have been termed specialized. The small contemporary mammals survived and flourished. Were these latter therefore generalized? Actually, it might be argued that the mammals, with their nonprimitive limbs, reduced toe joints, highly modified skulls and jaws, very modified teeth, brains, etc., were among the most specialized of then existing vertebrates.

See ANIMALS, DISTRIBUTION OF; EVOLUTION, ORGANIC; ANIMALS, PHYLOGENY OF; *see* also references under "Paleontology" in the Index.

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PALEOZOIC ERA, the age of ancient life, one of the major divisions of geologic time, beginning more than 500,000,000 years ago and lasting at least 300,000,000 years, as indicated on the accompanying geologic time chart. Rocks of the era are principally of sedimentary marine origin and contain the first abundant fossil record. The fossils indicate a predominance of marine invertebrate life throughout the era; fishes were abundant near the middle; and toward the end terrestrial life, consisting of amphibians, primitive reptiles, and insects, became prominent. The latter half witnessed the rise of land plants and the first forests, giving rise to the world's major coal deposits. The era is subdivided into six periods: Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian; in North America the Carboniferous Period, or Great Coal Age, often is subdivided into the Mississippian and Pennsylvanian.

Geologic Time Chart

System and Period	Series and Epoch	Distinctive Records of Life	1,000 Years
CENOZOIC ERA			
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	
	Paleocene	First placental mammals	70,000
MESOZOIC ERA			
Cretaceous		Extinction of dinosaurs	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
PALEOZOIC ERA			
Permian		Reptiles developed, conifers abundant	235,000
Carboniferous			
Upper (Pennsylvanian)		First reptiles, coal forests	260,000
Lower (Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000
Ordovician		First primitive fishes	400,000
Cambrian		Marine invertebrates	500,000
PRECAMBRIAN TIME			
		Few fossils	1,500,000–4,000,000

During the era's closing stages enormous mountain ranges were formed in various parts of the world, including the Appalachians, the Hercynian, or Variscan, ranges, the high ranges of central Asia, and others bordering the Pacific Ocean. The earth's most unusual glaciations took place in near-tropical latitudes of the Southern Hemisphere, notably in Australia, Tasmania, India, Africa, and South America. Those of India were near sea level and within 18° of the Equator. At the same time widespread aridity is indicated elsewhere by great salt and gypsum deposits, particularly in western North America. These pronounced physical changes extinguished most of the characteristic plant and animal species.

For details *see* separate articles on the subdivisions of the era, as PERMIAN SYSTEM; CARBONIFEROUS SYSTEM AND PERIOD, etc. *See* also PALEOBOTANY; PALEONTOLOGY; and references under "Paleozoic Era" in the Index. (R. E. JN.; X.)

PALERMO (ancient PANORMUS), a city and port of Sicily and the capital of the autonomous region of Sicily in the Italian Republic, and the seat of an archbishop, lies on the northwestern coast at the head of the Bay of Palermo, facing east. Pop. (1961) 592,614 (commune). Behind the town is a fertile plain, known as the Conca d'Oro, backed by mountains.

Palermo's earliest buildings were on a tongue of land between two former streams to the north and south of the present Via Vittorio Emanuele; the streams flowed into a small creek, the old port, of which the Cala is all that remains. The town expanded north and south and during the Arab period it was called Khalesa, a name which survives in the Kalsa quarter at the southeast of the town. The Marina, or esplanade, runs beside the bay west of the Cala, between the shore and the 17th-century Villa Giulia, said to be the oldest public garden in Europe. The modern port lies to the north at the foot of Monte Pellegrino (1,988 ft.) and has two main entrances. It can take ships of large tonnage.

The earliest civil buildings date from the time of the Norman kings. In the royal palace is the Cappella Palatina, founded in 1132 but not completely decorated until *c.* 1189; it is one of the masterpieces of the Middle Ages. The vaulted wooden roof is carved and painted in Saracenic style and the cupola and upper parts of the walls are covered with mosaics, executed by Greek workmen from Constantinople, including the Pantocrator in the apse and in the cupola, scenes from the life of Christ in the central square, an Old Testament cycle (from the Creation to Jacob's wrestling with the angel) in the nave, and the lives of SS. Peter and Paul in the aisles. The royal palace also contains the Norman stanza, a room decorated with mosaics of hunting scenes probably executed between 1160 and 1170. Of the same period are the royal country palaces encircling the city, such as the Favara, the Cuba, and the Zisa (in which last some mosaics survive).

Two Norman-Byzantine churches, S. Cataldo (11th century) and S. Giovanni degli Eremiti (1132), have small red cupolas. The mosaics (1143–51) of the Martorana (1143), founded by the Greek admiral George of Antioch, are incompletely preserved. These include the Pantocrator in the cupola, as well as saints, prophets, and some New Testament scenes. The cathedral, founded in 1185 by Gualterio Offamilio (Walter of the Mill), an Englishman sent by Henry II of England as tutor to William II of Sicily, has been much altered. The facade dates from the 14th–15th centuries, the portico from the 15th, and the cupola from the 18th. It contains the tombs of King Roger II and the emperor Frederick II. Other churches of special interest are S. Francesco d'Assisi (13th century, restored), the S. Spirito (in the

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VIEW OF PALERMO FROM THE BAY. IN THE FOREGROUND IS THE OLD PORT

suburbs) where the Sicilian Vespers (*q.v.*) started in 1282, and Sta. Maria della Catena (late 15th century, restored).

Two other notable medieval palaces are the Scláfani and the Chiaramonte (14th century). The 16th century saw the construction of further palaces, of new streets, and of the Porta Nuova and the Porta Felice, the only two remaining city gates. Spanish influence appeared in the 17th century, when the Quattro Canti or Piazza Vigliena, Palermo's central intersection, was laid out; it is adorned with statues and other sculptures.

The National Archaeological Museum has rich collections, including metopes and funerary objects from the ancient Greek city of Selinus, well-preserved Etruscan urns and other items from Chiusi (Clusium), medieval and Renaissance sculptures, and Sicilian majolica. The Palazzo Abbatelli houses the National Gallery of Sicily and the Politeama Garibaldi contains the Gallery of Modern Art. The Teatro Massimo (late 19th century) has one of the largest stages in Europe. Other institutions include the National Library, the Municipal Library, the university, and the Ethnographical Museum in the Parco della Favorita, about 4 mi. away near Monte Pellegrino.

The principal industry is provided by large shipyards. Chief exports of the port include citrus and other fruits, preserved foods, furniture, glass, and textiles. Main imports include grain, meat, coal, paper, machinery, metals, chemical products, and fertilizers.

Palermo is linked to the mainland by regular shipping services (Naples), by train ferry via Messina, and by air. It is connected coastwise and north-south by internal railways and roads. The international airport of Punta Raisi (30 km.; 18½ mi. W) links Sicily with North Africa and the Middle East.

Founded by the Phoenicians in the 8th century B.C., Panormus was never taken by the Greeks. It came into Roman hands in 254 B.C. during the First Punic War and was made a Roman colony under Augustus. After passing in turn to the Vandals (440), the Byzantines (535), and the Arabs (832), who made it the capital of the emirate of Sicily (948), it had its greatest period as the centre of a cosmopolitan civilization when it was the capital first of the Norman (1072) and then of the Hohenstaufen (1194) rulers of Sicily. In 1266 it passed to the Angevins, against whom it revolted in 1282 (*see* VESPERS, SICILIAN). Thereafter it came under the control of the various rulers of Sicily (*q.v.*) until it was captured by Garibaldi in 1860 and in the following year was united with Italy.

PALERMO PROVINCE has an area of 1,937 sq.mi. and a population (1961) of 1,101,816. It extends from the Madonie Mountains on the east to the Gulf of Castellammare on the west. The Conca d'Oro behind Palermo City is the only extensive lowland. Wheat and fruits are grown and livestock (mainly sheep and goats) are raised. There is marble quarrying and sulfur mining. Chief cities besides Palermo include Termini Imerese, Bagheria, Corleone, Lercara Friddi, Monreale, Carini, and Castelbuono. Piana degli Albanesi (14½ mi. S of Palermo) was founded in the 15th century by Albanian refugees from the Ottoman occupation of Albania. These people preserve their own language and belong to the Orthodox Church. Above the town is an artificial lake and a hydroelectric power station.

See also references under "Palermo" in the Index.

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PALES, an Italian god and goddess of flocks and shepherds. The festival called Parilia (less correctly Palilia) was celebrated in their honour on April 21. In this festival the Pales were invoked; the stalls were cleansed and purified with magico-religious substances and the herdsmen leaped three times across bonfires of hay and straw. It is described in Ovid's *Fasti*. The Parilia came to be regarded as the birthday celebration of Rome.

PALÉS MATOS, LUIS (1898–1959), Puerto Rico's most distinguished lyric poet, noted particularly for his "Negro" poetry, collected in *Tuntún de pasa y grifería* (1937). This poetry is characterized by Negro motifs, which Palés Matos (a white man) interprets with all the artistry of a distant disciple of the Spanish Baroque, and by syncopated rhythms, onomatopoeic devices, alliteration, and striking rhymes. Palés Matos' vocabulary is enriched with a luxuriance of words heard, read, or invented, and encompasses proper names, geographic terms, mythological references, and descriptions of Afro-Antillian rites, beliefs, and cus-

toms. Another characteristic of his poetry is a note of skepticism and melancholy, an ironic counterpoint to the Negro themes; in this respect he differs from other poets who dwell on Negro life.

Palés Matos was born in Guayama, Puerto Rico, in 1898. He began by writing mannerist verses (*Azaleas*, 1915) but very soon found his own direction and, after 1926, became one of the leaders of the Negro poetry movement. *Poesía, 1915–56* (1957), revealing intimate, personal moods, presented another facet of his personality; his Negro poems were seen to be only episodes in one protracted expression of an anguished insight into primitive life and of human dissolution into nothingness. Palés Matos also published narrative prose, *Litoral* (1952). He died in San Juan on Feb. 23, 1959.

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(E. A.-I.)

PALESTINE, the name of a former land of the eastern Mediterranean comprising parts of modern Israel, Jordan, and Egypt. It is also known as the Holy Land because Jesus Christ lived and taught there. Palestine was named after the Philistines who occupied the southern coastal part of the country in the 12th century B.C. The area, first called Philistia, gave its name in the 2nd century A.D. to Syria Palaestina, the southern portion of the Roman province of Syria. The name Palestine was revived as an official title when the British were given a mandate for the government of the country after its release from Turkish rule in World War I. It is still in popular use as a general term to define a traditional region, but this usage does not imply precise boundaries. The area of Palestine may perhaps best be defined, therefore, by extending it from the Mediterranean on the west to the Arabian Desert on the east; and from the lower Litani (Leontes) River in the north to the Gaza Valley in the south. Its northern and southern limits would thus correspond roughly with the proverbial extent of the Holy Land, from Dan to Beersheba.

Its area is small, about 150 mi. long and 80 mi. wide, but its strategic importance is immense, as through it pass the main roads from Egypt to Syria and from the Mediterranean to the hills beyond the Jordan. On a broad view, Palestine incorporates a part of the high edge of the Arabian Plateau, and its chief physical features are the outcome of the following processes: uplift and moderate folding which have raised the main hill masses; fracture and subsidence, producing the deep rifts and clefts which have severed these hills into their present partitions; the eruption of lava in certain districts; and the silting of the maritime plain with alluvium from the mountains, smoothed by the current which sweeps round from the mouths of the Nile. Palestine consequently includes a number of regions of very distinct geographical character.

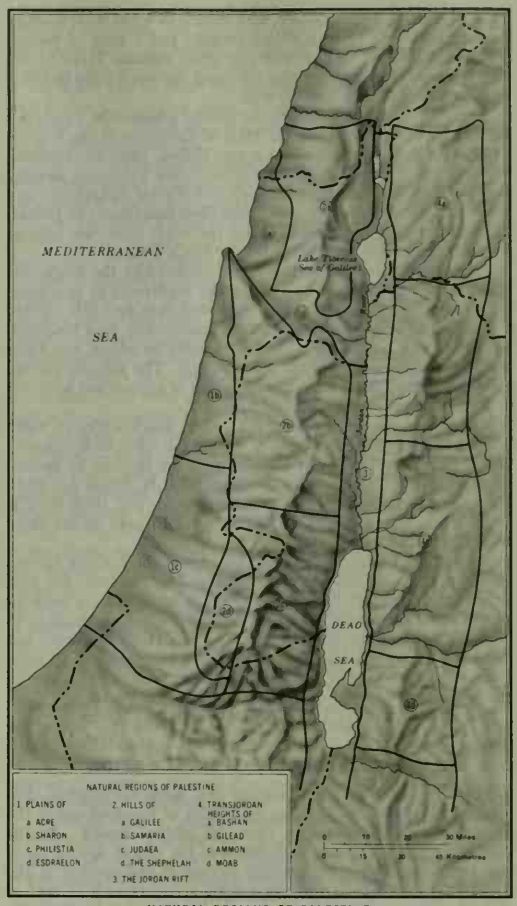
Settlement is closely dependent on water, which is rarely abundant. The rainfall, which arrives in the cool half of the year, decreases in amount in general from north to south and from the coast inland. Perennial rivers are few, and the shortage of water is aggravated by the porous nature of the limestone rocks over much of the country.

The article is divided into the following sections:

I. Geographical Regions
II. Archaeological Exploration
III. Prehistory and History
  A. Stone Age and Chalcolithic
  B. The Bronze Age
  C. The Iron Age
  D. From Alexander the Great to A.D. 70
  E. Roman Palestine
  F. From the Arab Conquest to A.D. 1900
  G. From A.D. 1900 to 1948
IV. The Holy Places

I. GEOGRAPHICAL REGIONS

Of the coastal lowlands the most northerly is the Plain of Acre, which extends with a breadth of 5–9 mi. for about 20 mi. from Ras en Naqura (the Ladder of Tyre) in the north to the Carmel promontory in the south, where it is a mere 200 yd. wide. Southward it opens out rapidly into the Plain of Sharon, about eight miles wide and extending south to the latitude of Jaffa. Once ill drained and covered with marshes and oak woods, the Sharon plain has been reclaimed for fields and fruit groves laid out between scattered sandstone ridges on which the villages are placed. South of the spur of low hills which approaches the coast about Jaffa, the maritime plain widens still more into the fertile region of Philistia, a district of rich orange groves, irrigated orchards, and wide fields of grain.



NATURAL REGIONS OF PALESTINE

The Plain of Esdraelon or Megiddo, formed by subsidence along lines of faults, separates the hills of southern Galilee from the mountains of Samaria. The plain, 16 mi. wide at most, narrows to the northwest, where the Qishon River breaks through to the Plain of Acre, and to the southeast, where the river (the modern Jalud), which rises at the Well of Harod, has carved the Valley of Jezreel into the side of the Jordan trough. Covered with rich basaltic soils washed down from the Galilean hills, Esdraelon is important both for its intrinsic fertility and for the great highway it opens from the Mediterranean to the lands across the Jordan. The maritime plain connects with that of Esdraelon by the pass of Megiddo and several lesser routes between the mountain spurs of Carmel and Gilboa.

The hill country of Galilee (*q.v.*) is better watered and more thickly wooded than that of Samaria or Judaea. North of the

Plain of Asochis, Upper Galilee, with heights of 4,000 ft., is a scrub-covered limestone plateau, thinly peopled and a zone of refuge. To the south Lower Galilee, with its highest moutain Tabor (1,929 ft.), is a land of east-west ridges enclosing sheltered vales like that of Nazareth, with rich basaltic soils.

Samaria (*q.v.*), the region of the ancient kingdom of Israel, is a hilly district extending from the Plain of Esdraelon to the latitude of Ram Allah. Its mountains, Carmel, Gilboa, Ebal, and Gerizim, are lower than those of Upper Galilee, while its basins, notably those of Dothan (the Sahl Arraba) and Nablus (Shechem), are wider and more gently contoured than their equivalents in Judaea. Samaria is easily approached from the coast over the hills of Ephraim, and from the Jordan by the Fari'a Valley.

From Ram Allah in the north to Beersheba in the south, the high plateau of Judaea (*q.v.*) is a rocky wilderness of limestone, with rare patches of cultivation, as around Bira and Mt. Hebron (Al Khalil). It is separated from the coastal plain by a longitudinal fosse and a belt of low hills of soft chalky limestone, about five to eight miles wide, known as the Shephelah. The Judaean plateau falls abruptly to the Jordan trough, which is approached with difficulty along the wadis Kelt and Mukallik.

The Jordan trench is a deep rift valley, which varies in width from 3 to 14 mi. In its northern section the lakes Hule (Huleh; Hula) and Tiberias (Sea of Galilee; *q.v.*) are blocked by natural dams of basalt. Descending to about 1,290 ft. below sea level, the valley is exceedingly dry and overheated, and cultivation is restricted to rare oases, as at Jericho, or at En-gedi by the shore of the Dead Sea.

Beyond the Jordan trough, the high edge of the Arabian Plateau captures a considerable rainfall. Below Mt. Hermon, the high volcanic tableland of Bashan and the hills of Gilead are lands of oak forests and cattle. Farther south, the rolling uplands of Ammon (whence the modern Amman) and Moab are drier, but there too cultivation is practised. Israelite occupation of all these lands east of the Jordan in biblical times was precarious because of the pressure of nomadic folk from the side of the desert.

See also DEAD SEA; ISRAEL; JORDAN; JORDAN RIVER.

(WM. C. B.)

II. ARCHAEOLOGICAL EXPLORATION

From the time of the Byzantine and medieval pilgrims, Europeans have been interested in the history of Palestine and in the identification of sites known from the biblical record. As the possibilities of travel and exploration in the Orient opened up in the 19th century, the background picture of the country in the classical period began to be filled in by accounts such as that of J. L. Burckhardt of his visit to Petra (Jordan) in 1812, while the earliest reliable study of biblical sites was made by Edward Robinson in 1838. This era of exploration culminated in the foundation in 1865 of the Palestine Exploration Fund, under the aegis of which not only were sites identified but a detailed map was made (based on the most exact professional standards, since it was carried out by officers of the Royal Engineers) upon which the sites could be recorded.

Serious excavation of sites began with Sir Charles Warren's examination in 1867 of the walls of Jerusalem by an incredible series of shafts and tunnels, an admirable piece of exploration but carried out at a period before there were adequate archaeological techniques for establishing chronology. A major step not only in Palestinian but in general Near Eastern archaeology had been taken when W. M. F. (later Sir Flinders) Petrie carried out his excavations of Tell el Hesi (Israel) in 1890. Petrie went to Palestine with a background of Egyptian archaeology, which has its framework of a fixed calendar and relatively abundant epigraphical material. He was therefore accustomed to fitting his archaeological material into a historical framework, and also he had developed the method of assembling material of the preliterate period in a sequence-dating based on typological grounds. In Palestine he had to deal with a different phenomenon, that of a mound in which objects appeared at different depths. He interpreted the mound as the result of the decay of successive towns, upon the ruins of which their successors were built, an interpretation simple in modern eyes but new at the time. Each level was dated by imported Egyptian objects which were dated in terms of the Egyptian calendar. Petrie's absolute datings are no longer accepted, but the general principle that the growth of these Near Eastern sites can be interpreted in terms of the stratigraphic levels, which must ultimately be dated by relation to Egypt or some other country with a recognizable chronology, is basic to all research in Palestine and many other countries. Petrie's excavations at Tell el Hesi were of short duration but revolutionary importance.

It was not however for many years that the developments that should have followed this first exposition of method were made. Indeed, in the simple form used by Petrie they are not everywhere applicable even for broad results. In the first decade of the 20th century, the great sites of Gezer, Samaria, and Jericho (*qq.v.*) were excavated, but the complexities of the stratification, which the methods employed could not solve, and the lack of an established pottery chronology diminished the value of the results.

The greatest contribution to the knowledge of pottery dating in the years up to 1920 was in fact made by one who was not primarily an excavator, the Dominican Father Hugues Vincent. By a devoted study of all finds that came to his notice, Father Vincent in those years built up a basic pottery chronology which was to be invaluable to all subsequent students.

The establishment of British control in 1919 saw the be-

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MAJOR ARCHAEOLOGICAL SITES OF PALESTINE

ginning of an era of intense and very fruitful archaeological work. No longer did would-be excavators have to struggle for months to get the necessary authorization from the central officials at Constantinople and to overcome the obstruction of local officials; under the direction of the newly constituted department of antiquities they received both guidance and every encouragement in their projects.

In these circumstances, a very large number of excavations on sites of outstanding importance were carried out in the years between the establishment of the Mandate and the growth of unsettled political conditions owing to Arab-Jewish dissension in 1936–39. In this period, excavations were carried on at the major sites of Megiddo (*q.v.*), Beth-shan (Beisan; *q.v.*), Jerusalem (*q.v.*), Lachish (*q.v.*), Samaria, and Jerash (Gerasa; *q.v.*), supplemented by many others, at sites perhaps less famous in repute but producing results of very great archaeological importance.

Tell Beit Mirsim.—The excavation that in fact provided a basic reference book for all Palestinian archaeologists was that of Tell Beit Mirsim, a site of no major historical importance, excavated by W. F. Albright between 1926 and 1932. In this, Petrie's basic stratigraphic methods were applied, and the combination of this with Albright's unrivaled knowledge of comparative material, both epigraphical and archaeological, produced a framework for the dating of pottery and other finds, of which the importance cannot be overemphasized. Tell Beit Mirsim very rightly became a "bible" for Palestinian archaeologists in the years between World Wars I and II.

The results of all the excavations in Palestine at this period can however be criticized on the grounds that as far as excavation methods were concerned Palestinian archaeologists were out of touch with the methods being developed by their colleagues in Europe, especially in England and Germany. Stratification was still understood simply as a matter of superimposition of buildings, as first set forth by Petrie in 1890, with no regard to the complications introduced by hill sites, terracing, disturbances by robbing of walls or grave digging which introduced objects into a level lower than their chronological horizon; there was in fact no exact tracing of layers in the soil upon which all exact stratification must depend. A great mass of labourers and a very small field staff could in these circumstances never produce exact results. The results of all the great excavations of the years between the wars have now to be edited and used with this in mind.

Beth-shan.—The first of these great excavations was that at Beth-shan (Beisan, Israel), the important site at the eastern end of the Plain of Esdraelon, famous in biblical history in the story of Saul and Jonathan. Excavations there by the University of Pennsylvania began in 1922 and lasted till 1933. For the most part, attention was concentrated on the summit of the mound, where an area was investigated that contained sacred buildings from the Middle Bronze Age down to a Byzantine church. Only a very limited sounding penetrated the lower levels, giving hints of most interesting material. The finds were of great importance, but their use by archaeologists is hampered by two things. In the first place, the excavators used exclusively for dating purposes Egyptian objects which were either claimed to be associated with the rest of the finds on erroneous stratigraphical grounds or were in fact heirlooms of an earlier period; none of the Beth-shan groups can be used as a basis for dating to the periods to which they were assigned (and unfortunate repercussions of these datings spread far and wide), though they can be of great value if re-edited. The second great drawback about the Beth-shan excavations is that a very high proportion of the results was never published.

Megiddo.—At the other end of the Plain of Esdraelon, the magnificent mound of Megiddo (Israel) was excavated by the Oriental Institute of the University of Chicago between 1925 and 1939. The original plan was to excavate the complete mound from top to bottom; but after 1930, when a level of *c.* 1000 B.C. had been reached, it became necessary to restrict the excavations to soundings only, of which only one penetrated from top to bottom of the mound. Like those of Tell Beit Mirsim, the Megiddo publications have become a "bible" for reference concerning successive archaeological levels. Though producing material on a far greater scale than the other site, the Megiddo results are less reliable, for the mass and rather mechanical excavation methods employed, with far too little site supervision, failed to recognize complications such as terracing and to make the distinction between finds in houses and in tombs or graves which by chance penetrated to the same absolute level. Much editing is again necessary to make safe use of the Megiddo evidence.

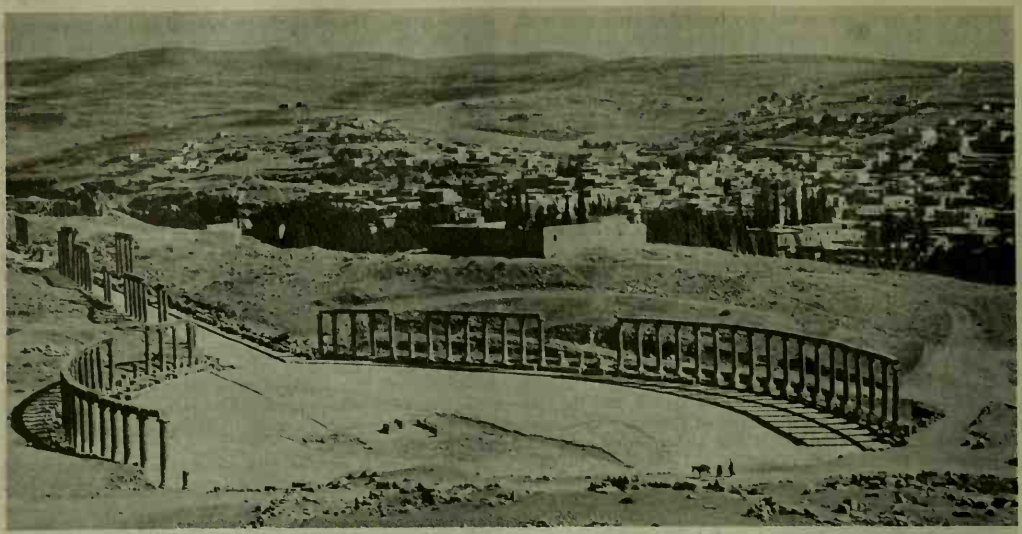
Samaria.—The excavation of Samaria (Jordan), begun by Harvard University in 1908, was resumed by a joint American, British, and Hebrew University excavation in 1931, under the direction of J. W. Crowfoot of the British School in Jerusalem. The great importance of Samaria is that there are a number of historically fixed points in its chronology, its foundation as the capital of the northern kingdom by Omri *c.* 880 B.C., its destruction by the Assyrians in 722 B.C., and the great building operations carried out there by Herod the Great *c.* 30 B.C. The excavations were complicated by the nature of the site, a steep-sided hill, and by the frequent robbings of stone-built walls. Excavations by contemporary British methods were, however, successful in identifying intact deposits associated with, or bracketed between, those fixed historical points, thereby providing a useful framework of closely dated pottery and other materials.

Jericho.—As at Samaria, excavations at Jericho were resumed at this stage, with an expedition from Liverpool led by John Garstang between 1930 and 1936. The primary object of these excavations was to identify remains associated with the biblical period. A succession of town walls were identified as belonging to the Early, Middle, and Late Bronze ages, and walls and buildings destroyed by fire were ascribed to the period of Joshua. Unfortunately, in a site of complicated stratification, the excavation methods were not sufficiently exact to make correct identification. A highly important result of the excavations was the discovery that below the remains of successive cities of the Bronze Age there was a deep deposit belonging to the Neolithic period, which gave an unexpected glimpse of the antiquity of settlement in Palestine.

Jerash.—The most important excavations concerning the classical period were those at Jerash (ancient Gerasa, Jordan). The first clearances on the site had been made by a German expedition in 1905–07, under U. J. Seetzen, resulting in the clearance of a wonderful series of classical structures, temples, theatres, forum, and monumentally laid-out streets. In 1925 work was resumed by G. Horsfield and a joint British-American expedition led by J. W. Crowfoot. The principal structures revealed were a number of Christian churches with interesting mosaics.

Lachish.—The final major excavation of the period between World Wars I and II was the British Wellcome-Marston expedition to Tell ed Duweir, one of the finest mounds in the country, identified as the site of Lachish, under the direction of J. L. Starkey. Like those at Megiddo, the excavations, begun in 1932, aimed to excavate the site completely from top to bottom. As at Megiddo, a mere beginning was made, only the later Iron Age levels being completely cleared, and the excavations came to an untimely end with the murder of Starkey in 1938 early in the political disturbances. The most dramatic find of the excavations was the series of documents on potsherds dating to the time of the Babylonian invasion of Palestine at the beginning of the 6th century B.C. Other finds in tombs and soundings gave tantalizing glimpses of the history of the town back to the Early Bronze Age, in the 3rd millennium B.C., and still earlier occupation in the neighbourhood.

Other Expeditions.—Besides these excavations of major sites, there were many expeditions on a smaller scale, often with results of at least as great importance. Perhaps the most outstanding of these were the excavations in caves on the slopes of Mt. Carmel (*q.v.*; in Israel) by the British School and the American Prehistoric Society under the direction of Dorothy Garrod, which were the first to produce exact evidence for the Paleolithic and Mesolithic periods in Palestine. Another important excavation was that of the Pontifical Biblical Institute at Teleilat Ghassul in the Jordan valley, which first brought to light an important phase of the Chalcolithic period.



FEDERICO ARBORIO MELLA

COLONNADED FORUM AND PART OF THE STREET OF COLUMNS AT THE GRECO-ROMAN CITY OF JERASH (GERASA), IN JORDAN

An excavation that came at the very end of this period was that carried out by the department of antiquities at the site of Khirbet Mefjar, near Jericho, under the direction of J. W. Hamilton. Here was revealed a magnificent Ommayad palace of the 7th century A.D., with mosaics of the postclassical period as beautiful as any yet found, and very elaborate stucco decorations.

Since excavations were resumed after the disturbances of the closing stages of the Mandate, a large number of key sites have been explored. The first important excavations were those of the École Biblique at Tell el Far'ah near Nablus (Jordan), under the direction of the Dominican Father R. de Vaux, a site with a history stretching from the Neolithic to the Iron Age; the most striking point to be established was that this was the site of Tirzah, the predecessor of Samaria as the capital of the northern kingdom. Father de Vaux was also responsible for excavations carried out at Khirbet Qumran, the home of the community from the library of which came the Dead Sea Scrolls.

In 1952 the excavation of Jericho was resumed by the British School in Jerusalem. The new work enabled the dating of the Bronze Age levels to be revised. More important still was the much fuller examination of the Neolithic levels, which revealed two successive Pre-Pottery Neolithic cultures, dated by the carbon-14 method respectively to *c.* 7000 B.C. and *c.* 6000 B.C., with a preceding Mesolithic stage.

The most important excavation of a new site was that undertaken between 1955 and 1958 by Israeli archaeologists, led by Y. Yadin, at Hazor (*q.v.*; Tell el Qedah), in which the history of this major site was traced from the Middle Bronze Age to the Iron Age. A vast number of other excavations on a lesser scale were also carried out in Israel during this period, perhaps the most interesting being a series at sites such as Beersheba and Mezer, which have greatly supplemented knowledge of the Chalcolithic period in the 4th millennium B.C.

III. PREHISTORY AND HISTORY

A. Stone Age and Chalcolithic

Paleolithic Period.—The Paleolithic era of Palestine was first fully examined by Dorothy Garrod in her excavations of caves on the slopes of Mt. Carmel. In these caves overlapping sequences were discovered that established a succession of industries and fauna for the Middle and Upper Paleolithic. The finds showed that at this stage Palestine was culturally linked with Europe, and human remains were recovered showing that the inhabitants were of the same group as the Neanderthal inhabitants of Europe.

Mesolithic Period.—Overlying the Paleolithic deposits in these same caves was found a succession of Mesolithic levels, though it is probable that there was an intervening gap. The finds in these levels exhibited a basic similarity of culture with the Mesolithic of Europe, but with regional differences, and to this culture the name Natufian was given. The Natufians lived in caves, as did their Paleolithic predecessors, but there is a possibility that they were experimenting in agriculture, for the importance to them of the collection of grain is shown by the artistic care that they lavished on the carving of the hafts of their sickles and in the provision of utensils for grinding.

In the 1950s evidence began to accumulate of Natufian occupation on open sites. At the site of 'Ain Mallaha (Israel), Jean Perrot excavated a site where there was a succession of curvilinear houses in which the industry was purely Natufian, and near to the Lower and Middle Natufian of Mt. Carmel.

'Ain Mallaha perhaps provides a link which is not clearly illustrated in the history of Jericho as so far discovered. At the base of the Jericho *tell* or mound was found a structure that is probably not domestic and is probably a sanctuary, shown by the finds to belong to the Lower Natufian and dated by carbon-14 to *c.* 7800 B.C.; it is perhaps to be identified as a sanctuary established by Mesolithic hunters beside the perennial spring that for millennia has attracted men to Jericho, in recognition of its life-giving properties.

The succeeding stage at Jericho is that of permanent occupation, but with a population that lived in flimsy shelters more suitable to a nomadic existence. The flint and bone industries showed that the people who lived in these shelters were the cultural descendants of the Mesolithic hunters. But the permanence of the settlement, indicated by a "nucleus *tell*" building up a deposit 13 ft. high, shows that the transition from a nomadic to a settled life had been made, and it may be inferred that the experiments in agriculture that can be suggested for the Natufians of Mt. Carmel were now being prosecuted ever more successfully to allow this occupation on one spot.

Neolithic Period.—The next development at Jericho is dramatic. Solidly built houses appear, curvilinear in plan and often single-roomed, thus typologically to be linked with a primitive hut but structurally far in advance by reason of solid walls of mud-

GEORGE HOLTON—PHOTO RESEARCHERS, INC.

Bethlehem seen from the tower of the Christmas bell on the Church of the Nativity, the traditional site of the birthplace of Jesus

MIDDLE EAST ARCHIVE

Traditional site of the baptism of Jesus, the Jordan River near Bethabara

FRITZ HENLE—PHOTO RESEARCHERS, INC.

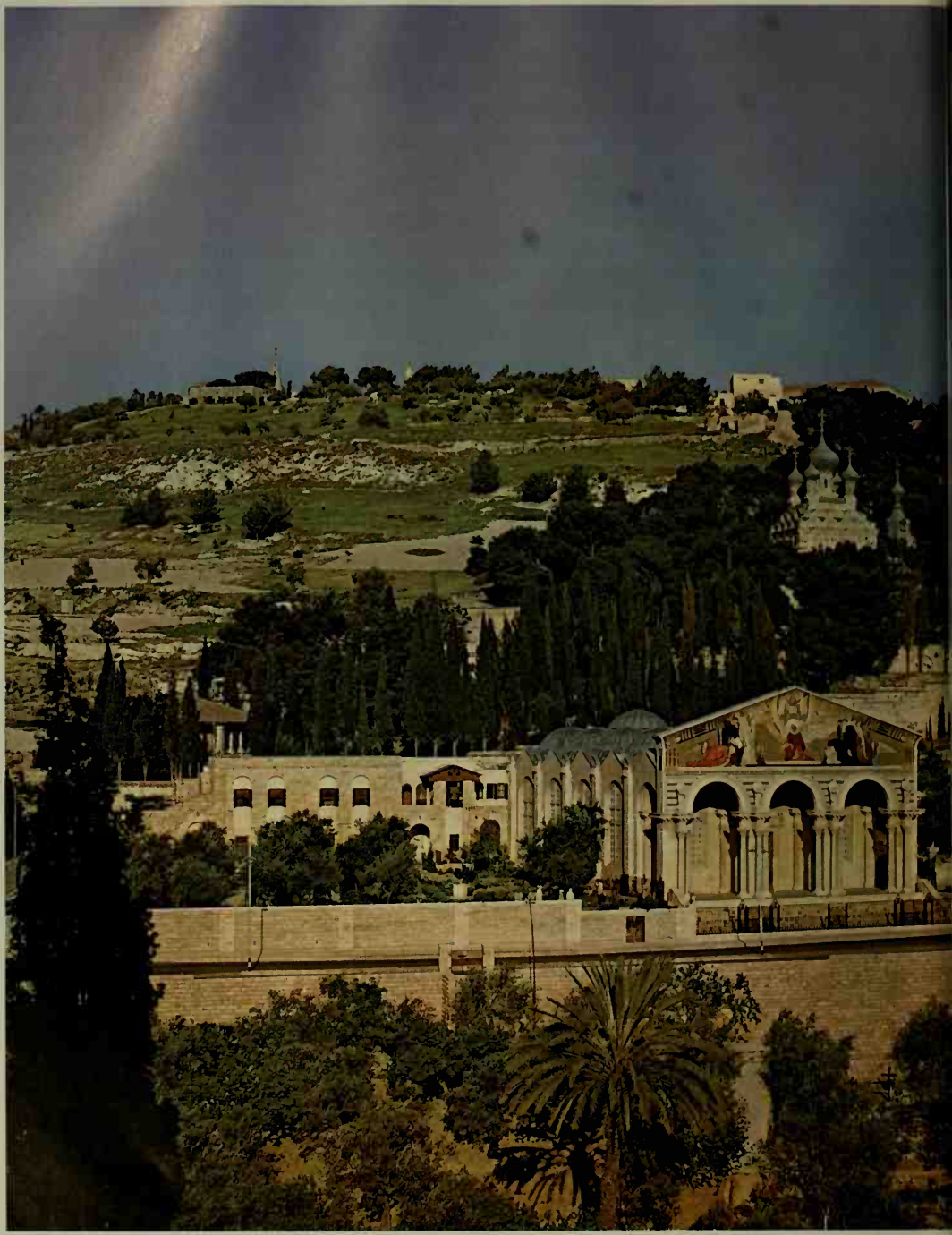
Valley of Jezreel (Esdraelon), a large fertile valley lying between the mountains of Galilee and the mountains of Samaria and forming a historic connecting link to the Mediterranean for the areas east of the Jordan

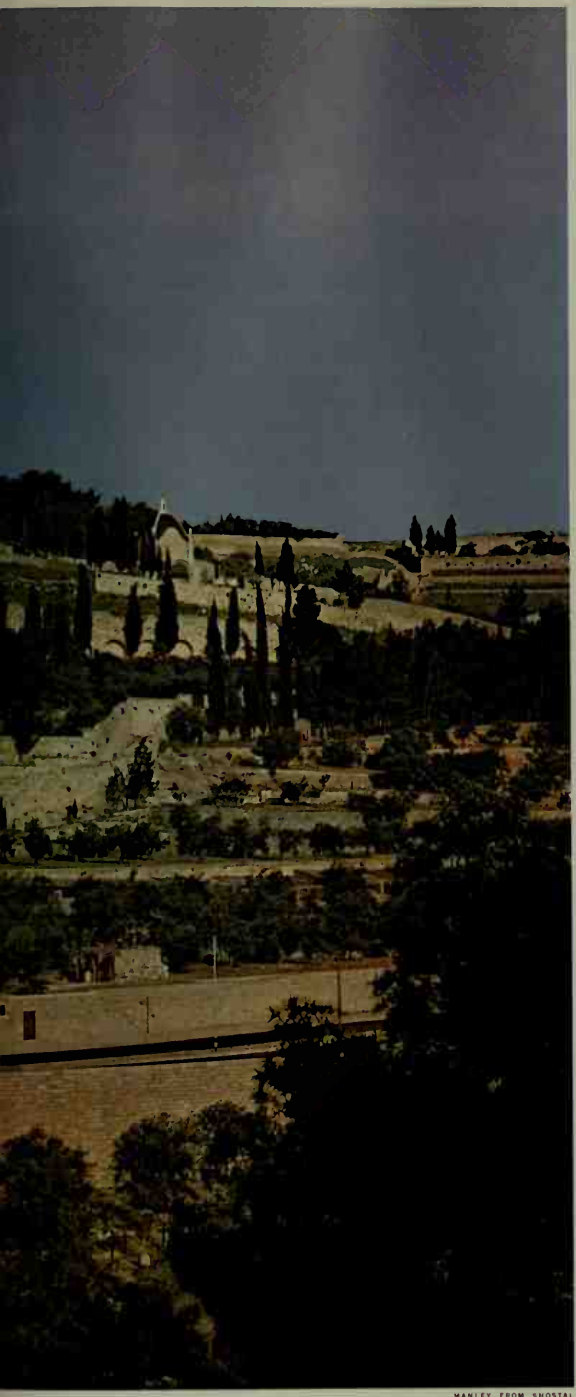
MIDDLE EAST ARCHIVE

Mosque of Hebron (in Jordan) adapted from a 12th-century church built by the crusaders on the site of an earlier structure

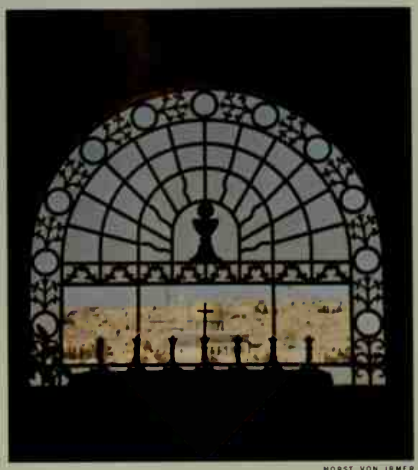
SITES OF RELIGIOUS SIGNIFICANCE

PALESTINE





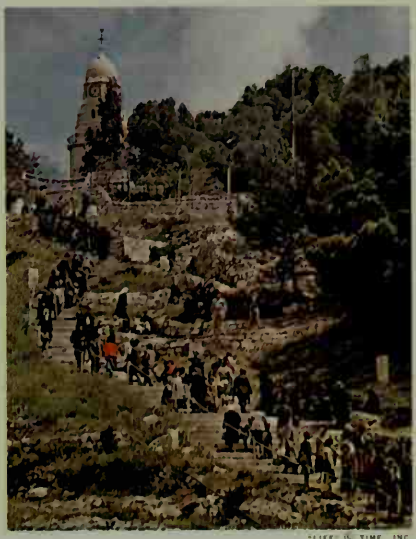
MANLEY FROM SHOSTAL



HORST VON IRMER

Old City, seen from the altar of the Church of Dominus Flevit. Dome of the Rock (centre) is on the site from which Mohammed is believed to have ascended to heaven and on which, in an earlier time, stood the Temple of Solomon

JERUSALEM



"LIFE" © TIME, INC

Pilgrims ascending "Mt. Zion" to visit David's tomb and the traditional scene of the Last Supper

Mount of Olives. The Church of All Nations is in the foreground, the Russian Church of St. Mary Magdalene in the centre background

PALESTINE

NELSON GLUECK

Ancient road through the Jebel Ideid in the Negev. Branches of the track lead eastward to Petra, westward to Sinai, and southward toward the Gulf of Aqaba

THE COUNTRY

"LIFE" © TIME, INC.

Haifa, the area's largest port, seen from Mt. Carmel; beyond, the Bay of Acre

JERRY COOKE—PHOTO RESEARCHERS, INC.

Farmlands overlooking a cove of the Sea of Galilee (Lake Tiberias) from the west

brick. The dramatic aspect of this development is that at an early stage the houses spread over an area that may be as much as ten acres and were very soon surrounded by an elaborate defensive system. From this it can be inferred first that permanent settlement was very firmly established; second that reasonably successful agriculture must have been established, since the population, perhaps to be estimated as about 2,000–3,000, of a settlement of this size could not otherwise have been supported; and third that irrigation must have been practised, since, though the spring of Jericho stimulated vegetation in its neighbourhood, in a state of nature its waters would have reached an area too small to support a settlement of this size. Irrigation requires considerable social organization, and this may have been the stimulus to the community organization of which the remarkable defenses provide evidence. These defenses had a long history, but the salient point is that by *c.* 7000 B.C. they enclosed this area estimated at ten acres, with, at one point at least, a great stone-built tower still standing 30 ft. high.

This stage in the history of Jericho is in the present state of knowledge unique in the history of Palestine, though it is of course certain that this urban community did not grow up in isolation; its contemporaries, however, are yet to be found. For the culture that succeeded it there is more evidence. The break between the earlier and later Pre-Pottery Neolithic stages at Jericho was absolute, and the newcomers arrived with a fully fledged culture. The great distinction was in house form, which was rectangular and many-roomed, with the rooms, floored with highly burnished plaster, arranged round courtyards. Like its predecessor, the second group was an organized community that defended its settlement with a town wall. The artistic achievements of this people are illustrated by some remarkable portrait heads, in which the features are molded over actual human skulls; these heads can probably be interpreted as evidence of a form of ancestor worship.

The culture of the inhabitants of the earliest town at Jericho certainly developed on the spot, for important elements, such as the flint industry, show an unbroken sequence. That of the second group did not develop out of it and would appear to have been imported from outside Palestine. Within Palestine it apparently was widespread, for a flourishing village of certainly related culture has been found as far south as Beidha, near Petra, and increasing evidence has been coming to light in a number of other sites. The original centre of diffusion has not yet been found. But it is clear that the very interesting site of Catal Huyuk in Asia Minor excavated by J. Mellaart is related to the Palestinian sites, and there may be a common origin in Syria.

At this important stage of the beginnings of settlement, Palestine may have developed more rapidly than any other area in western Asia so far known. The stage was followed however by one of retrogression. The place of the town- and village-dwelling Pre-Pottery Neolithic people was taken by others who, though they used pottery, were in every other respect more primitive; at Jericho they lived in huts sunk into the ruins of the houses of their predecessors. A second group of Pottery Neolithic people is linked with similar groups found widely distributed in Palestine, for instance at Sha'ar ha Golan (Jordan) on the Yarmuk River as well as at Jericho, and is also linked with the earliest inhabitants of Byblos (*q.v.*). This link with Byblos associates this stage with that of the widespread appearance of villages round the Fertile Crescent in the 5th millennium B.C.

Chalcolithic Period.—It was not till after about 1952 that excavations began to reveal a picture of events in Palestine in the 5th–4th millennia B.C. In this period the transition from the Neolithic to the Chalcolithic took place, and there is often doubt as to the correct terminology. The general picture is one of separate groups, some perhaps descendants of the indigenous Neolithic population, some immigrants, living simple semisedentary lives in small villages or family groups. The exact chronology and interrelationships of the groups have yet to be established.

It was probably early in the 4th millennium that there appeared a group that was certainly immigrant, though it is not yet possible to be specific about the country of origin, probably owing to the lack of excavation in Syria. They can be conveniently called the Ghassulians, since the characteristic pottery and flints first attracted attention in the excavations of Teleilat Ghassul in the Jordan valley. Here there was a permanent village site, with several successive layers of occupation and probably to be associated with reasonably efficient agriculture. The phase can be called Chalcolithic, since copper axes were found at Ghassul, and this is confirmed by the finds at sites near Beersheba (in Israel), with pottery and a flint industry allied to those of Ghassul but not identical with them. At Beersheba there was an undoubted copper-working industry, with the ore presumably imported from Sinai, and there was also evidence of an ivory-working industry, both proving the growth of a class of specialist craftsmen. The houses of the Beersheba settlements were of a very peculiar type, being originally constructed as artificial caves cut into the soft marl, and only gradually, as it were, coming to the surface, as structures were built over the collapsed caves. The wide distribution of this group is only gradually coming to light. In the 1950s a number of village settlements were found stretching up the coastal plain and adjacent foothills. But certainly allied to the Ghassulians were the people inhabiting a number of camping sites investigated in the course of Petrie's excavations in the neighbourhood of Tell el Far'a (near Gaza) in southern Palestine in 1930. Here, their way of life was adapted to their environment, the fringe areas of cultivation, and they were at least seminomadic.

The region in which the Ghassulian settlements have been found is mainly in the south of Palestine, with an extension up the coastal plain and its fringes. It impinges on the area in which the next development took place. The stage was set for this development by a series of incursions, approximately contemporary, of groups that, on their arrival in Palestine, were essentially nomadic, for they seem to have brought no developed civilization with them. Nevertheless, it was at the sites in which the evidence of the presence of these newcomers is found, such as Jericho, Tell en Nasbeh, 'Ai, Tell el Far'ah near Nablus, that in the next phase the towns develop; it is very noticeable that the Ghassulian sites seem to die out and disappear. It therefore seems appropriate to designate this stage the Proto-Urban period.

A carbon-14 dating at Jericho for a relatively early phase of this period gave a date of *c.* 3260 B.C. It is clear that it was in the last centuries of the 4th millennium B.C. that the composite elements in Palestine, indigenous Neolithic-Chalcolithic, immigrant Ghassulian, and the various immigrant Proto-Urban groups, were being amalgamated into what was to become the sedentary urban population of the Early Bronze Age in the 3rd millennium.

Palestine dating is henceforth linked to Egyptian dating down to the time of the Hebrew monarchy; the interpretation of Egyptian dates in the revised *Cambridge Ancient History* is followed in this article.

B. The Bronze Age

Early Bronze Age.—It was in the Early Bronze Age that most of the towns that are known in historic times came into existence. The growth of these towns can be approximately correlated chronologically with the development of the Old Kingdom in Egypt, Early Bronze I corresponding to the Late Predynastic period and Early Bronze II being cross-dated by finds to the time of the 1st dynasty, *c.* 3100 B.C. Evidence of the early phases of the Early Bronze Age comes mainly from Megiddo, Jericho, and Tell el Far'ah. At the latter site, the town received its first walls, massively built in mud-brick, with an elaborate gateway flanked by towers, in E.B. I. At Jericho, it is not yet clear at what stage the site was first walled, but it must have been early in E.B., for the town walls had a very long history in this period. But though walled towns began to appear early in E.B., the spread of towns seems to have been slow, and the flourishing period of most towns was in E.B. III. At Megiddo, structures of E.B. I and II are unimpressive and straggling, while in E.B. III there was a major town-planning development, with the sloping sides of the hill laid out in terraces; presumably at least at this stage there was a town wall, but it has not been located. At Beth-shan there would seem to be an increase in wealth and density of occupation, but the lower levels on this site have been investigated in a sounding only, and

no town wall has been found; one of the features of the E.B. III levels at Beth-shan is the appearance of the ware, foreign to Palestine, known as Khirbet Kerak. This ware is widely distributed in Syria and Asia Minor, and it is certainly evidence of contacts with a group perhaps originating in the Caucasus; in Palestine the contacts seem to have been peaceful. Khirbet Kerak, at the southern end of the Sea of Galilee, the site at which the ware was first found, is another town with strong town walls belonging to this period. At 'Ai, a little north of Jerusalem, there was also an elaborate defensive system then.

All these sites are in northern or central Palestine, and it was here that the Early Bronze Age towns seem to have developed. The towns of southern Palestine, for instance Tell ed Duweir, Tell Beit Mirsim, and Tell el Hesi, seem only to have been established in E.B. III.

In the course of the 3rd millennium, therefore, walled towns begin to appear all over Palestine. There is no evidence that the next step of unification under the leadership of a single town, as happened in Mesopotamia and Egypt, took place in Palestine; they presumably remained independent city-states, except insofar as Egypt may at times have exercised a loose political control. The evidence would suggest that the interiors of the towns were closely built up, with substantial structures, certainly including temples, for instance at Tell el Far'ah, Megiddo, and 'Ai. Each town must have had under its control an area sufficient for the needs of its population, in which agriculture was developed and flocks pastured. It was probably at this stage, therefore, that the first large-scale clearance of forest took place.

It may be that this clearance of forest had a drastic effect on the economy of Palestine. Uninhibited clearance of woodlands may have a far-reaching effect on physical conditions. At Jericho, there was remarkable evidence of denudation of the land surface at a period between *c.* 2600 B.C. and 2300 B.C. The climax of the urban development of E.B. III may therefore have been followed by a phase of decay. Certainly by about the 23rd century B.C., the whole civilization had been destroyed by the invasion of nomadic tribes, probably Amorite (though *see* AMORITES for another view).

Intermediate Early Bronze-Middle Bronze Period.—At Jericho there was clear evidence of destruction of the town and its walls, with an interval, in which the newcomers must have lived in tents, before an entirely new type of buildings appears. At no stage at this or any other site in this Intermediate Early Bronze-Middle Bronze period were there any town walls, and occupation seems to have been indifferently on the ruins of the older towns and spreading into the surrounding countryside.

At most places, in fact, the evidence concerning the newcomers is found in their tombs rather than in their dwellings. It would seem that they were seminomadic pastoralists, only loosely attached to a centre, to which they may have brought back their dead for burial during their seasonal returns. The evidence from the tombs confirms both the tribal organization to be expected among such people, and also the complete break between them and the E.B. town dwellers. Pottery, weapons, and all other objects in use are entirely distinct from those of the preceding period. The burial practices again are completely different. In the place of the large tombs containing several hundred bodies buried successively, at almost all sites now the tombs were for individual interments, or where, as at Megiddo and Beth-shan, there were more than single bodies, the type of the tombs is entirely different from that at any other period.

Confirmation of tribal organization comes from the evidence of a number of groups with slightly different burial practices and equipment. At Jericho there is evidence of seven groups, at Tell el 'Ajjul two, none identical with those of the other site, nor with those at Tell ed Duweir or Tell Beit Mirsim. The burial of disordered skeletons in a number of cases suggests the habits of nomads returning only seasonally to the tribal burial ground.

The contemporary groups in northern Palestine, for instance at Megiddo and Beth-shan, had some connection, as shown by the pottery, with some of those at Jericho, but at Megiddo there are suggestions of more sedentary life. A succession of three phases of massively built temples seems to belong to this period, though certain ascription is made difficult by the inadequacy of the excavation records.

The types of burials could also be interpreted as indicating that the inhabitants of Megiddo at this period were less primitive than their contemporaries elsewhere in Palestine. The general picture is the same, of allied groups but with variant equipment and practices, for at Megiddo again there are two groups distinguished by different pottery and different burial practices. One of these groups buried their dead in a large cave; apparently as at Jericho and elsewhere most of the bodies were already decomposed when placed in the tomb. This was also the case in the second group, but in this case the architectural precision of the plan of the shaft tomb, with a shaft from which an entrance led into a central chamber, with side chambers following a stereotyped plan, does suggest a degree of sophistication that would be appropriate in a group that could build architecturally designed temples.

The E.B.-M.B. people of Megiddo belong to a northern group. A close connection between the finds at Megiddo and those at El Husn in Jordan has long been recognized. Pottery of the period has been published from a very limited sounding at Beth-shan, the great site that balances, at the eastern end of the Plain of Esdraelon, Megiddo at the western end. An examination of the unpublished records of the excavations (made by Mrs. Garner James) shows that at this site too there were tombs of the elaborate type of the shaft tombs of Megiddo.

It is not easy to establish the chronology of this period in the history of Palestine, for nomads do not have much contact with literate civilizations. It does however seem reasonable to associate this incursion of nomads with the invasions of Asiatics into Egypt that brought the Old Kingdom to an end. An initial date of 23rd–22nd centuries B.C., depending on the interpretation of the Egyptian evidence, and a final date of the 20th century B.C. seems probable.

The picture of Palestine at this period is thus unequivocally that of a country occupied by a number of allied tribes; between them there are many features in common, but there are many differences. The most diagnostic point is that, with the possible exception of the northern group, they made no contribution at all to town life. The different groups had tribal centres, but they were essentially seminomadic pastoralists. This description fits well that in the Book of Joshua of the Amorites who lived in the hill country, as opposed to the Canaanites who lived in the plains and on the coast, areas favourable to agriculture. (*See* also JOSHUA, BOOK OF.)

Middle Bronze Age.—It is in fact the next period that introduces the Canaanite culture as found by the Israelites on their entry into Palestine. It is the Middle Bronze Age that provides the background for the beginning of the story of the Old Testament, and in this period that the patriarchs wandered through Palestine. It is marked by a break as abrupt as that which ended the Early Bronze Age. Pottery types, weapon types, burial practices are all new. Once more an urban civilization based on agriculture is established. A new people had arrived in Palestine, a people that was accustomed to dwell in towns. The newcomers, arriving perhaps in the 20th century B.C., at first were few in numbers. But where they settled, there grew up towns of the widespread Middle Bronze Age civilization of Palestine. This civilization was intimately connected with that of the towns of the Phoenician-Canaanite coast. In the culture introduced at this stage there is no break down at least to the 12th century B.C., and this is therefore the culture found by the Israelites who infiltrated into Palestine in the 14th and 13th centuries B.C.

With the Middle Bronze Age arose a large repertory of new forms in pottery, and for the first time in Palestine it was turned entirely on a fast wheel. Comparisons of Palestinian M.B. I pottery forms with metallic and ceramic forms at Byblos, dated by Egyptian contacts, suggest that these forms were brought to Palestine around the 19th century from coastal Syria. Bronze weapons of a distinctive type, paralleled also on the Syrian coast, are found at Megiddo, Jericho, and Tell el 'Ajjul. The dead were once more buried in family tombs and not as individuals. The M.B. I period seems to have been comparatively short and may be dated from

1900 to *c.* 1850; the newcomers at first settled on existing town sites. The expansion of town life in Palestine really began in M.B. II (*c.* 1850–*c.* 1550), in which the material culture was a direct development from the preceding stage. Several towns of Middle Bronze Age Palestine were defended by plaster-faced ramparts (most clearly discernible at Jericho), an imported method of fortification giving evidence of a new and alien influence superimposed upon the existing Canaanite culture. These were probably introduced by the Asiatic Hyksos (*q.v.*), who secured control of northern Egypt *c.* 1730 and who may have included elements of a grouping of people, largely Semitic, called the *Habiru* (= Egyptian 'Apiru = Hebrew?). These people appear to have established a military aristocracy in Palestine, bringing to the towns new defenses and new prosperity without interrupting the character of their culture; this was to survive the destruction of Megiddo, Jericho, and Tell Beit Mirsim which followed the expulsion by Egypt of the Hyksos into Palestine at the end of the Middle Bronze Age (*c.* 1550). (K. M. K.)

Late Bronze Age.—There was no sharp break between the Middle and the Late Bronze ages in Palestine. The region seems to have remained culturally, and perhaps politically, a province of the Hyksos kings until the expulsion of the latter from Egypt. About 1550 B.C., shortly before the death of Ahmose I, the first native Pharaoh of the New Empire, the Egyptian armies began to conquer Palestine, probably completing their task during his successor's reign. Under Queen Hatshepsut (*c.* 1503–1482), Palestine revolted against Egyptian domination, but the rebellion was put down firmly by her successor, Thutmose III, who established a stable administration, maintained through the reigns of his immediate successors. Egyptian administrative documents excavated in both Egypt and Palestine show in considerable detail how the provincial government was organized and even how it operated during the century 1450–1350 B.C. This period is often known as the "Amarna Age," and is vividly illustrated by several hundred cuneiform letters found at Tell el Amarna (*q.v.*), site of the capital of the "heretic king" Ikhnaton. The unusual concern of the Pharaohs with the affairs of Palestine, which was then as poor in relation to its neighbours as in modern times, was chiefly a result of the fact that control of it was necessary for the defense of Phoenicia and southern Syria, menaced by Mitanni down to *c.* 1375 and by the Hittite empire after that date.

In about 1310 B.C. the increasingly weak rule of the last Pharaohs of the 18th dynasty was replaced by the strong arm of the second and third kings of the 19th dynasty, Seti I and Ramses II (1304–1237 B.C.). These kings blunted the southward thrust of the Hittites and consolidated the crumbling Egyptian empire. However, the exactions of foreign bureaucrats, combined with internal decay, had so enfeebled the Canaanite vassal princes of Palestine that it was comparatively easy for the incoming Israelite tribes to occupy most of the hill country of both Transjordan and western Palestine in the course of the closing decades of the 13th century B.C. During a short interlude of anarchy that followed the last weak kings of the 19th dynasty, Egyptian rule was completely extinguished, and the ephemeral victories of Ramses III in the early decades of the 12th century scarcely affected Palestinian history. *See* also CANAAN.

C. The Iron Age

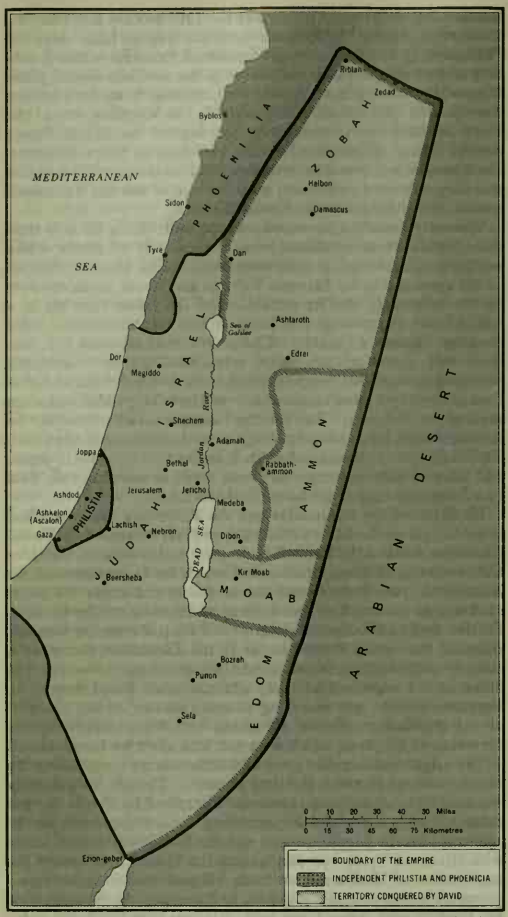
Israel.—Though the Israelite tribes invaded Palestine before the end of the Late Bronze Age, they did not become firmly established in their new home until the early decades of the 12th century. Their number was increased greatly during the conquest of Canaan by seminomadic Hebrew tribes already in Palestine, as well as by many settled Canaanites (*e.g.*, the Gibeonites), who joined the invaders against their sedentary neighbours. Excavation has made it clear that the Israelites began building amid the ruins of their precursors and that new settlements sprang up rapidly all through the hill country. Had events followed their normal course the resurgent Canaanites, who had not been driven from the coastal plain or the Plain of Esdraelon, might have overwhelmed the scattered and unorganized Israelite clans, but this was prevented by the great invasion of the sea peoples in the time of Ramses III, in the early decades of the 12th century B.C. (*see* SEA PEOPLES). Among the invaders from the Aegean basin were the Philistines (*q.v.*), who were to conquer all Palestine within a century and a half after their settlement in the southern coastal plain. Meanwhile three other peoples were settling down in southern Transjordan: the Edomites in the south, the Moabites east of the Dead Sea and the Ammonites on the edge of the Syrian Desert east of Gilead. Considered by the Israelites as fellow Hebrews, these peoples had begun to settle down before the Israelite invasion and they remained polytheists until the end of the Old Testament period. (*See* AMMONITES; EDOM; MOAB.)

The early Israelites possessed a strong centralizing force in their monotheistic faith, combined with a stern code of ethics, which set them apart from all their neighbours. The Mosaic tradition of the covenant (*q.v.*) between Yahweh and Israel, made concrete by the tabernacle and its ritual, bound the tribes together in a cultic bond resembling the later Greek amphictyonies. (*See* TWELVE TRIBES OF ISRAEL.) Characteristic of all these organizations was a central sanctuary, surrounded by its worshipers. Straining against this religious bond were disruptive tribal forces held in leash by a loose alliance between the tribes, which was often severed by civil war. But for the constant attacks launched by its neighbours, Israel would perhaps never have attained any political solidarity. As it was, salvation from its foes lay only in union, and after abortive attempts had been made at one-man rule, Saul (*q.v.*) became king of all Israel (*c.* 1020 B.C.).

He defeated the Ammonites and the Philistines, but was killed in battle against the latter *c.* 1000 B.C. and was succeeded by David. The latter crushed the Philistines (*c.* 990) and conquered the three Hebrew states of Transjordan, after which the intervention of the Aramaeans from Syria forced him to defeat and annex the states of Aram as far north as the borders of Hamath on the Orontes. Farther east he established some sort of control over the nomadic tribes of the Syrian Desert as far as the Euphrates, though it is scarcely probable that Israelite domination was very effective. At home David organized a stable administration based largely on Egyptian models, and according to tradition carried out a census of the population. Death prevented him from completing the execution of his plans, which were put into effect by his successor.

The reign of Solomon (*q.v.*; mid-10th century) represents the culmination of Israelite political history. Though he gradually lost control over outlying territories conquered by David, he was extraordinarily successful in organizing the economic life of the country. On the Mediterranean and the Red Sea he joined forces with Hiram of Tyre, who was leading the Phoenicians toward the exploitation of Mediterranean trade. Expeditions to Ophir (*q.v.*) brought the rich products of Africa to Palestine. At the same time the Israelite king entered into trade relations with the Arabs as far south as Sheba (Yemen). These activities would have been impossible but for the development of new principles in shipbuilding and for the recent domestication of the Arabian camel and its use in caravans. Among other lucrative undertakings of the king were his development of the copper mines of Edom and his construction of refineries at Ezion-geber (modern Tell el-Kheleifeh) on the Gulf of Aqaba. Most of the wealth thus gathered was spent in elaborate building operations, which included the Temple and royal palace in Jerusalem, as well as numerous fortified towns and "chariot cities." Best known of the latter is Megiddo, where excavations have disclosed stable accommodation for more than 400 horses. But royal activities on such a vast scale cost more than was produced by foreign trade and the tribute of vassal states, so the Israelites themselves were forced to submit to conscription in royal labour gangs as well as to heavy levies of various kinds. It is not surprising that the people of northern Israel revolted after the great king's death, thus disrupting the united monarchy.

The rump kingdom of Israel lasted for two full centuries, sharing the worship of Yahweh and the Mosaic tradition with its smaller southern neighbour, Judah. After a period of intermittent warfare between Judah and Israel, King Asa of the former entered into an alliance with the growing kingdom of Damascus by which the latter attacked northern Israel, thus relieving pressure on Judah. This move cost Israel its Transjordan territory



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PALESTINE DURING THE TIME OF DAVID AND SOLOMON

north of the Yarmuk River and ushered in a long series of wars between Israel and Damascus, which did not end until the capture of Damascus by the Assyrians in 732.

The best-known phase of Israelite history is the period during which the great prophets, Elijah and Elisha, flourished, under the Omrides of the 9th century. Omri himself, founder of the dynasty, selected Samaria as his capital and began the construction of elaborate defenses and royal buildings, which have been uncovered by excavations. His son Ahab (*q.v.*) was alternately hero and villain of the principal stories of the prophets; he became involved in complex international maneuvers, which ended with his ignominious death at Ramoth-Gilead. The dynasty of Omri closed amid torrents of blood (*c.* 841 B.C.); it was followed by the dynasty of Jehu, which lasted for nearly a century. This was a period of extreme oscillations, from the catastrophic defeat of Israel (*c.* 815 B.C.) and the destruction of its army by Hazael, king of Damascus, to the triumphs of Jeroboam II (*c.* 786–746 B.C.). Meanwhile Judah also oscillated between periods of prosperity and weakness; when it was strong it controlled Edom and the caravan routes of the south from Midian to the Mediterranean; when it was feeble it shrank behind its own narrow boundaries. Great kings like Asa, Jehoshaphat, and Uzziah alternated with weaklings.

In 740 the death knell of Western independence was sounded by the capture of Arpad in northern Syria by the Assyrian king Tiglath-pileser III. Events followed with dizzying speed. In 738 Israel and Judah paid tribute to Assyria for the first time in decades; in 733 the Assyrians devastated Gilead and Galilee, turning the entire land into Assyrian provinces except for the territory of two tribes, western Manasseh and Ephraim; in 732 Damascus was captured and Aram ceased to exist as a state; in 724 the siege of Samaria began. Finally, in the first months of 721, Samaria was taken and Israel became politically extinct.

Assyrian and Babylonian Rule.—Judah was now the sole heir of the glories of David and Solomon. Hezekiah (*q.v.*; *c.* 715–*c.* 686), lured by promises of Ethiopian aid, attempted to resist Assyria, but was defeated and compelled to pay a crushing tribute. Only the timely intervention of an epidemic which decimated the Assyrian army saved Judah from total devastation. The eloquent guidance of Isaiah restored the morale of the people, and even the weakness of Hezekiah's son Manasseh did not bring complete ruin. Another strong king, Josiah (*c.* 640–609), arose in time to restore the ebbing fortunes of Judah for a few years during which much of the ancient territory of united Israel was brought back under the rule of the Davidic dynasty. Assyria was rapidly declining in power, and in 612 its hated capital, Nineveh, was destroyed by the Medes. Josiah's successful rebellion ended when he fell in battle against a more powerful contender for the Assyrian succession, Necho of Egypt.

Meanwhile the Chaldean kings of Babylonia were rapidly gaining strength. Nabopolassar of Babylon and Cyaxares of Media divided the old Assyrian empire between them, and the former's son, Nebuchadrezzar, gained control of Syria and Palestine in swift campaigns. However, the defeated Egyptians continued to intrigue in Palestine, whose native states repeatedly joined anti-Babylonian coalitions, all of which collapsed of themselves or were crushed by the Chaldean armies. Jerusalem (*q.v.*) was twice besieged, in 597 and after 589. Finally, about 587, it was stormed and destroyed. The prophet Jeremiah, who had foreseen the tragic denouement and had repeatedly warned his people against their suicidal policy, died in Egypt. Judah was devastated and almost depopulated.

The Persian Empire.—In 539 Cyrus II of Persia followed up his triumph over Media by conquering Lydia and Babylonia, thus making himself ruler of the greatest empire hitherto known. One of his first acts was to decree (538) the restoration of Judah and the building of the Temple. A large number of Jewish exiles in Babylonia returned to Jerusalem, and work on the Temple was begun. However, the political situation was extremely unfavourable, since Judah south of Hebron had been occupied by Edomites escaping from Arab pressure, while the tiny remainder north of Hebron had passed under the control of the governor of Samaria. The latter was able by political intrigues to prevent completion of the work of rebuilding the Temple. After the accession of Darius I the Jews took advantage of the civil wars and rebellions which were racking the empire to press work on the Temple, urged on by the fiery prophets Haggai and Zechariah. In 516 B.C. the Second Temple was finished, but the Jews had meanwhile aroused the suspicion of the Persian authorities and further efforts to improve their situation were discouraged.

Matters rested in this unsatisfactory state until *c.* 445 B.C., when the Jewish royal favourite, Nehemiah, deeply stirred by reports of the sorry condition of Judah and Jerusalem, succeeded in obtaining royal support for a mission to Palestine (*see* EZRA AND NEHEMIAH, BOOKS OF). Knowledge of the exact sequence of events is complicated by the confused state of documentary sources, and the chronology of events in the time of Ezra and Nehemiah is not certain. It is probable that Ezra was sent to Palestine through the good offices of Nehemiah. However this may be, the two very different leaders were able to establish both the religious autonomy of Judah and the practice of normative Judaism so firmly that they continued with little change for several centuries.

Information concerning the history of Palestine in the period following the age of Nehemiah is very scanty. There is mention

of Persian intervention in the priestly affairs of Judah in the time of the high priest Johanan (*c.* 400 B.C.). It is known that the province of Judah continued to be administered by high priests who struck their own coins, and that the provinces of Samaria and Ammon remained under Yahwist governors of the houses of Sanballat and Tobiah. In 343 Artaxerxes III Ochus is said to have devastated parts of Palestine in connection with his reconquest of Egypt. Eleven years later the country passed into Macedonian hands after Alexander's conquest of Phoenicia. *See* also JEWS: *Earliest Times to A.D. 135.* (W. F. A.)

D. From Alexander the Great to A.D. 70

To Alexander Palestine was, as to many before him, a corridor leading to Egypt, the outlying Persian province. Consequently, in his attack on that province after the Battle of Issus (333), he confined his attention, in his passage southward, to reducing the coastal cities which might form bases for the Persian fleet. The Jews he left undisturbed in their religion and customs. The high priest remained the head of the Jewish state, perhaps assisted by a council of elders.

The Ptolemies.—After the death of Alexander (323), Palestine, with much of Syria and Phoenicia, fell to Ptolemy, the founder of the Ptolemaic dynasty which ruled Egypt for nearly 300 years, who established himself as satrap in Egypt in 323 B.C. and became king in 305 (*see* PTOLEMIES).

The successors of Alexander, including Ptolemy and Seleucus, defeated Antigonus Monophthalmus, one of Alexander's generals, who had almost succeeded in recreating under his sole rule Alexander's great empire, at Ipsus in Phrygia in 301 B.C. This victory confirmed Ptolemy in his possession of his territory, although he had arrived too late for the battle, and Seleucus, whose participation in it had been decisive, at first disputed Ptolemy's claim to Syria and Phoenicia and actually occupied northern Syria. This early dispute laid the foundations of a century of bitter antagonism between the house of Ptolemy and that of Seleucus, an antagonism which led to war five times within a century and was finally stilled only by Palestine's passing in 200 B.C. into the hands of the Seleucid dynasty. The northern boundary of the kingdom established by Ptolemy I lay apparently slightly north of the modern Tripolis, perhaps on the course of the Nahr el Kebir (ancient Eleutherus) River, and there are no signs of any important change in this frontier throughout the next century.

Of Ptolemaic rule in the southern part of this territory, Palestine, little is known. What little can be discovered, mainly from writers of a later period, especially the author of the First Book of Maccabees and Josephus, suggests that unlike the northern region, known as Syria and Phoenicia, the area was left in much its previous state with considerable power and authority in the hands of the native chieftains.

More is known of taxation than of administration. A story preserved by Josephus (*The Antiquities of the Jews*, xii, § 154 ff.) indicates that tax farming was employed for the collection of local taxes. It seems likely that there were additional extraordinary taxes levied by edict from Egypt.

Knowledge of the economic and commercial life of Palestine in the middle of the 3rd century is, on the other hand, fuller and more reliable. It is drawn from the dossier of letters received and written by Zenon, the confidential business manager of the chief minister of Ptolemy II Philadelphus (285–246), who in 259 was sent to Palestine and Syria where his master had commercial interests. These letters speak particularly of a trade in slaves, especially of young girls for prostitution, in whom there appears to have been a brisk trade, with export to Egypt. Zenon's records also testify to a considerable trade in cereals, oil, and wine. Inevitably, like all imports to Egypt, Palestinian exports worked under state monopoly, without which the internal monopolies of Egypt would have been undermined. Palestine, like Egypt and Syria, seems to have had no economic freedom under Ptolemaic rule; in all transactions the hand of the government's agents is clearly visible.

Of the material culture of Palestine in the Ptolemaic period far less is known. The population seems, as in Syria, to have been divided between the hellenized cities (*poleis*) of the coast, notably Ascalon and Joppa, and the rural population living in villages (*komai*). The fact that several cities had Ptolemaic dynastic names (Philadelphia, Philoteria, Ptolemais) must not lead to overemphasis of the desire of the early Ptolemies to urbanize and raise the standard of living of the people of Palestine. It seldom appears that they did more than rename a previously existing city—a practice not uncommon in the Hellenistic world. In fact, unlike the Seleucids, the Ptolemies do not appear to have been great city builders. Nor do they appear to have encouraged the outward forms of independence in local government. It appears likely from the story of the Phoenician tax farmers mentioned above that considerable authority lay in the hands of the wealthy, yet the fact that both Ascalon and Joppa issued Ptolemaic regal coinage, but apparently no autonomous bronze coinage, suggests a rigid control. However, the absence of epigraphical evidence from the cities of Ptolemaic Palestine renders any judgment about the conditions of the cities very hazardous. Archaeology, too, helps but little, since the buildings of Roman Palestine have swamped most of the Hellenistic remains. One exception must be noted: the tombs of the hellenized Sidonian military settlers at Marisa in Idumaea, the walls of which are decorated with frescoes of fine hunting scenes, indicate that Hellenic civilization had penetrated deep into the non-Greek population in this period.

The chronic state of hostility between Egypt and the Seleucid house, which in much of the 3rd century B.C. had been concerned with the coastal regions of western Asia Minor, received a new impetus with the accession to the Seleucid throne of the energetic Antiochus III the Great (223–187), who aimed to win southern Syria and Palestine from Egypt, now weakly governed, and thereby establish the frontier to which Seleucus I had unwillingly renounced his claim in 301 B.C. After his severe defeat by Ptolemy IV at Raphia in 217, however, Antiochus was for several years occupied with internal troubles, and it was therefore not until about 200 B.C. that he could think again of an attack on Egypt. There a child—Ptolemy V Epiphanes—had recently ascended the throne, and the government was in the hands of overpowerful ministers who were more concerned with feathering their own nests than with preserving the integrity of the kingdom. At Panion, on the northern boundary of Galilee, the armies of Antiochus and Ptolemy met and Ptolemy was defeated. Thus the Ptolemaic possessions north of the Sinai desert, including Palestine, passed into the hands of the house of Seleucus.

The Seleucids.—The Seleucids brought to the problem of the administration of Palestine a different tradition from that which had been behind Ptolemaic rule. (*See* SELEUCID DYNASTY.) The latter was based on that careful exploitation of territory which was possible in a small and closely knit land like Egypt, and had thence been extended to the Ptolemaic provinces. This had never been possible for the Seleucids, who had always been masters of regions so vast as to render a unified and absolute control impossible. There is no sign of oppression in Seleucid government of the native peoples—they seem, on the contrary, to have aimed at improving the natives' status as far as possible, largely through bringing them into contact with Greek modes of urban existence.

It might then be supposed that Seleucid rule would have been popular in Palestine. In fact, however, it was under Seleucid rule that the great uprising of the Jewish people, the revolt of the Maccabees, occurred. The explanation of this paradox is perhaps twofold. First, the Seleucids were in need of money, and second, the throne, at a critical time, was occupied by a tactless and neurotic king. Present-day knowledge of Seleucid rule in Palestine before the accession of Antiochus Epiphanes is very slight. The years from 188 B.C. onward were lean years for the dynasty, since the war with Rome, which had ended (in 189) in a complete Roman victory, had cost it not only almost the whole of Asia Minor but also a yearly indemnity of 15,000 talents. It is therefore not surprising that the first glimpse of Seleucid rule in Palestine tells of an attempt by Heliodorus, the leading minister of Seleucus IV (187–175), to deprive the Temple in Jerusalem of its treasure. His failure was soon ascribed to divine protection.

With the accession of Antiochus (*q.v.*) Epiphanes in 175 B.C. relations rapidly deteriorated. Antiochus appears to have aimed at a wholesale restoration of the Seleucid empire in the east, including an occupation of Egypt, as a counter to the loss of the western province occasioned by the Peace of Apamea. He made an unwise beginning in Palestine by establishing a philhellenic high priest, and it is clear from this and from his whole subsequent policy that he wished to extirpate Jewish religion from its central stronghold (there is no indication that he persecuted Jews of the Diaspora living in the cities of his kingdom).

Antiochus invaded Egypt in 170 or 169 B.C., returning to Syria by way of Jerusalem, where he and his army despoiled the Temple of all its wealth. Two years later, after his humiliating expulsion from the gate of Egypt by the Roman legate, he sent a financial official to exact taxes from the cities of Judaea. Antiochus' official attacked the city of Jerusalem by guile and largely destroyed it. He then built a fortified position on the citadel, called by the Greeks the *Akra*. This became the symbol of Judah's enslavement, though in itself the presence of a royal garrison in a Hellenistic city was by no means unusual. Its imposition was followed by an open attack on religious practice, many of the rites of which were forbidden. Noncompliance with the order, which contained many items calculated to raise the bitterest resistance in the hearts of law-abiding Jews, such as the prohibition of circumcision and the abolition of the observance of the Sabbath, was punishable by death. Finally on the 25th day of the Hebrew month Kislev (December), 168 B.C., the "abomination of desolation," namely the altar of Zeus, was set up in the Temple in Jerusalem. It was this above all which summoned forth the resistance of the sons of the aged priest Mattathias led by Judas Maccabaeus. (*See* MACCABEES.)

The resistance, it must be emphasized, came from only a section of the population. The century and a half of Greek rule had hellenized much of the upper class of Jerusalem, and some of the characteristic features of Greek city life, such as the ephebic institute for the training of youths and the gymnasia, had been established on the initiative of this section of the ruling class which was able to accept a less radical observance of Judaism and combine it with loyalty to the throne. Throughout the revolt and indeed until the closing days of the Hasmonaean house, there is always this third element to be taken into account.

Judas proved himself a leader of high quality. He successfully resisted the weak forces sent by the Seleucid authorities, and after three years of intermittent warfare he succeeded in purifying the Temple, though the *Akra* still remained in Seleucid hands (Dec. 165 B.C.; the chronology of the Maccabees here followed is that of E. Schürer; see *Bibliography*).

After the death of Antiochus Epiphanes (163) the numbers of claimants to the Seleucid throne made a continuous policy toward Palestine impossible, because each claimant felt the need to seek support wherever it might be found. Thus, Jewish high priests were bought and bribed by the kings and dynasts of Syria. This development enabled Judas and those who succeeded him to hold their own and eventually to establish a hereditary dynasty. In 163 an agreement was reached with the Seleucid regent Lysias (who feared the appearance of a rival in Syria), through which the Jews received back their religious liberty. But at the same time the regular practice of pagan worship, beside the Jewish, was established, and a Seleucid nominee was appointed high priest. Thus were laid the seeds of fresh revolt.

Almost immediately Judas again took the field and scored a considerable victory over Nicanor, the Seleucid general, in which Nicanor was killed. Within two months, however, Demetrius I, the Seleucid king, sent Bacchides to take up a position near Jerusalem, and in the engagement which followed Judas lost his life (161).

The Hasmonaean Priest-Princes.—In the following years dynastic disputes within the Seleucid empire prevented a succession of rulers from settling the Palestinian question. Jonathan, the brother and successor of Judas (161–143), seems in the opening years of his leadership to have established a sort of secondary government in Michmash near Jerusalem, in opposition to the

PALESTINE DURING THE MACCABAEAN PERIOD

recognized government in the city itself. It was a sign of his growing power and of the importance of favouring the Hasmonaean party generally that in 153 one of the Seleucid pretenders, Alexander Balas, in order to outplay the legitimate king, Demetrius I, granted Jonathan the office of high priest and gave him the Seleucid rank of a courtier, thereby legitimizing his position. Demetrius II, at the request of Simon the successor of Jonathan (143–135), granted the Jews freedom from taxation in 143/142, and at the same time Simon acquired the status of a recognized secular ruler; the year of his assumption of rule was regarded as the first of a new era, and official documents were dated in his name and by his regnal year.

In 142–141 Simon forced the Syrian garrison on the *Akra* to surrender, and the Jews passed a decree in his honour, granting the right of permanent incumbency to Simon and his successors, until "an accredited prophet" should arise. It was thus in Simon's reign that the rule of the priest-prince was transformed into a secular hereditary rule. The Seleucid king recognized this, granting Simon the right to issue his own coins.

Simon's reign was one of expansion abroad, at the expense of the Seleucid authorities, and peace and prosperity at home. His son, John Hyrcanus I (135–104), reigned as a secular monarch, save that his coins bear the legend "John the high priest." In the year of his accession Antiochus Sidetes, the last great Seleucid king, set out to reconquer Palestine; he laid waste the country, besieged Jerusalem, and imposed harsh terms on Hyrcanus when he surrendered (134).

The death of Sidetes, however, and the reaccession of Demetrius

II, enabled Hyrcanus to reconquer much territory outside Judaea. Toward the end of his reign he conquered and destroyed Samaria, despite opposition both from the reigning Seleucid, Antiochus Cyzicenus, and from Cyzicenus' brother-in-law Ptolemy Lathyrus. In internal policy, however, he made the grave error of quarreling with one of the two main Jewish ecclesiastical parties, the Pharisees, who followed the Law with great strictness and with whom the Maccabaean movement had in origin close affinity, and siding with their opponents, the more liberal Sadducees. This is an early instance of that denial of the revolutionary origin of the movement which became very obvious in the reign of Alexander Jannaeus. Hyrcanus I was succeeded by Aristobulus (104–103), who extended Hasmonaean territory northward and is said to have assumed the title of king (*basileus*), though on his coins he appears, like Hyrcanus I, as high priest.

The reign of his brother and successor Alexander Jannaeus was long (103–76) and largely filled with wars. He imposed his rule rigorously over an increasingly large area, including both Transjordan and the cities of the coast. Still more clearly than Hyrcanus I he attests the change in direction and aim of the Hasmonaean house. He was the bitter enemy of the Pharisees, his coins bear Greek as well as Hebrew legends, and his title on them is simply "King Alexander." He was succeeded by his widow, Salome Alexandra, who reversed his policy and was guided by powerful religious advisers, members of the Pharisaean movement. After her death in 67 B.C. her two sons Aristobulus and Hyrcanus II fought for the succession. Hyrcanus was defeated but was encouraged to reassert his rights by Antipater, an Idumaean, son of the governor of Idumaea and father of the future Herod the Great.

At this stage the Romans appeared on the scene. Pompey the Great during his reorganization of the lands of the newly conquered Seleucid kingdom also arranged the affairs of Palestine (63 B.C.). He attempted to arbitrate between the brothers and eventually, after he had laid siege to and captured Jerusalem, appointed Hyrcanus II as high priest without the title of king adopted by his predecessors. He also imposed taxes on the Jews and curtailed Jewish dominions, removing a number of Greek cities from Hasmonaean rule and transferring them to the jurisdiction of the newly appointed governor of Syria.

FROM A. H. M. JONES, "THE HERODS OF JUDAEA," THE CLARENDON PRESS, OXFORD

PALESTINE DURING THE TIME OF HEROD THE GREAT AND HIS SONS

After the death of Pompey, however, the power of Antipater and his family greatly increased. Hyrcanus II became a figurehead of no importance, and Antipater himself, in return for services to Julius Caesar, received Roman citizenship and was awarded the title of "procurator of Judaea" while his sons Phasael and Herod became respectively governors (*strategoi*) of Jerusalem and Galilee. The unexpected occupation of Palestine by Parthian troops in 40 B.C. altered the situation. Antigonus, the son of Aristobulus and therefore a legitimate Hasmonaean, won the favour of the Parthians and was established by them as king and high priest of Jerusalem. Phasael committed suicide, while his brother Herod escaped to Rome.

The Herodian House and the Roman Procurators.—Herod, in Rome, was recognized by the senate, with the approval of Octavian and M. Antonius (Mark Antony), as king of Judaea (40 B.C.) and returned to Palestine in 39 B.C., from which shortly afterward Roman troops expelled the Parthians, whose popularity in Palestine had been and subsequently remained considerable. After struggles against Antigonus, the Parthian nominee, in which he was assisted by Roman troops, Herod eventually captured Jerusalem, and shortly afterward married a niece of Antigonus, thus probably consoling those who remained loyal to the memory of the now almost defunct Hasmonaean house—Antigonus, when he fell into the hands of his enemies, being executed by order of Mark Antony.

The accession of Herod, the Roman protégé, the Idumaean and gentile, brought to Palestine the peace which in the years of independence it had often lacked. His long reign (37–4 B.C.) was marked by general prosperity. Between 31 and 20 Augustus restored to him the Jewish territories which Pompey had taken away, and in this enlarged kingdom he created a sound administrative system of Hellenistic type. Toward the end of his life the complex demands of a vast family (he had ten wives at least) led him into difficulties regarding the succession, and it was then that he developed into the gruesome and vicious figure which Christian tradition has made so familiar. (*See* also HEROD.) On his death the country again entered a period of divided rule, which led to the re-establishment of direct Roman government. Augustus decided in 4 B.C., in the presence of the three sons of Herod, that Archelaus should rule Judaea, Samaria, and Idumaea (*i.e.*, central and southern Palestine), Antipas Galilee and Peraea (Transjordan) and Philip Trachonitis, Batanaea, and Auranitis (the area between the Decapolis and Damascus).

The fate of the rulers (of whom Philip and Antipas were called tetrarchs, Archelaus ethnarch) and their territories was different. Philip (*q.v.*), the most peaceable of the three, ruled the northern area until his death in A.D. 34. Antipas reigned in Galilee and Peraea until A.D. 39, but was then banished by Caligula on the ground that he had parleyed with Rome's enemies (*see* HEROD ANTIPAS). Archelaus reigned for ten years only; he was removed at the request of his subjects in A.D. 6 (*see* HEROD ARCHELAUS). The government of southern Palestine then passed to a series of undistinguished Roman procurators, the last of whom (Pontius Pilate, A.D. 26–36, under whom Jesus Christ was crucified) lost office for the unnecessary massacre of some Samaritans. On his removal Palestine was united under Herod Agrippa I (*q.v.*), the protégé of the emperor Gaius, who succeeded Philip in the north in A.D. 37. The tetrarchy of Antipas was added on his removal in 39. On the death of Agrippa in 44 the entire kingdom passed under Roman rule and was made a procuratorial province.

Disturbances in the early years of procuratorial rule were frequent and largely caused by maladministration. Serious trouble arose under Ventidius Cumanus (48–52), and under his successor, the imperial freedman Felix (52–60), rebellion was open though sporadic. The attempted extortions of Gessius Florus, procurator 64–66, led in 66 to the decisive and final outbreak.

The organization of the Jews was better than it had previously

PATELLANI—PIX FROM PUBLIX

SO-CALLED TOMB OF ABSALOM, EAST OF JERUSALEM IN THE KIDRON VALLEY, BUILT DURING THE REIGN OF HEROD THE GREAT

been, and they were successful in an early engagement against the governor of Syria, who had advanced to Palestine with two legions to assist the hard-pressed procurator.

In 67, however, Vespasian, the future emperor, with his son Titus, arrived with a force of about 60,000 men, and the war became increasingly bitter. By the end of 67 Galilee was captured, and Judaea was reduced in three campaigns which ended with the fall of Jerusalem in A.D. 70. The Temple was destroyed, though tradition recorded that Titus gave orders that it was to be spared, and the city became the permanent garrison town of a Roman legion. By A.D. 73 all resistance had ceased. Palestine now became the province Judaea, the name of the part being taken for the whole. (P. M. F.)

E. Roman Palestine

After the destruction of Jerusalem a legion (*X Fretensis*) was stationed on the site, and the rank of the provincial governor was raised from *procurator* to *legatus Augusti*. Caesarea Palestinae, the governor's residence, became a Roman colony, and a new city, Neapolis (modern Nablus), was founded at Shechem, the religious centre of the Samaritans. Deprived of the Temple, the Jews found a new religious centre in the rabbinical school of Jamnia (Jabneh). There was a Jewish revolt at the end of Trajan's reign, quelled by Lusius Quietus. In A.D. 132 Hadrian's decision to build a Roman colony, Aelia Capitolina, on the site of Jerusalem provoked a much more serious revolt, led by Bar-Cochba. It was ruthlessly repressed by Julius Severus; nearly 1,000 villages were destroyed and more than half-a-million men killed. The garrison was increased to two legions, *VI Ferrata* being stationed at Caparcotna in Galilee. In Judaea proper the Jews seem to have been virtually exterminated, but they survived in Galilee, where Tiberias became the seat of the Jewish patriarchs. In Judaea new pagan cities were founded, Eleutheropolis and Diospolis (formerly Lydda) under Septimius Severus, and Nicopolis (formerly Emmaus) under Elagabalus.

With the conversion of Constantine I to Christianity a new era of prosperity began for Palestine. The emperor himself built a magnificent church on the site of the Holy Sepulchre, his mother Helena built two others, at the place of the Nativity at Bethlehem and of the Ascension in Jerusalem, and his mother-in-law Eutropia built a church at Mamre. Palestine began to attract floods of pilgrims from all parts of the empire. It also became a great centre of the eremitic life; men flocked from all quarters to become hermits in the Judaean wilderness, which was soon dotted with monasteries. Constantine added the southern half of Arabia to the province, but the addition was later (357–358) made a separate province under the name of *Palaestina Tertia* or *Salutaris*. At the end of the 4th century Palestine was divided into two provinces, *Prima* with its capital at Caesarea, and *Secunda* with its capital at Scythopolis (Beisan). The governor of *Prima* bore the high rank of proconsul from 382 to 385 and again from 535 onward. A *dux* of Palestine commanded the garrison of all three provinces.

The bishop of the civil capital, Caesarea, was, according to the usual rule, metropolitan of the province, but the bishops of Jerusalem were claiming special prerogatives as early as the Council of Nicaea. Eventually Juvenal, bishop of Jerusalem from 421 to 458, achieved his ambition and was recognized by the Council of Chalcedon (451) as patriarch of the three provinces of Palestine.

There was a revolt of the Jews in Galilee in 352, which was suppressed by the Caesar Gallus. Under Marcian and again under Justinian there were revolts of the Samaritans. Palestine was also troubled by the Monophysite controversy. When Juvenal returned from Chalcedon, having signed the canons, the monks of Palestine rose and elected another bishop of Jerusalem, and military force was required to subdue them. Gradually, however, the Chalcedonian doctrine gained ground, and Palestine became a stronghold of orthodoxy. Apart from these disturbances the country enjoyed peace and prosperity until in 611 Khosrau II, king of Persia, invaded the country, captured Jerusalem (614), destroyed the churches, and carried off the True Cross. In 628 Heraclius recovered Palestine and subsequently restored the True Cross to Jerusalem, but ten years later Jerusalem fell to the Arabs.

(A. H. M. J.)

F. From the Arab Conquest to A.D. 1900

The Rise of Islam.—The successful unification of the Arabian Peninsula by the first caliph, Abu Bakr (A.D. 632–634; *see* Caliphate), made it necessary to channel the warlike spirit of the Arab tribes into new outlets. Abu Bakr, therefore, "wrote to the people of Mecca, Ta'if, Yemen, and all the Arabs in Nejd and Hejaz, summoning them to a holy war (*jihad*) and arousing their desire for it and for the booty to be got from the Greeks." (P. K. Hitti, *The Origins of the Islamic State*, Columbia University Press, New York, 1916.) He then dispatched three detachments of about 3,000 (later increased to about 7,500) men each to start operations in southern and southeastern Syria. He died, however, before he could witness the results of these undertakings. The conquests he started were carried on by his successor, the caliph Omar I (634–644).

The first battle took place at Wadi al 'Arabah, south of the Dead Sea. The Byzantine defenders were defeated and retreated

toward Gaza, but were overtaken and almost annihilated (Feb. 4, 634) at Dathin. In other places, however, the natural advantages of the defenders were more effective, and the invaders were hard pressed. Abu Bakr ordered Khalid ibn al-Walid, then operating in southern Iraq, to rush to the aid of his fellow generals on the Syrian front. The combined forces won a bloody victory (July 30, 634) at a place in southern Palestine which the sources call Ajnadain. All of Palestine then lay open to the invaders. Bozrah, Fihl, and Beisan were seized, and the enemy, after a further defeat, sought safety within the walls of Damascus. In Sept. 635, after a siege of six months, the city surrendered (according to some authorities, Bozrah and Beisan fell in 636).

In the meantime, the emperor Heraclius was mustering a large army and in 636 dispatched it against the Arabs. Khalid relinquished Homs (Hims), Damascus, and other strategic towns and concentrated his troops on the Yarmuk, the eastern tributary of the Jordan River. The decisive battle which delivered all of Syria to the Arabs took place on Aug. 20, 636. Towns which had been relinquished were then easily recaptured. Only Jerusalem and Caesarea held out, the former till 638, when it surrendered to the caliph himself; the latter till Oct. 640. Palestine, and indeed all of Syria, was then in Muslim hands. After the surrender of Jerusalem Omar divided Syria into four administrative districts (*jund*): Damascus (Dimashq), Homs (Hims), Jordan (al-Urdunn), and Palestine (Filastin). Jordan included Galilee and extended east to the desert; Palestine covered the region south of the Plain of Esdraelon. (According to some authorities, the four *jund* were those of Damascus, Jabiya, Homs, and Kinnasrin.)

Omar lost no time in emphasizing Islam's interest in the holy city as the first *qibla* toward which Muslims turned their faces in prayer and as the third holiest spot in Islam. On visiting the Temple area and finding the place suffering from neglect, he and his followers cleaned it with their own hands and declared it a sacred place of prayer.

Under the Omayyads, Palestine formed, with Syria, one of the nine main provinces of the empire. The province consisted of the four administrative districts mentioned above together with that of Kinnasrin, north of Homs. Each *jund* was administered by an amir assisted by a financial officer (*'amil*). This pattern continued, in general, up to the time of Ottoman rule.

For various reasons, the Omayyads paid special attention to Palestine. The process of arabization was gaining momentum there. It was one of the mainstays of Omayyad power and important in their struggle against both Iraq and the peninsula. When Omayyad rule in the peninsula was contested by Abdullah ibn al-Zubayr the caliph Abd-al-Malik (685–705), in order to weaken the position of his rival, attempted to divert the annual pilgrimage from Mecca and Medina to Jerusalem. In 691, therefore, he erected the Dome of the Rock on the site of the Temple of Solomon which was also the alleged halting station of the Prophet on his nocturnal journey to heaven. This magnificent structure represents the earliest Muslim monument still extant. Close to the shrine to the south, Abd-al-Malik or, according to some, his son, al-Walid I (705–715), built the Aqsa mosque. Another Omayyad caliph, Omar II (717–720), imposed humiliating restrictions on his non-Muslim subjects, particularly the Christians. Conversions arising from convenience rather than conviction then increased. These conversions, together with a steady tribal inflow from the desert, changed the religious character of the inhabitants. The predominantly Christian population gradually became predominantly Muslim.

Abbasid Rule.—Omayyad rule ended in 750. Along with Syria, Palestine became subject to Abbasid authority, and, like Syria, it did not readily submit to its new masters. Unlike the Omayyads who leaned on the Yemeni (south Arabian) tribes, the Abbasids, in Syria, favoured and indeed used the Qays (north Arabian) tribes. Enmity between the two groups was, therefore, intensified, and became an important factor in Palestinian politics. Pro-Omayyad uprisings were frequent and received Palestinian support. In 840/841, a Yemenite, Abu Harb the Veiled, unfurled the white banner of the Omayyads and succeeded in recruiting a large number of followers, mainly among the Palestinians who regarded him as the *sufyani* (saviour) whose appearance was to save the land from the hated Abbasids and to restore Omayyad rule. Though the insurrection was put down by the armies of al-Mu'tasim, the *sufyani* idea persisted.

Under the Abbasids, the process of Islamization which received its initial impetus under the Omayyad Omar II gained added momentum as a result of further restrictions and disabilities imposed upon non-Muslims by Harun al-Rashid (786–809) and more particularly by al-Mutawakkil (847–861). During the first half of the 9th century, however, signs of internal decay began to appear in the Abbasid empire. Petty states, and some indeed not so petty, mushroomed in different parts of the realm. One of the first to affect Palestine was the Tulunid dynasty (868–905) of Egypt, which marked the beginning of the disengagement of Egypt and, with it, of Syria and Palestine from Abbasid rule. During this period Palestine also experienced the destructive operations of the Karmatians. After a brief restoration of Abbasid authority, Palestine came under Ikhshidid rule (935–969). (*See* EGYPT: *History: Medieval Period.*)

The Fatimid Dynasty.—In the meantime the heretical Fatimid dynasty was rising to power in North Africa. It moved eastward to seize not only Egypt but also Palestine and Syria and to threaten Baghdad itself. The Fatimids (*q.v.*) seized Egypt from the Ikhshidids in 969, and in less than a decade were able to establish a precarious control over Palestine and Syria, where they faced Karmatian, Seljuk, Byzantine, and periodic Bedouin opposition. Palestine was thus often reduced to a battlefield. The country suffered even greater hardship, however, under the Fatimid caliph al-Hakim (996–1021), whose erratic behaviour was at times extremely harsh, particularly on his non-Muslim subjects. He reactivated the earlier discriminatory laws imposed upon Christians and Jews and added new ones. In 1009 he ordered the destruction of several churches including the Church of the Holy Sepulchre.

In 1071 the Seljuks, after their victory at Manzikert, captured Jerusalem. The Fatimids recaptured the city in 1098 only to deliver it a year later (1099) to a new enemy, the crusaders of western Europe.

The Crusades.—A year after the capture of Jerusalem by the crusaders, the Latin kingdom of Jerusalem was established (Christmas day, 1100). Thereafter there was no effective check to the expansion of the crusaders' power until the capture of Edessa by the atabeg of Mosul, Imad-al-Din (Zangi), in 1144. Zangi's anticrusader campaign was carried on after his death by his son Nureddin (Nur-al-Din Mahmud) and, more effectively, by the famous Saladin (*q.v.*). After consolidating his position in Egypt and Syria, Saladin waged relentless war against the "infidel" Franks. Six days after the capture of Tiberias in 1187, he dealt the crusaders a crushing blow at the decisive battle of Hattin (Hittin) (July 4, 1187). Palestine was once more Muslim. Further attempts by the crusaders to regain control of Palestine proved ineffective, primarily because of incessant quarrels among the crusaders themselves, although a few of them, such as Richard I of England during the Third Crusade (1189–92) and Louis IX of France, leader of the Seventh Crusade, performed heroic deeds. Ironically, it was left to an emperor of dubious Christian standing, Frederick II, to negotiate in 1229, while under excommunication, a ten-year treaty temporarily restoring Jerusalem, Nazareth, and Bethlehem to the Christians. Fifteen years later (1244), with the help of the Khorezm (Khwarizmian) Turks, who were driven from their central Asian abode by the Mongol Genghis Khan, the Ayyubid sultan al-Salih restored Jerusalem to Islam.

While the Ayyubids in Egypt were losing ground to the Mamelukes, the Mongol sweep westward continued, placing the crusaders, as it were, between two fires. To make matters worse, the crusaders themselves were hopelessly riddled with dissension. In 1260 the fourth Bahri Mameluke, Baybars, emerged as a champion of Muslim resurgence. After taking part in the defeat of the Mongols at 'Ayn Jalut in Palestine, he became sultan; during 1263–71 he carried out annual raids against the harassed Franks. His task was resumed by the seventh Bahri Mameluke, Qalawun

(1279–90), and his son and successor al-Ashraf, during whose reign the last of the crusaders were driven out of Acre (May 18, 1291). A sad chapter in the history of Palestine thus came to an end. (*See* CRUSADES.)

The 14th and 15th centuries were in many ways a "dark age" for Palestine. Under the Bahri Mamelukes (1250–1382), Palestine formed a part of the kingdom of Damascus, second only to Egypt in the Mameluke domains. While Palestine enjoyed no special benefits, it shared in the general ills which Mameluke misrule brought in its wake, and suffered the ravages of several epidemics, including the great pestilence, the same Black Death which in 1348–49 devastated Europe. The fall of the Bahri Mamelukes and rise of the Burji Mamelukes (1382–1517) failed to improve conditions. During the reign of the second Burji sultan, Nasir-al-Din Faraj (1398–1405), the last onslaught of the Mongols, which made the name of Timur (Tamerlane) a synonym of destruction and plunder, took place. Although Palestine was spared the pillage of his hordes, it could not escape its disastrous repercussions as the Mamelukes moved through in a vain attempt to defend Damascus against the invader. Only the death of Timur in 1405 averted further tragedy. It also pitted the Mamelukes against the rising power of the Ottoman Turks for the control of western Asia. Hostilities broke out when Sultan Qait Bey contested, in 1486, with Bayazid II the possession of some border towns. The climax came three decades later on Aug. 24, 1516, when the Ottoman sultan, Selim I, routed the armies of al-Ghawri. Palestine began its four centuries under Ottoman domination.

Turkish Rule.—Under the Ottoman Turks, Palestine continued to be linked administratively to Damascus until 1830 when it was placed under Sidon; then under Acre; then once again under Damascus until 1887–88, at which time the administrative divisions of the Ottoman Empire were settled for the last time and Palestine was divided into the *mutasarrifiyahs* of Nablus and Acre, both of which were linked with the vilayet of Beirut; and the autonomous *mutasarrifiyah* of Jerusalem, which dealt directly with Constantinople. With varying fortunes often accompanied by revolts, massacres, and wars, the first three centuries of Ottoman rule isolated Palestine from and insulated it against almost all outside influences. The monotony was only occasionally broken by spectacular individual careers, such as that of Fakhr-al-Din II, the Ma'nid ruler of the Lebanon (1590–1635), who extended his control as far south as Galilee; or that of Zahir al-'Umar (*c.* 1737–75), who dominated the political life of northern Palestine for nearly 40 years; or that of Ahmad al-Jazzar, governor of Acre, who in 1799, with English naval help, successfully defended that city against Napoleon.

This period came to an end with Napoleon's abortive attempt (1798–1801) to carve for himself a Near Eastern empire. Egypt, always a determining factor in the fortunes of Palestine, came, after the French withdrawal, under the rule of the viceroy Mohammed Ali (*q.v.*), who soon embarked upon a program of expansion at the expense of his Turkish overlord. In 1831 his armies occupied Palestine, and for nine years he and his son Ibrahim gave the Holy Land a fairly enlightened administration. Their tolerant rule opened the country to Western influences and enabled Christian missionaries to establish many schools which proved of inestimable value in accelerating the process of modernization. When in 1840 the British, the Austrians, and the Russians came to the aid of the sultan, the Egyptians were forced to withdraw and Palestine reverted to the Ottomans. Increased European interest, however, led to the establishment of consulates and vice-consulates by the powers in Jerusalem and in the ports. In the meantime, the "reforms" which the powers had induced the sultan to promulgate did not fail to improve the lot of minorities. Later the country witnessed a marked increase in the inflow of foreign settlements and colonies, French, Russian, and German. By far the most important, in spite of their initial numerical insignificance, were the Zionist agricultural settlements which foreshadowed later Zionist endeavours for the establishment of a Jewish national home and still later a Jewish state in Palestine. The earliest of these settlements was established by Russian Jews in 1882. In 1896 Theodor Herzl issued his *Der Judenstaat* and advocated an autonomous Jewish state, preferably in Palestine. Two years later, he himself went to Palestine to investigate its possibilities and, possibly, to seek the help of the German emperor William II, who was then making his spectacular pilgrimage to the Holy Land. (N. A. F.)

G. From A.D. 1900 to 1948

In the early years of the 20th century the Palestine Arabs shared a general Arab renascence. Palestinians found opportunities in the service of the Ottoman Empire, and Palestine deputies sat in the Ottoman parliament of 1908. Several Arabic newspapers appeared in the country before 1914. The number of Zionist colonies, mostly subsidized by Baron Edmond de Rothschild, rose from 22 in 1900 to 47 in 1918, but the majority of the Jews were town-dwelling, Orthodox (Challukkah) Jews. The population, poor but progressive and predominantly agricultural, was about 700,000 in 1919 (568,000 Muslim Arabs; 74,000 Christian Arabs and others; and 58,000 Jews).

World War I and After.—For an account of the military operations in this theatre of the war *see* WORLD WAR I: *From Verdun to the Entry of America*. Palestine was hard hit by the war, for to the destruction caused by the fighting were added famine, locusts, epidemics, and the punitive measures of Ahmed Jemal Pasha, the Turkish commander in chief. Jerusalem was captured by British forces under the command of Gen. Sir Edmund (later Field Marshal Viscount) Allenby in December 1917 and the rest of the country was occupied by the British by October 1918. The Arabs maintained that Palestine was included in the area the independence of which Britain promised in the exchange of correspondence in July–Oct. 1915 between Sir Henry McMahon, high commissioner of Egypt, and Husain ibn Ali, then sherif of Mecca. By May 1916 Britain, France, and Russia had reached an agreement according to which, *inter alia*, the bulk of Palestine was to be internationalized. In November 1917 Arthur Balfour, the British secretary of state for foreign affairs, addressed a letter to Lord Rothschild, a leading representative of British Jewry, promising British support for the establishment in Palestine of a national home for the Jewish people on the understanding that "nothing shall be done which may prejudice the civil and religious rights of existing non-Jewish communities in Palestine. . . ." (*See* also ZIONISM.)

Britain's postwar problem in Palestine was to secure international sanction for the continued occupation of the country in a manner consistent with its wartime commitments. A British military administration was set up after the capture of Jerusalem and a general international framework existed for Britain in article 22 of the covenant of the League of Nations signed in June 1919. This article recognized the provisional independence of the former Ottoman Arab provinces subject to the assistance of a mandatory power in whose selection the wishes of the communities themselves were to be consulted.

In July 1919 a general Syrian congress held at Damascus and attended by Palestinian delegates passed a resolution electing Amir Faisal, son of Husain ibn Ali (king of the Hejaz), king of a united Syria (including Palestine) and rejecting the Balfour declaration. King Faisal was, however, deposed by the French in July 1920. In the meantime Pres. Woodrow Wilson, who had endorsed the Balfour declaration before its publication, failing to secure Anglo-French agreement to the formation of an inter-Allied commission of inquiry, dispatched the U.S. King-Crane commission to the former Arab provinces of the Ottoman Empire to ascertain the wishes of their inhabitants regarding the postwar settlement of their territories. The commission reported that 1,350 petitions, comprising 72% of the total received from the whole of Syria, were anti-Zionist and that Zionist spokesmen contemplated the dispossession of the Arabs. They recommended a serious modification of the "extreme Zionist program." In April 1920 anti-Zionist riots in Palestine resulted in five Jews being killed and 200 wounded. A commission of inquiry attributed the riots to Arab disappointment at the nonfulfillment of the promises of independence and to their fear of economic and political subjection to the Zionists. In July the military administration was ended

and Sir Herbert (later Viscount) Samuel was appointed the first high commissioner of a new civilian administration.

The Mandate.—The terms of the Mandate had yet to be settled, and both Britain and the Zionists worked for the incorporation of the Balfour declaration into the Mandate instrument. Although the Mandate was not approved by the League of Nations until July 1922, the administration in Palestine proceeded with the implementation of the Balfour declaration and in August 1920 announced a quota of 16,500 Jewish immigrants for the first year. This announcement aroused Arab opposition, which was organized in the form of Christian-Muslim associations throughout the country. In May 1921 anti-Zionist riots resulted in 46 Jews being killed and 146 wounded. A commission of inquiry attributed the riots to Arab fear of Jewish immigration. Impressed by Arab opposition, the British government issued in a white paper in June 1922 an interpretation of its concept of the Jewish national home. The intention was not that Palestine as a whole should be converted into a Jewish national home but that such a home should be established in Palestine. Immigration would not exceed the economic absorptive capacity of the country and steps would be taken to set up a legislative council. These proposals were rejected by the Arabs, both in principle and because Jewish immigration which had a political objective was to be regulated by an economic criterion.

In July 1922 the Mandate instrument for Palestine was approved by the League council, its preamble incorporating the Balfour declaration and stressing the Jewish historical connection with Palestine. Article 2 made the mandatory responsible for placing the country under such "political, administrative and economic conditions as will secure the establishment of the Jewish National Home . . . and the development of self-governing institutions." Article 4 allowed for the establishment of a Jewish agency to advise and cooperate with the Palestine administration in matters affecting the Jewish national home. Article 6 required that the Palestine administration, "while ensuring that the rights and position of other sections of the population are not prejudiced," under suitable conditions would facilitate Jewish immigration and close settlement of Jews on the land. In September 1922 Trans-Jordan, although included in the British Mandate of Palestine, was excluded from the scope of the Balfour declaration under protest from the Zionists, and on Sept. 29, 1923, the Mandate came officially into force.

The Jewish National Home.—During 1923 the British high commissioner tried to win Arab cooperation by the offer first of a legislative council and then of an Arab agency. Both offers were rejected by the Arabs as falling far short of their national demands. The years 1923–29 were relatively quiet; Arab passivity was partly due to the drop in Jewish immigration in the years 1926–28. In 1927 Jewish emigrants exceeded the immigrants and in 1928 there was a net Jewish immigration of ten persons only. Nevertheless the national home continued to consolidate itself in terms of urban, agricultural, social, cultural, and industrial development. In August 1929 negotiations were concluded for the formation of an enlarged Jewish agency to include non-Zionist Jewish sympathizers throughout the world.

This last development, while accentuating Arab fears, gave the Zionists a new sense of confidence. In the same month a dispute concerning religious practices at the Wailing Wall in Jerusalem flared up into communal clashes in which 133 Jews were killed and 339 wounded, the Arab casualties, mostly at the hands of the military, being 116 killed and 232 wounded. The report of a commission of inquiry attributed the clashes to the fact that "the Arabs have come to see in Jewish immigration not only a menace to their livelihood but a possible overlord of the future." In October a technical report by Sir John Hope Simpson established that there was at that time no margin of land available for agricultural settlement by new immigrants. These reports raised in an acute form the question of where Britain's duty lay if its specific obligations to the Zionists under the Balfour declaration clashed with its general obligations to the Arabs under article 22 of the covenant of the League of Nations.

Arab Grievances.—A statement of policy made by the colonial secretary in October 1930 accorded some priority to Britain's obligations to the Arabs. This was seen by the Zionists to cut at the root of their program, for if the right of the Arab resident were to gain priority over that of the Jewish immigrant, whether actual or potential, the Jewish national home would come to a standstill. In February 1931 the British prime minister, Ramsay MacDonald, addressed an explanatory letter to Chaim Weizmann, president of the Jewish agency (from which position he had resigned in protest against the 1930 statement), which was virtually a return to the 1922 white paper policy. This letter convinced the Arabs that recommendations in their favour made on the spot could always be annulled in London by Zionist influence at the centre of power. In December 1931 a Muslim congress was called at Jerusalem and attended by delegates from 22 Muslim countries to warn against the dangers of Zionism. In 1933 a boycott of Zionist and British goods was proclaimed. In the same year the Nazi accession to power gave a great impetus to Jewish immigration, which jumped to 30,000 in 1933, 42,000 in 1934, and 61,000 in 1935, though the majority of immigrants still came from outside Germany. In November 1935 the Arab political parties collectively demanded the cessation of Jewish immigration, the prohibition of land transfer, and the establishment of democratic institutions. In December the British administration offered a legislative council of 28 members on which the Arabs (both Christian and Muslim) would have 14 seats and the Jews 8. Although not represented in the council in proportion to their numbers, some of the Arabs were willing to consider the proposal, but the Zionists criticized it bitterly as an attempt to freeze the national home through a constitutional Arab stranglehold. The subsequent debate in the British House of Commons, in which the legislative council proposal was attacked by both parties as anti-Zionist, touched off the long-smoldering Arab rebellion.

The Arab Rebellion.—In April 1936 the Arab political parties formed an Arab higher committee presided over by Haj Amin al-Husaini, mufti of Jerusalem, which called for a general strike. The strike was maintained for six months. Simultaneously with the strike, Arab rebels, joined by volunteers from neighbouring Arab countries, took to the hills, and by the end of the year the movement assumed the dimensions of a national revolt. The strike was called off in October at the request of the heads of the neighbouring Arab states, but the armed rebellion continued.

A royal commission of inquiry presided over by Lord Peel published its findings in July 1937. It attributed the revolt to the Arab desire for independence and fear of the Jewish national home. It declared the Mandate unworkable and Britain's obligations to Arabs and Jews mutually irreconcilable. It therefore recommended the partition of the country. Should the Mandate be continued, "political, social and psychological factors" in addition to economic factors should be taken into consideration in regulating Jewish immigration, which should have "a political high level" of 12,000 immigrants a year for the following five years. The Zionist attitude to partition was ambivalent. For the first time a British official body explicitly spoke of a Jewish state: the area allotted to this state was immensely larger than the existing Jewish landholdings; and the commission had gone to the extent of recommending the forcible transfer of the Arab population from the proposed Jewish state. But the Zionists still needed mandatory protection for their further development and left the door open for an undivided Palestine. The Arabs were horrified by the idea of the dismemberment of the country and particularly at the suggestion of their forcible transfer. As a result the momentum of the revolt increased during 1937 and 1938, in spite of extensive British military operations and the outlawing in October 1937 of the Arab higher committee, most of the members of which (except Haj Amin and a few others who escaped arrest) were deported to the Seychelles Islands.

In September 1937 the League council authorized the mandatory to prepare a detailed partition plan. A technical commission entrusted with this task reported in November 1938 against the Peel Commission's plan, largely on the ground that the number of Arabs in the proposed Jewish state would be almost equal to the

number of Jews, and put forward alternative proposals which drastically reduced the areas and sovereignty of the proposed states. A British statement of policy published simultaneously announced the impracticability of partition and called for a round-table conference in London. Although the Arab revolt continued well into 1939 it gradually lost its vigour and national character. Casualties suffered since 1936 (but excluding 1937) were conservatively estimated at 3,112 Arabs killed and 1,775 wounded, 329 Jews killed and 857 wounded, and 135 British killed and 386 wounded. In addition 110 Arabs were hanged and (in 1939) 5,679 Arabs were held in detention. The Arabs of Palestine never afterward recovered from their sustained effort of defiance of the British administration.

The White Paper of 1939.—No agreement was reached at the London conference held during Feb.–March 1939, and the British government in a white paper in May 1939 made a unilateral statement of policy based upon the assumption that the Jewish national home pledge had already been substantially fulfilled and that indefinite Jewish immigration and transfer of Arab land to Jews were contrary to the spirit of article 22 of the covenant of the League and to British undertakings to the Arabs under the Mandate. Within the next five years 75,000 Jews would be allowed into the country; thereafter Jewish immigration would be subject to Arab "acquiescence." Land transfer would be allowed only in certain areas in Palestine and an independent Palestinian state would be considered within ten years. The Arabs, although in favour of the new policy, could not agree to it largely because of mistrust of Britain and the provision for the extension of the Mandate beyond the ten-year period. The Zionists were shocked by the statement, which they considered a deathblow to their program and a betrayal of the Balfour declaration. Britain was accused of appeasing the Arabs and consulting its strategic interests in the area as a result of the deterioration of the international situation. The 1939 white paper marked the end of the Anglo-Zionist entente.

The Jewish national home had, however, made remarkable progress since 1918. Zionist colonies had increased from 47 to about 200. Between 1922 and 1939 Jewish landholdings had risen from 148,500 ac. to 383,350 ac. and the Jewish population from 83,790 to 445,457 (30% of the total population). Tel Aviv had developed into an all-Jewish city of 150,000 inhabitants and £80,000,000 of Jewish capital had been introduced into the country. The outbreak of war prevented the League council from discussing the white paper.

World War II.—The Zionists found themselves in World War II in the paradoxical position of having to fight the 1939 white paper policy while rallying to Britain's side against the common enemy. The publication in February 1940 of the new land transfer regulations and the announcement in November 1940 of the decision to accommodate illegal Jewish immigrants for the duration of the war outside Palestine caused a recrudescence of the activities of the Zionist underground organizations. Already before the war the Haganah, sponsored by the Jewish agency, and a dissident group, the Irgun Zvai Leumi, had gone into action against the Arabs. After the battle of El Alamein and as news of the terrible tragedy that was befalling European Jewry percolated to the outside world tension mounted in Palestine. In November 1943 Britain announced the extension of the five-year limit on Jewish immigration as 32,000 of the 75,000 immigration certificates were still unused. The Irgun, which earlier in the war had cooperated with Britain, joined hands during 1944 with the Sternists, a splinter group, in widespread attacks, culminating in the murder of Lord Moyne, British minister of state in Cairo, in November 1944. The attacks were resumed in 1945, probably with the cooperation of the Haganah. The end of the war saw the Palestine Jewish community vastly strengthened. In September 1944 a Jewish brigade group was formed, a total of 27,000 Jews having enlisted in the British forces. Jewish industry was given immense impetus and a Jewish munitions industry developed which in 1942–43 manufactured 3,600,000 antitank mines for the British forces. In 1943 a vast Zionist network for the theft of arms from British Middle East installations was uncovered. Zionist armament in Palestine was partly revealed when some arms and ammunition (325 rifles, 96 mortars, and 425,000 rounds of ammunition) were discovered in the Zionist colony of Yagur in June 1946. Equally important was the support won by the Zionists in the United States, to which they had shifted their major political effort after 1939. In May 1942 at a Zionist conference held at the Biltmore Hotel in New York David Ben-Gurion on behalf of the Jewish agency gained support for a program demanding unrestricted immigration and a Jewish army, and the establishment of Palestine as a Jewish commonwealth. An increasing number of pro-Zionist statements was elicited from U.S. congressmen and politicians, particularly in 1944, an election year. In August 1945 Pres. Harry S. Truman requested Clement Attlee, the British prime minister, to facilitate the immediate admission of 100,000 Jews into Palestine, and in December the U.S. Senate and House of Representatives asked for unrestricted Jewish immigration to the limit of the economic absorptive capacity of Palestine.

The Arabs had remained quiescent throughout the war, and some 12,000 of them enlisted in the British forces. The neighbouring Arab countries began to take a more direct interest in Palestine. In March 1945 the covenant of the League of Arab States was drawn up with an annexe emphasizing the Arab character of Palestine (*see* ARAB LEAGUE). In December 1945 the Arab League declared a boycott of Zionist goods. The pattern of the postwar struggle for Palestine was emerging unmistakably.

Proposal for Partition.—In November 1945, in an effort to secure U.S. co-responsibility for a Palestine policy, Ernest Bevin, the British secretary of state for foreign affairs, announced the formation of an Anglo-American commission of inquiry. Pending the report of the commission Jewish immigration would continue at the rate of 1,500 persons per month beyond the 75,000 limit set by the 1939 white paper. In April 1946, the commission recommended the continuation of the mandate, the repeal of the land regulations of 1940 and the immediate admission of 100,000 Jews, thus returning to the policy of the 1922 white paper. The commission, however, criticized the presence of Jewish underground forces, whose total strength it estimated at 65,000. President Truman immediately endorsed the recommendation for the admission of 100,000 Jews, but Britain stipulated the prior disbandment of the underground forces. A plan of provincial autonomy for Arabs and Jews was worked out in an Anglo-American conference in June–July 1946 which became the basis for discussions in London between Britain and the representatives of Arabs and Zionists.

In the meantime Zionist pressure in Palestine was intensified in the form of a calculated policy of illegal immigration on a hitherto unprecedented scale and of closely coordinated attacks by all Zionist underground forces. These culminated in an outrage in Jerusalem on July 22, 1946, when a part of the King David Hotel containing British government and military offices was blown up, with the loss of 91 lives. On the Arab side a meeting of Arab kings and heads of state at Inchass in Egypt in May 1946 reaffirmed the Arab character of Palestine, and at a meeting of the Arab League in Bludan, Syria, in June secret resolutions were adopted threatening British and U.S. interests in the Middle East if Arab rights in Palestine were disregarded. With the failure of the London conference in February 1947, Britain, unwilling to take strong punitive measures against the Jewish community, harassed by the zeal of President Truman, and wishing not to embroil itself any further with the Arab countries, referred the Palestine question to the United Nations. A UN commission of inquiry recommended on August 31 in a majority report the partition of the country into Arab and Jewish states, which should retain an economic union, Jerusalem and its environs to be international. These recommendations were substantially adopted by the General Assembly in a resolution dated November 29, partly because of the agreement of the U.S. and U.S.S.R. on partition and partly because of pressure on some small states by Zionist sympathizers in the U.S. All the Islamic Asian countries, however, voted against partition, and an Arab proposal to query the International Court of Justice on the competence of the General Assembly to partition a country against the wishes of the majority of its in-

habitants (there were 1,269,000 Arabs and 678,000 Jews in Palestine in 1946) was narrowly defeated.

The Zionists welcomed the proposed partition because of its recognition of a Jewish state and because 55% of Palestine (though this included the large desert area in the south, the Negev) was allotted to the state at a time when Zionist landholdings were under 8% of the total area of the country. As in 1937 the Arabs were violently opposed to partition both in principle and because there were to be almost as many Arabs as Jews in the Jewish state itself. Britain was unwilling to implement a policy that was not acceptable to both sides and refused to share the administration with the UN Palestine commission which was to supervise the transitional period. Britain set May 15, 1948, as the date of the end of the Mandate.

UNITED NATIONS PARTITION PLAN FOR PALESTINE ADOPTED IN 1947

Civil War.—Soon after the UN resolution communal fighting broke out in Palestine. The Zionists mobilized their strength and redoubled their efforts to bring in immigrants. In December 1947 the Arab League pledged its support to the Palestinian Arabs by every means short of direct intervention and organized a force of 3,000 volunteers. Civil war spread with the progressive dismantling of the British administration, and by mid-January 2,000 casualties had resulted from the fighting.

Early in March 1948 the U.S. expressed its opposition to a forcible implementation of partition, and on March 16 the UN Palestine commission reported its inability to implement partition because of Arab resistance and the attitude of the British administration. On March 19 the U.S. called for the suspension of the efforts of the UN Palestine commission and on March 30 for the declaration of a truce and the further consideration of the problem by the General Assembly.

The Zionists, insisting that partition was binding and anxious about the change in U.S. policy, made a major effort to establish their state. Operations "Nachshon" and "Jephtha" were launched on April 1 and 18 respectively. The success of these offensives coincided with the failure of an Arab attack on the Zionist settlement of Mishmar Haemek, the death in battle of an Arab national hero, Abdul Kader Husaini, in command of the Jerusalem front, and the massacre by Irgunists of 250 civilian inhabitants of the village of Deir Yasin. On April 22 Haifa fell to the Zionists as a result of a surprise attack, and Jaffa, after severe mortar shelling, surrendered on May 13. Simultaneously with their military offensives the Zionists launched a campaign of psychological warfare. The Arabs of Palestine, badly led, and ill equipped in civil defense, collapsed, and tens of thousands of refugees streamed in terror into the neighbouring Arab countries where public opinion then demanded the intervention of the regular Arab armies. Toward the end of April the Arab countries, with the exception of Egypt, decided to take this step upon the termination of the Mandate on May 15.

On May 14 the last British high commissioner, Gen. Sir Alan Cunningham, left Palestine. On the same day the state of Israel was proclaimed and within a few hours won *de facto* recognition from President Truman. Early on May 15 units of the regular armies of Syria, Trans-Jordan, Iraq, and Egypt (which had taken the decision on May 12) crossed the frontiers of Palestine. For the history of Palestine after May 15, 1948, *see* ISRAEL; JORDAN.

(W. A. K.)

IV. THE HOLY PLACES

Palestine is sacred to the three religions of Judaism, Christianity, and Islam. Tradition identifies certain sites as the exact scenes of events connected with Old Testament patriarchs, prophets, and kings, of the acts of Jesus Christ related in the Gospels and of the traditional visit of the Prophet Mohammed. The historical authenticity of these sites in most cases cannot be proved, but they have for centuries been the goal of pilgrimage. The major holy places are concentrated in the region of Jerusalem (*q.v.*), though other important districts are Galilee (*q.v.*) for Judaism and Christianity and Hebron (*q.v.*) for Judaism and Islam. The great majority of these sites are in Jordan, the only major one on the Israeli side of Jerusalem being the Coenaculum (the upper room of the Last Supper) with David's tomb beneath it. Galilee, however, is entirely within Israel, and so are certain minor sites in the Jerusalem area, such as the monastery of the Cross, 'Ain Karim (the traditional birthplace of John the Baptist), and the tombs of the Sanhedrin.

Within the medieval walls of Jerusalem itself the major sites

A. F. KERSTING

TEMPLE AREA (HARAM ASH-SHARIF) INSIDE THE GATE OF THE CHAIN, JERUSALEM

are the Holy Sepulchre (or Anastasis; *see* SEPULCHRE, HOLY), the Temple area (or Haram ash-Sharif), and the western, or Wailing, Wall, which is actually the lower part of one wall of the Haram. Other sites inside the walls include the Armenian convent of St. James; the Syrian convent of St. Mark, which is one claimant for the site of the Last Supper; and the crusader church of St. Anne at the pool of Bethesda. Outside the walls to the east are the tomb of the Virgin Mary, the Garden of Gethsemane and the mosque of the Ascension on the Mount of Olives.

Five miles to the south lies Bethlehem with the great complex of the Church of the Nativity and associated convents, while just to the north of Bethlehem stands the small building known as Rachel's tomb. At Hebron the cave of Machpelah, reputed to contain the tombs of Abraham, Sarah, Isaac, and Jacob, is covered by a fortresslike structure, originally a Christian basilica but now converted into a mosque. In Galilee the chief Christian sites are at Nazareth (the Virgin's well, the house of the holy family, the church of the Annunciation and the Mount of Precipitation [Luke iv, 28–30]) and on the northwestern side of the lake. Here are the traditional site of the feeding of the 5,000, with the remains of the Byzantine church of the Loaves and Fishes at 'Ain Tabgha, and the ruins of a 2nd–3rd-century synagogue at Capernaum.

The fact that the same holy places are revered by the adherents of more than one religion has led to bitterness and difficulty. Since the early Omayyad period the site of the ancient Jewish Temple has ranked in sanctity for the Muslims only after Mecca and Medina and is the traditional scene of Mohammed's miraculous ascension to heaven from the Masjid al Aqsa, or "farthest sanctuary," a name now given to the large building at the southern end in which the prayers are held. In the centre of the Haram is the magnificent Dome of the Rock, covering the former Jewish rock of sacrifice, which also is revered by Muslims as the point from which the ascension is held to have been made. During the Crusades this building was known as the *Templum domini* and was thought to be the actual Temple.

The Wailing Wall, in the southwest, forms one side of a narrow open enclosure outside the Haram. The most sacred site in Judaism, it was until 1948 the scene of constant Jewish worship, especially on the anniversary of the destruction of the Temple by the Romans in A.D. 70, but after 1948 Jews were forbidden access to it. At Hebron non-Muslims were not allowed beyond the seventh step of the flight leading to the Haram, though childless Jewish women were permitted to push petitions through a hole in the wall said to communicate with Sarah's tomb. From 1922 non-Jewish visitors, after obtaining permission from the Muslim supreme council, were admitted to the Haram, though never into the cave containing the tombs of the patriarchs. At some of the lesser holy places, however, there has been more latitude. Thus, Rachel's tomb near Bethlehem, though a Muslim building, was open to Jews until 1948, and at the graceful little chapel of the Ascension, built by the crusaders on the Mount of Olives, but now transformed into a mosque, the Latins are allowed to celebrate Mass on Ascension day from midnight until noon, and on the Eastern Ascension day the Greek Orthodox, Syrians, Copts, and Armenians are permitted to set up altars in the courtyard. The tomb of David on the so-called Mt. Zion just southwest of the walls is especially complicated, since it is revered by members of all three religions, the Christian tradition being that this was the scene of the Last Supper and the descent of the Holy Spirit. Before 1948 non-Muslims were admitted into the building, but non-Muslim worship of any kind was forbidden. It is now on the Israeli side of the border, and the lower part has been dedicated to the Jews slaughtered by the Nazis. Beside the tomb of David is the neo-Romanesque church of the Dormition.

Quarrels have also been severe among the various Christian bodies, especially since the Crusades, the major contestants being the Latins and Orthodox. In many parts of the country trouble is avoided by the recognition of two sites close to each other, as in Gethsemane, on the site of St. Stephen's martyrdom and at Cana of Galilee. However, this is not possible in the Holy Sepulchre or the Church of the Nativity. In 1333 the pope granted authority over the holy places to the Franciscans, though the rights of the Latins in the Holy Sepulchre remained few until Turkish times. From then on, however, they steadily increased their authority until in 1740 they claimed the whole of the church excepting only the choir, which forms the Orthodox cathedral. In 1555 they gained permission to repair the roof of the rotunda, which contains the sepulchre itself, and thereafter forbade any other church to celebrate the liturgy within the tomb. Fortunes changed after a fire in 1808, when the right to repair the roof (which carries with it the title to the building) was granted to the Orthodox. The dispute continued until the mid-19th century, when the theft of the silver star in the Grotto of the Nativity and argument over the ownership of the keys of the church were the occasion of a quarrel which was a contributory cause of the Crimean War

(*q.v.*). During the greater part of the 19th century the policy of Turkey had been ostensibly to preserve the *status quo*, and this was continued by Britain during the Mandate and then by Jordan, which employs an Arab Anglican adviser on the holy places.

The Orthodox, Latin, and Armenian patriarchs are regarded as having equal authority, and the details of their separate rights are carefully delineated. Thus in the grotto at Bethlehem the Orthodox may hang six lamps, the Armenians five, and the Latins four. The other churches have in the course of centuries been ousted from their original position with regard to the holy places. The Copts and Syrians have only small altars in the two churches, and the Ethiopians have been banished from the Holy Sepulchre altogether to a group of small buildings erected on the roof, where on the Saturday in Holy Week they hold the ceremony of searching for the Body of Christ.

The major ceremonies of the church year at Jerusalem naturally take place at Easter, while those at Bethlehem are at Christmas. These latter are divided between the Western Christmas on Dec. 25 and the Orthodox Christmas on Jan. 7. At the Western Christmas, Mass is said at midnight in the neighbouring Latin church, and then the patriarch proceeds with the *bambino* to the grotto, though he must keep to the red carpet which marks the path from the door of the Latin church. On this night also the Orthodox give permission to the Anglicans to conduct a service of carols in the courtyard. Their own service, 13 days later, is held in the main body of the church, and it is traditional on this night to swing the great candelabra which hang from the roof from side to side. The Armenians celebrate Christmas and Epiphany together on Jan. 19.

The Easter ceremonies commence on Palm Sunday, when there is both an Orthodox and a Latin procession from the Mount of Olives to the gate of Jerusalem (in most years, however, the Western and Orthodox Easters do not coincide). On Thursday in Holy Week each performs the ceremony of the feet washing, the Latins in the church before the sepulchre and the Orthodox in the courtyard. There is a similar ceremony for the Syrians at the convent of St. Mark and in the Armenian cathedral of St. James. On Good Friday there is a solemn Latin procession along the *Via Dolorosa*, with a brief service at each station of the cross and a short sermon in a different language at each station. The Orthodox do not celebrate the liturgy on Good Friday, but in the afternoon there is a service commemorating the entombment.

On Holy Saturday occurs what is certainly the most exciting of all the Eastern ceremonies, the service of the holy fire. The Holy Sepulchre is packed with people, all carrying candles, every cranny and balcony being occupied, with the Armenians on the south side of the rotunda and the Orthodox on the north. All the lights are extinguished, and the Orthodox patriarch, accompanied by an Armenian vardapet, enters the tomb, which is then closed. Suddenly, from holes on either side of the tomb, flaming torches are passed out to the crowd, who burst into shouts of praise, and in a moment the whole church is ablaze with light, signifying the resurrection of the Light of the World. Special runners carry the flame to the Armenian cathedral and the Orthodox churches, and before World War I it was taken also to Jaffa, where a ship was waiting to carry it to Russia. On Holy Saturday eve starts the Orthodox Easter service which lasts the greater part of the night.

The season is also that of the Jewish Passover, and on Mt. Gerizim near Nablus there is the unique Samaritan Passover, at which lambs are still sacrificed as in ancient times. At Easter also the Muslims have a pilgrimage to Nebi Musa, the traditional site of Moses' tomb near Jericho.

That the tradition of the holy places is still developing is shown by the inauthentic "garden tomb," revered since the 19th century by some Protestants as the site of Calvary. *See* also references under "Palestine" in the Index. (D. Ba.)

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PALESTRINA, GIOVANNI PIERLUIGI DA (*c.* 1525–1594), Italian composer of over 105 Masses and 250 motets, was probably born in the town of Palestrina, near Rome. The precise date of his birth is unknown. The ancient name of the town Palestrina was Praeneste, hence the composer's latinized signature Joannes Petraloysius Praenestinus, frequently encountered in contemporary documents. He is known to have been one of the choirboys at Sta. Maria Maggiore in 1537, when he was about 12 years old, but in all probability he had gone to Rome a few years previously. Giacomo Coppola and Robin Mallapert were choirmasters at Sta. Maria Maggiore between 1537 and 1539 and Palestrina probably studied under them. Fermin le Bel became choirmaster in 1540 and may have helped him in organ playing, for in 1544 Palestrina was engaged as organist and singer in the cathedral of his native town. His prowess there attracted the attention of the bishop who later became Pope Julius III.

In 1547 Palestrina married Lucrezia Gori, and three sons were born to them: Rodolfo, Angelo, and Iginio. Only the last outlived his father. In 1551 the family was in Rome, where Palestrina took up the first of his papal appointments, *maestro di cappella* of the Julian Chapel. Before he was 30, he published his first book of Masses (1554), dedicated to Julius III, and the following year he was singer in the pontifical choir. About this time he became composer to the papal chapel. Yet he did not neglect the secular side of his art, for his first book of madrigals appeared in 1555, unfortunately at a time when the lenient regime of Julius III had given way to the sterner discipline of Paul IV. A *motu proprio* of the new pope forbade married men to serve in the papal choir and Palestrina together with two of his colleagues received a small pension by way of compensation for their dismissal.

For the next five years Palestrina directed the choir of St. John Lateran, but his efforts were continually thwarted by singers whose quality was almost as limited as their number, due to the fact that very little money was available for music. Eventually he broke away from this uncongenial milieu and returned to Sta. Maria Maggiore, the scene of his first musical training. About 1566 he taught at the Roman seminary. Cardinal Ippolito d'Este II having invited him to take charge of the music at the Villa d'Este in Tivoli, he was in the service of the cardinal from 1567 to 1571. In 1583 he was invited to Mantua but his terms, as when he had

been invited to Vienna in 1568, were too high. From 1571 until his death Palestrina served continuously as *maestro di cappella* of the Julian Chapel in Rome. His sons Rodolfo and Angelo, his wife, and his brother Silla died between 1572 and 1581. Shortly after the death of his first wife he married Virginia Dormili, the widow of a wealthy merchant. He died in Rome on Feb. 2, 1594.

Although Pope Gregory XIII had commissioned Palestrina and Annibale Zoilo to restore the plainchant then in use to something like its pristine condition, the task proved to be too great and Palestrina's editorial work gave way to a new flow of creative music. In the last 12 years of his life, he published four books of Masses, three of motets, three of madrigals, as well as offertories, litanies, hymns, and Magnificats. After his death his youngest son, Iginio, tried to claim the money due to his father by completing the plainsong recension, but since this was proved to be the work of others, the money was not forthcoming.

Palestrina's musical output, though vast, maintained a remarkably high standard in both sacred and secular works. His 105 Masses embrace many different styles, and the number of voices used ranges from four to eight. The time-honoured technique of using a plainsong *cantus firmus* (*q.v.*) as the tenor is found in such Masses as *Ecce sacerdos magnus, L'homme armé, Ut re mi fa sol la, Ave Maria, Tu es Petrus,* and *Veni Creator Spiritus.* Palestrina's mastery of contrapuntal ingenuity may be appreciated to the fullest extent in some of his canonic Masses, which include *Repleatur os meum, Sacerdotes Domini,* and *Ad coenam agni providi.* His ability to ornament and decorate a solemn plainsong, making it an integral part of the texture and sometimes almost indistinguishable from the other, freely composed parts, is evident from some of his Masses based on hymn melodies; *e.g., Jesu nostra redemptio, Aeterna munera Christi, Jam Christus astra ascenderat,* and *Sanctorum meritis.* Sometimes it is an antiphon that is paraphrased, as in *Sacerdos et pontifex, Ave Regina coelorum, Regina coeli laetare,* and *Beatus Laurentius.*

By far the greatest number of Masses employ what has come to be known as the "parody" technique, by which a composer made use either of his own music or that of others as a basis for his own new work. The Masses *Lauda Sion, O magnum mysterium, Sicut lilium inter spinas, Tu es Pastor ovium,* and *Veni sponsa Christi* are all based on Palestrina's motets with corresponding titles. Many other Masses derive from musical ideas by Palestrina's predecessors or contemporaries. His *Gabriel archangelus* is based on a work by P. Verdelot, *Io mi son giovinetta* on a madrigal by A. Ferrabosco the elder, *Nigra sum* on a motet by J. L'Héritier, *In te Domine speravi* on a motet by Johannes Lupi. Yet another type of Mass is demonstrated by the nine works written for Mantua; in these the Glorias and Credos are so arranged that plainsong and polyphony alternate throughout. Finally, there is a small but important group of Masses which are in free style, the musical material being entirely original. Perhaps the best-known example is the *Missa brevis* for four voices.

Palestrina's motets, of which more than 250 are extant, display almost as much variety of form and type as do his Masses. Most of them are in some clearly defined form, occasionally reflecting the shape of the liturgical text, though comparatively few are based on plainsong. Many of them paraphrase the chant, however, with an artistry that is every bit as successful as that of the Masses. The six-part *Assumpta est Maria,* three settings of *Alma Redemptoris Mater,* and three settings of *Lauda Sion* all follow the plainsong fairly closely, though sometimes only at the beginning. On the same level as the canonic Masses are such motets as *Cum ortus fuerit* and *Accepit Jesus calicem,* the latter apparently a favourite of the composer's since he is depicted holding a copy of it in a portrait now in the Vatican.

His 29 motets based on texts from the "Song of Solomon" afford numerous examples of "madrigalisms": the use of suggestive musical phrases evoking picturesque features, and apparent either to the ear or to the eye, sometimes to both. In the offertories, Palestrina completely abandons the old *cantus firmus* technique and writes music in free style, whereas in the hymns he paraphrases the melody usually in the highest voice. In the "Lamentations of Jeremiah" he brings effective contrast to bear on the sections with Hebrew and Latin text, the former being melismatic in style, and the latter simpler and more solemn. His Magnificats are mainly in four sets of eight, each set comprising a Magnificat on one of the eight "tones": *alternatim* structure is used here as in the Mantua Masses.

Although Palestrina's madrigals are generally considered of less interest than his sacred music, they show as keen a sense for pictorial and pastoral elements as one finds in any of his contemporaries. Over and above this, he is to be remembered for his early exploitation of the narrative sonnet in madrigal form, notably in *Vestiva i colli,* which was frequently reprinted and imitated. His settings of Petrarch also are of an exceptionally high order.

At the end of the 19th century the view that Palestrina represented the loftiest peak of Italian polyphony was in some ways detrimental to his reputation. Even more unfortunate was the insistence on "counterpoint in the style of Palestrina" as a *sine qua non* in the examination requirements of academies and universities. Generations of fledgling composers were taught to revere the music of Palestrina as a symbol of all that was pure in ecclesiastical counterpoint. Indeed, the greater part of his musical output, and in particular his Masses (where his unerring sense of tonal architecture may be heard at its best), still remains worthy of admiration.

Palestrina, unlike Bach, did not have to be rediscovered in the 19th century, though the dissemination of his achievement was helped by the interest of the romantic composers. In fact there always was a Palestrinian tradition mainly because his music supplied the need for a well-regulated formal system to be used for the embryonic composer in presenting himself to the unknown musical world.

Strict counterpoint was associated with a technique acquired in this way. It became a standard type of musical discipline which, however, gradually moved further and further away from its progenitor.

G. B. Martini and J. G. Albrechtsberger professed to admire Palestrina but their rules bore only a faint relation to the flexible contrapuntal manner of the 16th century. Possibly it was the practice of these and other pedagogues which produced an anti-Palestrina note in 18th-century writers. G. B. Doni allows Palestrina "a consummate art in harmonizing and in managing harmonies which please the ear marvellously, but the elocution is extremely barbarous and inconsistent." Pietro della Valle admitted that he was "surprised that it was the music of Palestrina which caused the Council of Trent not to banish music from the church; for if this music is still valued, it is not art music to be performed but to be preserved in a museum." Unfortunately the deliberations of the Council of Trent were either misrepresented or misunderstood ever since Agostino Agazzari first acclaimed Palestrina as the saviour of church music. Along with the *Missa Papae Marcelli* there were other works that received approval from the cardinal's commission in 1566, for Palestrina was a senior figure whose style commanded respect. Respect is still due to him both for his spiritual qualities and his technical mastery, and also for his natural balancing of discord and concord. This he brought about in a manner which only John Dunstable had achieved before him.

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PALEY, WILLIAM (1743–1805), English clergyman and philosopher whose books on Christianity, ethics, and science had a great influence for a century, was born in July 1743 at Peterborough. Educated at Giggleswick School and Christ's College, Cambridge, he graduated in 1763 as senior wrangler and was appointed fellow and tutor of his college in 1766. After becoming rector of Musgrave (1775), Dalston (1776), and Appleby (1777), he was made archdeacon of Carlisle (1782) and later a canon of St. Paul's (1794), subdean of Lincoln and rector of Bishop-Wearmouth (1795). He had a clear, logical mind, great power of marshaling and expounding argument, and considerable ability in collecting and estimating evidence. His reputation rests upon four

books: *The Principles of Moral and Political Philosophy* (1785), the subject on which he had lectured at Cambridge; *Horae Paulinae* (1790); *A View of the Evidences of Christianity* (1794), reading of which was compulsory for entrance to Cambridge University until the 20th century; and *Natural Theology* (1802). The last mentioned was the standard exposition of the teleological argument, and as such not only greatly influenced Darwin but was universally accepted until Darwin's own work was seen to have demolished it in its popular form. Since then, developments in the study of organic design, though not reestablishing the argument from the design of the watch to the existence of a watchmaker, have revived an interest in Paley's laborious insistence upon the relation of form to function. His book is based on John Ray's *The Wisdom of God Manifested in the Works of Creation* (1691), amplified by material from the anatomists of Paris and medical literature, and presented in strictly mechanistic terms without any reference to the influence of the environment or of problems of behaviour. Paley's other books have interest only as logical presentations of positions long since out of date. He died at Bishop-Wearmouth on May 25, 1805. *See* also TELEOLOGY.

See G. W. Meadley, *Memoirs of William Paley* (1809). (C. E. RA.)

PALGHAT, a town and district of Kerala, India. The town, headquarters of the district, lies 160 mi. S of Mysore. Pop. (1961) 77,620. Along the west coast, 50 to 100 mi. from the sea, run the steep rugged ranges of the Western Ghats, 3,000 to 9,000 ft. (900 to 2,700 m.) above sea level. It is only at Palghat that there is a real break in these ranges, a gap 16 mi. wide and popularly known as the Palghat Gap. The town's position, commanding the gap, has always made it a place of strategic and commercial importance. It has a large trade in food grains, tobacco, oils, and textiles. It is also a manufacturing centre for knives, locks, tiles, and matches. Government Victoria College (1898) and an engineering college are affiliated to Kerala University.

The local fort is considered to be of ancient origin, though nothing is known of its early history. Haidar Ali occupied it from 1757 to 1783, when the British captured it but abandoned it a year later. In 1790 it finally passed into British hands.

PALGHAT DISTRICT has an area of 1,982 sq.mi. and a population (1961) of 1,776,566. (G. KN.)

PALGRAVE, FRANCIS TURNER (1824–1897), English critic and poet, the editor of the influential *Golden Treasury* anthology, was born at Great Yarmouth on Sept. 28, 1824, and died in London on Oct. 24, 1897. Educated at Charterhouse and at Balliol College, Oxford, he spent many years in the education department of the civil service. During 1885–95 he was professor of poetry at Oxford. Palgrave was the friend of Gladstone (whose assistant private secretary he was in 1846), of Browning, Tennyson, Matthew Arnold, and many more of the notables of the time. He published original verse (*Visions of England*, 1880–81; *Amenophis*, 1892; etc.) and criticism, but his greatest service to poetry was *The Golden Treasury of English Songs and Lyrics* (1861), an anthology felicitous and catholic in selection, subtle in arrangement, and fine in judgment. It greatly influenced the attitude toward poetry of several generations and was of particular value in popularizing Wordsworth; notable omissions (within its original limits of Wyatt to the Romantics) were the Metaphysical poets of the 17th century and the poets of the Augustan age. Later editions modified Palgrave's original selection, which he had made in consultation with Tennyson.

See G. F. Palgrave, *F. T. Palgrave* (1899); C. J. Horne, "Palgrave's *Golden Treasury*," in *English Studies* (1949). (M. KL.)

PALI, a town and district in the Jodhpur division of Rajasthan, India. The town lies a few miles north of the Bandi River, a tributary of the Luni, and 39 mi. SSE of Jodhpur, and is on the Western Railway. Pop. (1961) 33,303. It comprises an ancient and modern quarter, each containing several temples. The most notable are Somnath, with an inscription dated A.D. 1143, and Naulakha, remarkable for having a mosque within its courtyard. Pali was an important centre of trade in ancient times, being on the main route from Sind and Gujarat to Delhi. The main industries are copper working, ivory carving, cotton printing and dyeing. There is a large textile mill.

PALI DISTRICT (area 4,792 sq.mi.; pop. [1961] 805,682) forms part of the Rajasthan Dry Area division. The chief towns besides Pali are Bali, Desuri, Jaitaran, Sojat, and Raipur. The district has two small textile mills at Sumerpur, oil mills, metal works, and cotton-ginning factories. (S. M. T. R.)

PALICI, in antiquity, a pair of local Sicilian gods who presided over the twin geysers still called Lago dei Palici, near Palagonia. The mysterious phenomenon awed the ancients, who held the place holy and swore by it oaths of the greatest weight. The site became an asylum for escaped slaves, whence its importance as a symbol during the Sicilian slave revolts. The Palici were only local, volcanic gods, divine derivatives of the geysers which they represented, but the mythographers made them the offspring of Zeus or Hephaestus.

See Diodorus Siculus, xi, 89; J. H. Croon, "The Palici," in *Mnemosyne*, vol. v, pp. 116–129 (1952). (T. V. B.)

PALIKAO, CHARLES GUILLAUME MARIE APOLLINAIRE ANTOINE COUSIN-MONTAUBAN, COMTE DE (1796–1878), French army officer who briefly headed the government during the collapse of the Second Empire, was born in Paris on June 24, 1796. Commissioned in the army in 1815, Cousin-Montauban passed through the staff college and went with the expedition of 1823 to Spain. Serving in Algeria from 1831, he won rapid promotion, and it was to him that Abd-el-Kader surrendered in person. General of division from Dec. 1855, he returned to France in 1857 to assume three home commands in quick succession. In command of the French troops in the joint Franco-British expedition to China in 1860, he took part in the victory of Palikao (Pa-li-chiao) on Sept. 21 and in the capture of Peking on Oct. 12. Appointed to the French Senate in Dec. 1860, he was created Comte de Palikao by Napoleon III in Jan. 1862.

When the Franco-German War broke out in 1870, Palikao was in command of the army corps at Lyons. Émile Ollivier's ministry fell on Aug. 9, and the empress regent Eugénie then entrusted the government to Palikao, who took the ministry of war. Overthrown by the republican revolution of Sept. 4, he withdrew to Belgium. When the government of National Defense refused his offer to serve it, he retired into private life. He died at Versailles on Jan. 8, 1878. He had published *Un Ministère de la guerre de vingt-quatre jours* in 1871. His *Souvenirs* appeared in 1932. (L. G.)

PALI LANGUAGE is the language of the canonical texts and commentaries thereon, collectively called Tipitaka, of the Theravāda Buddhist scriptures. (*See* PALI LITERATURE.) The term *pāli* meant first of all the canonical texts of these scriptures; its present use is a shortening of *pālibhāsā* "the language of the canon." The texts are preserved in Ceylon, as well as in Burma and Thailand to which they were carried from Ceylon. They originated, however, in north India in the first few centuries of Buddhism, and tradition has it that they were brought to Ceylon by the emperor Aśoka's son Mahinda (3rd century B.C.). At an unknown period after the introduction into Ceylon the use of Pali died out in India.

The language is a literary one based on a Middle Indo-Aryan dialect. Sanskrit, the literary language of the Hinduism to which the Buddha was in opposition, was expressly forbidden by him as a vehicle of teaching. This was presumably because it was already in his lifetime a learned language and not readily intelligible to the people he wished to convert. He preferred that his teachers should use their own vernaculars and those of the people in their preaching and teaching. Numerous Middle Indo-Aryan vernaculars were involved as time went on, and in all of them their own linguistic versions of the Buddha's words and sermons were preserved. As great centres of Buddhist learning grew up, certain of the versions attained prestige. None of them was unmixed; there must certainly have been great wandering teachers whose dialect versions were adopted in part even in the great centres.

Because of this multiplicity of dialects, all of which enjoyed equal authority, it has not been possible to assign a locality of origin to Pali. The Buddha himself was a native of Kosala (modern Oudh) and preached both there and in Magadha (the modern districts of Patna and Gaya), both localities being in or near the

modern Bihar. The term Māgadhī "the language of Magadha" was applied to Pali in Ceylon. But the Pali documents are written in at least two chief dialects of different chronological periods, one found in the old verses of the canon, the other one in the prose, both canonical and noncanonical, and in late verses. Neither dialect is closely related to Māgadhī Prakrit, of which a good deal is known through later documents and grammarians. Some Māgadhī-like forms are found in the Pali texts, but they are considered to be borrowings into the more original non-Māgadhī dialect. There have been many conjectures as to the true locality of origin of Pali. Nearly all scholars find themselves forced to think of regions farther west in northern India than Magadha. Takṣaśilā, the great university of the northwest, has been suggested, but perhaps Ujjayinī (Ujjain), the capital of Avantī, is most favoured by modern scholars. The great mixture of divergent dialectal forms seen in Pali is caused by the imposition of the variant linguistic versions on this basic western or west central dialect.

Characteristics of the Language.—Pali is the Middle Indo-Aryan language that is on the whole closest to Old Indo-Aryan, *i.e.*, Vedic and Sanskrit. It shows in general the same type of relationship to these that all the other Middle Indo-Aryan languages do. It is difficult, that is, to derive it entirely from either of the well-documented older dialects. Its basis is in all probability some other Old Indo-Aryan dialect than these two. Evidence for this is seen in such items as *idha* "here" beside Vedic and Sanskrit *iha* (*cf.* Avestan *iδa*), or the enclitic third personal pronoun *sē*, which is found in Avestan *še*, Old Persian *šaiy*, but not in Vedic or Sanskrit.

Phonology.—Of the Sanskrit vowels, *ṛ* is represented by *a*, *i* or *u*. The long diphthongs *āi* and *āu* coalesce with *ē* and *ō*. In general, long vowels remain only in open syllables and are shortened in close syllables; this produces two new vowels in Pali, short *e* and *o*; *e.g.*, *oṭṭha-* "lip"; Sanskrit *ōṣṭha-*.

Single Sanskrit consonants generally remain unchanged, except that *ḍ* and *ḍh* become *ḷ* and *ḷh* respectively (as in the Rigveda), and the three sibilants coalesce as *s*. Consonant clusters in general show assimilation and simplification to two consonants only; *e.g.*, *satta* "seven"; Sanskrit *sapta*, *aggi-* "fire"; Sanskrit *agni-*, *tikkha-* "sharp"; Sanskrit *tīkṣṇa-*. All final consonants disappear; *e.g.*, *vijju* "lightning"; Sanskrit *vidyut*.

Nouns.—The declension has been simplified in comparison with that of Sanskrit; *e.g.*, the dual number is lost. The eight-case system is reduced. The dative has almost entirely coalesced with the genitive; in the commonest declension, that in *a*, this case does remain to denote direction of motion and a few less common meanings. In the *a*- declension, the instrumental plural ends in *-ēhi* (*e.g.*, *dhammēhi*) which derives from a form like Vedic *-ēbhis* rather than from Sanskrit *-āis*. The ablative plural has coalesced with the instrumental plural and the dative plural with the genitive plural in all declensions. Stems ending in consonants have usually been converted to vowel declension types, either by loss of final consonants of the stems or by addition of a vowel after the consonant; *e.g.*, Sanskrit *āpad-* "misfortune" is represented by *āpā-* or *āpadā-*.

Verbs.—Changes in the verb system are even greater than in that of the noun. The middle voice is obsolescent, more so in the younger dialect than in the older. The passive system has active endings instead of middle. The perfect tense has almost disappeared. The past tense is an amalgam of imperfect and aorist forms, with complicated rules for the appearance or nonappearance of the prefix *a-*. The optative continues to be found; traces of the Vedic subjunctive are found in the old dialect.

Many of the verbs of the numerous types of the Sanskrit present system have been shifted to the commonest type which has a suffix *-a-*, the thematic type. There has also been a spread of a type with suffix *-ē-*, which derives from Sanskrit denominative verbs with suffix *-aya-*; *e.g.*, Sanskrit *kathayati* "he tells"; Pali *kathēti*, besides which there appears *vadēti* "he says" as well as the old type *vadati*, *maññēti* "he thinks" as well as *maññati* (Sanskrit *manyatē*). The present stem tends to spread through all other parts of the verb system, though some verbs retain a few historically correct forms, even besides the new ones, in the future or the past participle or elsewhere. An example of the spread of the present is seen in forms of the verb meaning "to drink," which in Sanskrit has a reduplicated present *pibati* "he drinks," but future *pāsyati* "he will drink" and gerund *pītvā* "having drunk"; in Pali corresponding forms are *pivati*, *pivissati* (and *passati*), *pivitvā* (and *pitvā*), and there are past forms *pivāsiṃ* "I drank," *apivi* "he drank."

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(M. B. E.)

PALI LITERATURE. Most of the extant older literature in the Pali language is arranged as the *Tipiṭaka Pāli*, the canon of the Theravāda school of Buddhism (*see* also BUDDHISM). Though it claimed to be the only orthodox tradition, the Theravāda was one of a number of schools which gradually became separated as Buddhism was propagated over northern India after the *Nirvāṇa* (Sanskrit; Pali, *Nibbāna*) of the Buddha (*see* GAUTAMA BUDDHA). Located originally in central and western India, this school apparently rehearsed its canon orally in a dialect of that region (of the 5th–3rd century B.C.), in accordance with the Buddha's injunction that his followers should remember his teaching in their own dialects (rather than in the Sanskrit of Brahmanical learning). Comparison with what remains of other canons shows that the Pali canon consists largely of a common heritage of teaching ascribed to the Buddha, in which minor modifications may have been made and to which certain secondary texts have been appended. The latest important additions are compositions of about the 2nd century B.C. From the essential similarity of the older texts to those of other schools, and from their contents, it may be said that the Pali canon represents primarily the literature of the middle Ganges basin and the empire of Magadha (*q.v.*) between the 6th and the 4th centuries B.C., with a secondary and later extension to the west.

Some time before the 5th century A.D. the language of the canon came to be regarded (through a new gloss on the Buddha's injunction, which happened to be ambiguous: "own" being either "his own" or "my own") as the Buddha's own language, and moreover as Māgadhī, the northeastern dialect. No longer a current vernacular, Pali came to be used as the standard and international language of Theravāda Buddhism. This literary language flourished in India, especially south India, down to about the 14th century A.D.; in Ceylon, where it was introduced by the 3rd century B.C.; Burma, where it spread from Ceylon by the 11th century A.D.; Siam (Thailand), Cambodia, Laos and Vietnam, where it was still in use in the 20th century. It also flourished briefly in Indonesia in about the 11th century. The Pali canon was written down in Ceylon in the 1st century B.C.—the prejudice in favour of oral transmission having broken down under the stress of practical needs—while the later literature is a purely written literature.

Divisions of the Canon.—The *Tipiṭaka* ("Threefold Basket"; Sanskrit, *Tripiṭaka*, *q.v.*) is arranged in three parts: *Vinaya Piṭaka*, an elaboration of 227 rules of the Buddhist monastic discipline, with an account of the founding of each by the Buddha, which includes also a brief life of the Buddha to his founding of the order and a record of events in the order down to the first great schism (*c.* 386 B.C.); *Sutta-piṭaka*, the doctrines (*dhamma*) of Buddhism developed in dialogues (*sutta* or *suttanta*), stories and poems; and *Abhidhamma Piṭaka*, a collection of treatises in which Buddhist philosophy is elaborated systematically in accordance with Theravāda teaching. As literature in the narrower sense it is the *Sutta* which is the most interesting of these divisions; it is much the largest and it includes the earliest texts. The *Abhidhamma* is a secondary systematization of the doctrines of the *Sutta;* the *Vinaya* is mainly legalistic in content, though it has a few incidental narratives of literary merit and much matter of sociological interest.

The "Sutta."—The dialogues contain discussions on philosophical and metaphysical topics (such as the nature of the universe; whether there is a "soul"; "immortality"; transmigration; free

will; the deity; causation; and ethics) and on the good life—on the unsatisfactory nature of the pursuit of transient worldly happiness and on the Buddhist Way of renunciation, harmless living, self-control, self-possession, wisdom and meditation leading to equanimity or detachment, *upekhā*, in which state *nibbāna* ("enlightenment") may be attained. The Buddha is described traveling in various countries of eastern India and engaging in these dialogues, given in direct speech in a lively, incisive style, on meeting with Brahmanical priests, other wandering philosophers and ascetics, kings and nobles and men and women of many professions in the cities. To those living "in the world" (*i.e.*, not renouncing it for the life of a wanderer seeking detachment), social virtues and good friendship are recommended as promoting the happiness of the individual and of society. Humour abounds in the discourse of the Buddha, for example when he narrates stories to illustrate the degeneration of society which resulted from the attempts of a king to prevent crime in his own way, in disregard of External Law (*dhamma*), or the pompous bumbug of a deity ("God") who pretends to be omnipotent and omniscient and claims to have created the universe, but is chiefly concerned to avert having his ignorance exposed before the other inhabitants of heaven. The best dialogues are the longer ones, collected in the *Dīgha-nikaya* ("Collection of Long Dialogues"), which is probably the most ancient and authentic part of the *Sutta*, judging from the richness and fluency of its language and the variety and originality of its episodes. Sometimes verses or short poems occur in the dialogues; for example, a spontaneous verse (*udāna*) uttered under the inspiration of some event, usually with metaphorical allusion to Buddhist teaching, or a concise summary of doctrine, or even on one occasion a love song accompanied on the *vīṇā*. One dialogue with numerous incidental verses in elaborate lyric metres (describing the qualities of a Buddha) is said to have been added by the disciple Ānanda (*q.v.*) after the Buddha's *Nibbāna;* another contains some curious folklore verses on the guardian spirits of the four quarters of the earth, one of whom rules over a utopian realm where there is no property and no work. The *Dīgha*, with three other *Nikayas*—the *Majjhima* ("Medium-length"), *Saṃyutta* ("Classified") and *Aṅguttara* ("Enumerating")—form the interlocking but not quite homogeneous *Four Nikāyas*.

The poetry of the canon, except as noted above and the songs (*geyya*) in the first section of the *Samyutta*, is collected in a fifth *nikāya*, the *Khuddaka-nikāya* ("Collection of Minor Texts"). This perhaps originated as a collection of poems by followers of the Buddha, including, however, some short dialogues attributed to the Buddha himself. The Buddha is said to have disapproved of poetic composition as a worldly means of gaining a livelihood (though he recommended the hearing of songs and his discourse abounds in similes, stories and occasional verses, which seem to give a lead to the poetic presentation of *dhamma*), hence after his *Nibbāna* the official recension of doctrine may at first have excluded the *Khuddaka* texts. These were greatly expanded down to at least the 3rd century B.C., and new genres were exploited for the propagation of Buddhist teaching.

Pali poetry may be classified into lyric, in which nearly 30 different metres are used, and word music and a great variety of rhythmical patterns prevail; and epic, restricted in the main to a single narrative metre having a very flexible line which can avoid monotony. Pali metres are quantitative, but whereas the narrative metre, which is archaic, permits of variation of rhythm except in the final cadence by the substitution of one short for one long syllable and is based on the number of syllables in the line (16 in two groups of 8, the half-cadence contrasting with the final cadence), the lyric metres are strictly quantitative: two short syllables are exactly equal to, and may sometimes be substituted for, one long. Most Pali lyric metres imply a musical phrase as basis, a structure which was new to Indian poetry in the 5th century B.C. Along with certain features of style, figures of speech, vocabulary and content, these new metres of Pali poetry are the prototypes of those of the *kāvya* literature in Sanskrit and Prakrit and eventually in Apahhraṁśa, classical Hindi, etc. It is to obscure Pali (or originally Māgadhī) pioneers, such as Vāgisa, Tālaputa and Ānanda, that we owe the forging of the medium of India's greatest poetry. Certain dramatic dialogues in verse implying some kind of performance have been adduced as evidence concerning the development of the Indian drama in this period.

In the *Khuddaka* the *Jātaka* (*q.v.*), in its longer stories, contains the best examples of Pali epic poetry. It is interesting to compare the storytelling technique seen in the *Dīgha* (which contains a few *jātakas,—i.e.*, stories of the Buddha's births or incarnations—but in prose) with that of the *Jātaka* itself (in verse), particularly as some stories are common to both works. An epic narrative (*akkhāna*) could be in prose or verse; it was only later that the two forms diverged sufficiently from the basic popular tradition of storytelling to become the contrasting Sanskrit *kāvya* genres of prose *akkāyikā* ("history") and verse *mahākāvya* ("epic"). Many *Jātaka* pieces have too few verses to narrate a story, and give only the climax or most significant speech or the moral of a once well-known story (to be freely extemporized when required). In a few cases the full story is preserved in ancient form in the *Dīgha* or elsewhere. The *Jātaka* is a remarkable treasury of ancient folk tales (with only a veneer of Buddhist ethics) and a rich source of data on ancient society. The *Khuddaka* also includes four inferior narrative books in verse, compiled as edifying material for routine preaching (*e.g.*, lives of Buddhas, *Buddhavaṁsa;* legends of monks and nuns, *Apadāna*). Then there are the lyric anthologies (the work of several hundred authors, both men and women), the *Dhammapada, Suttanipāta* and *Theragāthā* and *Therigāthā*, the last three containing also ballads and some fine though short epic episodes. Besides five other miscellaneous books, the *Khuddaka* includes also an extensive philosophical compendium (*Paṭisambhidāmagga*) similar to the *Abhidhamma* books.

The "Abhidhamma."—The *Abhidhamma* originated as an elaboration and explanation of certain lists and summaries of points of doctrine called *Mātikā* ("notes"). Most of the constituent *mātikās* and much of the explanation are to be found scattered in the *Sutta*, the basic list being promulgated in the *Dīgha* account of the Buddha's instructions to the monks before his *Nibbāna*. It consists of the *Vibhaṅga*, the basic synopsis of *mātikās* and explanations; the *Dhammasaṅgani* and *Dhātukathā*, which are primarily cross-classifications of points of doctrine (on ethics, psychology, physics) leading toward a synthetic system of natural and moral philosophy; the *Puggalapaññatti*, which enumerates types of character; the *Kathāvatthu*, consisting of polemic on points disputed with other schools of Buddhism and exemplifying early techniques of debate and logic; and the *Yamaka*, a manual of exercises in formal logic. The *Paṭṭhāna* is a grandiose elaboration of a general theory of causality synthesized from elements of causal theory (fundamental to the early Buddhist doctrine of the nature of the universe and of man's predicament in it) in the *Sutta* and *Vibhaṅga*.

Later Pali Literature.—This begins with a long dialogue (in the *Dīgha* style), cast in the external framework of a "history" or historical novel (*akkāyikā*), the *Milindapañha*. The work seems to have grown gradually by large accretions to a kernel of (probably) the 1st century B.C. The *Netti* and *Peṭakopadesa*, theoretical works on exegesis, are of about the same period. These are Indian works, as is the earliest extant grammar (Kaccayana's, of unknown date) but in about the 5th century A.D. the Mahāvihara (Great Monastery) in Anurādhapura, the ancient capital of Ceylon, became the main centre of Theravāda studies. In India new schools and movements in Buddhism adopted new languages and eclipsed the Theravāda school, which adhered to its canon in the ancient Pali. From the 3rd century B.C. the Sinhalese had translated oral commentarial (*Aṭṭhakathā*) traditions into the ancient Sinhalese language in order to interpret the canon. By about A.D. 100 this Sinhalese commentary had attained comprehensive scope and was closed. In Pali (verse), successive writers in Ceylon, down to the 4th century A.D., compiled the *Dīpavamsa* ("History of the Island").

In the 5th century A.D. Indian Buddhists studying at Anurādhapura undertook a translation into Pali of the essential parts of the Sinhalese commentary, to make them accessible wherever Pali

was known. An entirely new style of Pali was evolved. Buddhaghosa wrote the *Visuddhimagga* (an introductory exposition of the whole range of doctrine according to the Sinhalese tradition) and running commentaries on the *Vinaya, Four Nikāyas, Abhidhamma* and two *Khuddaka* texts. Commentaries on the remaining *Khuddaka* books and the *Netti* were written by Dhammapāla, Buddhadatta, Upasena, Mahānāma and the anonymous authors of the *Jātaka Commentary* (which includes full stories for all the *Jātakas*), *Dhammapada Commentary* (which adduces more than 400 illustrative stories) and *Apadāna Commentary*.

At the beginning of the 6th century A.D. Mahānāma wrote the *Mahāvaṃsa* ("Great History"), a verse chronicle based on the *Dīpavaṃsa* but unified in treatment and much more polished in style. It may be said to inaugurate a new phase in Pali literature: that of the later *kāvya*. This is not continuous with the old Pali *kāvya* in the canon, the direct successors of which were in Sanskrit and Prakrit, but derives its style from these successors after they had carried *kāvya* through several centuries of fashion and refinement. Mahānāma states that his aim is to inspire good people with religious emotion. His chronicle, like the *Dīpavaṃsa*, narrates the history of Buddhism from the Buddha's complete Enlightenment to the 3rd century B.C. in India and the 4th century A.D. in Ceylon. Influenced by the conventions of an epic *kāvya*, Mahānāma interrupts his annals to celebrate elaborately the deeds of the two great Sinhalese kings primarily responsible for the introduction and firm establishment of Buddhism in Ceylon, Devānampiyatissa (3rd century B.C.), and Duṭṭhagāmaṇi (1st century B.C.), who is regarded as a national hero who freed his country from Tamil rule. Later poets in Ceylon wrote supplements (often called *Cūlavaṃsa*, "Little History") to the *Mahāvaṃsa*. The first and longest, written by Dhammakitti (13th century), centres on the epic treatment of Parakkamabahu I (12th century) as a national hero.

The chronicle epic was adopted for the histories of various countries of southeast Asia and for other narratives, particularly the life of the Buddha: *e.g.*, Medhaṅkara's (Ceylon; 13th century) *Jinacarita*, and the anonymous Mālālaṅkara (Burma; 18th century). The Buddhālaṅkāra of Sīlavaṃsa (Burma; 15th century) tells the favourite story of the Buddha's previous incarnation as Sumedha, when he first resolved to become a Buddha. Several other works deal with specific aspects of religious history. The prose (*Mahā*) *Bodhivaṃsa* (by Upatissa, *c.* A.D. 970), on the bringing of a cutting of the Buddha's Enlightenment Tree to Ceylon, is of great stylistic interest as displaying much of the vocabulary of contemporary Sanskrit *kāvya* assimilated to Pali. The style of the true Sanskrit *mahākāvya* (with its several cantos in different metres, often of lyric origin, instead of in the ordinary narrative metre only) is exemplified in Dhammakitti's *Dāṭhāvaṃsa* (Ceylon, *c.* 1200) on the Tooth Relic. There are 20th-century *mahākāvyas* such as Medhānanda's (Ceylon) *Jinavamsadīpa* (published 1917), a life of the Buddha. Of biography may be noted Mahāmaṅgala's (? Ceylon, ? 14th century) *Buddhaghosuppatti*, a popular religious novel on the life of the saint, and the learned Nāṇābhivaṃsa's *Rājādhirājavilāsinī* (Burma; 18th century) which celebrates the deeds of the contemporary king of Burma, Bodōpayā.

The later lyric *kāvya* is well exemplified by the anonymous (? 10th century) *Telakaṭāhagāthā*, on renunciation, recited by a monk thrown into a caldron of boiling oil but miraculously remaining alive for a time because of his innocence, and the *Pajjamadhu* of Buddhappiya (an Indian monk living in Ceylon; 13th century), describing the Buddha. The much longer *Samantakūṭavaṇṇanā* of Vedeha (Ceylon; 13th century) is on the borderline of epic and lyric, describing the Buddha's life and (mythical) visits to Ceylon, culminating with that to its highest peak (Adam's peak). Vedeha's descriptions of Sinhalese scenery are remarkable.

The genre of *citrakāvya*, or poem displaying virtuosity in word play and in the mere technicalities of *kāvya* composition as an end in themselves, is represented in extreme form by the *Jinālankara* of Buddharakkhita (Ceylon; 12th century) on the life of the Buddha (this life being as it were the form, and virtuosity in composition the content, of the poem).

Ānanda's (late 12th century) *Saddhammopāyana* is a simple but effective didactic poem in 19 cantos urging the reader to seize the opportunity of following the Buddhist Way. The description of the sufferings of animals, especially as beasts of burden, is a fine example of his art.

The anonymous 13th-century *Hatthavanagallavihāravamsa* ("History of the Hatthavanagallavi Monastery") is a *kāvya* in mixed prose and verse (a *campu*) in which Pali prose receives its most elevated and elaborate treatment, imitating the style of the Sanskrit novels of Bāṇa. Vedeha's *Rasavāhinī* is an outstanding collection of popular old stories.

Exegesis did not end with the Pali versions of the commentaries nor with the numerous handbooks on various aspects of philosophy (*e.g.*, the nine "Little Finger" manuals) and the discipline. Much old Sinhalese material remained untranslated. After about the 8th century the Pali commentaries were provided with subcommentaries (*tīkā*) which explained their words and thus incidentally elaborated the exposition of the basic canonical texts. As a rule the *tīkās* are more technical than the commentaries, and they provide a thorough basis for modern lexicography. The earliest cycle of *tīkās*, of the 8th or 9th centuries, consists of Ānanda's (an Indian working in Ceylon) work on the *Abhidhamma*, Dhammapāla's on the *Four Nikāyas* and the *Jātaka* and Vajirabuddhi's (also Indian) on the *Vinaya*. A Dhammapāla, a pupil of Ānanda, wrote a sub-subcommentary on his teacher's *tīkā*.

In the 12th century Sāriputta (Ceylon) wrote detailed *tīkās* on the *Vinaya* and the *Four Nikāyas*, while his contemporary Kassapa in south India wrote a succinct *Vinaya tīkā* which might be more easily assimilated by his pupils. There is a cycle of *tīkās* (undated) on the *Khuddaka*, and many *tīkās* on such treatises (regarded as "commentaries") as the *Visuddhimagga*. A "new" *Dīgha tīkā* was written in Burma in the 18th or 19th century.

Numerous grammars, also lexicons, works on metrics, poetics, etc., were produced in Ceylon and Burma, the 12th century marking the culminating point of this activity in both countries (Moggallāna and Saṃgharakkhita in Ceylon, Aggavaṃsa in Burma). There are also several works in Pali on medicine, law, astronomy, aesthetics and bibliography.

See also SANSKRIT LITERATURE; GAUTAMA BUDDHA.

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PALIMPSEST, from the Greek *palimpsestos*, "scraped again," a term referring to any inscribed surface from which one text has been removed so that the space could be used again for another. In antiquity the word was applied loosely to any writing material that had been cleared and reused, *e.g.*, to papyrus and waxed tablets, although the former was surely too fragile to withstand

the rubbing or scraping that is implicit in the etymology of the word. Plutarch says that Plato found Dionysius like a *biblion palimpseston*, in that his tyrant nature, being *dusekplutos*, "hard to wash out," showed through like imperfectly erased writing. The reference here is quite clearly to washing the writing off papyrus. Extant palimpsests are almost exclusively of vellum or parchment.

In late classical and medieval times the scarcity and costliness of vellum were so great that it was quite frequently salvaged after the text, which had been inscribed thereon, fell into neglect. One method of preparing parchment for reuse, described in a codex of Munich, was to soak it overnight in milk, sprinkle it with flour, dry it under pressure and then scour it with pumice and chalk. Rarely a book might be doubly palimpsest, *i.e.*, exhibit two erased texts with a third one overlying them. The texts marked for obliteration were usually those of the longer classical works such as those of Plautus, Cicero, Sallust, Livy and Fronto. No complete work, however, has been found in the original text of a palimpsest, portions of different books having customarily been used to supply the material for the new volume. Prejudice against pagan authors seems not to have been involved, even in the monasteries, in the selection of books from which the writing was to be expunged. Any codex no longer in regular use was liable to suffer this fate. For example, an uncial text of the Bible was destroyed in the 9th century to make room for the works of Probus and other grammarians. In the case of Greek manuscripts, however, a synodal decree of A.D. 691 forbade the destruction of intact manuscripts of the Scriptures or of the church fathers.

Palimpsests are especially frequent among the books written at Bobbio and St. Gallen. Unquestionably the practice of reusing inscribed parchment resulted in the destruction of vast quantities of early texts which would be of immense value to modern scholarship. But, in view of the disuse into which they had fallen, it may be doubted how many of them would have been preserved, and the superimposed text was responsible for the preservation of some which might otherwise have been lost. Important texts of Cicero, Livy, Plautus, the two Plinys and Seneca survive in palimpsests. The pioneer in the study and reading of palimpsests was Angelo Mai.

To bring out the original writing of a palimpsest chemical agents, such as tincture of gall and hydrosulfate of ammonia, were often used. While temporarily effective, these were likely to cause permanent damage to the surface to which they were applied; ultraviolet photography has taken their place as the safest and most satisfactory tool in the decipherment of obscure palimpsest texts. The basis for the technique is the fact that some substances fluoresce under ultraviolet light more strongly than others, and that often the remnants of the ink of the original writing, which may be quite invisible to the naked eye, operate to "kill" the fluorescence of the underlying material so that the old writing appears dark against a fluorescing background. The process can sometimes be aided by the application of anthracene ($C_{14}H_{10}$) in alcohol, which is harmless to vellum, as well as to paper, and serves to increase their fluorescence for a period of about one week. If there is underwriting on both sides of the leaf, each side must be treated separately, and a sufficient time will have to elapse for the anthracene crystals to evaporate from the first side before the other can be examined.

See for important palimpsests, Wattenbach, *Schriftwesen*, 3rd ed., pp. 299–317; also *Exempla Codicum Latinorum* of Zangemeister and Wattenbach. (A. F. St.)

PALISSY, BERNARD (1510–1589), French Huguenot potter and writer, particularly associated with decorated rustic faïence, was born in 1510 at Agen, Lot-et-Garonne. At first he learned glass painting, but eventually, after journeys in the south and in the Ardennes that brought him into contact with great humanists, he settled as a surveyor and potter in Saintes, near La Rochelle. Persecuted as a Protestant, he was imprisoned until the constable Montmorency employed him in the decoration of the château d'Ecouen. Then in 1570, helped by his sons, Palissy built a pottery grotto for Catherine de Médicis in the garden of the Tuileries. His appointment, about 1565, as "inventor of rustic pottery to the king and the queen-mother" had enabled him to work in Paris near the Louvre and to come in contact with the sculptor Jean Goujon.

From 1575, in Paris, he gave public lectures on natural history which, published in 1580 as *Discours Admirables* (Eng. trans. by A. la Rogue, 1957), became extremely popular. In these are revealed a writer and scientist, a creator of modern agronomy and a pioneer of the experimental method. His scientific views generally were much in advance of those of his contemporaries.

Palissy was shown a white, glazed cup, probably Chinese porcelain, which so pleased him that he determined to discover the secrets of its manufacture. Palissy described in *De l'Art de la terre* his first laborious researches, undertaken despite his poverty and harassment as an ardent Huguenot.

Again menaced by the growing struggle against Protestants, Palissy took refuge in the homes of the princess of Sedan and Robert de la Marck, in eastern France, but returned to Paris in 1575. Imprisoned again for religious reasons in the Conciergerie in 1588, he was transferred to the dungeons of the Bastille, where he died in 1589.

Palissy's pottery, derived from the rustic pottery made in Europe during the 15th century, generally consists of oval or circular dishes, ewers, *tazze* and sauceboats. It can be grouped into four successive phases: subjects at times modeled from nature, pieces with cleverly marbled surfaces; animal and vegetable; allegorical and mythological low reliefs; and, about the 1580s, reproductions of the metal work of François Briot and others.

It is almost certain that Palissy never used the potter's wheel. His best-known pieces evidently have been pressed into a mold and then finished by modeling or by the application of ornament, based on contemporary engravings, molded in relief. The pottery is a firm, nonporous paste resembling faïence, glazed in two kinds of hard, transparent lead enamel. No signature or mark has ever been found on Palissy's authentic productions. His molds were again used during the 17th century at Avon near Fontainebleau and at Manerbe, Calvados, where a few enameled earthenware statuettes were produced. The influence of the great potter was revived between 1840 and 1870 through the copies executed by E. Avisseau of Tours and later by Georges Pull of Paris.

The best collections of Palissy's ware are in the Louvre and the Cluny museum, Paris, in the museum at Sèvres; in England, in the Victoria and Albert museum, the British museum and the Wallace collection, all in London.

Bibliography.—H. Delange, *Monographie de l'oeuvre de Bernard Palissy* (1862); A. Tainturier, *Les Terres émaillées de Bernard Palissy* (1863); Anatole France, *Oeuvres de B. Palissy* (1880); E. Dupuy, *Bernard Palissy*, new ed. (1902); L. Dimier in *Gazette des Beaux-Arts* (1934, 1936); P. Munier, "Contribution á l'étude des céramiques de Palissy," *Bull. Société Française de Céramique*, no. iii (1949); G. de Rothschild and S. Grandjean, *Bernard Palissy et son école* (1952). For Palissy as a Huguenot, *see* F. Rossignol, *Les Protestants illustres*, vol. i (1863). (S. Gr.)

PALITANA, a town in the Bhavnagar district of Gujarat, India, lies on the Khari stream, a tributary of the Shetrunji, 31 mi. S.W. of Bhavnagar town. Pop. (1961) 24,581.

Toward the southwest, 1 mi. away, is the Shetrunjaya (Satrunjaya) hill, 1,977 ft. above sea level, the most sacred of the five hills of the Jains and a true city of the gods with 863 temples, some dating from the 11th century.

The summit can be reached from Palitana by a motor road. Devout pilgrims ascend it once a day for 99 days and also perform circumambulations of its principal temple.

The town is connected with Sihor and Bhavnagar by rail, and with Ahmedabad, Amreli and other towns by road. The chief industries are stone carving, cotton ginning, oil crushing, cement and the manufacture of harmonium reeds.

The Shetrunji irrigation project, 5 mi. from the town, was started in 1955. Palitana was the chief town of the princely state of the same name, ruled by Gohel Rajputs. It merged with Saurashtra in 1948 and with Bombay in 1956. With the bifurcation of Bombay state on May 1, 1960, it became part of Gujarat. (V. A. M. J.)

PALK STRAIT, a channel, 40 mi. wide, between northernmost Ceylon and southeast India, is separated from the Gulf of

Mannar to the southwest by the line of reefs called Adam's Bridge (*q.v.*).

The strait, named after Sir Robert Palk, governor of Madras in 1763–66, includes many small Ceylonese islands. It receives the Vaigi river from south Madras. The southern part of the strait is known as Palk bay.

PALLADIANISM, a term applied to any architecture similar to that of Andrea Palladio (*q.v.*) in northern Italy. Palladio, however, did not originate the so-called Palladian motif, which is believed to have been used first by Bramante. The term is specifically applied to the architecture of the period 1715–60 in England when British taste relied heavily on the designs of Palladio and those of Inigo Jones (1573–1651) who had introduced High Renaissance architecture into England.. Palladian architecture is characterized by symmetry, monumentality and an academic use of classical forms.

A Palladian window or motif is composed of a central arched opening flanked by a smaller rectangular opening on each side. Columns usually separate the openings. The motif derives its name from Palladio's use of the arrangement in the town hall at Vicenza, the so-called basilica (1549–1614). (A. K. L.)

PALLADIO, ANDREA (1508–1580), Italian architect who had a profound influence on the 18th-century classical revival, was born Andrea di Pietro on Nov. 30, 1508, either in Padua or Vicenza. He began his career as a stonemason and sculptor. About 1536 he came to the attention of the humanist scholar Gian Giorgio Trissino, who became his patron, arranged for him to study in Rome and later took him into the "Accademia Trissiniana." In 1540 Trissino gave Andrea the name Palladio, after the angel in his poem "L'Italia Liberata dai Goti" who explains the divine significance of geometrical forms in architecture. The name was well chosen, for Palladio's lasting importance rests on his theoretical treatises on proportion in architecture generally and in Roman architecture in particular. Most influential of these was *I Quattro Libri dell' architettura* (Venice, 1570, with many later editions and translations).

Palladio's greatest influence was not on the architecture of his own time but on that of the 18th century, when his work and writings inspired much imitation and emulation, particularly in England and America (*see* Palladianism). His two guidebooks on the antiquities of Rome (Rome, 1554) and his illustrations of Daniello Barbaro's edition of *Vitruvius* (Venice, 1556) were the earliest publications to treat Roman buildings with scientific scholarship, and they remained standard reference works on Roman architecture through the 18th century; his buildings in Vicenza, which had little more than local fame in his lifetime, became models for a great body of 18th-century architecture. Paradoxically, perhaps, Palladio's own architectural development shows a steady retreat from that strict observance of classical rules with which Palladianism is associated toward the much freer handling of classical elements typical of mannerist art during the later 16th century in Italy.

Those of his works that follow Roman models most closely and were most admired by 18th-century neoclassicists were all early and built in or near Vicenza. The basilica (Palazzo della Ragione), so-called because it was supposed to re-create a Roman basilica, was conceived as early as 1538 and begun in 1549; the Palazzo Chiericati, a much-copied exercise in the correct handling of Roman orders, was begun in 1550; and the Villa Rotunda (or Capra), most influential of all Palladio's dozen-odd villas and perhaps of all his buildings, was built 1550–53. With identical porticoes on all four arms of its Greek-cross plan, the Rotunda demonstrates Palladio's early adherence to the strictest symmetry, as well as his mistaken belief that such porticoes were found on the façades of Roman houses.

By contrast, Palladio's late works all show distinctively mannerist and proto-baroque characteristics. Most important of these are three churches in Venice: the façade of S. Francesco della Vigna (begun in 1566), S. Giorgio Maggiore (begun 1566, completed by Vincenzo Scamozzi 1602–10) and Il Redentore, one of his finest works (dedicated 1576, completed 1592). In designing their façades, Palladio interlocked two classical temple fronts with truly

BY COURTESY OF G. E. KIDDER SMITH

PALAZZO CHIERICATI (NOW THE MUSEO CIVICO), VICENZA, ITALY, BY ANDREA PALLADIO. MID-16TH CENTURY

mannerist complexity; mannerist, too, are the optical and psychological effects he produced by ingenious arrangements of interior colonnades and interpenetrating spatial units. Palladio's last work was the Teatro Olimpico in Vicenza, begun in 1580, three months before his death on Aug. 19. Although Vitruvius' description of a classical theatre was his immediate inspiration, the receding vistas and optical tricks he employed are likewise imbued with the quite un-Palladian spirit of mannerism.

See also references under "Palladio, Andrea" in the Index.

Bibliography.—A. Dalla Pozza, *Palladio* (1943); F. Burger, *Die Villen des Andrea Palladio* (1909); H. Pée, *Die Palastbauten des Andrea Palladio* (1941). *See* also R. Blomfield, *Six Architects* (1935); and R. Wittkower, *Architectural Principles in the Age of Humanism* (1950), for Palladio's theories and a complete bibliography. (An. G.)

PALLADIUM, an image of Pallas (Athena), especially the archaic wooden image of the goddess standing and armed that was preserved in the citadel of Troy as a pledge of the safety of the city. It was said that Zeus threw it down from heaven when Ilus was founding the city of Ilium, and that Odysseus and Diomedes carried it off from the temple of Athena, thus making the capture of Troy possible. Many cities in Greece and Italy claimed to possess the genuine Trojan Palladium (the ancients spoke of at least two, a false one that had been exposed to public view in Troy, and the true one in the temple of Athena there), but it was particularly identified with the figure brought to Italy by Aeneas and preserved in the shrine of Vesta at Rome.

The Palladium was a common subject in Greek art, as was its theft in literature. The story of its fall from heaven perhaps signifies that the Palladium was originally a baetylus (*q.v.*).

(T. V. B.)

PALLADIUM is a chemical element which is a precious silver-white metal, one of the six platinum metals (*see* Platinum Metals). With a specific gravity of 12.03, it is the lightest of the platinum metals. It has also the lowest melting point of the group, 1,550° C. It boils above 2,500° C. but very gradually loses weight by volatilization below its melting point. As a metal, palladium is ductile and easily worked. The chemical symbol for palladium is Pd; atomic number is 46 and atomic weight is 106.4.

Palladium is not tarnished by the atmosphere at ordinary temperatures. Consequently, the metal and its alloys serve as substitutes for platinum in jewelry and in electrical contacts, and the beaten leaf is used for decorative purposes. Relatively small amounts of palladium alloyed with gold yield a white gold. Palladium is useful for the preparation of dental alloys. Since it is much lighter than platinum, palladium has been used for the construction of astronomical and other fine instruments.

Palladium occurs as a minor constituent of most native platinum-bearing alloys, and is associated with a number of gold, silver and nickel ores. William Wollaston first isolated palladium from crude platinum in England. Instead of announcing the discovery of the element in the customary way, he circulated an anonymous

advertisement of the new metal for sale in 1803. Because of this unorthodox procedure the claim that the new metal was not an element but an alloy of platinum and mercury was widely accepted for a time. However, Wollaston explained his source of the palladium in 1804 together with his announcement of the discovery of the element, rhodium. He named the element in honour of the newly discovered asteroid Pallas.

Surfaces of palladium function as excellent catalysts for many chemical reactions. They are especially effective in reactions involving either hydrogen or oxygen gas. These catalysts are normally very thin deposits of palladium on an inert supporting material. They have proved valuable in the laboratory for the reduction or hydrogenation of organic compounds. In gas analyses, it is possible with careful temperature control to burn hydrogen and olefin hydrocarbons with oxygen on a palladium surface so that methane and saturated hydrocarbons do not react.

The exceptional behaviour of hydrogen with palladium has been carefully studied. Under suitable conditions the metal absorbs more than 900 times its own volume of hydrogen. The metal expands and becomes harder, stronger and less ductile in the process. A metallic or alloylike hydride, which is a reducing agent, is formed; and a composition corresponding to the formula Pd_2H can be obtained. The hydrogen can be completely removed by increased temperature and reduced pressure. Since hydrogen passes rapidly through the metal at high temperatures, heated palladium tubes which are completely impervious to other gases function as practical semipermeable membranes and can be used to pass hydrogen into and out of closed gas systems, or for hydrogen purification.

Palladium is attacked more readily by acids than any of the other platinum metals. It dissolves slowly in nitric acid to give $Pd(NO_3)_2$, and with concentrated sulfuric acid it yields $PdSO_4$. A series of palladium compounds can be prepared with the normal +2 oxidation state.

A number of the complex compounds closely resemble corresponding compounds of platinum, although complexing groups are usually replaced more rapidly for palladium. A yellow hydroxide, soluble in either acid or alkali solutions, is insoluble in water. The hydroxide can be dehydrated to give the black PdO by heating to just below its decomposition temperature of 850° C. The oxide also forms as a thin blue coating on the surface of massive metal heated to just above 750° C. in the air, and can be prepared by heating the metal in a fused potassium hydroxide and potassium nitrate mixture. PdO can be oxidized to a brown unstable Pd_2O_3 by ozone or by electrolysis. Strong oxidizing agents can be used to prepare a series of palladium compounds with the +4 oxidation states, including hydrous PdO_2. These compounds, similar to corresponding compounds of platinum (IV), are, however, more readily reduced. Palladium can be separated from other platinum metals by precipitation of insoluble palladium (II) cyanide or by precipitation with dimethylglyoxime, an organic reagent. All palladium compounds are easily decomposed or reduced to the free element. Ignition of its compounds produces the sponge metal. An aqueous solution of potassium tetrachloropalladate (II), K_2PdCl_4, serves as a sensitive detector for carbon monoxide or olefin gases because a black precipitate of the metal appears in the presence of exceedingly small amounts of these gases. *See* also references under "Palladium" in the Index.

(D. S. Mn.)

PALLADIUS (*c.* 363–before 431), bishop of Helenopolis and later of Asuna (both in Asia Minor), champion of St. John Chrysostom, and author of the Lausiac History, was born in Galatia (Asia Minor). After becoming a monk in 386, he was in Palestine before going to Alexandria (388) and then to the Nubian Desert and the monastic settlement of Scete in Egypt. After returning to Palestine about 399 he went to Asia Minor and in 400 was consecrated bishop of Helenopolis, probably by Chrysostom. He visited Rome in 405 to plead Chrysostom's cause with the emperor Honorius. In 406 he was exiled by the emperor Arcadius to Syene (modern Aswan) and later to Antinoe. He was allowed to go back to Galatia in 412, and in 417 was translated to the see of Asuna. He died before 431.

His Lausiac History (so-called because it was dedicated to Lausus, an imperial official), a collection of instructive histories of hermits, gives a sober and veridical picture of monastic life of the period, the result of personal contact with the desert fathers. The dialogue on the life of Chrysostom ascribed to Palladius is generally considered to be authentic.

Bibliography.—Lausiac History ed. by A. R. Lucot with French trans. (1912); Eng. trans. by W. K. L. Clarke (1918); interpolated text in J. P. Migne, *Patrologia Graeca*, vol. xxxiv (1860). Life of Chrysostom ed. by P. R. Coleman-Norton (1928) and in J. P. Migne, *Patrologia Graeca*, vol. xlvii (1858); Eng. trans. by H. Moore (1921). *See* also J. Quasten, *Patrology*, vol. iii (1960). (A. O.)

PALLADIUS, RUTILIUS TAURUS AEMILIANUS, a farmer and Latin writer on farming who lived some time between the end of the 3rd century and the first decades of the 6th and of whom nothing is known except what can be learned from his writing. He is the author of works in 15 books. The first 13 form his *Opus agriculturae*. After an introductory book each month has a book devoted to it. The 14th book is on veterinary medicine. The 15th, on grafting, consists of a short preface in prose and 85 elegiac couplets, competent but monotonous and lacking in ease. Palladius' prose is careful but plain. It has many features of colloquial language. His work was much used in the Middle Ages and was translated into Middle English.

Bibliography.—Books i to xiii and xv ed. by J. C. Schmitt in the "Teubner Series" (1898) and with French trans. by Cabaret-Dupaty (1844). Book xiv ed. by J. Svennung (1926). *See* also J. Svennung, *Untersuchungen zu Palladius und zur lateinischen Fach- und Volksprache* (1935) and in *Eranos*, vol. xxv–xxvii (1927–29); H. Widstrand, *Palladiusstudien* (1926). (G. B. A. F.)

PALLAS, PETER SIMON (1741–1811), German naturalist and traveler who journeyed extensively in Asia and made important natural history collections and geological observations, was born in Berlin on Sept. 22, 1741, the son of Simon Pallas, professor of surgery in Berlin. He was intended for the medical profession and studied at Berlin, Halle, Göttingen, and Leiden, but he early displayed a strong leaning toward natural history and at the age of 15 had outlined new classifications of certain groups of animals. In 1761 he went to England to study collections and make geological investigations; he was elected a foreign member of the Royal Society at the age of 23. He then went to the Netherlands, and the results of his investigations were published at The Hague in 1766 in his *Elenchus Zoophytorum* and *Miscellanea Zoologica*, and in 1767–1804 in his *Spicelegia Zoologica* (Berlin).

He was appointed professor of natural history in the Imperial Academy of Science, St. Petersburg, in 1768, and the same year appointed naturalist of a scientific expedition to Russia and Siberia. He spent six years on the journey, going by Kazan to the Caspian; lived among the Kalmyks; crossed the Urals to Tobolsk; visited the Altai mountains; traced the Irtysh to Kolyvan; went to Tomsk and the Yenisei, crossed Lake Baikal; and extended his travels to the frontiers of China. The leading results of this famous expedition were given in his *Reise durch verschiedene Provinzen des rüssischen Reichs* (3 vol., St. Petersburg, 1771–76), richly illustrated with coloured plates. Special results of that journey include the publication of *Sammlung historischer Nachrichten über die mongolische Völkerschaften* (2 vol., St. Petersburg, 1776–1802); *Novae species Quadrupedum* (1778), contributions to the dictionary of languages of the Russian Empire 1786–89; *Icones insectorum, praesertim Rossiae Siberiaeque peculiarium* (1781), *Zoographia Rosso-Asiatica* (3 vol., 1831); and articles in the *Transactions* of the St. Petersburg and Berlin academies.

The empress Catherine II bought his collections but allowed him to keep them for life. She also gave him a large estate at Simpheropol, and 10,000 rubles toward establishing a home. He went there toward the end of 1795, but Pallas found the climate of the Crimea too extreme, and after the death of his second wife in 1810 went back to Berlin where he died on Sept. 8, 1811. During the 15 years spent in the Crimea he continued his studies, and devoted considerable efforts toward improving the cultivation of vines. Pallas' industry was remarkable, and embraced not only all branches of natural history but extended into geology, geography, ethnology, and many other fields. He was credited by Baron Cuvier with having changed geological ideas, for his ob-

servations on the two great mountain chains of Siberia led him to a general theory on the formation of mountains and the succession of different types of rocks. His memoir gave birth to a new geology, the forerunner of ideas developed by his contemporaries, H. B. de Saussure, J. A. Deluc and A. G. Werner (*qq.v.*).

Although prematurely aged by the incredible hardships undergone during his travels, and suffering from chronic dysentery most of his life, he continued his activities to the very end, and even in his last years made plans for the study of natural history collections in France and Italy.

See the essay of C. A. Rudolphi in the *Transactions* of the Berlin academy for 1812; G. Cuvier's *Éloge* in his *Recueil des éloges historiques . . . .*, vol. ii (1819–27); and W. J. Jardine, *The Naturalist's Library*, vol. iv (1833–43). (Ed. He.)

PALLAVA, the name of an Indian dynasty that originated about the early 4th century A.D. as indigenous subordinates of the Satavahanas in the Deccan. Thereafter they were contemporaries of the Ikshvakus, moving into Andhra, and thence to Kanchi (Kancheepuram), where they became "lords of Tondai-mandalam." Their rule extended to *c.* 880, but their genealogy and chronology are highly disputed. The Pallavas of the Prakrit records are earlier, but perhaps not quite distinct from those of the Sanskrit records. The Vishnugopa defeated by Samudra Gupta (*q.v.*) belongs to the first group and the Simhavarman mentioned in the *Lokavibhaga* as reigning from A.D. 436 to the second. Rapidly Tamilized, they were the emperors of the Dravida country, patrons of Buddhism, Jainism, and the Brahmanical faith, of music, painting, and literature. Original in the arts, they were in general ineffective in withstanding military pressure from the Western Chalukya (*q.v.*). The Pandya (*q.v.*) rulers never completely accepted their leadership, and their capable feudatories, the Chola (*q.v.*) kings, gradually ousted them from power.

Their greatest monuments are architectural, in particular the Shore Temple, the monoliths, "Arjuna's penance," and the Varaha cave (7th century) at Mahabalipuram (Mamallapuram), once a flourishing port. Their style and that of the Chalukyas appear to have exerted a mutual influence. Under the Pallavas, Tamil and Andhra commercial enterprise and a limited amount of colonization in southeast Asia are marked, but they inherited rather than initiated Tamil interference with Ceylon. Their ruler Simhavishnu's mother (mid-6th century) may have been a Christian. Mahendra-varman I wrote (*c.* 620) the *Mattavilasam*, a farce in Sanskrit pillorying the manners of his day. *See* also India-Pakistan, Subcontinent of: *History: Ancient History: Dynastic Rivalries, 650–1200;* Kancheepuram.

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PALLAVICINO, SFORZA (1607–1667), Italian cardinal, historian, and theologian, author of a history of the Council of Trent written in refutation of Paolo Sarpi's (*q.v.*), was born in Rome on Nov. 28, 1607. He joined the Society of Jesus in 1637 and became successively professor of philosophy (1639) and theology (1643) at the Roman College. In 1651 he was appointed by Pope Innocent X to the commission on Jansenism. His elevation to the cardinalate in 1657 was published in 1659. He died in Rome on June 5, 1667.

Pallavicino's *Istoria del concilio di Trento*, two volumes (1656–57), is only one of the many books on philosophy and theology published in the incomplete 33-volume collection of his works (1844–48).

See C. Sommervogel, *Bibliothèque de la compagnie de Jésus*, vol. vi, col. 120–143 (1895); biography by I. Affò, 5th ed. (1845). (E. J. Bs.)

PALLES, CHRISTOPHER (1831–1920), lord chief baron of the court of exchequer in Ireland, whose judgments are cited as high authority in the English and U.S. courts, was born in Dublin on Christmas Day, 1831. He was educated at Clongowes Wood College and Trinity College, Dublin, and was called to the Irish bar in 1853. He took silk in 1865. In politics, he was a Liberal and served successively as solicitor general and attorney general for Ireland before being made chief baron of the Irish exchequer in February 1874, just before the fall of Gladstone's first ministry.

He retained his precedence and title of chief baron until his retirement in 1916, notwithstanding the merger of the court of exchequer with the Queen's Bench Division in 1897.

His reputation for clarity of exposition and learning in the common law was outstanding, and even in his lifetime was not confined to the circle of those who practised before him in Ireland. Palles also did much in the development of higher education in Ireland. He died at Dundrum, County Dublin, on Feb. 14, 1920.

See F. Elrington Ball, *The Judges in Ireland 1221–1921* (1926). (R. G. M. B.)

PALLOTTINE FATHERS (Society of the Catholic Apostolate; Societas Apostolatus Catholici; S.A.C.), a Roman Catholic society of common life founded at Rome on April 4, 1835, by St. Vincent Pallotti (1795–1850). The Pallottine Fathers and associated Brothers are promoters of Catholic Action (*q.v.*). Their objective is to make each person an apostle. Because of this universal objective, their work is all-embracing. They administer parishes, schools, and colleges; conduct retreats and missions; direct lay organizations; serve as chaplains in hospitals, prisons, and the armed forces; promote the Catholic press; and work in home and foreign missions. The Pallottine Sisters were founded in 1843 by Pallotti as a separate congregation. The Pallottines are established on all six continents. *See* also Orders and Congregations, Religious. (E. L. K.)

PALM, any plant of the large, chiefly tropical family Palmae, which ranks next to the grasses in order of economic importance. They were termed the princes of the plant kingdom by the great botanist Linnaeus. Indeed, they are noble in appearance, most of them being tall and stately.

DISTRIBUTION AND IMPORTANCE

Distribution.—Although the palms are incompletely known, there are thought to be about 210 genera with probably between 3,000 and 4,000 species. These are mainly tropical, but with some representatives in temperate regions. Most palms will not usually grow above 4,000 ft. in altitude, but some species of the wax palm (*Ceroxylon*) are found at 13,000 ft. or higher (2,000 ft. above the timberline) in the northern Andes. The hair palm (*Chamaerops humilis*), of the Mediterranean region, is the only native European palm; the date palm (*Phoenix dactylifera*) from the same region is of African origin. A number of other species of palms are distributed in various parts of the African continent. In eastern Asia palms extend along the coast reaching Korea and southern Japan, whereas in western Asia the northern limit is Afghanistan. In North America several genera occur in the southern United States, and in South America the southern limit is reached by the syrup palm or wine palm (*Jubaea spectabilis*) of Chile, at about latitude 37° S. New Zealand is the southernmost point of palm distribution in the Eastern Hemisphere.

W. H. HODGE

FIG. 1.—CUBAN ACROCOMIA (A. ARMENTALIS)

The palms native in the continental United States comprise 14 species belonging to 9 genera. In California one palm is native, the fan-leaved Washington palm (*Washingtonia filifera*); this plant occurs around the borders of the Colorado desert, in canyons along streams, or in seepage places in the open; it also occurs in southwestern Arizona. Several palmettos (*Sabal*) are present: *S. texana* is native in Texas

EDGAR AUBERT DE LA RUE

FIG. 2.—DOUM PALM HAVING SEVERAL STEM FORKS. A VARIETY OF HYPHAENE FOUND IN TANGANYIKA

near the mouth of the Rio Grande; the dwarf palmetto (*S. minor*) is native in eastern Texas, Oklahoma, Arkansas, Alabama, the Carolinas, and Florida; *S. louisiana* is found only in Louisiana and Texas; and the cabbage palmetto (*S. palmetto*) ranges from North Carolina to Florida along the coast. The saw palmetto (*Serenoa repens*) is almost a weed in the pinelands ranging from South Carolina to the Florida keys and along the Gulf Coast to Louisiana; and the needle palm (*Rhapidophyllum hystrix*) occurs from Mississippi to Florida and South Carolina. All the other palms native in the United States are confined to Florida; most of these are found in the warmer parts from the latitude of Miami southward. They include the thatch palms (*Thrinax microcarpa, T. parviflora*), silver palm (*Coccothrinax argentea*), saw cabbage palm (*Acoelorraphe wrightii*), cherry palm (*Pseudophoenix sargentii*), *Sabal etonia* and royal palm (*Roystonea regia*).

The great centres of palm distribution are tropical America (with about 500 species concentrated in Brazil alone) and tropical Asia. Large genera confined to tropical America include *Bactris, Geonoma, Mauritiella, Chamaedorea*, and *Attalea*, whereas those found only in the Old World tropics are *Calamus, Daemonorops, Areca, Hyphaene*, and *Livistona*. The raffia palms (*Raphia*) are found in both the New World and Old World tropics, and the coconut palm (*Cocos nucifera*) is apparently pantropical in its native state.

Palm genera may be arranged in seven tribes, distinguished by the kind of leaves, the sexual condition of the flowers, the character of the seed, the position of the raphe, etc. Other characteristics of minor importance are the habit of the plant; the position of the spathes; the estivation of the flowers; and the nature of the stigma, ovary, and fruit.

JOHN H. GERARD

FIG. 3.—A MUCH-BRANCHED FLOWER CLUSTER OF THE PRINCESS PALM (DICTYOSPERMA ALBUM)

Economic Aspects.—Palms are of the greatest economic importance. They furnish food, shelter, clothing, timber, fuel, building materials, fibres, paper, starch, oil, sugar, wax, wine, tannin, dyeing materials, resin, and a host of minor products, which make them most valuable to native populations in the tropics and to tropical agriculturists.

Sugar and liquids capable of fermentation are produced by the following palms: toddy fish tail (*Caryota urens*), nipa (*Nipa fruticans*), coconut, palmyra (*Borassus flabellifer*), lady (*Rhapis vinifera*), sugar (*Arenga pinnata*), and *Mauritiella vinifera*. Starch is procured in abundance from the stems of sago palms (*Metroxylon*). Leaves of many of the palms are used as a thatching material for primitive tropical homes. The fruit of the African oil palm (*Elaeis guineensis*) yields palm oil when crushed and boiled, and dried coconut endosperm produces an oil used widely in commerce. Wax is obtained from the leaves of the Arikury palm (*Arikuryroba schizophylla*) and the carnauba palm (*Copernicia cerifera*). Fruits of the date palm are the staple food of some districts of North Africa; edible fruits are also produced by the peach palm, or pejibaye (*Guilielma gasipaes*), of tropical America. Many species, *e.g., Roystonea oleracea, Sabal palmetto, Cocos nucifera, Euterpe globosa*, and others, are valued for their "cabbage," the terminal bud (the removal of which causes the death of the tree). The terminal bud of some of these species is served, under the name "millionaire's salad," by some of the finest restaurants in the United States. The coco-de-mer, or double coconut (*Lodoicea sechellarum*), is found only in the Seychelles Islands. Its fruit is huge, weighing up to 40 lb., and contains a pair of seeds. The betel nut palm (*Areca catechu*) is cultivated in tropical Asia and certain Pacific islands for its fruits, which are chewed wrapped in a peppery leaf with a pinch of lime.

BY COURTESY OF UNITED FRUIT COMPANY

FIG. 4.—BETEL NUT (ARECA CATECHU)

In the United States several species of palms can be grown successfully out-of-doors as far north as Oregon, from latitude 42° to 46° N; in England, at latitudes of 50° N, it is possible to grow the following out-of-doors: the Mediterranean hair palm, windmill palm (*Trachycarpus fortunei*), Canary Island date (*Phoenix canariensis*), and Chilean wine palm. Some palms, such as *Rhapis flabelliformis*, the hair palm, and several species of *Chamaedorea*, are suited for ordinary greenhouse culture and the dry atmosphere of living rooms. Potted plants of the sentry palms or kentias (*Howea*), Chinese fan palm (*Livistona chinensis*), and Weddell palm (*Syagrus weddelliana*) make stately indoor specimens.

FORM AND FUNCTION

Palms are usually characterized by the presence of an unbranched stem bearing a tuft of leaves at the tip; these leaves, often gigantic in size, are firm in texture and are divided feather-fashion (pinnately) or fan-fashion (palmately). The flower clusters are borne on simple or branching spikes generally associated with leaflike structures called spathes. Each flower consists of a perianth of six greenish inconspicuous segments arranged in two rows and, when bisexual, six stamens and a pistil containing one to three carpels, each with a single ovule. The fruit is either dry or fleshy, and the seed consists almost entirely of endosperm along with the very minute embryo. Some of the more important modifications are noted briefly.

Stem.—In many palms the stem is relatively tall (as much as 200 ft. in the genus *Ceroxylon*), erect, unbranched, cylindrical, or dilated below so as to form an elongated cone, either smooth

PHILIP GENDREAU

FIG. 5.—FRUITING COCONUT PALM (COCOS NUCIFERA)

or covered with the projecting remnants of the former leaf petioles, or marked with circular scars indicating the position of those leaves that have dropped off. It varies in diameter from the thickness of a cattail stem (as in *Chamaedorea*) to a sturdy pillar-like structure as in the royal palm, Chilean wine palm, palmyra palm, and the talipot palm (*Corypha umbraculifera*). In other cases the slender stem is prostrate, or scandent by means of hooked prickles (as in the rattan palms, *Calamus*) that enable the plant to support itself on adjacent trees and permit the stem to grow to great lengths (*see* VINE). Sometimes the trunk, or that portion of it above ground, is so short that the plant is said to be "stemless," as in the nipas, which grow in and along tidal streams in the Indo-Pacific region, and in the saw palmettos of the southeastern United States. In many species of palms the trunk is covered with a dense network of stiff fibres (as in the coconut palm), often compacted together at the free ends into spines (as in the Cuban acrocomia, *Acrocomia armentalis*). This material, which is so valuable for cordage, consists of the fibrous tissue of the leaf stalk, which in these cases persists after the decay of the softer portions. Some palms, especially those growing in shallow soils, characteristically produce adventitious roots at the base of the stem which apparently anchor the trees more firmly in the soil. The underground stem of some palms (*e.g.*, the rattans) is a rhizome which lengthens horizontally by development of a terminal bud. Lateral suckerlike branches form thickets of canelike stems. Branching of the main stem above ground is unusual; however, in the doum palm (*Hyphaene thebaica*) of Egypt the stem forks.

JOHN H. GERARD

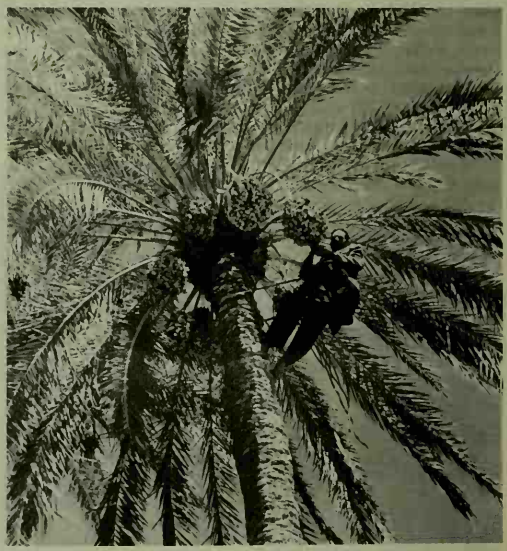
FIG. 6.—CROWN OF LEAVES OF CHINESE FAN PALM (LIVISTONA CHINENSIS)

The internal structure of a palm stem does not differ materially from that of most monocotyledons. Woody tissue is scattered in bundles throughout the stem rather than being concentrated in a ring, or rings, around a central soft pith as in woody dicotyledons. The trunk becomes progressively harder and more woody as a result of the sclerification of new fibre strands or, in a few species, by the formation of secondary "conjunctive" tissue containing new vascular bundles. In addition to this, palms do not produce a true bark but develop an outer hard layer of strong tough fibres instead. In fact, this outer layer is sometimes so tough that only the sharpest ax can penetrate it.

Leaves.—Leaves of palms are arranged either at more or less distant intervals along the stem, as in the rattans and *Daemonorops*, or are clustered in tufts at the end of the stem, thus forming those noble crowns of foliage generally associated with the idea of a typical palm. The adult leaf usually has a sheathing base tapering upward into a stalk or petiole to which the blade is attached. In *Copernicia* and *Coccothrinax*, the petiole develops spines of various sizes. The size of palm leaves varies within wide limits, some being only inches long, as in young specimens of the Weddell palm, while those of some raffias may exceed a length of 50 ft. In form the leaves are rarely simple or undivided except in the juvenile stages of some species; usually they are more or less divided, either in a palmate fashion as in the fan palms (*e.g., Latania, Borassus, Chamaerops, Sabal*) or pinnately as in the feather palms (*e.g., Areca, Kentia, Calamus, Daemonorops*). The shape of the leaflets is generally more or less linear, but in *Caryota* and *Martinezia* they are broad and wedge-shaped. Palm leaves are often covered with hairs or spines, and sometimes coated with fairly thick deposits of wax, as in many species of *Copernicia*.

Flower.—The inflorescence of palms ranges from a simple fleshy spike to a much-branched axis which is studded with numerous small flowers (as many as 60,000,000 per plant in the talipot palm) and enveloped by one or more spathes. The average palm inflorescence ranges from 2 to 6 ft. long, but in the talipot palm it is often more than 20 ft. in length. This latter palm flowers only once (between 30 and 40 years of age); it develops the huge inflorescence and, after the fruit ripens, the tree dies.

The individual flowers are usually greenish and inconspicuous; their general structure has been described above. They are either bisexual or unisexual. When unisexual, the male and female flowers are usually produced on the same tree (*i.e.*, monoecious, as in the tribe Areceae and a number of genera in other tribes) but not always in the same season, for a tree in one year may produce male flowers and in the next year female flowers. In some cases the male and female flowers are on separate trees, *i.e.*, dioecious, as in *Rhapis, Lodoicea, Hyphaene, Ceroxylon, Latania,* and *Phoenix*. Sometimes the flowers are modified by an increase in the number of parts; thus the normal 6 stamens may be increased to 12, 24, or even hundreds. Pollen is carried from the anthers by wind or insects to the stigma of another flower. This is sometimes facilitated by the elastic movements of the filaments and anthers which liberate the pollen so freely that the atmosphere



PAUL POPPER

FIG. 7.—WORKER PICKING FRUIT FROM A DATE PALM (PHOENIX DACTYLIFERA) IN AN IRANIAN GROVE

is visibly clouded with pollen. This often occurs in the case of the Egyptian date palm.

Fruit.—Palm fruits vary in size, shape, and structure. In the date and betel nut they are fleshy or relatively soft, enclosing a hard seed. The coconut fruit is similar to a plum or cherry; the fibrous outer portion corresponds to the outer fleshy portion and the shell corresponds to the stone or pit of these two plants. The coconut seed is actually the edible fleshy and liquid parts inside the shell. Other fruits, like those of *Raphia*, *Mauritiella*, and *Metroxylon*, are covered with a series of overlapping scales.

The seeds are variable in size and shape, but they always consist of a mass of endosperm, a tiny embryo, and a seed coat. The hard date seed, the fleshy and liquid parts of the coconut seed, and the hard seeds of the ivory palm (*Phytelephas macrocarpa*) of tropical America and *Metroxylon amicarum* of the Caroline Islands are primarily endosperm tissue.

See also the references under "Palm" in the Index.

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(V. H. B.; L. H. BA.; S. F. G.)

PALMA, JACOPO (PALMA VECCHIO, originally JACOPO NEGRETI) (*c.* 1480–1528), Venetian painter of the High Renaissance, a distinguished minor painter whose craftsmanship and finish were superlative, was born at Serinalta, near Bergamo. His namesake and more prolific great-nephew is known as Palma Giovane (Palma the Younger). A competitor of Titian, and a follower of the tradition of Giorgione and Giovanni Bellini, Palma occupies an inferior position in both popular and critical esteem. He has been called a painter of dull pictures, though this is an undiscerning estimate. As with the work of other Venetian Renaissance masters, it is only in a work entirely by him that the effect is one of subtle nobility. What may in the work of a follower appear as dullness or lack of inspiration is gentle serenity in the master's work.

Palma made the type of Venetian contemplative religious picture known as the *sacra conversazione* (*i.e.*, a group of historically unrelated sacred personages grouped together, usually in a landscape setting) particularly his own. To his late 15th-century subject matter he applied the vision of Giorgione in colour and fused soft-focus effects. Palma's particular refinement of the Giorgionesque technique was his use of transparent glazes, most of which later deteriorated. Palma's figures have a monumentality about them, a characteristic especially noticeable in his finest work, the Sta. Barbara altarpiece in Sta. Maria Formosa, Venice. Probably in imitation of such half-length female figures by Titian as the "Flora" (Florence) or "Woman With a Mirror" (Paris), Palma developed an ideally feminine, blonde, pretty type, a bit heavy in form. Examples of this type may be found in Palma's works in Berlin, London and Vienna. An especially striking late version is the "Three Sisters" (Dresden). This work, along with many of his last products, shows the influence of Lorenzo Lotto. Forty of Palma's works remained unfinished at his death and were finished by his pupils. Presumably this accounts for the variable quality of his work.

PALMA GIOVANE (Jacopo Palma) (1544–1628), the grandnephew of Palma Vecchio, was born and died in Venice. The last Venetian mannerist, he continued the style after it had become completely outmoded. Though prominent, he was never really a leader, so he easily painted tasteful pieces matching the work of greater men. His lack of an original style made him an able assistant to the aged Titian whose last work, the "Pietà," he finished and signed. Palma Giovane's drawings have always been esteemed by connoisseurs for their vigorous, varied style and rich imagination, without the triviality of his oils. (J. MN.)

See C. Ridolfi, *Le Maraviglie dell'Arte*, ed. by D. V. Hadeln (vol. 1, 1914; vol. 2, 1924) and A. Spahn, *Palma Vecchio* (1932).

PALMA, RICARDO (1833–1919), Peruvian man of letters, best known for his legendary sketches of colonial Peru, one of the most popular collections in Spanish-American literature, was born in Lima on Feb. 7, 1833. At the age of 20 he joined the navy, and in 1860 was forced by political exigencies to flee to Chile, where he devoted himself to journalism. Six years later he returned to Lima to join the revolutionary movement against Spain. He also took part in the War of the Pacific (1881), and during the Chilean occupation courageously protested against the vandalistic destruction of the famous National library by Chilean soldiery.

After the war Palma was director of *La Prensa* in Buenos Aires, but soon was recalled to Peru to rebuild the National library; he remained its curator until his death in Lima, Oct. 6, 1919. In 1887 he founded the Peruvian academy.

Palma's literary career began in youth with light verses, romantic plays and translations from Victor Hugo. His *Anales de la inquisición de Lima* (1863) was followed by several volumes of poems. His fame derives chiefly from his charmingly impudent *Tradiciones peruanas*—short prose sketches, which mingled fact and fancy, of the pageantry and intrigue of colonial Peru. Their sources were the folk tales, legends and racy gossip of his elders, plus historical bits gleaned from the National library. The first six volumes of this series appeared between 1872 and 1883; they were followed by *Ropa vieja* ("Old Clothes") (1889), *Ropa apolillada* ("Moth-Eaten Clothes") (1891), *Mis últimas tradiciones* (1906) and *Apéndice a mis últimas tradiciones* (1910).

See for selections in English and bibliography, Palma's *The Knights of the Cape*, trans. by Harriet de Onis (1945). (J. C. D.)

PALMA (or PALMA DE MALLORCA), capital town of the Balearic Islands (*q.v.*), a Spanish province, is situated in the southwest of the island of Majorca (Mallorca) in the centre of the 10-mi.-wide Palma Bay. Pop. (1960) 159,084 (mun.). The old quarters have many beautiful houses of the 16th and 18th centuries. Notable buildings include the Gothic cathedral (1230–1601); Bellver Castle, on the hill of the same name (14th century); La Lonja, the former exchange, now a museum (15th century); Almudaina Palace, former residence of the Arab dynasty, and now the captain general's headquarters (restored in the 12th and 16th centuries); the Sea Consulate (17th century); bishop's palace (17th century); and the town hall (16th century). The modern part, with its fine buildings, promenades, and gardens, stretches along the coast for seven miles. Palma has good educational facilities, including a section of the University of Barcelona, and several art galleries and museums.

Palma is connected to the mainland by frequent air and sea services. There are direct flights to many European cities, and steamers connect with Europe, Africa, and New York. The most important occupations are the tourist trade and the manufacture of furniture, footwear, and fabrics. The many crafts include embroidery, pottery, artistic glass and iron work, palmetto and raffia basketwork, and olive wood carving.

Little is known of Palma before 123 B.C. when the Romans conquered Majorca, making the archipelago a Roman province. Attacked by the Vandals in the 5th century, it became part of the Byzantine Empire a century later. In the 8th century it fell to the Arabs, and in 1229 was conquered by James I, who united it with the crown of Aragon. On his death it became independent, but was again incorporated into Aragon by Peter IV in the 14th century. It became part of the Spanish monarchy upon the marriage of Ferdinand II of Aragon (1452–1516) and Isabella of Castile. (L. SA. B.)

PALMA (or SAN MIGUEL DE LA PALMA), an island in the Spanish archipelago of the Canary Islands (*q.v.*). Area 281 sq.mi. (728 sq.km.). Pop. (1960) 67,141. Only 29 by 17 mi., Palma has a huge volcanic crater, 6 mi. in diameter with walls over 5,000 ft. high. The crater rim is breached on the west by a canyon but elsewhere forms a mountain ridge up to 7,900 ft. in altitude. Its well-watered slopes are densely wooded and deeply dissected by ravines. The more recent lava streams, including that formed on the western flank in 1949, are naked. Santa Cruz de la Palma (pop. 12,967), the capital, handles most of the exports of bananas, tomatoes, tobacco, and embroidery. The island has some motor roads and an air strip. (R. P. BE.)

PALMAS DE GRAN CANARIA, LAS: *see* LAS PALMAS.

PALM BEACH and **WEST PALM BEACH,** sister cities of Palm Beach County, Fla., U.S., are located on the Atlantic coast, 287 mi. S of Jacksonville and 67 mi. N of Miami. Palm Beach, known as Palm City until 1887, occupies an ancient sandbar and is separated from West Palm Beach by a lagoon known as Lake Worth. It is one of the most luxurious winter resorts in the U.S., with palatial hotels, clubs, and private estates. Three bridges span the lake which is usually dotted with yachts and small boats. West Palm Beach occupies an elevated ribbon of land for eight miles along the sand ridge common to most of the Florida east coast. It is also a pleasure resort but in addition is a commercial and financial centre of a wide area. Both cities are on the Atlantic Intracoastal waterway which traverses Lake Worth.

Because of their southerly location and the marine influences, the Palm Beaches have an equable climate that attracted settlers after the American Civil War. They did not become fashionable as winter resorts until after Henry M. Flagler extended his Florida East Coast Railroad into the area in 1894 and built several luxurious hotels to attract northerners. Within a few years Palm Beach became known as the American Riviera and was frequented by wealthy and famous personages, many of whom later built and maintained winter homes there. For years West Palm Beach served as a transfer point and domicile for Palm Beach workers, but with the development of transport facilities it became a major tourist centre.

On the creation of Palm Beach County in 1909, West Palm Beach became the county seat and in the intervening years far outstripped its more exclusive sister city in growth and population. Pop. (1960) Palm Beach, 6,055; West Palm Beach, 56,208. The West Palm Beach standard metropolitan statistical area (Palm Beach County) in 1960 had a population of 228,106. (For comparative population figures *see* table in FLORIDA: *Population.*) Both cities adopted commission-manager governments, West Palm Beach in 1919 and Palm Beach in 1922. The former is the hub of an expanding metropolitan area with business and financial interests catering to local service and to industries allied to farming, cattle raising, and commercial fishing. West Palm Beach also benefited from the state's increasing industrial activity, and in the 1950s and early 1960s many new industrial plants located in Palm Beach County, including a jet engine facility.

The Palm Beaches are served by rail, road and air. The port of Palm Beach became one of the busiest in the state, visited by tanker and cargo vessels, and barges going to the Lake Okeechobee ports through the St. Lucie canal. Tropical storms occasionally visit the Palm Beaches, the hurricane of September 1928 being notably devastating.

The cultural facilities of the two cities include Palm Beach Junior College (1933), one of the state's largest, the Norton Art Gallery and Theatre and Memorial Library. A popular recreation is the excellent fishing in the nearby Gulf Stream and from the piers, bridges, and beaches. (J. E. D.)

PALM CIVET (TODDY CAT), the name of several species of small mammals of the family Viverridae. Their name is derived from their main habitat, palm trees. The common palm civet (*Paradoxurus*), about the size of a domestic cat, yellowish gray and spotted, is found from central China and India to the Molucca Islands. The masked palm civet (*Paguma*) lacks spots and has a blackish facial mask. The small-toothed palm civet (*Arctogalidia*) has three dorsal stripes, the lateral ones often broken into spots. These two forms are found from China to Sumatra and Borneo. The banded palm civets have dark transverse dorsal bands. One genus (*Hemigalus*) occurs from Tenasserim to Borneo. The other (*Chrotogale*) is found in Tonkin and Laos. They all feed on small animals, fruit, and vegetation. *See* also CIVET.

(JO. E. H.)

PALMELA, PEDRO DE SOUSA HOLSTEIN, DUQUE DE (1781–1850), one of the leading Portuguese statesmen and diplomats of the 19th century, was born at Turin, in Piedmont, on May 8, 1781, during his father's tour of duty in the diplomatic corps. His family, and particularly his mother, had suffered from the Marquês de Pombal's despotism. Educated abroad and at Coimbra, Palmela entered the army in 1796 and the foreign service in 1802. He was a friend of Madame de Staël and of Alexander von Humboldt, campaigned with Wellington in the Peninsular War, and represented Portugal in Rome (1802), Spain (1810), and Great Britain (1812). With the title of conde (from 1812), he also took part in the Congress of Vienna. In 1817 he was appointed Portuguese minister of foreign affairs, but it was only in 1820 that he arrived in Rio de Janeiro, where the court then was, so that he did not serve long. He returned to Portugal with King John VI in 1821 and was created marquês in 1823. In later years he was for short periods minister of foreign affairs again (1835), president of the chamber of peers (1841), and prime minister (1842 and 1846). A moderate liberal along British lines, he urged John VI to embrace constitutionalism. Having allied himself with the Liberal party on John VI's death (1826), Palmela stalwartly identified himself with the movement that in 1834 put Maria II on the throne; and it was largely thanks to his subsequent efforts that she remained queen. Duque de Palmela from 1833, he played an active role in politics and diplomacy almost until his death on Oct. 12, 1850, in Lisbon, in his palace of Lumiar.

See M. A. Vaz de Carvalho, *Vida do Duque de Palmela,* 3 vol. (1898–1903). (M. CA.)

PALMER, ALEXANDER MITCHELL (1872–1936), U.S. lawyer and government official who gained nationwide attention as a militant foe of Bolshevism in 1919–20, was born at Moosehead, Pa., on May 4, 1872. He graduated from Swarthmore College (Swarthmore, Pa.) in 1891, studied law for two years and began to practise in Stroudsburg, Pa. He became an active member of the Democratic Party and served in the U.S. House of Representatives for three terms (1909–15). Palmer lost a three-cornered contest for the U.S. Senate in 1914, but received successive appointments from Pres. Woodrow Wilson as judge on the U.S. court of claims (1915), as alien property custodian (1917) and as attorney general (March 4, 1919). In the latter post, he helped to promote the postwar "red scare" and pressed for the deportation of alien radicals. Palmer made an unsuccessful bid for the presidential nomination in 1920 and resumed his law practice in Stroudsburg the next year. He died there on May 11, 1936.

See S. Coben, *A. Mitchell Palmer: Politician* (1963). (G. H. MA.)

PALMER, EDWARD HENRY (1840–1882), English orientalist, distinguished as a linguist and as a traveler, was born on Aug. 7, 1840, at Cambridge. He early showed linguistic ability, learning Romany from gypsies while at school, and Italian from political exiles while working in London as junior clerk in a wine merchant's firm (1856–59). During convalescence from a serious illness, he wrote light verse and plays, showing the talent for versification that later distinguished his translations, and in 1860 he began to learn Urdu, Persian, Arabic, and Hebrew from Oriental scholars in Cambridge. He read classics at St. John's College (1863–66) and, while an undergraduate, taught Arabic, catalogued the Arabic and Persian manuscripts in King's and Trinity College libraries, and was foreign correspondent in Urdu to two Indian newspapers. In 1867 he was elected fellow in Oriental studies at St. John's, and published *Oriental Mysticism,* a translation of a Persian treatise.

In 1868–69 he joined an Ordnance Survey expedition following the Israelites' route from Egypt through the Sinai desert to Jerusalem, and in 1870 accompanied the naturalist and explorer Charles Tyrwhitt Drake on a further exploration of the desert, financed by the Palestine Exploration Fund. He described both journeys in *The Desert of the Exodus* (2 vol. 1871). In the same year he published, with his friend Walter Besant, *Jerusalem, the City of Herod and of Saladin,* which presented a Muslim view of the city's history.

While professor of Arabic at Cambridge (1871–81), Palmer published the Persian-English volume of *A Concise Dictionary of the Persian Language* (1876; completed in 2 vol. by G. Le Strange, 1883–84); a scholarly edition of the poetical works of Beha-ed-din Zoheir (1876), followed by a free metrical translation (1877);

The Song of the Reed, and Other Pieces (1877), containing translations from Persian and Arabic and original poems; and a translation of the Koran (1880; World's Classics, 1928), which despite inaccuracies, conveys the true atmosphere of the desert. After leaving Cambridge, he became a contributor to the *Standard*. In 1882 he was asked by the government to return to Sinai to enlist the sheikhs' support for the proposed British occupation of Egypt, and to take measures to ensure the safety of the Suez Canal. After a successful first mission, he was ambushed and murdered at Wadi Sudr (Aug. 11, 1882).

See W. Besant, *Life and Achievements of E. H. Palmer* (1883); A. J. Arberry in *Oriental Essays* (1960).

PALMER, SAMUEL (1805–1881), English landscape painter and etcher, whose watercolour landscapes are distinguished by a dreamy, poetic quality, was born in London on Jan. 27, 1805. He first exhibited at the Royal Academy in 1820 and at the British Institution in 1821. Palmer was deeply influenced by William Blake. He died at Reigate on May 24, 1881.

Palmer's English metrical version of Virgil's *Eclogues*, which was published posthumously in 1883, contains reproductions of his watercolours, and etchings completed by his son A. H. Palmer. His paintings may be seen in a number of galleries, including the Tate Gallery and the Victoria and Albert Museum in London.

PALMERSTON, HENRY JOHN TEMPLE, 3RD VISCOUNT (1784–1865), one of Britain's ablest and most powerful foreign secretaries for a total of 16 years and prime minister for a total of 9 years, was during the last 15 years of his life the dominant personality in English politics. His forceful handling of foreign affairs promoted his country's influence abroad, and because he so often expressed the views of his countrymen, delighting and gratifying them by his assurance, his patriotic prejudices, and outspoken comments, he acquired and retained immense popularity and influence at home.

Temple was born in London on Oct. 20, 1784, the elder son of Henry, 2nd Viscount Palmerston, and his wife Mary, née Mee. Part of his childhood was spent in Italy and France. He was sent to Harrow School in 1795 and in 1800 went to Edinburgh University, where he attended the lectures of the philosopher Dugald Stewart, with whom he boarded. In 1802 he succeeded to the viscountcy, an Irish peerage which did not debar its holder from membership of the House of Commons. He was at St. John's College, Cambridge, from 1803 to 1806. After several electoral failures he found a seat in Parliament in 1807 as member for Newport in the Isle of Wight. Influence had already secured for him a junior lordship of the admiralty in the duke of Portland's second administration (1807–09), and when Spencer Perceval formed his government in 1809 he offered to the 25-year-old Palmerston the chancellorship of the exchequer. Palmerston, however, preferred the less important office of secretary at war, charged with the financial business and the supplies of the army without a seat in the cabinet. Showing no signs of an ambitious temperament or of great political ability, he remained in this post, under five prime ministers, until 1828, entering the cabinet only under George Canning in 1827. During this period he was chiefly known as a man of fashion and was rightly regarded as having little influence on the general policy of the government. Few knew that in this thankless office he had proved himself an efficient and devoted administrator.

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HENRY JOHN TEMPLE, 3RD VISCOUNT PALMERSTON. PHOTOGRAPH TAKEN ABOUT 1860

Within the great Tory coalition Palmerston supported the more reformist group, the "Canningites"—which included William Huskisson and William Lamb (afterward 2nd Viscount Melbourne)—and he resigned with them from the duke of Wellington's cabinet in 1828. Finding himself in opposition, he cultivated his interest in foreign affairs. He made several visits to Paris, where he foresaw the impending revolution; and on June 1, 1829, he made his first great speech on foreign affairs. Palmerston was no orator, for his language was unstudied and his delivery somewhat embarrassed, but he addressed the House of Commons in language adapted to the capacity and temper of his audience. When the Whig Earl Grey became prime minister in November 1830, Palmerston accepted the office of foreign secretary which he was to hold (with a short intermission from 1834 to 1835) until September 1841, and again from July 1846 until December 1851.

Foreign Secretary (1830–34, 1835–41, 1846–51).—As foreign secretary, Palmerston was to make himself respected and even feared abroad. He owed his reputation fundamentally to hard work. He read and thought much more about foreign affairs than did any of his colleagues or his continental rivals; and he always had the current business of the foreign office at his fingertips. However, he approached some questions of foreign policy with such passion, personal animosity, and imperious language that Queen Victoria and some of his colleagues regarded him as a dangerous minister, and he caused much irritation in other countries. He cared deeply for the prestige of Britain, for the spread of liberal and constitutional regimes, and for the abolition of the slave trade. Though on occasions he could show great tact and patience, and even guile, he was often devastatingly forthright and provocative. His attitude toward France is the best illustration of his ambivalence. Throughout his career in high office he continually emphasized the importance of good relations with France, even when this weakened his own position in England. But he frequently gave great offense by his frank public and private statements of disagreement with French policy, and by his unconcealed scorn of French strength and his references to Waterloo. It was never easy to tell whether the insults were calculated or not, but Palmerston certainly sometimes spoke unpardonably reckless words. Moreover he was so sure of himself that he was liable to push matters unnecessarily to extremes, a tendency best illustrated by the Don Pacifico incident (*see* below).

Belgium, Spain, and Portugal.—When Palmerston became foreign secretary in November 1830, the existing settlement of Europe had just received a severe shock from the revolutions in France (July) and Belgium (August). Britain was well satisfied with the accession of Louis Philippe in France but was disturbed by the revolt of Belgium (*q.v.*) against the king of the Netherlands. Palmerston induced the powers to agree that Belgium should be independent (January 1831), and Prince Leopold of Saxe-Coburg became king in July. But prolonged and intricate negotiations were necessary to avert the serious danger of French intervention at various stages and to force the Dutch to accept the agreements. In this matter Palmerston worked to maintain peace and stability in Europe and in accordance with the traditional British desire to prevent a major power from gaining undue influence in the Low Countries. The surmounting of all the difficulties was a solid success for his diplomacy.

At this time both Spain and Portugal were troubled by disputes over the succession to their thrones. The young queens Maria II of Portugal and Isabella II of Spain, the representatives and hope of the constitutional parties in these countries, were hard pressed by their absolutist uncles Dom Miguel and Don Carlos. Palmerston gave valuable support to the queens by concluding with them and with France a quadruple alliance (April 22, 1834), which formed a counterpoise to the alliance of the three absolutist monarchies of Russia, Prussia, and Austria. He also allowed a British legion to serve with the Spanish constitutionalist troops.

The Near Eastern Crisis (1839–41) and the First Chinese War (1839–42).—In Near Eastern politics Palmerston had been from the first a strenuous supporter of the claims of the Greeks against the Turks (*see* GREEK INDEPENDENCE, WAR OF). But he had not long been foreign secretary before he began to lay great stress upon the importance to Britain of defending and maintaining intact the Ottoman Empire. He believed that Turkey could be re-

formed. His two principal aims in the Near East were to prevent the establishment of Russia on the Bosporus and of France on the Nile. He regarded with apprehension the Treaty of Unkiar Skelessi which Russia extorted from the sultan in 1833 as the price of its assistance against Muhammad Ali, pasha of Egypt (*see* EASTERN QUESTION). When, in 1839, Muhammad defeated the sultan and appeared to threaten the existence of the Ottoman dynasty, Palmerston helped to effect a combination of all the Western powers, whose representatives signed the collective note of July 27, 1839, pledging themselves to maintain the independence of the Turkish Empire. It soon became clear, however, that France would not go so far as to join in coercing Muhammad, and Palmerston made a convention for that purpose with Russia, Austria, and Prussia on July 15, 1840. The cabinet had refused to adopt Palmerston's view of the Eastern Question at two earlier crises, in 1833 and 1835, and had only now with great difficulty been won over. There seemed good reason to doubt whether Muhammad could be checked and it was feared that France might go to war in his support. Palmerston's colleagues were very reluctant thus to weaken and perhaps to destroy the Anglo-French alliance. Muhammad withdrew, however, thus proving Palmerston's calculations entirely correct. His triumph was completed by the signature, on July 13, 1841, of the Straits Convention, which ensured that the Dardanelles and Bosporus should be closed in peacetime to large warships of all nations.

Relations with China had deteriorated during the 1830s, and in 1839, in an attempt to suppress the opium trade, the Chinese confiscated cargoes belonging to British merchants and harassed the British residents in Canton. Although his strong protests to the Chinese were criticized in Parliament in April 1840, Palmerston won the debate and shortly afterward a punitive expedition was sent to Canton. The Treaty of Nanking (1842), which ended the First Chinese War, was concluded after Palmerston had ceased to be foreign secretary, but its terms—the cession of Hong Kong and the opening of five treaty ports to foreign traders—were the direct results of Palmerston's policy.

The Spanish Marriages.—During Sir Robert Peel's second ministry (1841–46) Palmerston was often critical of the government's foreign policy, but he was not active in opposition and for the most part led a retired life. Lord John Russell's failure to form an administration in December 1845 was partly due to Earl Grey's objection to the reappointment of Palmerston to the foreign office. But in July 1846 the difficulties were overcome, on the understanding that Russell should exercise a strict control over Palmerston's proceedings. A few days sufficed to demonstrate the futility of this expectation, for Palmerston quickly became involved in a quarrel with France over the marriage of Louis Philippe's son the duc de Montpensier with Luisa, sister and heiress of Queen Isabella II. In 1843 Louis Philippe had agreed that this marriage should not take place until an heir had been born to Isabella, but in 1846 he arranged not only his son's marriage with Luisa but also the marriage of Isabella with her supposedly impotent cousin. Palmerston, who feared that the crowns of Spain and France might thereby become united, was unable to prevent the marriages. This dispute destroyed the Anglo-French alliance and was a contributory cause in the downfall of Louis Philippe (*q.v.*).

The Revolutions of 1848.—During the year 1848 revolutions broke out throughout the continent of Europe and shook every throne except those of Russia, Spain, and Belgium. Palmerston's natural sympathies were with the rebels; he allowed arms made in England to be sent to help the Sicilians against King Ferdinand of Naples, and, when the Hungarian leader Lajos Kossuth visited England in 1851, only the indignation of Queen Victoria and the peremptory veto of the cabinet prevented Palmerston from receiving him at his house in Carlton Gardens. Nevertheless, Palmerston's primary aim was the maintenance of peace, which in his view depended largely on the continued existence of certain powerful states. Although favourable to the establishment of a strong independent state in northern Italy, his encouragement of Charles Albert of Sardinia-Piedmont was tempered by a desire not to weaken Austria and a great fear of French intervention in Italy. His failure to give any practical support to the Hungarians derived from his belief that a strong Austria-Hungary was essential for the stability of Europe. But he showed his disapproval of the way in which Russia and Austria suppressed the revolt, and when the old regimes were restored he was regarded with suspicion and resentment by every major power except France. He himself claimed, with some justice, that his attitude, and particularly his pressure on France, had preserved the peace of Europe.

The Don Pacifico Incident.—In 1850 occurred the incident for which Palmerston is perhaps best remembered and which clearly illustrated the less balanced aspect of his policy. In that year he took advantage of the questionable claims of David Pacifico (*q.v.*) against the Greek government to organize an attack on the little kingdom, where the regime had proved less liberal than Palmerston had hoped. Greece was, by the terms of the 1832 Convention, under the joint protection of Britain, Russia, and France, and the two latter states protested against Palmerston's action. Nevertheless he persevered, despite the risk of provoking war. His policy was censured in the House of Lords but upheld in the House of Commons by a majority of 46 after he had made perhaps the most eloquent and powerful speech of his life.

Dismissal.—Palmerston had not infrequently taken important steps of which the court and most of his colleagues disapproved, and he asserted and exercised an arbitrary dominion over the foreign office. The queen and the prince consort did not conceal their indignation at his behaviour and at the fact that Russell could not control him. In August 1850 the queen required the prime minister to bring to Palmerston's notice a memorandum setting out his obligation as foreign secretary to submit his dispatches for royal sanction and not to alter them after she had seen them. It was not until December 1851, however, that Palmerston provided sufficient excuse for Russell to take action. Without the concurrence of his colleagues and in the face of popular condemnation, Palmerston expressed to the French ambassador his approval of the *coup d'état* of Louis Napoleon (afterward Napoleon III). Russell thereupon dismissed him, and his career as foreign secretary was over.

Home Secretary (1852–55).—Palmerston's career now entered upon a new phase. Just as it had not been expected, in the years between 1809 and 1829, that Palmerston, despite his early promise, would ever become foreign secretary, so, during the following 20 years, it seemed improbable that he would ever become prime minister. He was older than Russell; he was a late recruit to the Whigs; and he was absorbed in the foreign office. But the Pacifico debate, followed immediately by the death of Peel (July 2, 1850), established Palmerston as the most powerful minister in the Commons, and his strident assertion of British nationalism had made him a popular hero. While out of office between 1851 and 1852 he gained an independent following of M.P.'s, and he helped to turn out Russell's government in February 1852. From that time he seems to have been bidding for the leadership of the Whigs. He refused to join the earl of Derby's ministry, but in December 1852 he accepted the office of home secretary in the Earl of Aberdeen's coalition cabinet. There he did valuable work on sanitary, penal, and other social reforms, closing the London burial grounds and forbidding interments in churches, introducing winter assizes to reduce the time spent in awaiting trial, and, with his friend the earl of Shaftesbury, extending the operation of the Factory Acts. He resigned in December 1853, ostensibly because Russell persisted in presenting a project of parliamentary reform which appeared to him unnecessary. But his action was widely interpreted as a protest against the weak policy of the government toward Russia. He rejoined the cabinet little more than a week later and remained loyal to his colleagues during the worst moments of the Crimean War (1854–56). Russell's resignation (January 1855) broke up the ministry in February, and it was discovered that neither he nor Derby could command sufficient support to form a new government. Palmerston, with the country behind him, undertook the task.

Prime Minister (1855–58, 1859–65).—Palmerston's first job was to restore the situation in the Crimea, and this he achieved by a combination of good luck and good judgment. The administra-

tion of the British Army was reformed; Sevastopol was taken in September 1855; and, on March 30, 1856, peace was signed at Paris. The British had been anxious to defeat Russia more thoroughly, but French pressure for a treaty was such that Palmerston thought it necessary to agree. Russia was nevertheless forced to make substantial concessions (*see* EASTERN QUESTION), and Queen Victoria, for once appreciative, conferred on him the Garter, a rare distinction for a member of the House of Commons.

Foreign Affairs.—Palmerston's popularity was now at its height. He was assailed in Parliament by Gladstone, Disraeli, and the Manchester Radicals, but the country was with him. When he sent gunboats to shell forts near Canton after the arrest of the Chinese crew of the Chinese-owned but British-registered lorcha "Arrow" (the Second Chinese War, 1857), Palmerston was defeated by a hostile combination of parties in the House of Commons. He dissolved Parliament and appealed to the nation. The result was a rout of the extreme Radical Party and the return of a majority pledged to support Palmerston. The suppression of the Indian Mutiny (1857–58) further enhanced his prestige.

Very suddenly, however, in February 1858, the House of Commons turned against this overpowerful minister. Palmerston was defeated on his measure to remove conspiracies to murder abroad from the class of misdemeanours to that of felonies, brought in as a consequence of Felice Orsini's attempt on the life of Napoleon III, which had been planned in England. As Russell had done in 1851, the Commons now took the opportunity to bring Palmerston down at a moment when he was thought to be "truckling to France." But in June 1859 he returned to power as head of a broadly based cabinet including Russell and Gladstone and supported by Richard Cobden and John Bright. He remained prime minister until his death and dominated the foreign policy of the government.

Although Palmerston approved the French invasion of Italy (1859) insofar as it contributed toward the establishment of Italian independence, the annexation of Savoy and Nice revived his suspicions of the good faith of Napoleon III. He believed that war with France must be regarded as a possibility, and in 1860 he induced the Commons to vote £9,000,000 for the fortification of British ports and arsenals. He opposed the Suez canal project of Ferdinand de Lesseps on the ground that it would establish a powerful French company on the soil of Egypt.

On the outbreak of the American Civil War in 1861, Palmerston acknowledged that it was the duty of the British government to remain neutral. When, however, two Southern envoys were taken by force from the "Trent," a British packet, he insisted on their release and on a full and complete reparation, and dispatched troops to Canada. He was less correct in his attitude toward the construction in England of privateers for the South; the "Alabama" was allowed to sail (*see* "ALABAMA" ARBITRATION), but when it was learned that two further ships were being built, he solved the problem by suggesting that they should be bought for the British Navy.

The last important foreign question in which Palmerston was involved arose out of the attack (1864) by the Germanic Confederation, under the leadership of Austria and Prussia, on the kingdom of Denmark and the duchies of Schleswig and Holstein (*see* SCHLESWIG-HOLSTEIN QUESTION). Palmerston sympathized with Denmark and in a speech made on July 23, 1863, had suggested that it would receive military aid from Britain. He also tried to induce France and Russia to uphold the protocol of London (1852), which had guaranteed the integrity of the Danish dominions. But these powers held aloof, and the conference called in London in April 1864 was without effect. Palmerston was unable to satisfy the Danish hopes he had aroused, and the Prussian chancellor Bismarck successfully called his bluff and took the first step toward effecting German unification under Prussian leadership. Palmerston's policy during this crisis was censured as one of "meddle and muddle," and he was reduced to defending himself by an appeal to his government's record in domestic affairs. He was saved by Alexander Kinglake's introduction of an amendment that sidetracked the censure motion.

Home Policy.—An appeal to his government's domestic record rang somewhat hollow, for Palmerston had carried little legislation of importance during his premierships. In internal affairs the most important achievements of his ministries were the budgets of Gladstone, chancellor of the exchequer from 1859 to 1866. Especially notable was that of 1860, which reduced the tariff to a minimum and implemented the treaty of commerce with France, negotiated mainly by Cobden. Palmerston was not wholly in sympathy with Gladstone's advocacy of free trade, and opposed it when the loss of revenue resulting from the reduction of tariffs hampered the progress of his own favourite defense schemes. The two men disagreed publicly over the repeal of the duties on paper, which the lords prevented in 1860 but which was carried by Gladstone's pertinacity in the following year. A parliamentary reform bill was introduced by Russell on behalf of the government in 1860 but abandoned in face of the apathy of the Commons. Fully accepting the Reform Act of 1832, which he had helped to pass, Palmerston remained conservative by the standards of the generation which entered Parliament after its passage. He repudiated Gladstone's idea of a large extension of the franchise in 1864, and he saw little need for domestic changes, saying "we cannot go on adding to the statute book ad infinitum."

In 1865 Palmerston dissolved Parliament and won the ensuing general election but died on Oct. 18, at Brocket Hall in Hertfordshire, before he could meet the new House of Commons.

Political and Personal Characteristics.—As prime minister Palmerston showed himself not only efficient, as was to be expected, but also open-minded, good-humoured, and tactful in dealing with the House of Commons and with colleagues of widely differing opinions. He tended to dominate his foreign secretaries, the Earl of Clarendon and Russell, though by skilful management rather than by dictation. But in his second ministry the cabinet was very strong in ability, and he could not always win it to his view. He showed magnanimity toward the Radicals and was loyal, even to a fault, to his subordinates. His popularity at home remained steady, and he came to be regarded as the representative Englishman; usually referred to as "Pam," he was as well known to the general public as Sir Winston Churchill was in his later years. This unique popular appeal and his pragmatic approach to home affairs enabled him to dominate political life in his last years. During the transitional period when the power of patronage had dwindled low and the power of the party machine had still to rise high, Palmerston provided an element of stability in political life. The Conservative split of 1846 had ensured that the Liberal side of the House of Commons should be in the majority. It was Palmerston who gave to this majority some cohesion, by making few demands on his supporters' loyalty, by accepting wide variations of opinion among them, and by falling back, in case of need, on the reluctant admiration of the Tory opposition. They preferred him to any other Whig; the Liberals preferred him to any Tory. Although his tenure of power delayed reforms, he did much to maintain Liberal strength in the House of Commons and in the country and, under his leadership, the Whig-Radical coalition was gradually forged into the Liberal Party of Gladstone's heyday.

It is, however, by his successes as foreign secretary that Palmerston is chiefly remembered. The most durable of these, little noticed at the time, concerned what he called the main object of his public life—the extirpation of the slave trade. The creation of Belgium was one of his major achievements. Otherwise, what most caught the imagination of his countrymen was his constant, high-spirited assertion of British power, based on the existence of a British Navy then universally regarded as invincible. By his extensive publication of diplomatic papers he was largely responsible for the growth of popular interest in, and knowledge of, foreign affairs.

Palmerston appeared to many an uncomplicated character, the type of the bluff, good-humoured, manly, insular Englishman. He was admired for his defiance of foreigners, of the British climate, and of age. On his 80th birthday he was on horseback nearly all day, inspecting the fortification of the south coast. But he was in fact far from typical, in his knowledge of languages and of foreign countries, and in his ability and industry. Beneath the unruffled, frank exterior he was passionate and calculating.

His private life was very free in his youth but became suddenly cozy and respectable when he married (December 1839), at the age of 55, Lady Cowper (formerly Amelia Lamb), sister of Lord Melbourne, whom he had loved for years while she was Lord Cowper's wife. She assisted his career by making his house the social centre of politics, and survived him by four years.

See also references under "Palmerston, Henry John Temple" in the Index.

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PALMERSTON NORTH, a town in the Wellington land district of the North Island, New Zealand. It lies on the Manawatu River at the crossing of the main trunk railway, 80 mi. NE of Wellington. Pop. (1961) 41,014. The town has a large central square and numerous parks and gardens; it is the seat of a university college, of the Massey Agricultural College and of the Dairy Research Institute. Palmerston North's industries include manufacturing works, knitting mills, a box factory, and a printing plant. It is the market and distribution centre for the fertile surrounding pastoral district. The town is served by the national airline and is a railway and road junction. (A. M. P. H.)

PALMETTO, a popular name for any of several fan-leaved palms, especially *Sabal* species. The common palmetto, or cabbage palmetto (*Sabal palmetto*), is a native of the southeastern United States. It has an erect stem, up to 80 ft. high, and deeply cut fan-shaped leaves, 5 to 8 ft. long; the fruit is a black drupe ¼ to ½ in. long. The trunks make good piles for wharves, as the wood resists the attacks of borers; the leaves are used for thatching. The palm is grown as a pot plant in greenhouses. A similar species, the Texas palmetto (*S. texana*), occurs in southern Texas and Mexico. The terminal bud, or "cabbage," is eaten. The dwarf palmetto (*S. minor*) appears to be stemless, its leafstalks arising from the ground, while the Bermuda palmetto (*S. blackburniana*) has a moderately long trunk, sometimes 35 ft. tall. Other palms called palmetto because of their resemblance to *Sabal* species are *Serenoa repens*, the saw palmetto, and *Rhapidophyllum hystrix*, the needle palm or blue palmetto. *See* also PALM.

PALMGREN, SELIM (1878–1951), Finnish pianist and composer who helped establish the school of Finnish national music. Born at Björneborg (Pori) on Feb. 16, 1878, he entered the Helsingfors (Helsinki) Conservatory in 1895, studying composition with Martin Wegelius and the piano with Walter Petzet. From 1899 to 1901 he studied with Busoni in Germany and later continued his studies in Italy. In 1909 he was appointed conductor at Åbo (Turku), Finland, where his opera, *Daniel Hjort*, was produced the following year. It was revised by Palmgren for its production in Finnish at Helsinki in 1929. From about 1912 he toured Europe as a pianist, sometimes accompanying the singer Maikki Pakarinen (d. 1929), whom he had married in 1910. He visited the U.S. (1920–21) and in 1923 taught composition at the Eastman School of Music, Rochester, N.Y. In 1930 he was a music critic in Helsinki and in the same year married the singer Minna Talwik. From 1939 to 1951 he was professor of composition at the Sibelius Academy at Helsinki, where he died on Dec. 13, 1951. Palmgren is best known for his smaller piano pieces, among them the *Finnish Lyric Pieces*, inspired by folk songs. In his larger piano works, notably his piano concertos, he was influenced by Liszt. His memoirs were published at Helsinki in 1948.

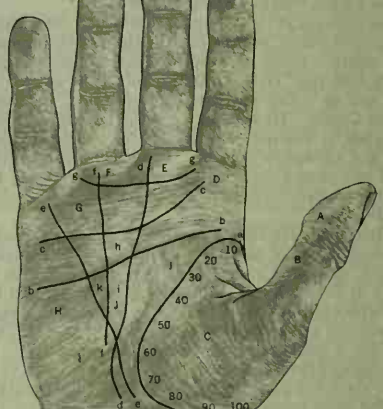
PALMISTRY (CHIROMANCY, CHIROSOPHY), a system of divination (*q.v.*) in which the structure of the hand is interpreted as being associated with the psychology and future of the individual. It is said to have existed in China as early as 3000 B.C., and in Greek literature it is treated even in the most ancient writings as well-known belief.

In most modern countries, palmistry has little popular acceptance or influence, but it has been heavily practised in modern China, combined with podoscopy (divination by means of the feet). Chiromancy is also extensively practised in India. In 20th-century Syria and Egypt the palmist has been seen plying his trade at the cafés, and among Arabs chiromancers are consulted as to the probable success of enterprises. It was probably from their original Indian home that the traditional fortunetelling of the gypsies was derived.

The system has the charm of simplicity and definiteness, as an application of the doctrine of signatures. In the course of ages every detail has been brought under a formal set of rules, which need only mechanical application. In past times there were considerable divergences in the practice, but at present there is a fairly uniform system. One school lays special stress on the general shape and outline of the hand. Such characteristics as softness or hardness and dryness or moisture are also taken into account.

The lines held to be of cardinal importance are shown in the figure. These lines isolate certain swellings or monticuli, also illustrated. The relative sizes of these mountains are assigned definite psychological and predictive correlates: the mount of Venus with charity, love, libertinage; the mount of Jupiter with religiosity, ambition, love of honour, pride, superstition; the mount of Saturn with wisdom, good fortune, prudence (or when deficient improvidence, ignorance, failure); the mount of the Sun when large is said to make for success, celebrity, intelligence, audacity, when small meanness or love of obscurity; the mount of Mercury indicates love of knowledge, industry, aptitude for commerce, and in its extreme forms on the one hand love of gain and dishonesty, on the other slackness and laziness. The mount of Mars is related to degrees of courage, resolution, rashness, or timidity; the mount of the Moon indicates sensitiveness, morality, and good conduct, or immorality, overbearing temper, and self-will.

The swellings on the palmar faces of the phalanges of the several fingers are also held indicative, the first and second of the thumb, respectively, of the logical faculty and of the will; the first, second, and third of the index finger, of materialism, law and order, idealism; those of the middle finger, humanity, system, intelli-



DETAILS EXAMINED IN CHIROMANCY

(A) first phalanx; (B) second phalanx; (C) mount of Venus; (D) mount of Jupiter; (E) mount of Saturn; (F) mount of Apollo; (G) mount of Mercury; (H) mount of Mars; (I) mount of the Moon; (J) plain of Mars; (ae) line of life (numbers indicate years); (bb) line of the head; (cc) line of the heart; (dd) line of Saturn or fate; (ee) line of the liver; (ff) line of Apollo or fortune; (gg) ring of Venus; (h) the quadrangle; (i) triangle; (j) upper angle; (k) inner angle; (mmm) rascettes or bracelets

gence; of the ring finger, truth, economy, energy; and of the little finger, goodness, prudence, reflectiveness.

Over and above these there are other marks, crosses, and triangles, of which more than 100 have been described and figured by different authors, each with its interpretation; and in addition the back of the hand has its ridges.

To the anatomist the roughnesses of the palm are of considerable interest. The folds allow the thick skin to bend in grasping, while the skin is tied by connecting fibres of white fibrillar tissue to the deep layer of the dermis along the lateral and lower edges of the palmar fascia and to the sheaths of the flexor tendons. The folds vary with the relative lengths of the metacarpal bones, with the mutual relations of the sheaths of the tendons and the edge of the palmar fascia, somewhat also with the insertion of the palmaris brevis muscle (*see* HAND).

Subcutaneous fat is restricted to the intervals between the lines along which the skin is anchored and makes these intervals project; these are the monticuli. The swelling of the mountain of Venus indicates the size of the muscles of the ball of the thumb and can be increased by exercise. Similarly the hypothenar muscles for the little finger underlie the three ulnar marginal mountains, the sizes of which depend on their development and on the prominence of the pisiform bone.

The belief that these structures have psychic or occult predictive meaning lacks scientific support. However, the hands do show evidence of their owner's health, cleanliness, occupational and nervous habits (*e.g.*, as evidenced by calluses or nail-biting). Hands are routinely examined in medical diagnosis and provide clues with which the palmist may often astound the unsophisticated. *See* also FORTUNETELLING.

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PALMITIC ACID is one of the more important straight-chain, saturated fatty acids (*see* CARBOXYLIC ACIDS). It occurs in practically all natural fats and oils, often associated with stearic acid; because of its wide occurrence it is often regarded as the characteristic saturated acid of natural fats. Many fish oils contain about 10%, cottonseed oil about 20% and palm oil up to 40% of palmitic acid. Like the other fatty acids, it does not occur in the free state but is normally found as an ester of glycerol, called a glyceride, or as an ester of a long-chain alcohol. Tripalmitin (*see* below), the triester of glycerol and palmitic acid, is a typical example of a triglyceride.

Palmitic acid, $CH_3(CH_2)_{14}CO_2H$, is a colourless solid existing in various crystalline forms of which the one melting at 62.9° C. is the most stable. It is a monocarboxylic acid and shows all the reactions typical of this class of compound, such as the formation of esters by reaction with alcohols, *e.g.*:

$$C_{15}H_{31}.CO_2H + MeOH \longrightarrow C_{15}H_{31}.CO_2Me + H_2O$$

in which Me represents the methyl group. Another example is the formation of its acid chloride by treatment with phosphorus pentachloride or oxalyl chloride,

$$C_{15}H_{31}.CO_2H + PCl_5 \longrightarrow C_{15}H_{31}.COCl + POCl_3$$

Soaps are the sodium or potassium salts of long-chain carboxylic acids and the potassium salt of palmitic acid is the major constituent of shaving creams and some liquid soaps. However, its use in these cases is diminishing as a result of the adoption of other detergents. Soap manufacture is the alkaline hydrolysis of glycerides and is often referred to as saponification. Hydrolysis of tripalmitin is a representative saponification reaction:

$$\begin{array}{l} C_{15}H_{31}.CO.O.CH_2 \\ | \\ C_{15}H_{31}.CO.O.CH \\ | \\ C_{15}H_{31}.CO.O.CH_2 \\ \text{tripalmitin} \end{array} + 3\,KOH \longrightarrow \begin{array}{l} \text{potassium} \\ \text{hydroxide} \end{array} \quad 3C_{15}H_{31}.CO_2K \quad \begin{array}{l} \text{potassium} \\ \text{palmitate} \end{array} + \begin{array}{l} CH_2.OH \\ | \\ CH.OH \\ | \\ CH_2.OH \\ \text{glycerol} \end{array}$$

It has been established that palmitic acid, which contains 16 carbon atoms, is biosynthesized from acetic acid, which contains 2 carbon atoms, by a process involving acetyl-coenzyme A as the intermediate. The transformation *in vivo* of palmitic to stearic acid is possible by a further condensation involving acetic acid. *See* also OILS, FATS AND WAXES.

See K. S. Markley, *Fatty Acids, Their Chemistry and Physical Properties* (1947); A. E. Bailey, *Industrial Oil and Fat Products* (1945). (W. D. OS.)

PALM OIL: *see* OIL PALM; OILS, FATS AND WAXES.

PALM SPRINGS, a city of Riverside county, in southern California, U.S., celebrated as the originator and model of the desert resort city. Almost 100 mi. E. of Los Angeles, it enjoys popularity as a resort from January through April. The climate is dry, warm and stimulating. Even in summer, when the heat is excessive, many persons, often aided by air-conditioning, live in Palm Springs. The town is beautifully situated in the Coachella valley, immediately under the precipitous slopes of Mt. San Jacinto.

The Agua Caliente Indians, who live in the area, possess (under treaty) alternate sections of land in the city. Palm Springs' modern history began in 1909 when Nellie N. Coffman founded a sanatorium there. This later became the Desert Inn. The potentialities for a general resort began to be realized in the 1920s under the leadership of Philip L. Boyd, who became the city's first mayor when it was incorporated in 1938.

For comparative population figures *see* table in CALIFORNIA: *Population*. (A. C. TR.)

PALM SUNDAY, the first day of Holy Week (*q.v.*) and the Sunday before Easter, so called from the blessing and procession of palms (*i.e.*, leaves from the date palm or twigs from trees locally available) that is customary on this day in commemoration of Christ's triumphal entry into Jerusalem. These special ceremonies were already taking place toward the end of the 4th century in Jerusalem and are described in the *Peregrinatio Etheriae* (*q.v.*; *see* also CHURCH YEAR); in the West the earliest evidence of them is found in the Bobbio sacramentary (8th century). During the Middle Ages the ceremonies were elaborated: the procession went from one church (where the palms were blessed) to another where the Mass was sung. The principal feature of the Mass which follows the procession is the chanting of the account of the passion of Christ by three deacons, one taking the part of Christ, one the narrative part and the third singing the words of the apostles and the crowd (Matt. 26:36–27:54). Musical settings for the crowd parts are sometimes sung by the choir. After the reform of the Roman Catholic liturgy for Holy Week in 1956 the ceremonies were somewhat simplified. The palms should be blessed outside the church and the procession then goes to the church. The day is now called Second Passion Sunday or Palm Sunday.

In the Byzantine liturgy the Eucharist on Palm Sunday is followed by a procession in which the priest carries the icon representing the events commemorated on this day. Some of the traditional ceremonies were revived in Anglican Churches in the 19th century.

See H. Thurston, *Lent and Holy Week* (1904); R. Peil, *A Handbook of the Liturgy* (1960). (L. C. S.)

PALMYRA, an ancient city, in modern Syria, located in the desert about 90 mi. (145 km.) E of Homs and 150 mi. (240 km.) W of the Euphrates. The name "Palmyra" does not derive from the extensive palm groves of the oasis but is the Greek and Latin form of TADMOR, the pre-Semitic name of the site, still in use in modern times.

History.—A Tadmorean appears on an Akkadian tablet from Cappadocia in the 19th century B.C. In the following century Tadmor and its inhabitants are named in two letters from Mari, and at the end of the same millennium Tiglath-pileser I "defeated the Akhlame-Aramaeans from Tadmor in the land of Amurru" to Babylonia. Toward the middle of the 10th century, Solomon is said to have built "Tadmor in the wilderness," but this assertion of II Chron. 8:4 is a rewriting of I Kings 9:18, where it is said that Solomon built Tamar, to the south of the Dead Sea. The Chronicler, wishing to illustrate the extension of Solomon's kingdom as far

as the Euphrates (*cf.* I Kings 4:21; Hebrew text 5:1), replaces Tamar in Palestine with Tadmor in Syria. This rehandling is evidence that Tadmor was already an important city in the 3rd century B.C., which presupposes that the Seleucids, who were ruling in both Mesopotamia and Syria, had made the road through Palmyra one of the routes of east-west trade.

Two centuries later, this trade had already reached international proportions. This is clear from a passage in the 2nd-century historian Appian: in 41 B.C.,

> Antony sent his horsemen to Palmyra . . . with orders to sack it. He had no grievances against the Palmyrenes, situated between Romans and Parthians, except their astute policy. They were merchants who sought in Persia the products of India and Arabia to resell them among the Romans . . . . But the Palmyrenes . . . crossed the Euphrates with their goods . . . and stationed archers along the bank. The horsemen fell upon a deserted city (*Civil Wars*, v, 9).

Pliny's reference to "the privileged position" of Palmyra and its role of arbiter between the Romans and the Parthians (v, 25, 88) concerns the same period, although the *Natural History* did not appear until A.D. 77. To judge from the earliest Palmyrene inscriptions, power was still in the hands of the tribes who made up the local population. These met in a popular assembly and elected a chief. It was under Tiberius (at the latest) that this autonomy came to an end. In A.D. 17 the emperor sent his adopted son Germanicus to the east, and a dedication at Palmyra by the legate of *legio X Fretensis* marked his passage. The governor of the province of Syria was represented there by an official (*tetagmenos*). About 129, the emperor Hadrian visited the city, which took the name of Hadriana Palmyra and became a *civitas libera*, which gave it a certain financial independence under the control of an imperial curator. It was granted the title of *colonia*, with exemption from taxes, by Caracalla between 212 and 217. The age of the Antonine and Severan emperors was the most prosperous for Palmyra, and the activity of traders and soldiers from the city is attested at this time from Rome to the Persian Gulf.

When under Ardashir I (*c.* 224–*c.* 240) the Sasanians supplanted the Parthian dynasty of the Arsacids in Iran and southern Mesopotamia, the road to the Persian Gulf was soon closed to Palmyrene trade. These difficulties, to which was added the instability of the Roman Empire, favoured the setting up of a personal rule at Palmyra, where authority had hitherto been regularly exercised by the Senate and two archons, later two strategi. At the beginning of the 3rd century, the city of Tyre honoured (with a statue?) a Palmyrene, "the *clarissimus* Septimius Odainath," explicitly styled "senator" (Roman) in his epitaph. The history of his family is known from inscriptions and above all from the *Augustan History* (*q.v.*) and Zosimus. In 251, in a Greek dedication in the Great Colonnade at Palmyra, his son Septimius Hairan bears the same title, but with that of "exarch of the Palmyrenes," rendered by the corresponding Palmyrene text as "chief of Tadmor." It was Odainath the younger (his brother rather than his son; better known by his Latin name Odaenathus) who brought this family of Arab origin—his great-grandfather bore the Arab name of Wahballat—into world history. He was appointed governor of Syria Phoenice by Valerian, who was captured by Shapur I in 260. But on the return journey the Sasanian king was attacked by Odaenathus, who granted himself a title identical with Shapur's, "king of kings." It was apparently Gallienus who conferred on him that of *corrector totius Orientis* ("governor of all the east"). In 261 he relieved the emperor of two pretenders, Ballista and Quietus. On two occasions, apparently (262 and 267 or 268), he pushed his troops up to the walls of Shapur's capital, Ctesiphon. Odaenathus' eldest son, called Herodianus and Herodes, had taken part in his father's campaigns and also received the title of "king of kings," and therefore of heir apparent. Both were assassinated shortly after the last campaign, when Odaenathus was preparing to take part in the struggle against the Goths in Asia Minor. (*See* also ODAENATHUS.)

Odaenathus' wife, Zenobia (*q.v.*), reputedly had a hand in the murder, out of jealousy at seeing this son of a previous marriage preferred to her son Wahballat (Latin Vaballathus). The queen governed effectively and had her son take his father's titles of "king of kings" and *corrector totius Orientis*. In 270 the armies of Palmyra entered Asia Minor and Vaballathus proclaimed himself *imperator*, still recognizing Aurelian as *Augustus*. During the winter of 270/271 Zabdas, the Palmyrene general in chief, seized Egypt. A year later Zenobia and Vaballathus proclaimed themselves *Augusti*, but Aurelian regained Asia Minor and defeated Zabdas' cavalry at Antioch and Emesa. The Palmyrenes evacuated Egypt. Aurelian advanced as far as Palmyra. During the siege, Zenobia escaped to ask Shapur for help but was recaptured by Roman cavalry. Palmyra opened its gates to the emperor (autumn 272). Zenobia and her son were taken prisoner. The following year the inhabitants proclaimed emperor a relative of Zenobia's, and Aurelian had to leave the Danube for Palmyra, which he took without a struggle and gave over to pillage and fire (273). Zenobia and two of her sons, Herennianus and Timolaus, graced the triumph which Aurelian celebrated in 274.

The subsequent history of Palmyra is of purely local interest. Under Diocletian part of the city was surrounded with a stout wall. It remained the chief station on the *strata Diocletiana* which linked Damascus to the Euphrates. But Palmyra was becoming a Christian city, and in 325 its bishop, Marinus, attended the Council of Nicaea. In 634 Khalid ibn al-Walid took Palmyra in the name of the caliph Abu Bakr. Since the end of the Ottoman Empire after World War I, Palmyra, situated on the Kirkuk-Tripoli pipeline and at the junction of the routes through the Syrian Desert, has become a town of about 12,000 inhabitants (there could have been 30,000 in Zenobia's time).

Language and Script.—To judge from personal names, the population of Palmyra in Greco-Roman times already included as many Arabs as Aramaeans, but the language and to a large extent the religion remained Aramaean. Palmyrene is a continuation of "imperial Aramaic" as it is known from the Elephantine papyri and the Book of Ezra. Since the oldest dated inscription is only from 44 B.C., it is not surprising that Palmyrene appears more developed than the Judaeo-Aramaic illustrated by the Book of Daniel and the Dead Sea Scrolls. Thus in the perfect the final *-ā* of the feminine plural is replaced by the *-ū* of the masculine; the causative form is *af'el*, not *haf'el*. It is close to Nabataean, but without its archaic features. Thus the suffix *-hōm* (third person plural) becomes *-hōn* in Palmyrene. Above all, it exhibits certain "eastern" features, like the plural in *-ē*, characteristic of two neighbouring dialects, Old Syriac and Hatraean. These are intrusive elements, found in Palmyrene side by side with the corresponding "western" forms; thus *taggārē*, "merchants," beside *taggārayya*, much more common.

There are no grounds for concluding that the spoken language of Palmyra was East Aramaic, and that only the official language of inscriptions remained imperial Aramaic. The script also reflects Palmyra's position between east and west; there are really two scripts. The monumental script is at first remarkable for its spacious curves, but from the time of Hadrian it contracts, with elegant breaks in the letters. At the same time a Mesopotamian cursive appears at Palmyra, akin to the Syriac script and used by the Palmyrenes established at Doura-Europus (*q.v.*) ever since 33 B.C. Both cursive and monumental derive from the Aramaic cursive of the Seleucid Empire. Nearly 2,000 Palmyrene inscriptions have been discovered, some of which also include a parallel text in Greek and occasionally in Latin as well. Most are votive, honorific, or funerary inscriptions; no records, public or private, have yet been discovered. It is not known whether the Palmyrenes composed works of literature in Aramaic, but the liturgy certainly used that language. The *Augustan History* records that Zenobia dictated a letter to Aurelian in Aramaic, but the Neoplatonic philosopher Longinus lived at her court and she was in regular correspondence with the bishop Paul of Samosata, whom Aurelian expelled from his see of Antioch. Greek was therefore the vehicle of ideas at Palmyra. (*See* also ARAMAEANS; SEMITIC LANGUAGES.)

Trade.—The great bilingual inscription known as the Tariff of Palmyra (*Corpus Inscriptionum Semiticarum*, ii, 3913) and those carved below the (lost) statues of the great caravan leaders, particularly in the agora, as also the data of the *Periplus of the Erythraean Sea* concerning the products bought in India, give information about the organization and nature of the trade of the

Palmyrenes. Rich citizens like Marcus Ulpius Yarhai, honoured with a dozen statues, financed the caravans. Palmyrene commercial settlements served the stations in the Parthian cities through which the caravans passed; the texts name Seleucia on the Tigris and its river port Vologesias, then Babylon, Forat (Basra) and finally Charax at the mouth of the Tigris. This was the capital of Mesene, a vassal kingdom of the Parthians. At Charax one took ship for Scythia (*i.e.*, India), and the names of two Palmyrene captains are known. Their ships brought back spices, pearls, turquoises, dyestuffs, and fabrics—Indian cottons and Chinese silks, fragments of which have been found in the tombs of Palmyra. Some of the trade probably used the "silk road" across the plateaus of Asia.

The Roman customs stationed on the Parthian frontier levied a heavy duty on merchandise, probably a quarter of its value. The municipality of Palmyra, through a publican, exacted duty on what was made or used on the spot. These (not the customs dues) are the dues listed in the Tariff. They affected salt, purple wool, perfumed oil (called myrrh in the Greek text), bronze statues, slaves, etc. Goods in transit were probably put in bond untaxed. Profits were considerable, as the value of an article could increase 100-fold from the east to Rome (Pliny, *Natural History*, vi, 23, 101).

The Palmyrenes did not merely work the Persian Gulf route. A Greek inscription from Coptos on the Nile talks of "the Erythraean [Red Sea] shipowners from Adriana Palmyra." The Palmyrene dedications found at Rome were doubtless made by traders. Palmyrenes were numerous at Doura-Europus, although that city, situated on the Euphrates, was too far north to constitute a regular stage on the way to the Persian Gulf. There was a troop of Palmyrene archers there even during the time when the Parthians were masters of it; they would then be mercenaries in Parthian service. Many Palmyrene archers served in the Roman army, and are found mounted on dromedaries in North Africa and as cavalry in the Danubian provinces.

The Monuments.—The ruins allow the network plan of the city to be clearly seen. At first glance, everything recalls Greco-Roman art. The principal axis, oriented east-west, is a street with a double portico (still partly standing; the Great Colonnade) and ornamented with three nymphaea. In the centre the Tetrapylon is made up of four piers, each bearing four columns. To the south are the agora (a square with four colonnades), the Senate house and the theatre. A little to the east a temple was uncovered in 1963–64 by Syrian archaeologists who attributed it provisionally to the god Nabu. North of the Tetrapylon a Swiss mission (1954–56) brought to light the courts and numerous reliefs of the sanctuary of Baal Shamen, the "lord of heaven." At the western end, a Polish mission (1959 onward) excavated the vast complex called Diocletian's camp, which some interpret as Zenobia's palace. At the eastern end, a triumphal arch of triangular plan joins the Great Colonnade to the avenue leading to the monumental entrance of the chief sanctuary of Palmyra, dedicated in A.D. 32 to Bel, Yarhibol, and Aglibol (French excavations). The court has four porticoes and measures nearly 700 ft. (200 m.) a side; it includes a ritual basin and a large altar for sacrifices (an arrangement recalling that of the Temple at Jerusalem), as well as a banqueting hall. The cella is peripteral and has an adyton (niche for the cult image) at each end (as a rule Syrian temples have only one).

Palmyrene art is a branch of Greco-Oriental art. In architecture, the Corinthian order marks almost all the monuments, but the abundance of scrolls and geometrical motifs, the low relief, the preference for frontal representation, and the hieratic nature of the images of gods reveal the influence of Mesopotamia and Iran. Parthian (later Sasanian) costume alternates with the toga or Hellenistic (and later Roman) military costume. The jewelry of the female busts, simple at first, becomes progressively heavier. The frescoes of the hypogea (underground funerary chambers) of Palmyra and the places of worship in Doura make known even the glistening colours of the materials. Funerary architecture includes an original type of mausoleum: the funerary tower with several stories of burials. From the 2nd century this gives place to the hypogeum (of Alexandrian type) and the funerary temple.

Religion.—The principal deity of the Aramaeans of Palmyra was Bol, probably merely a local pronunciation of Baal (*q.v.*), "lord." Bol soon became Bel by assimilation to the Babylonian Bel-Marduk. Like the latter, he presided over the movements of the stars, and the Palmyrenes associated with him the sun and moon gods, Yarhibol and Aglibol. Another heavenly triad formed around the Phoenician god Baal Shamen, the "lord of heaven," more or less identical with Hadad (*q.v.*). But here the sun was Malakbel, originally a vegetation god. The sun was also worshiped under the name of Shamash, probably introduced by the Arabs. The same is true of Arsu ("the kindly") and Allat, "the goddess" par excellence, identified with Athena. It was Astarte (and probably also Astor) who corresponded to Aphrodite (*see* ASTARTE). The Syrian Atargatis (*q.v.*) and the Babylonian Nabu (*q.v.*; at once Mercury and Apollo) were equally popular. But over against this heterogeneous polytheism there emerged from the 2nd century A.D. the Unnamed God, "he whose name is blessed for ever, the merciful and good." This was a refined version of the cult of Baal Shamen as "lord of the world." The importance of thiasoi (religious associations) and religious banquets should also be underlined; the terra-cotta entrance tokens (more than a thousand different types are known) give abundant information about these. Festivals followed the calendar of the rest of Syria: vernal and luni-solar, with intercalary months.

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PALO ALTO, a city of Santa Clara county, California, U.S., and the seat of Stanford University (*q.v.*), is about 30 mi. SE of San Francisco. It is one of a string of suburban cities along the densely built-up bay shore of the San Francisco peninsula. Rolling hills and a spur of the coast range separate it from the Pacific Ocean 18 mi. SW. Gaspar de Portolá's 1769 expedition is said to have camped near El Palo Alto, the tall redwood tree from which the city derived its name. Palo Alto was laid out in 1891 as a "dry" village for Stanford University, and deeds still prohibit liquor sales in the original townsite; the population, however, soon pushed boundaries into surrounding "wet" territory. World War II began an inrush of industries and boosted the population of the little residential city to 52,287 (1960). (For comparative population figures *see* table in CALIFORNIA: *Population.*) As expansion in other directions was blocked by neighbouring cities and the bay shore, Palo Alto, by annexation, continued to press into the western hills. Charter revisions in 1950 brought a city manager and a centralized administration.

Pioneer radio experiments by Lee de Forest and others paved the way for a concentration of electronics laboratories and plants. The Ames Aeronautical laboratory and Stanford Medical School attracted various types of industry and research admitted under stringent planning requirements. (E. V. C.)

PALO ALTO, a site in southeastern Texas about 9 mi. NE of Matamoros, Mex., was the scene of the first battle of the war between the United States and Mexico (1846–48). Mexican troops had crossed the Rio Grande to besiege Ft. Brown across the river from Matamoros, and to threaten Gen. Zachary Taylor's supply centre at Point Isabel. Taylor, with an army of about 2,200, marched along the road from Point Isabel to Matamoros. The two armies met at Palo Alto in the middle of the afternoon, May 8, 1846.

The Mexican commander, Gen. Mariano Arista, hoped to win through superiority in numbers and the use of crack cavalry units, but Taylor's superior artillery repulsed the attacks by the Mexicans. When night ended the fighting, both armies occupied approximately the same ground as at the beginning of the battle. The Mexican forces, however, had suffered much greater casualties,

and their officers and men were disheartened by their lack of success. Early the following morning they retired southward to a defensive position near Resaca de la Palma, where another minor battle was fought the next day.

See Robert S. Henry, *Story of the Mexican War* (1950); Holman Hamilton, *Zachary Taylor, Soldier of the Republic* (1941). (H. W. Bv.)

PALOLO WORM, a polychaete annelid (*Palola viridis*, also known as *Eunice viridis*) that inhabits coral reefs in the Polynesian Islands of the South Pacific and that exhibits remarkable lunar periodicity in its reproduction. The palolo (the Samoan name) were considered delicacies by the Polynesians, who gathered them for a feast. They appear regularly in enormous numbers in the early morning for two days during the last quarter of the moon in October (a small swarming) and November (a vastly larger swarming). The islanders can predict the appearance of the worms by observing the phases of the moon.

The adults live in cavities of the coral reef rock. At the time of reproduction, the much longer, thinner posterior regions, filled with sex products, become detached and swim to the surface of the sea where the eggs and sperm are discharged; the shorter, thicker anterior regions remain in the reef rock and regenerate new posterior ends. The Atlantic palolo (*Eunice schemacephala* or *Eunice fucata*) is widely distributed in the rock coral of the West Indian region, and has similar swarming habits. The posterior epitokous regions appear in the plankton about daylight during the last quarter of the June–July moon. The swarming of the palolo worm, in relation to the phases of the moon, has been the object of considerable research in biological rhythms. *See* also ANNELIDA.

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PALOVERDE (Span. *palo verde*, "green tree"), the name given to the genus *Cercidium* of the pea family (Leguminosae), comprises a small group of trees and shrubs scattered through the arid regions of southwestern United States, Mexico, Central America, and Venezuela. Three species are indigenous to the United States, two of which become arborescent. Blue paloverde (*C. floridum*) is a grotesque tree, 15 to 20 ft. high, found in desert areas of southern California, Arizona, and Mexico, including lower California. It is usually a short-trunked, intricately branched tree, with smooth, conspicuously green bark, and minute leaves which quickly wither and fall, their function being assumed by the green elements (chlorophyll) in the bark. The bright yellow flowers, borne in axillary clusters, are followed by cylindric beanlike pods about three inches long. The paloverde is a characteristic woody plant along washes in the Colorado desert. Border paloverde (*C. macrum*) is a Mexican tree which attains its northern limits in southeastern Texas. It may be distinguished readily from the former species by its flattened, podlike fruits. (E. S. Hr.)

PALUDAN-MÜLLER, FREDERIK (1809–1876), Danish poet whose work expresses a moral criticism of the aestheticism of the Romantic movement. The son of a clergyman who later became bishop of Aarhus, he was born on Feb. 7, 1809, at Kerteminde on the island of Fünen. In 1835 he graduated in law at Copenhagen, but meanwhile he had gained fame as a poet with *Danserinden* (1833), an epic in three cantos written in Byronic ottava rima. The narrative is interrupted by numerous digressions, mainly expressing ideas of love and passion also borrowed from Byron.

The world-weariness expressed in Paludan-Müller's poetry at this time was not a mere literary fashion, however. In the 1830s the popular young poet passed through a mental and religious crisis, during which he was nursed by his cousin, Charité Borch, whom he married in 1838. With her he was able to achieve the mental harmony and spiritual strength preached in his later work. He withdrew from society and until his death (in Copenhagen, Dec. 28, 1876) lived almost in seclusion.

His main work, *Adam Homo*, the first part published in 1841, the remaining two parts not until 1848, is an epic in 12 cantos, again in ottava rima. Its hero, the gifted and good-natured son of a clergyman, climbs the ladder of social success and ends by becoming a baron. The poem is a satire on human nature: Adam, as he becomes successful, also becomes shallow, and gradually loses his individuality. It is only through the faithful love of Alma Stjerne, whom he has jilted, that, in the apocalyptic final canto, he is saved from doom. The story unfolds against the background of contemporary Danish society, which is described with satirical wit, and when the first part appeared, it was received as the beginning of a Danish *Don Juan*. Paludan-Müller no longer shared Byron's conception of love, however, and through Alma he expounds his new theory of will and obedience.

His later works are mainly imaginative and philosophical poems expressing a lofty idealism. They include dramatic poems based on mythology (*Venus*, 1841; *Dryadens Bryllup* and *Tithonus*, both 1844); biblical epics (*Abels Død*, 1844); a narrative in dialogue form (*Benedikt fra Nurcia*, 1861); a drama (*Kalanus*, 1854, in which Alexander the Great kneels before the Indian prophet of renunciation); and *Adonis*, his last poem, published in 1874. Paludan-Müller's *Poetiske Skrifter* were published in eight volumes (1878–79). A selection was edited by Carl S. Petersen, three volumes (1909).

Paludan-Müller's theme, constantly discussed and amplified in his poems, is the fundamental conflict between passion and intellect, pleasure in the world and renunciation of it, life and death. He stands as the counterpart of Adam Oehlenschläger (*q.v.*), and *Adam Homo* may be regarded as a revised *Aladdin*, in which Oehlenschläger had expressed the spirit of Danish romanticism.

See V. R. A. Andersen, *Paludan-Müller* (1910). (O. A. F.)

PALYNOLOGY, the branch of natural science that deals with the structure and classification of the discrete microscopic products of plant life commonly known as pollen grains and spores, as well as certain minute organisms and parts of organisms. The study embraces both living and fossil forms. In substance, palynology as a field of research is more comprehensive than "pollen analysis," the science from which it was derived, and has implications and relationships with the earth sciences as well as the plant sciences, especially those aspects dealing with historical geology, stratigraphy, and paleontology. In addition to pollen grains and spores, it is appropriate to include in palynology the study of a variety of microscopic planktonic organisms, many of uncertain position in the evolutionary scheme, such as coccolithophorids, discoasters, hystrichosphaerids, and dinoflagellates. The field does not embrace the biological behaviour and physiological activity of these organisms and of pollen and spores, but rather their description, classification, and distribution in time and space. Certain well-defined groups of microorganisms such as diatoms and the protozoa are conventionally excluded from the province of palynology.

Because of their minute size (usually less than 100 microns), production in enormous numbers, and widespread distribution by wind and water, the objects of palynological study occur as fossils in a wide range of sedimentary rocks. Because of high resistance to decay and to physical alteration, fossil pollen grains, spores, and planktonic organisms may be examined in much the same way as parts of living plants. In order to examine them individually, however, it is necessary first to free them from their sedimentary matrix. This is effected by a variety of physical and chemical techniques, including solution or disaggregation of the mineral or organic matrix, flotation in heavy liquids, bleaching, and staining. The objective in all procedures is to free the microfossils and prepare them for study at high magnification.

The concentration of pollen grains, spores, and other microscopic entities varies widely in diverse sediments. In certain coals (cannel coal) they are among the dominant constituents of the entire sediment, whereas in limestones and sandstones the concentration may be extremely low. In many sediments externally devoid of fossils the utilization of palynological techniques yields large assemblages of identifiable microfossils.

The phases of palynology that deal exclusively with fossils are outgrowths and extensions of methods and principles that were developed in the study of peat deposits of northern Europe during

the early decades of the 20th century. In these studies the presence, absence, and relative abundance of the pollen of various species of trees from known depths in the bog were statistically determined. Inasmuch as the forest composition determines the pollen types that are trapped on the surface of a bog at any given time, it follows that changes in the pollen content reflect regional changes in forest composition. It was established that forest changes were induced by climatic change over the many thousands of years since glacial ice disappeared from northern Europe. A relationship was thus established between the pollen content of the peat, the age (position in the bog), and climate. The early studies were carried out chiefly in Sweden through the pioneer efforts of the geologist L. von Post and the botanist G. Lagerheim. The early studies became known as pollen analysis, and for many years the field was largely restricted to studies of postglacial deposits. Extension of the study of pollen grains and spores to geologically older deposits, and the inclusion of other microfossils, vastly extended the scope of palynology.

The well-established evolutionary sequence of organisms based on the large remains of fossil plants occurring in sedimentary rocks is also recorded by the sequence of plant microfossils in sediments. Microfossils are therefore of aid in determining geologic age and are of especial importance in sediments that are devoid of gross fossils. Due to their abundance, diversity, and minute size, microfossils can be extracted from small samples of rock secured in drilling operations. Palynological study is hence of practical application to petroleum exploration and other geologic studies involving subsurface sediments and structures.

Palynology has contributed much to knowledge of the fossil record of plant life, both in the sea and on the land. Identification of pollen grains, spores, and other microfossils has greatly aided delineation of the geographic dispersal and geologic spread of many groups of the plant kingdom from early Cambrian time to the present.

See also POLLEN GRAINS. (EL. S. B.)

PAMIRS, a mountainous area, mainly in the Tadzhik Soviet Socialist Republic of the U.S.S.R. but also partly in the Kirgiz Soviet Socialist Republic and in Afghanistan and China. The derivation of the word is perhaps from Persian *pai-mir* "the foot of mountain peaks." It lies north of the northern foothills of the Hindu Kush and is bounded on the north by the Trans Alai (Zaalayskiy) Range, on the east by the Kashgar Range and on the west by the valley of the Pyandzh River along which the border between the U.S.S.R. and Afghanistan runs. The Pamirs thus extend over an area of about 250 mi. from west to east and 140 mi. from north to south. The area is divided by the great meridional mountain chain of Sarykol (Khrebet Sarykolskiy), with its main peak of Muztagh Ata (24,757 ft.), which forms the border between China and the U.S.S.R. This chain divides the high-level sources of the Amu-Darya (Oxus) on the west from the rivers which flow into the depression of Kashgar on the east. West of the Sarykol two main forms of relief can be distinguished, the landforms of the eastern area contrasting with those of the western. The conventional dividing line between these two areas is drawn south along the north-south range of Zulumart (roughly 73° E longitude); it crosses the Murghab River and passes Lake Yashil-Kul to the middle reaches of the Pamir River. The eastern area (west of the Sarykol) has a mean altitude of almost 20,000 ft., broken by relatively low peaks of 3,000–4,000 ft., with rounded outlines, and by ranges divided by broad, flat valleys and depressions at heights of 12,000–14,000 ft. The base of the valleys and depressions are filled with moraine, diluvial, and alluvial deposits. The type of relief gradually changes toward the west, the valleys becoming deeper. The western area is disposed in parallel ranges running northeast to southwest and has sharp, jagged crests rising from 6,000 to 10,000 ft. above the valleys. The lower slopes and valley bottoms have less extensive moraine deposits than the eastern area. The Chinese Pamirs east of the Sarykol, inhabited by Tadzhik (Tajik), Kirgiz and other populations, have a landscape similar to the western Pamirs.

The Pamirs belonged to the Alpine geosynclinal region and comprise four latitudinal tectonic zones. The southernmost zone consists of Precambrian metamorphic rocks intruded by Tertiary granites and gabbros. North of this is a tectonically simple zone of geosynclinal deposits ranging in age from Carboniferous to Cretaceous. The third zone is tectonically complex, consisting mostly of steeply folded thrust masses of metamorphosed Paleozoic strata intruded by Tertiary granites. The northernmost zone is also complex with steep folds and thrusts involving Upper Paleozoic, Mesozoic, and Tertiary rocks.

The Kashgar Range contains the highest peak in the Pamirs, Kongur or Kungur (25,324 ft.). In the west the highest point is the Communism Peak (24,590 ft.), in the Academy of Sciences Range (Khrebet Akademii Nauk); in the north the Trans Alai Range has the Lenin (formerly Kaufman) Peak of 23,405 ft.; both, but especially Communism Peak, are surrounded by extensive glaciers. Smaller glaciers are found in the eastern Pamirs. Altogether, there are well over 1,000 glaciers in the Pamirs covering an area of more than 3,000 sq.mi. The snow line varies from about 12,500 ft. in the northwest to 17,000 ft. in the area of Lake Kara-Kul and in the southwest Pamirs.

West of the Sarykol the following have been conventionally recognized as distinct Pamirs (in the sense of valleys reaching up in long slopes to the foot of mountain peaks): (1) the Great Pamir (Khrebet Yuzhno-Alichurskiy), north of the Wakhan (formerly Emperor Nicholas II) Range and Lake Zorkul (Victoria; Sar-i-köl); (2) the Little Pamir (Malyy Pamir), south of the Wakhan Range, in the area of Lake Chakmaktinkul; (3) the Pamir-i-Wakhan, the narrow trough of the Pamir River which joins the Pyandzh at Kala-i-Pyandzh; (4) the Alichur Pamir (Khrebet Severo-Alichurskiy), lying along the rivers Gunt and Alichur, which are separated from one another by Lake Yashil-Kul and bounded on the north and south by the Northern and Southern Alichur ranges respectively, thus being situated immediately to the north of the Great Pamir; (5) the Sarez Pamir, in the area of Lake Sarez (Sarezskoye Ozero) and the Murghab River, north of the Northern Alichur Range. Southeast of the Sarykol is the Taghdumbash Pamir lying in China and Kashmir along the Wakhjir-Jilga (Karachukur) River.

The climate of the Pamirs is continental, especially in the eastern Pamirs where broad, closed basins retain the cold air in winter. In the region of the Fedchenko Glacier, in the Academy of Sciences Range, the mean annual precipitation is 31 to 39 in., but it falls to less than 8 in. in the valleys. In the high mountains of the eastern Pamirs it is less than 3 or 4 in. Winter in the eastern Pamirs is long and severe, although snowfall is light; the average January temperature at about 12,000 ft. is −18° C (0° F). Frosts of −34° to −40° C (−30° to −40° F) are common and permafrost is widespread. Summers are cold, short, and dry; the average July temperature is 14° C (57° F). Mean annual precipitation is 2.4 in., coming mostly in the spring. The air is dry and there are sharp daily and annual fluctuations in temperature.

PRINCIPAL RANGES AND PEAKS IN THE PAMIR MOUNTAINS

The valleys of the western Pamirs have somewhat higher temperatures and greater precipitation; the average temperature in January at about 7,000 ft. is −7° C (19° F) and in July 22° C (72° F). Annual precipitation at a height of 6,000–6,500 ft. is 6.2 to 8.8 in., which falls mainly in the winter and spring. Differences of absolute height and of relief lead to strong local climatic variations within this general pattern.

Vegetation in the eastern Pamirs is scanty, and the area is a high mountain desert devoid of trees. The moist bottoms of valleys and basins have the densest plant cover which forms dry, hummocky meadows yielding the best pasture of the area. The only vegetable fuel in the eastern Pamirs is a low-growing shrub-like *Eurotia*. In the western Pamirs the flora is somewhat richer; up to a height of more than 8,000 ft. patches of shrub and small trees occur against the general background of a desert or semi-desert landscape. Dense growths of willow, *Hippophaë*, birch, poplar, hawthorn (*Crataegus*), etc., cluster along the courses of the rivers. In irrigated areas vineyards and orchards of apricot, apple, walnut, and mulberry are found. Artemisia and the saxaul are characteristic of this zone, but between 8,000 and 10,500 ft. semi-desert conditions give way to a type of mountain steppe vegetation with fescue and feather grass. Then, up to 13,000 ft., is a zone with the heaviest precipitation and this supports a meadow vegetation. Shrubs and small trees continue to occur sporadically to altitudes of nearly 12,500 ft.

The fauna of the Pamirs is relatively poor. In the eastern Pamirs the *arkhar*, a mountain sheep, and the long-tailed marmot are found, as well as a few species of birds and two of fishes. In the western Pamirs the *kiik*, a mountain goat, the brown bear, wolf, fox, snow panther, lynx, and weasel are found, and there is also a greater variety of birdlife than in the eastern Pamirs.

The mineral resources of the Pamirs have been little studied. There are known deposits of gold, lead, copper, iron, and other metals, as well as crystal, mica, talc, asbestos, lapis lazuli, Iceland spar, etc. Salt and coal also occur in some areas. The gold, iron, precious stones, and salt of the region have been exploited in a primitive fashion and on a small scale from ancient times, but the development of these activities has been hindered by lack of transport facilities.

The railway line from Samarkand up the Fergana Valley runs through Andizhan to Karasu, where a southern branch proceeds to Osh. In tsarist days a poor road just suitable for wheeled traffic extended from Osh to Irkeshtam on the Chinese border. This traditional caravan route from the oases of Russian central Asia to Kashgar (Sufu) and beyond is now a main road running in a southerly direction from Osh over the passes of Chiyirchik and Taldyk to Sary-Tash, thence over the Tomurun Pass, through Irkeshtam, to the east, and roughly parallel with the Kyzyl-su to Kashgar. From Sary-Tash another main road extends south, passing east of Lake Kara-Kul, over the Akbaytal Pass to Murghab, then westward over the Naizatash, Tagarkaty, and Koytezek passes, down the Toghuzbulok Valley to the Gunt Valley, at the foot of which Khorog is situated, close to the Afghan border. The main road then follows the border and the Pyandzh River as far as Umarak, where it turns north and then west to reach the railway again near the Fergana Valley. At least parts of other famous trade routes which cross the Pamirs transversely from Yarkand (Soch'e) or Kashgar in the east to the Fergana Valley or the Pyandzh Valley and Afghanistan in the west have been improved and are suitable for wheeled vehicles.

Largely as a result of improvements in transport facilities gold is mined and salt extracted in several places in the Gorno-Badakhshan Autonomous Oblast (*q.v.*) of the Tadzhik S.S.R. Farming and some horticulture (mainly fruit growing) have also been developed mainly in the western Pamirs where most of the population, of mountain Tadzhiks, is concentrated in the lower sections of the valleys. Livestock farming, mainly of sheep and goats, but with some yaks, has developed chiefly on the upland pastures of the eastern Pamirs where there is a sparser population in which Kirgiz predominate.

The first recorded traveler in the Pamirs was a Chinese of the 7th century; his route from Badakhshan to Kashgar was that followed by Marco Polo in the 13th century. Explorers from India first began to be active in the Pamirs about 1860; they were soon followed by Russians from the north (A. P. Fedchenko in 1871) and British from the south (Sir Douglas Forsyth in 1874); it is from this period that the first reliable investigations of the area may be dated. In the 1880s and early 1890s there were border disputes along the Pyandzh River between the Afghans and the Russians. In 1893 the Afghans were forced to withdraw from the right bank of the Pyandzh and in 1895 a joint Russian-British commission met near Lake Zorkul and demarcated the frontier eastward to the Chinese border. Right-bank Badakhshan was formally handed over to the Amir of Bukhara, but in fact power remained in the hands of the Russian military officials in the area, under the direction of the military governor of the Fergana region. The settlement of 1895 had been preceded by a spate of explorations culminating in the journeys of Sven Hedin and Lord Curzon. Russian and other explorers continued to be active in the area early in the 20th century; but the most important Russian expeditions were the Pamir expedition of the U.S.S.R. Academy of Sciences of 1928–30 and the Tadzhik-Pamir expedition of 1932. A joint Anglo-Soviet mountaineering expedition climbed several peaks in the Pamirs, including Communism Peak, during the summer of 1962. (R. E. F. S.)

PAMPA, LA: *see* La Pampa.

PAMPANGA, an agricultural province in the heart of the central plain, Luzon, Philippines, drained by several rivers and their tributaries which empty into Manila Bay. Most of the province is level and is used for the production of rice and sugarcane. The western border is within the foothills of the Zambales Mountains. The lower delta land, bordering on Manila Bay, is an area of mangrove and nipa palm swamps, some of which have been converted into fish ponds. Candaba Swamp, on the Pampanga-Bulacan border, is a huge, shallow lake during the wet season, but during the dry season the water recedes and its floor is the principal melon-producing district of the Philippines. Area of the province 827 sq.mi.; pop. (1960) 617,259.

The principal towns are San Fernando, the capital, Guagua, and Angeles. Clark Air Force Base, near Angeles, is the largest U.S. military installation in the Orient. (An. C.)

Pampangan is the name of the seventh largest Philippine ethnolinguistic group, which had a population of 641,795 in 1948. They occupy Pampanga principally but also inhabit portions of Tarlac, southern Nueva Ecija, and northeastern Bataan. Their language, *Kapampangan*, is Central Philippine but differs from that of their neighbours. Their region, extending northward from Manila Bay and drained by the Pampanga River, has a high population density; there are large numbers of tenant farmers as well as many landless workers. Rice and sugarcane agriculture, fishing, and the manufacture of nipa palm products are major activities. The province has long been a focal point for unrest, as in the rebellion against Spain (1896–98), and in the Hukbalahap movement, which developed into a large-scale revolt in the 1950s (*see* Philippines, Republic of the: *History*).

Pampangans have maintained a strong character and distinctiveness despite their closeness to Manila. They have been reluctant migrants except for nearby Manila where they have formed close-knit groups with strong ties to their provincial communities. There is a considerable Chinese element in the population, introduced through early trade and commerce, and Chinese middlemen are active in the rice and other industries. Mexican soldiers introduced during the Spanish period settled in Pampanga where their descendants were completely assimilated by the 1960s. (F. R. E.)

PAMPAS, a vast plain stretching across central Argentina from the Atlantic coast to the foothills of the Andes and bounded by the Chaco in the north and Patagonia in the south. The name comes from a Quechua Indian word meaning "a flat surface" and South Americans use it in the singular, *la pampa*. Several smaller plains in other parts of South America, such as the desert of northern Chile, are also referred to as pampa.

The area of the Argentine pampa is about 293,436 sq.mi. (760,000 sq.km.). The pampas has a very gradual slope from southeast

to northwest, from 66 ft. above sea level at Buenos Aires to about 1,640 ft. at Mendoza. At that latitude the distance across is about 620 mi. Apart from a few sierras in the northwest and south, most of the region appears perfectly flat. The soil consists chiefly of fine sand, clay and silt washed down toward the Atlantic by the great rivers or blown in dust storms from the west. The climate varies; summers are hot in the northwest, but near the coast they are cooled by the Falkland current.

Periodically cool winds from the south meet the warm air from the tropical north, creating violent gales accompanied by heavy rain in the neighbourhood of Buenos Aires. These storms are known as pamperos.

The pampas is divided into two distinct zones. In the west is the dry pampas, largely barren, with great saline areas, brackish streams, and sandy deserts. Some parts are covered with stunted scrub. To the east of this arid zone lies the temperate, well-watered humid pampas, economic heart of Argentina and the main source of its wealth. Originally the humid pampas was covered with tussocks of rough prairie grass, and it was destitute of trees except for an occasional, solitary *ombú*, "the lighthouse of the pampas."

From the middle of the 19th century the region was transformed. Previously the Spaniards had introduced cattle and horses but had made no attempt to develop the land. The animals were rounded up by *gaucho* cowboys, who were celebrated for their horsemanship, hardihood, and lawlessness. After the liberation from Spain, and with the progressive extermination of the wild Indians who roamed the plains, landowners began to employ immigrants (chiefly Italians) to cultivate their *estancias*, sowing alfalfa (lucerne) for fodder, and maize, and finer pastures. They fenced their lands with barbed wire and imported pedigree cattle and sheep from Great Britain. Railways were built across the pampas. The gauchos gradually became *peones* (labourers), and horses have been increasingly replaced by tractors.

The southeastern area between Mar del Plata and Tandil, being relatively cool and containing much swampy land, has been devoted to the breeding of high-grade sheep and cattle, with almost no agriculture. A second (western) belt extending in a curve for about 600 mi. from Bahía Blanca in the south to Santa Fe in the north is used principally for the cultivation of alfalfa and wheat, with some cattle raising. Around Rosario maize and flax are the chief crops, with some cattle. The vicinity of Buenos Aires has been developed to supply the capital with vegetables, fruit, and milk. (GE. P.)

PAMPERO: *see* WIND: *Local Winds*.

PAMPHLET, a word generally derived from *Pamphilet*, the familiar title of a popular medieval minuscule, now lost, and first used in a 14th-century text in contradistinction to "book." After the invention of printing, short unbound or loosely bound booklets were called "pamphlets," and because polemical and propagandist works on topical subjects were circulated in this form, the word came to be used to describe them. By librarians and bibliographers it is still used to classify any short work, unbound or bound in paper covers. The word tract is almost synonymous with pamphlet, although generally used of works on religious subjects.

Pamphlets began to be published in England, France, and Germany soon after the invention of printing, and the first great age of pamphleteering was inspired by the religious controversies of the early 16th century. In France, so many pamphlets were issued in support of the Reformed religion that edicts prohibiting them were promulgated in 1523, 1553, and 1566. In Germany, the pamphlet was first used by the leaders of the Reformation to inflame popular opinion against the pope and the church, and Martin Luther was one of the earliest and most effective pamphleteers. The coarseness and violence of the pamphlets on both sides, and the public disorder attributed to their sale, led to their prohibition at the Diets of Nürnberg (1522–23) and Speyer (1529), Augsburg (1530), and Regensburg (1541), and by imperial edict in 1589. In England, the tradition of the popular satiric pamphlet was begun with Simon Fish's *A Supplicacyon for the Beggars* (1529), a bitter attack on the clergy, answered by Sir Thomas More in 1530.

The pamphlet was popular in the Elizabethan age, being used for religious controversy (notably in the Marprelate pamphlets of 1588–89, *see* MARPRELATE CONTROVERSY); and by such brilliant pamphleteers as Thomas Dekker, Thomas Deloney, Thomas Nashe, and Robert Greene (*qq.v.*) for romantic fiction, autobiography, scurrilous personal abuse, and social and literary criticism. Reporting of the activities of rogues and swindlers, a favourite theme, was begun by Thomas Harman's *A Caveat . . . for Commen Cursetors* (1566–67), and continued in Greene's "coney-catching" pamphlets. In the Jacobean period the pamphlet was used for most of the topics treated by modern journalism. Such writers as Richard Brathwait (1588–1673), John Taylor, the "Water-Poet" (1578?–1653), and Samuel Rowlands (1570–?1628/30) wrote pamphlets in prose and verse on a wide variety of catchpenny themes.

In France the Wars of Religion produced a flood of pamphlets. The didactic seriousness of the earlier religious pamphleteers gave way to a greater violence, especially in numerous pamphlets against the Jesuits, and to a more flippant and lively satire in pamphlets on the morals of the court and the chief ministers. The *Satire Ménippée* (1594; *see* FRENCH LITERATURE: *The 16th Century*), an effective mockery of the Catholic Holy League, is one of the most famous of French pamphlets. Pamphlets against Richelieu, Mazarin, Colbert, and Fouquet were published in France, Holland, and Flanders; those against Mazarin were called *mazarinades*. The pamphlets of Blaise Pascal (*q.v.*), known as *Les Lettres provinciales* (1656–57), raised the form to the level of literature. During Louis XIV's reign the pamphlet was popular for satiric description of the amours of the court, a notable example being the *Carte géographique de la cour* (1668), by Bussy-Rabutin.

In Germany a second outburst of pamphlets, similar in style to the first, was inspired by the controversies which culminated in the Thirty Years' War. The form was used first by the leading German princes, especially Maximilian of Bavaria and Christian of Anhalt, to defend their own actions and to attack those of others with scurrilous abuse.

In England, the pamphlet gained increasing propagandist influence during the political and religious controversies of the 17th century. Pamphlets played an important part in the debates between Puritan and Anglican, and king and Parliament, in the years before the Civil War, and during the war itself and the Commonwealth. The early radical Puritans John Bastwick, Henry Burton, and William Prynne (*q.v.*) were severely punished in 1637 for their anti-episcopal pamphlets, and John Lilburne, the leader of the Levellers (*q.v.*), was imprisoned for pamphleteering by Charles I, the Long Parliament, and Cromwell. During the Civil War and the Interregnum, the comparative freedom of the press led to pamphlets on a wide range of controversial subjects by John Gauden (*q.v.*), in support of the royalist cause; Gerrard Winstanley (1609—after 1660), the spokesman of the Diggers (*q.v.*), who advocated egalitarian socialism; James Harrington (*q.v.*), the republican philosopher; and John Milton (*q.v.*), who abandoned poetry for 20 years to write pamphlets in the cause of religious and civil liberty, and who, in *Areopagitica* (1644), an eloquent plea "to know, to utter and to argue freely according to conscience" produced a masterpiece of prose style.

The stricter enforcement of censorship at the Restoration checked the flow of pamphlets, and the rise of the newspaper and periodical (*qq.v.*) to some extent restricted their range. In the Restoration period and at the Revolution of 1688, however, the pamphlet became increasingly important as a political weapon. Andrew Marvell (*q.v.*) wrote influential political pamphlets, and those by George Savile, marquess of Halifax (*q.v.*), were notable for both literary style and political wisdom. In the Augustan age both Defoe and Swift (*qq.v.*) were masters of the polemical pamphlet, which became the chief vehicle for political controversy. The development of party politics gave employment to pamphleteers, the Whigs being supported by Addison, Steele, Bolingbroke, Prior, Atterbury, and Pulteney, and the Tories by Swift.

The pamphlet continued to be powerful throughout the 18th century. In North America the earliest pre-Revolutionary agita-

tion marked the beginning of a great tide of pamphleteering; between 1763 and 1783 about 2,000 pamphlets on the political issues of the day are estimated to have been issued. Some of these were first published in newspapers and then issued in pamphlet form, or vice versa. Among the writers whose pamphlets are notable both for literary quality and political influence may be mentioned James Otis (*q.v.*), John Dickinson (*q.v.*), and, first and foremost, Thomas Paine (*q.v.*), whose *Common Sense* appeared in January 1776, followed by the *Crisis* papers (December 1776–April 1783). After the United States was founded, a second tide of pamphleteering, only slightly diminished in volume, was occasioned by the proposal of a new constitution in 1787. From this material there emerge preëminently the *Federalist* papers (*see* FEDERALIST, THE), which, though not strictly speaking pamphlets (they appeared first in newspapers and then in book form), may be taken as summarizing the most original contributions the revolutionary generation of pamphleteers made to the discussion of government. *The Federalist* may also be regarded as marking the end of the era of the political pamphlet, thereafter largely replaced by newspapers and magazines on the one hand and by the printed book on the other.

In France the 18th century was also notable for its pamphlets, and the form was used by Voltaire, Rousseau, Montesquieu, Diderot, D'Alembert, D'Holbach, Helvétius, and Beaumarchais to express the philosophical ideas of the Enlightenment. Their pamphlets differ in style and subject from those in England: they are rather reasoned discourses than polemical tracts. With the approach of the French Revolution, the pamphlet became again a popular polemical weapon. One of the most effective pre-Revolutionary pamphlets was *Qu'est-ce que le Tiers État* (1788), by the Abbé Emmanuel Joseph Sieyès (1748–1836), who in this and two other pamphlets published before a meeting of the States General (1789) forcibly expressed the aspirations of the Third Estate. The Revolution itself produced many popular anonymous pamphlets, slandering the queen and the nobility, and commenting on events. The most complete collection of revolutionary pamphlets is that in the Bibliothèque Nationale, Paris. The Revolution also occasioned one of the most outstanding English pamphlets, Edmund Burke's *Reflections on the Revolution in France* (1790). It provoked many replies, the most famous being *The Rights of Man* (1791–1792) by Thomas Paine.

Of later French pamphleteers the most outstanding was Paul Louis Courier (*q.v.*), who wrote polemical masterpieces. The Revolution of 1848 also produced pamphlets. Louis François Veuillot (1813–83) supported Catholicism against the free-thinkers and anticlericalists in several pamphlets, and the form continued to be used for controversy, notably at the time of the Dreyfus affair.

In England, the pamphlet played a part in all the political movements of the 19th century. Perhaps the most notable in numbers were the pamphlets on Chartism and those written against the Corn Laws. Irish Home Rule also provoked vigorous pamphleteering. The *Tracts for the Times*, which began the Oxford Movement (*q.v.*), showed the continuing power of the pamphlet. At the turn of the century the Fabian Society propagated its political doctrines in a series of pamphlets to which George Bernard Shaw, Beatrice Webb, and Graham Wallas contributed.

In the 20th century the pamphlet has been used rather for information than controversy, chiefly by government departments and learned societies.

See also ENGLISH LITERATURE; FRENCH LITERATURE; GERMAN LITERATURE; POLISH LITERATURE; RUSSIAN LITERATURE; and their bibliographies; and the bibliographies of articles on writers mentioned above.

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PAMPHYLIA, a region in the south of Asia Minor, between Lycia and Cilicia, extending from the Mediterranean to Mt. Taurus. It was bounded on the north by Pisidia and was a country of small extent, having a coastline of about 75 mi. with a breadth of about 30 mi. Under the Romans the term Pamphylia was extended to include Pisidia and the whole tract up to the frontiers of Phrygia and Lycaonia. The country consisted of an alluvial plain, drained by the lower Catarrhactes, Cestrus (Aksu), Eurymedon (Kopru), and Melas (Manavgat) rivers, backed by the mountains of Taurus. Unlike the plain of Cilicia to the east, it had no convenient access through its bordering ranges to the plateau. The chief towns on the coast were: Olbia, the first town in Pamphylia, near the Lycian frontier; Attaleia (Antalya, *q.v.*); and Side (*q.v.*). On a hill above the Eurymedon stood Aspendus (*q.v.*) and above the Cestrus was Perga (*q.v.*). Between the two rivers, but somewhat farther inland, stood Sillyum, a strong fortress which defied even Alexander the Great.

According to Pliny, the original name of the country was Mopsopia, after Mopsus (*q.v.*), the hero who led bands of Greek settlers after the Trojan War both to this region and to the coasts of Cilicia and Syria farther to the east. The customs of the Pamphylians closely resembled those of the Cilicians, and doubtless the aboriginal stock had been mixed with immigrant Cilicians as well as with later Greek incomers; in classical times they spoke a Greek dialect resembling the Arcadian and Cyprian. The Pamphylians are first mentioned among the nations subdued by the Mermnad kings of Lydia, and afterward passed in succession under the dominion of the Persian and Macedonian monarchs. After the defeat of Antiochus III in 190/189 B.C. they were included among the provinces annexed by the Romans to the dominions of Eumenes of Pergamum; later they joined the Pisidians and Cilicians in piratical raids. Pamphylia was for a short time included in the dominions of Amyntas, king of Galatia, but after his death (25 B.C.) it lapsed into a district of a Roman province. The Pamphylians became largely hellenized in Roman times and have left magnificent memorials of their civilization at Perga, Aspendus, and Side.

See PISIDIA for bibliography. (WM. C. B.)

PAMPLONA, a city of northern Spain in the foothills of the Pyrenees, capital of the province (formerly kingdom) of Navarre, and an archiepiscopal see. Pop. (1960) 97,880. Situated on the left bank of the Arga River in the fertile region of La Cuenca, it is important for communications between France and Spain. The medieval core of the town, La Navarreria, is dominated by the cathedral, mostly 14th–15th century French Gothic, but with Romanesque remnants and a neoclassical facade by Ventura Rodriguez (1717–85). Notable, too, is the Gothic church (13th–14th century) in the old district of San Cernín or Sernín (*i.e.*, St. Saturninus, who traditionally evangelized the city). There are also the Cámara de Comptos (royal treasury, *c.* 1364); the Casa Consistorial (1741, with Baroque facade); and the Diputación Provincial (neoclassical) with the Archivo General de Navarra adjoining. The centre of the city, linking old and new, is the porticoed Plaza del Castillo. Southeast of this is the modern Plaza del Conde de Rodezno, with a monument of the Civil War (1936–39). Educational institutions include the Estudio General de Navarra for higher university studies and various specialist schools. Among the museums is the Museo de Recuerdos Históricos with mementoes of the Carlist Wars. The Taconera Gardens and the Media Luna Park are public; and public gardens also surround remains of the 16th-century fortifications. In the 1920s the fortifications on the south side were demolished to al-

low modern building. Industrialization has produced a suburban belt of factories and workers' dwellings.

Pamplona's chief tourist attraction is the Fiesta de San Fermin (the native-born St. Firminus, its first bishop), described in Ernest Hemingway's novel *The Sun Also Rises* (1926). Starting on July 6, the eve of the saint's festival, the fiesta lasts till the 14th, with daily bullfights preceded each morning by the famous *encierro* (enclosing) of the bulls, when they are driven through the streets behind crowds of skilfully dodging boys.

There are good rail services to Madrid via Soria and to Barcelona via Zaragoza (Saragossa). The town is well served by roads, including a link with Bayonne, France. Situated in a rich, irrigated cereal-producing area, Pamplona is a flourishing agricultural centre. Industry also prospers: the ancient crafts of wineskin, sandal, rope, and pottery making coexist with the manufacture of sanitary and kitchen ware, liquor, paper, and chemicals, and the milling of flour and sugar.

According to tradition, Pamplona was founded in 75 B.C. by Julius Caesar's rival Gnaeus Pompeius (Pompey) as a military settlement during his campaign against Quintus Sertorius. Its first name was Pompeiopolis or Pompaelo (corrupted by the Moors to Banbaluna). Almost derelict after Moorish and Frankish invasions and the final dismantling of its defenses by Charlemagne in 778, Pamplona was made capital of his kingdom of Navarre by Sancho III the Great (1000–35), his new foundation being known as the Ciudad de la Navarreria. The addition of two more self-governing districts, the Burgo de San Cernin and the Poblacion de San Nicolas, led to bloodshed ended only by Charles III the Noble's *privilegio de la union* in 1423. In 1521 Iñigo López de Recalde (afterward St. Ignatius of Loyola) was wounded during the attempt by Juan de Labrit (Jean d'Albret), Navarre's last independent king, to regain his throne from Castile. The citadel built by Philip II of Spain in 1571 made Pamplona the most strongly fortified town of the north. After the First Carlist War (1833–39), Pamplona ceased (1841) to be capital of the kingdom of Navarre and became capital of the new province of the same name.

PAN, originally an Arcadian deity who came to be worshiped throughout the Greek world, although he never attained any high moral development or prominent place in cult outside Arcadia. The name is a Doric contraction of *paon*, "pasturer," but was commonly supposed in antiquity to be connected with *pan*, "all." The spread of his ancient cult was relatively late; he was unknown to Homer, although he is the subject of one of the later Homeric hymns. He was associated by the Romans with Faunus (*q.v.*). His father is generally said to be Hermes; as his mother is often named Penelope, probably not the wife of Odysseus but commonly identified with her, one or another of the characters in the *Odyssey* is sometimes called his father. Pan is represented as more or less bestial in shape, generally having the horns, legs and ears of a goat; in later art the human parts of his form are much more emphasized, the bestial characteristics dwindling to a little pair of horns. His activities are those of a giver of fertility, and he is thus represented as vigorous and lustful. His chief concern is with flocks and herds, not with agriculture; hence he can make men, like cattle, stampede in "panic" terror; like a shepherd, he is a piper, a late legend representing him as the lover of a nymph Syrinx ("Panpipe"), who disappeared into a reed bed when he pursued her, Pan making the first pipe from the reeds (Ovid, *Metamorphoses*, i. 689–712). Like a shepherd, again, he rests at noon, and dislikes having his sleep disturbed; he can also send visions and dreams. Again like a shepherd, he haunts the high hills and another late story makes him love or be loved by the nymph Pitys ("pine tree").

BY COURTESY OF ANTIKEN SAMMLUNG, STAATLICHE MUSEEN ZU BERLIN

TERRA-COTTA STATUETTE OF PAN FROM ERETRIA, c. 300 B.C. IN THE STAATLICHE MUSEEN ZU BERLIN

Two picturesque stories are told of him. When the Athenians sent the runner Phidippides to ask help of Sparta before Marathon, he encountered Pan, who asked why Athens did not honour him, seeing that he was her friend and would be so again. After the battle, a cult of him was instituted, presumably because he had sent panic among the Persians (*see* Herodotus, vi. 105). In the time of Tiberius, as related by Plutarch, one Thamus, pilot of a ship making for Italy, was thrice called by name and bidden to give the news that "great Pan was dead." It was plausibly suggested by S. Reinach, although several scholars reject the idea, that what was really heard was "Tammuz, Tammuz, Tammuz the all-great is dead," a ritual lament for Tammuz-Adonis. "Thamus, the great Pan . . ." and "Tammuz the all-great . . ." in Greek would be practically indistinguishable in pronunciation.

Pan is insignificant in literature, aside from Hellenistic bucolic, but he is a very common subject in ancient art. His rough figure was antithetical to, for example, that of Apollo, who represented culture and sophistication; hence the story of their musical contest (*see* Midas).

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PANAETIUS (*c.* 180–109 B.C.), the founder of Roman Stoic philosophy, and a friend of Scipio Aemilianus and of Polybius, was born at Lindus in Rhodes. A pupil in Athens of Diogenes of Seleucia and of Antipater of Tarsus, he also studied the philosophies of Plato and of Aristotle. Many years resident in Rome, he was an influential member of the Scipionic circle and was invited to be Scipio's sole companion on an ambassadorial visit to the orient *c.* 140 B.C. Succeeding Antipater as head of the school, he passed the last 20 years of his life in Athens. While adhering to fundamental Stoic teaching, Panaetius tempered the rigid austerity of the ancient Stoa and introduced a new humanist note. He appears to have written less voluminously than other leading Stoics, and none of the five treatises attributed to him is extant. His important ethical treatise *On the Appropriate* was Cicero's model for the first two books of the *De Officiis*. His chief disciple was Poseidonius of Apamea. *See* Stoics.

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PANAMA (República de Panamá), a Central American republic lying between Costa Rica and Colombia, its boundary with the latter marking the division between Central and South America. The Panama canal, crossing the lowest and narrowest point of land between the Atlantic and Pacific, bisects the republic from ocean to ocean. Panama is bounded on the north by the Caribbean sea, an arm of the Atlantic, east by Colombia, south by the Gulf of Panama and the Pacific, and west by Costa Rica. The coast line on the Atlantic side is 477 mi., on the Pacific side 767 mi.

This article is divided into the following sections:

I. Physical Geography
II. Geographical Regions
III. History
IV. Population
V. Administration and Social Conditions
VI. The Economy

There are short articles on the provinces. Geographical, historical, economic and political aspects of Panama may also be found in Central America and Middle America.

I. PHYSICAL GEOGRAPHY

Geology.—West of the Canal Zone the mountain backbone of Panama consists of pre-Tertiary granite and metamorphic rocks,

PRINCIPAL PHYSICAL FEATURES AND MAJOR CITIES OF PANAMA

capped in the west by explosive deposits of several high Miocene and Pleistocene volcanoes. Pre-Tertiary rocks cover the southern half of Azuero peninsula and west of it they extend from the Pacific to the Caribbean. Mountain flanks and plains in northwestern and southwestern Panama, northern Azuero peninsula, hills of the Canal Zone and plains bordering the Gulf of Panama are made up of Oligocene, Miocene and Pleistocene marine sediments and recent alluvium.

Pre-Tertiary granite and metamorphic rocks cover most of Panama east of the Canal Zone and include the larger of the Pearl Islands (Archipiélago de las Perlas); however, in southeastern Panama, between two broad areas of the above rocks, are Oligocene and Miocene marine sediments.

Relief and Drainage.—Three-fifths of Panama consists of rolling hills to rough mountains. In the rugged Sierra de Chiriquí and Cordillera de Veraguas, 20 to 35 mi. wide, are several volcanic peaks, the highest Chiriquí (11,411 ft. [3,478 m.]). Terrain in the Canal Zone region consists of deep valleys and rounded hills. Eastward the rough Cordillera de San Blas, 7 to 18 mi. wide with summits nearly 4,440 ft. high, borders the Caribbean to Colombia. Caribbean lowlands are limited to alluvial-coastal plains, 5 to 20 mi. wide and mostly poorly drained, in Bocas del Toro and just west of the canal. Piedmont-alluvial-coastal plains, 5 to 20 mi. wide, fringe the Gulf of Chiriquí, cut across the base of Azuero peninsula, and border the Gulf of Panama to San Miguel gulf. East of the Canal Zone these and the Bayano, Tuira-Chucunaque and Balsas alluvial plains are poorly drained. Coiba Island, Azuero peninsula, several Pearl Islands and Serranía del Sapo are hilly to rough.

Many short rivers flow from the mountains to the coasts; the Chagres, Trinidad and other rivers empty into Gatun lake; longest rivers are the Tuira-Chucunaque and the Chepo or Bayano; only the Tuira is navigable for about 100 mi.

Climate.—Lowlands have temperatures of 80° F., with little monthly variation, but with a diurnal range of 15° F. Mean annual temperatures decrease from 74° F. at 3,000 ft. to 60° F. at 5,000 ft., and to 45° F. in the high Sierra de Chiriquí. The Caribbean coast and high mountains, with no distinct dry season, receive from 127 in. to 160 in., or more, precipitation per year. Annual precipitation at Santa Clara, on the coast 60 mi. west of Panama city, is 51 in., with January to April almost rainless; western Chiriquí plains receive 96 in. per year; southern Darién more than 100 in., with no distinct dry season. Wind velocities are low; maximum velocities are about 25 mi. per hour. Possible sunshine varies greatly, according to rainy days, which average less than 120 days per year on Pacific coast to more than 260 days on Caribbean coast and mountains.

Vegetation.—Mangroves and palm forests grow in swamps along portions of both coasts. Broadleaf evergreen forests cover about 60% of Panama. They are in areas with more than 80 in. of rain and no distinct drought season—Caribbean lowlands, hills and mountain slopes up to 6,500 ft., and all of San Blas and Sapo mountains and the upper Bayano, Tuira-Chucunaque and Balsas basins. They contain at least 90 tree families and 1,000 species, of which 200 grow to heights of 70 ft. or more, including balsa, brazilwood, Castilla, ceiba, jacaranda, jobo, laurel, lignum vitae, mahogany, rosewood, Spanish cedar, tamarind and Sapota. Above 6,500 ft. in western mountains are deciduous rain forests, dominated by oaks, alder and Loro. On Pacific lowlands and hills, from the western boundary to San Miguel gulf are large savannas interspersed with tropical semideciduous forest, including such species as almácigo, cedar, ceiba, mora, panamá (national tree, from which name of country is derived), roble de Sabana and ronron. Common drug and medicinal plants in Panama are arnica, copiaba, camomile, lancepod (sources of rotenone), star apple, tamarind, and wormseed.

Animal Life.—Abundant animal life includes: (1) deer, opossum, tapir, ocelot, raccoon and porcupine; (2) reptiles: crocodiles, lizards, snakes and turtles; (3) rodents: agouti, rats, mice; (4) numerous species of water and land birds, many beautifully adorned; (5) many species of butterflies, moths, beetles, bees, wasps, ants, flies and mosquitoes, many with protective colouration; and (6) numerous species of fresh-water and salt-water fishes (including Mollusca). The chief commercial fish caught are groupers, corbinas, mackerel, snappers and snooks.

II. GEOGRAPHICAL REGIONS

On the basis of physical geography and economic activities the Isthmus of Panama may be divided into five geographical regions.

Between the Cordilleras Veraguas and San Blas an east-west belt of valleys and high hills, nearly 60 mi. wide, crosses the isthmus. This is a region of interocean routes (canal, railway, highways and airlines) and population concentration, about 34% of the national total. About 40% of the working people of Panamá city and Colón are employed in the Canal Zone. This area, politically and economically the heart of Panama, produces most of the manufactured goods, and large quantities of foodstuffs.

The Pacific plains and hilly lands of the Azuero peninsula, extending from western Chiriquí to the lower Bayano valley, have 46% of the population of the country. With much level land fertile soils, high temperatures, and marked rainy and dry seasons they include most of the country's planted pastures and natural savannas (70% of the pastures consist of planted grasses.) Nearly all the bananas exported from Panama are grown on the western Chiriquí plains.

The whole region produces about 80% of the country's cattle, swine, poultry and animal products. It also produces nearly all the sugar and 75% of the rice, corn, beans, sweet potatoes, yucca and tobacco. Coastal waters supply nearly all the fish caught in Panama.

The Sierra de Chiriquí and Cordillera de Veraguas, rugged, rainy all year and mostly densely forested, are largely uninhabited on their northern slopes, but valleys on their southern slopes have about 13% of the country's population. These valleys produce most of the coffee of Panama and they also have important citrus fruit, dairy, cacao, tobacco, and lumbering districts, and mountain resorts.

The Caribbean plains and hills west of the Canal Zone, hot, rainy all the year, and mostly densely forested, are sparsely settled, with only 3% of the nation's population. These people are chiefly in Bocas del Toro plains, Panama's commercial banana region, until the late 1920s. This area produces cacao, abacá, rubber, forest products and foodstuffs for local consumption.

Mountains and lowlands of eastern Panama contain one third of the national area. Hot, rainy all year and densely forested, they support only about 4% of the country's population. Widely scattered, this population, without highways, railways and airlines, is engaged principally in subsistence agriculture, hunting, fishing and lumbering. (C. F. J.)

III. HISTORY

Rodrigo de Bastidas explored the northern coast of the Isthmus of Panama in 1501. It was not until his fourth and last voyage (1502) that Christopher Columbus, sailing along the isthmus, (then known as *Tierra Firme*) came within a few miles of the seas which he sought as the route to the Indies. These were followed in 1509 by Diego de Nicuesa sent by King Ferdinand of Spain to

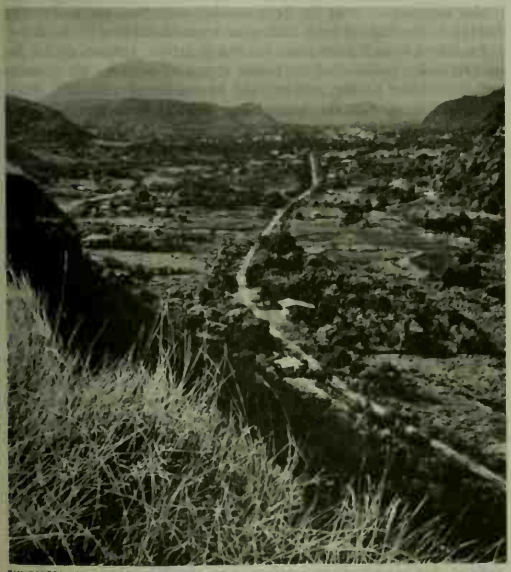
colonize *Tierra Firme*. None of these explorers was successful in establishing a colony, for the hostility of the natives, the lack of provisions, and the presence of disease defeated their efforts.

Colonial Period.—A more successful attempt was made by Martín Fernández de Enciso on the west shore of the Gulf of Darién. There at Santa Maria, Vasco Nuñez de Balboa (*q.v.*) induced the colonists to plant crops, taught them to befriend the Indians, and introduced many customs of the homeland. But the hope for riches impelled Balboa to seek and find the Pacific ocean (1513), which he called *El Mar del Sur* (South sea), and to claim it for his sovereign.

Under Balboa's successor, Gov. Pedro Arias de Avila (Pedrarias), Santa Maria was given a municipal charter and made the seat of a bishopric. In 1519 Pedrarias transferred his headquarters and that of the bishop across the isthmus to a little fishing village, Panama. In 1531 Francisco Pizarro sailed from this port for Peru, and thereafter the importance of Panama lay in its location. To it were brought the riches of the Spanish possessions to the south and north for transshipment across the isthmus on the *Camino real* (royal road) to Nombre de Dios and later to Porto Bello (*q.v.*), while in the opposite direction merchandise of the mother country was distributed to the colonies. Each year it was customary for a fleet of galleons to sail from Cádiz, Spain, with the merchandise, for Porto Bello and San Juan de Ulúa (Veracruz), Mexico. Arrival at Porto Bello was the occasion for a great fair at which old and new world produce was exchanged, attracting traders from all of the colonies. Porto Bello became notorious for the prevalence of disease and inflation.

The annual fairs and the fleet system presented targets of concentrated wealth for the famous buccaneers and privateers of the colonial period. Most famous of these was Sir Francis Drake who in 1572 attacked Nombre de Dios successfully, and in 1573 intercepted the mule train bearing the Spanish king's share of treasure to that port from Panama. One of Drake's lieutenants, John Oxenham, crossed the isthmus in 1575 and contrived to intercept the treasure ship from the Peruvian mines, but his exploit ended in disaster.

Drake returned to the isthmus in 1595 to burn Santa Maria and Nombre de Dios. He failed in an attempt to cross the isthmus for an attack on Old Panama city and died of fever in 1596. He was buried at sea in Porto Bello harbour. In 1602 William Parker captured and sacked Porto Bello. Of the 17th-century pirates Sir Henry Morgan was most distinguished for his seizure of this well-defended port and for an arduous expedition across the isthmus and capture of Old Panama city in 1671. Of quite a different character was the scheme of William Paterson (*q.v.*), founder of the Bank of England, to establish a trading post on the isthmus of Darién (*q.v.*), but the settlement of New Edinburgh succumbed to a variety of hostile forces.



TIM KANTOR—RAPHO GUILLUMETTE

HIGHLAND REGION IN THE SIERRA DE CHIRIQUÍ NEAR BOQUETE, PANAMA

The deterioration of the Spanish commercial system was evidenced by the asiento contract of 1713 which permitted England to trade one ship's cargo annually in the Spanish colonies. This concession encouraged an already vast illicit trade (including the French and Dutch participation), caused Spain to increase its naval patrols, and led to clashes with British sea power. In one of these Adm. Edward Vernon stormed Porto Bello in 1739. Nine years later the port's great fair was discontinued. Political subordination paralleled economic decline, and in 1751 the isthmus was demoted to a dependency of Santa Fé de Bogotá, Colombia.

Union with Greater Colombia.—Panama proclaimed its independence from Spain in 1821 after Simón Bolivar (*q.v.*) cleared New Granada of loyalist forces, but after a few months it voluntarily joined the Colombian union. In 1826 Bolivar invited representatives of the Latin-American states to Panama, where they assembled and passed resolutions for union and confederation. For a time Panama enjoyed considerable local autonomy under New Granada, but in 1843, under a new constitution, the executive power at Bogotá was greatly strengthened, including the appointment of provincial governors. Tomás Cipriano de Mosquera, elected president of Colombia in 1845, negotiated the building of the Panama Railroad and concluded a convention with the United States by which that country guaranteed the neutrality of and free transit across the isthmus.

The Panama Canal.—The gold rush to California in 1849 provided the impetus for building the railroad, which upon completion in 1855 encouraged the canal builders. The Universal Interoceanic Canal company headed by the builder of the Suez canal, Ferdinand de Lesseps, began construction, but legal entanglements, fraudulent financial arrangements and, particularly, disease, precipitated the collapse of the company in 1889.

The railroad operation and the canal construction brought a degree of prosperity to the isthmus but failed to bring political stability. For more than three decades after the mid-19th century, Panama experienced the effects of a weak and decentralized form of government at Bogotá. In 1886 Rafael Núñez, president of Colombia, reinstituted a highly centralized government and placed a conservative, clerical party in control. But whether it had the status of a state or a department, Panama was beset by chronic civil strife up to 1903, the year of its independence.

The possibility of the completion and the control of a canal under foreign auspices and the journey of the warship U.S.S. "Oregon" around Cape Horn during the Spanish-American War prompted a considerable agitation in the United States for a U.S.-controlled canal. On Nov. 6, 1903, three days after Panama's declaration of independence, the United States recognized the new republic and promptly signed a treaty authorizing construction of the canal. (For the construction and history of the Panama canal *see* PANAMA CANAL.)

The Republic of Panama and U.S. Relations.—On Feb. 13, 1904, a constitution was adopted which contained a provision authorizing U.S. intervention and which provided for a centralized government with the four provincial governors appointed and dismissed by will of the president. This arrangement was altered in 1917 and 1919 to allow popular election of president, vice-president, and governors. The constitutional convention of 1904 unanimously elected Manuel Amador Guerrero as the first president. Subsequent elections were tumultuous, and in 1908, 1912 and 1918 U.S. military forces intervened to preserve order.

The political history of the republic remained stormy, and there were many internal upheavals. At the outbreak of World War II American ministers of foreign affairs met at Panama city and in

the Declaration of Panama announced in Sept. 1939 a 300-mile-wide neutral zone around the Americas. Panama declared war on Japan Dec. 8, 1941, and on Germany and Italy Dec. 12. To strengthen defenses, the United States requested from Panama sites outside the canal zone for landing fields, roads and warning stations. The election of the pro-Fascist Arnulfo Arias to the presidency in June 1940 led to a protracted negotiation in which the Panamanian government demanded conditions and compensations. Among these were a monetary compensation for the sites, cancellation of a road construction debt, the transfer of certain properties of the Panama Railroad company to Panama, of the water and sewer systems of Panama and Colón, of surplus power from Alhajuela dam and a bridge over the canal.

In addition Panama requested a short-term lease for the sites, Panamanian use of the airfields, and partial criminal jurisdiction in the sites.

Although U.S. army units were authorized to begin operations on one of the sites on March 6, 1941, it was not until May 18, 1942, that the negotiations were terminated. This conclusion was facilitated when Arias was deposed in Oct. 1941 and succeeded by Ricardo Adolfo de la Guardia. Insofar as war circumstances permitted, the Panamanian conditions were met, and the U.S. congress approved legislation in April 1943, providing the necessary funds.

During and after the war the United States returned 98 defense sites to Panama, and on the remaining 36, the two countries engaged in long negotiations involving joint control, abandonment, length of tenure and U.S. economic benefits for the republic. Agreement was reached, but the Panamanian assembly, influenced by public pressure, rejected the proposals and the sites were abandoned in 1947.

The political pressures that led to the refusal by Panama willingly to permit the continued U.S. occupation of the military bases played a part in the return of Arnulfo Arias in 1949. He was welcome to such a degree that his election to the presidency followed. In 1951 opposition to him was stimulated by his closing of the privately owned Federal Trust company. Political and financial opponents called a general strike, and a run on a government-supported savings bank brought swift changes. The arrest of a former president, Ricardo de la Guardia, for inciting trouble was followed by the suspension of the constitution by President Arias and the reimposition of the 1941 authoritarian constitution. The balance of power lay with the national police force and its leader, José Remón. The Arias regime was overthrown in 1951, and the vice-president Alcibiades Arosemena succeeded to the presidency.

In the elections of May 11, 1952, Remón decisively defeated his opponent, Roberto Francisco Chiari, but his tenure was cut short by assassination on Jan. 2, 1955. His successor, José Ramón Guizado, held office only a few days because he was accused and convicted of conspiring to kill the president. Ricardo Arias Espinosa presided over the government during 1955, a year notable for the flow of capital into Panama. The work on the Inter-American highway and on local roads was promoted by a loan of $9,650,000 from the International Bank for Reconstruction and Development. In 1957 Panama witnessed the beginning of an investment, estimated to eventually total $93,000,000, in two oil refinery establishments by the Panama Refining company and the Panama Refining and Petrochemical company. New synthetic rubber and plastics industries were also announced.

As if to symbolize a new period of economic development, Ernesto de la Guardia, Jr., was inaugurated president on Oct. 1, 1956, in the national legislative building, now the ministry of justice, of which his son was the architect. His administration, so auspiciously begun, was not to run its course smoothly. In the spring of 1958 student riots led to the imposing of a state of siege and the threat of a general strike. The settlement of May 31 pointed to the nature of the antagonism that had been generated, for the tenure of guardsmen was henceforth limited and their control of the jails ended. The finding of caches of arms, the quelling of riots, and charges of subversive plotting marked the late summer days of that year. The new year provided little respite, for disorders occurred in each of the first four months, and Independence day produced an ominous march into the Canal Zone to raise the Panamanian flag there, a march that was turned back.

Roberto Francisco Chiari was the successful contender for the presidency in 1960. With a national debt of about $83,000,000 and a budget deficit of approximately $10,000,000, he announced plans for a vast program of slum clearance, housing, health services and hospital construction. By comparison the loans from the Inter-American Development bank and the Development Loan fund for housing and road construction, and the grant under the Alliance for Progress program appeared to be a small beginning. Serious differences of opinion developed in 1963 over the type of development plans to be favoured. Gravel-surface feeder roads and housing for low-income groups competed with more permanent highways and housing and schools for middle-income groups of the population. The plans for aiding the poorer people found a champion in former president Arnulfo Arias. He was generally favoured to win the presidency in the May elections of 1964, but Marco A. Robles, supported by President Chiari, won in a close contest.

In 1964 as in 1954 negotiations were under way to effect such changes in the treaty structure between Panama and the United States as necessary to answer some of the complaints of the former. Those of the earlier period bore fruit in the agreement of Aug. 23, 1955. It provided for an increase in the canal annuity from $430,000 to $1,930,000 and for the transfer to Panama of certain lands and improvements, including Paitilla Point. The United States agreed to the imposition by Panama of taxes on those working in the Canal Zone except for citizens of the United States and certain others. It yielded its monopoly over communication systems, any rights to build roads and its obligations concerning sanitation in Panama city and Colón.

Milton Eisenhower, brother of U.S. Pres. Dwight D. Eisenhower, conferred with President De la Guardia in July 1958, on Panama's need for capital to provide for its expanding population. De la Guardia expressed the desire for equal status for the Panamanian language and flag in the Canal Zone. In that same year the United States congress appropriated $19,000,000 for a bridge across the canal, and an instrument of transfer was signed that conveyed to Panama real estate valued at about $25,000,000. The disorders in 1958 and 1959 with the demands to fly the Panamanian flag in the Canal Zone led to a recognition by President Eisenhower that titular sovereignty over the Zone resided with Panama, and to the display of the flags of both nations at a specified place in the Zone.

President Chiari, soon after his inauguration, announced his intent to seek a revision of the treaty structure between his country and the United States, and in 1962 he conferred with U.S. Pres. John F. Kennedy on the issues between the two countries. They agreed to arrange for further discussions by the experts of both sides. In July 1963 the two presidents issued a communique indicating that the following agreements had been reached for the benefit of Panamanian employees in the Canal Zone: a binational labour commission was to be created, and health and life insurance equal to that enjoyed by U.S. citizens was to be made available; the minimum hourly wage was to be raised from 60 to 70 cents, effective July 1, 1963, and to 80 cents one year later.

Violence that precipitated a severe deterioration of relations between Panama and the United States broke out on Jan. 9, 1964. American students in Balboa, contrary to rule, displayed a U.S. flag at their school. About 200 Panamanian demonstrators then marched peacefully into the Canal Zone, but they triggered widespread violence upon their return to Panama. Mobs engaged first the police and then the military forces in a combat that resulted in more than 20 dead, many injured, and severe property damage. Panama severed diplomatic relations with the U.S. and accused it of aggression. Spokesmen for the United States denied the accusation, denied the use of tanks, machine guns and automatic weapons, and accused the Panamanian government through a directed press and radio of inciting people to violence and of delay in restoring order. Panama brought its charge before the United Nations Security council but without a request for specific action. Its complaint was referred to the Inter-American Peace committee, and, after its efforts failed, to the Council of the

Organization of American States. The discussions were protracted because Panama insisted upon agreement to a revision of the treaties between the two disputants as a precondition to re-establishing relations. On the other hand, the United States refused to proceed under precommitments. On April 3, 1964, relations were resumed. The two countries agreed to appoint special ambassadors to seek the elimination of the causes of conflict "without limitations or preconditions of any kind." (A. R. W.)

IV. POPULATION

Distribution and Growth.—In 1960 Panama's population was 1,075,541; the 1950 census gave 805,285. Less than 10% were tribal Indians living in the Darién jungles, on the San Blas archipelago, and in the western mountains. Approximately 11% were white and 13.3% Negro, according to the 1940 census. In 1950 no attempt was made to tabulate racial origin. Panamanians are proud of the relative amity in which people of different races have lived since Negro slaves were first imported by the Spanish settlers in the early 16th century. Negro, Indian, European and oriental strains are so intermingled that such distinctions as those between mestizo and mulatto are often impossible to draw. Because of their cultural differences and fear of their economic competition, however, British West Indian Negroes, whose ancestors provided labour for railroad and canal construction, are no longer freely admitted, although they are physically similar to many Panamanians of old stock.

Area and Population of Panama

Provinces	Area (in sq.mi.)	Population			
		1950 census		1960 Census	
		Number	Density per sq.mi.	Number	Density per sq.mi.
Bocas del Toro	3,332	22,392	6.7	32,600	9.8
Chiriquí	3,460	138,136	39.9	188,350	54.4
Coclé	1,931	73,103	37.9	93,156	48.2
Colón	2,861	90,144	31.5	105,416	36.8
Darién	5,996	14,660	2.4	19,715	3.3
Herrera	907	50,095	55.2	61,672	67.9
Los Santos	1,494	61,422	41.1	70,554	47.2
Panama	4,436	248,335	56.0	372,393	83.9
Veraguas	4,336	106,998	24.7	131,685	30.4
Total	28,753	805,285	28.0	1,075,541	37.4

Panama's population is growing fast. A high birth rate of 40.6 per 1,000 in 1961, and a low death rate of 8.0 explain its rapid annual rate of growth which was 32.6 per 1,000 inhabitants in 1961. Infant mortality was approximately 54.4 per 1,000 live births. Panama city has grown especially fast; it numbered 127,-874 people in 1950 and 273,440 in 1960. The population of Colón in 1960 was 59,598; that of David, 22,924; La Chorrera, 13,696; Chitré, 9,120; Santiago, 8,746.

The Pacific region south of the mountain range running along the western half of the Isthmus contains most of the population.

Culture.—Spanish is Panama's national language. Many Indians, however, speak no Spanish, and only recently have Panamanians of West Indian descent mastered the language. English is commonly spoken in the chief cities, and studied in high school and the university.

Almost all Panamanians are at least nominally Roman Catholic. They are, however, very tolerant of other religions. Numerous sects flourish, especially among those of West Indian ancestry.

Panamanian culture exhibits four distinct patterns besides those of the tribal Indians. Spanish colonial culture, with a considerable admixture of Indian elements, is evident in the small towns and villages of the interior. Neighbours and friends gather for working bees called *juntas*. After clearing land, harvesting a crop, or building a house, they feast on *sancocho*, a meat and vegetable stew, and on their favourite food, rice, and drink a corn liquor called *chicha*. Then they sing folk songs and dance such folk dances as the *tamborito*, *cumbia* and *punto* to the music of homemade guitars, violins and drums. On special occasions as the yearly festival of the patron saint many don folk costumes. Women wear *polleras*, voluminous white garments decorated with embroidery or appliqué, or the long, full, brightly flowered skirts called *montunas*, which are still everyday garb in some regions. Men wear the *montuno*, a long straight blouse of white homespun cotton decorated with fringe and painted figures or cross-stitch embroidery, which almost hides the knee-length trousers. Bull-baiting, cock fights, and displays of horsemanship follow Mass and the solemn procession in which the saint's image is carried around the village square.

In gay, cosmopolitan Colón and Panama city, colonial patterns have been radically altered by foreign influences and urbanization. Their position at "the crossroads of the world" and their economic fluctuations combine to make urban Panamanians tolerant of foreign ways, dependent upon luck and pleasure-loving.

The third cultural pattern, that of the Americans on the Canal Zone, is as nearly American as is possible in a tropical semi-military outpost. Sedate order, routine and regimentation provide a sharp contrast with the colour and bustle across the streets which divide Panama city from Ancon and Balboa, and Colón from Cristóbal.

The British West Indian Negro immigrants have long been a disunited and largely segregated group at the margin of Canal Zone-American and urban Panamanian culture. As the immigrant generation dies out and no new immigration is permitted, however, the remnants of island culture disappear, and the new generation becomes increasingly Panamanian. They retain English, however, as an economic asset and—along with other young Panamanians—adopt many superficial aspects of American life as presented in the movies and shops.

The Indians.—Prior to the Spanish conquest, Panama was inhabited by tribes of primitive indigenous Indians of whom the most important were the Cuna or San Blas, Guaymi and the Chocó groups. Descendants of the Cuna are now divided into two groups: those on the mainland Pacific slope of eastern Panama, and the San Blas Cuna who live in the archipelago of San Blas. Although Panamanian citizens, the Cuna live by their own tribal laws. The picturesque Chocó Indians are found in the Darién region. *See* also INDIAN, LATIN AMERICAN; CENTRAL AND NORTH AMERICAN LANGUAGES. (Jo. B. B.)

V. ADMINISTRATION AND SOCIAL CONDITIONS

Government.—Panama is a centralized republic. Its constitution, adopted in March 1946, provided universal suffrage and the secret ballot. The executive is the president (with two vice-presidents) elected for four years, with the power to appoint cabinet ministers, of which there are seven; government and justice, foreign affairs, finance and treasury, education, agriculture, public works, and labour, social welfare and public health. The unicameral national assembly consists of 53 deputies, with alternates, elected for four years, and convenes annually on Oct. 1 for 90 days. Each of the nine provinces is entitled to elect one deputy and two alternates for each 15,000 inhabitants, and one additional

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MINISTRY OF JUSTICE, SEAT OF THE NATIONAL ASSEMBLY AND THE SUPREME COURT IN PANAMA CITY

for any remaining fraction of not less than 7,500 inhabitants. The judicial organ, the supreme court, consists of five justices appointed by the executive, one every two years for ten-year terms. This court appoints minor magistrates throughout the country.

The constitution recognized Roman Catholicism, but at the same time guaranteed freedom of worship to other religions.

Living and Working Conditions.—In the 1950s Panama was one of the few countries of the world in which the cost of living actually dropped. Approximately 270,000 Panamanians were gainfully employed in the mid-1960s. Of this figure, about 60% were engaged in agriculture, 8% in commerce, 8% in services and 7% in manufacturing. In July 1958 U.S. legislation provided for the establishment of uniform wage scales, retirement benefits and employment opportunities in the Canal Zone for both U.S. and Panamanian employees.

Welfare Services.—Panama has a social security program providing for maternity benefits, compensation for injuries to workmen and allowances for the aged and indigent. In the 1960s infant mortality remained high, and there was a serious shortage of physicians, dentists and hospital beds. In coping with these and similar problems, Panama is among the Latin-American countries participating in the technical assistance programs offered on both a bilateral basis by the United States and a multilateral basis by the United Nations.

Education.—Panama's educational system, administered by the ministry of education, has the highest single appropriation of funds in the national budget, and consists of public preschool, primary and secondary grades. Higher education is offered by teachers' schools, trade schools, the National Institute, the Conservatory of Music and the advanced university. Primary education is compulsory and free. Efforts to make the Inter-American university a focal point for higher education throughout Latin America had a qualified success. The National University at Panama city is autonomous but state endowed, with more than 3,000 pupils in the mid-1960s. There were more than 1,000 public and private primary schools and 90 postprimary schools with a total of about 200,000 pupils. The illiteracy, about 28.3% (1950 census), excluding tribal Indians, is low for the Caribbean area.

Defense.—Panama has no army, navy or air force. There exists, however, a trained and efficient armed national police force of approximately 3,370 members. (G. I. B.)

VI. THE ECONOMY

Production.—The majority of farm families, constituting about 60% of the total population, live on small holdings in the southern coast region around the city of Panama and to the west. Rice is the universal staple, corn (maize) is also important, and the country is nearly self-sufficient in both. Yucca and beans are grown everywhere; and cattle provide much of the meat supply and some hides for export.

The large plantations of the U.S.-owned United Fruit company are in the western area. Bananas are shipped, largely from Puerto Armuelles on the south coast, and abacá from Almirante on the north coast. Cacao and coconuts are also exported. Three large sugar mills maintain plantations, supply the domestic demand, and export their produce.

The virgin forests east of the Canal Zone contain an abundance of tropical cabinet and dye woods; but these remain largely unexploited. There is a mahogany veneer plant near Panama city. Softwood exports have become substantial.

The leading mineral products are cement and salt, the latter from the sea flats near Aguadulce in Coclé. The gold and silver mines in Veraguas, known since colonial times, are worked on a small scale. Pearl fishing is conducted off the Pearl Islands in the Gulf of Panama; the shrimp industry is significant.

The cities of Panama and Colón have numerous retail shops where merchandise and curios from all over the world, brought duty-free, are sold in large volume to tourists passing through the canal. Assorted industries produce leather goods, soap, furniture, clothing, clay products and canned goods such as tomato paste and evaporated milk. A cement plant fills national needs and exports to the neighbouring republics.

Trade and Finance.—The monetary unit is the balboa, which is at par and freely convertible with the U.S. dollar. U.S. currency circulates extensively in the country, but there is no central bank.

Panama has an adverse balance of trade, but it is generally offset by invisible exports to the Canal Zone in the form of tourist expenditures, sales to ships and wages of Panamanians employed there. The latter are subject to taxation by Panama. The chief export commodity is bananas. More than 90% of the country's exports generally go to the U.S. (including the Canal Zone), but only about 60% of the imports are from there. About 12% of the imports come from continental Europe and 7% from the sterling area.

In 1961 the gross national product of Panama was valued at approximately 455,500,000 balboas; the total in 1960 was 409,400,000 balboas.

Transport and Communications.—The Pan-American highway is complete between Panama city and the Costa Rican border. There is a good highway between Panama city and Colón, and also a railway which was built about 1855 by William E. Howland and William H. Aspinwall, United States promoters. This railroad subsequently became the property of the United States government. Important international air services pass through the national airport at Tocumen.

Because of the canal there is an abundance of maritime shipping. Many steamship companies of other countries fly the flag of Panama to take advantage of the favourable shipping laws. Consequently, Panama's ostensible merchant marine is one of the largest in the world. *See* also references under "Panama" in the Index. (W. C. GN.)

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PANAMA, a province on the southern coast of the Republic of Panama. Its area of 4,436 sq.mi. is divided by the Panama Canal Zone, three-fourths lying to the east of the latter. Pop. (1960) 372,393, about 35% of the national total, who live mostly in urban centres within 25 mi. of the Canal Zone where the leading manufacturing industries of the country are located.

The province produces a variety of agricultural products for domestic consumption. The seat of provincial government is at Panama city. (C. F. J.)

PANAMA, capital of the Republic of Panama, located near the Pacific entrance of the Panama canal. Pop. (1960) 273,440.

Panama city is no longer a port. The harbour facilities lie in Balboa and many of the canal employees live in Ancón. Both are suburbs, located within the Canal Zone and governed by a branch of the United States defense department. Panama city is linked with Colón by the canal, the Panama railroad and the Transisthmian highway, with David and Chepo by the Pan-American highway, and from the airport at Tecumen with cities of the world.

Originally a native fishing hamlet, the old city (Panamá Viejo) was formally established in 1519 by Pedro Arias de Ávila, and made the seat of both secular and ecclesiastical authority. From the Andean countries bullion was shipped by sea to Panama and from there carried across the isthmus by pack animals to Nombre de Dios or Porto Bello where it was loaded on ships of the annual fleet bound for Spain. The city prospered until the depredations of the pirates and privateers curtailed trade. In 1595 Sir Francis Drake tried unsuccessfully to send a force across the isthmus to sack Panama, and in 1671 Sir Henry Morgan completely destroyed it. The city was rebuilt in 1674 seven miles west of the old site by Alonso Mercado de Villacorta. It was built with a central plaza around which were placed the cathedral, the governor's house and the bishop's palace. Of the modern buildings, most prominent are the Palace of Justice, La Presidencia, the National palace, and the hotel El Panamá. The University of Panama is located there. Political decline accompanied economic decay, and in 1751 the area became a province of New Granada (Colombia.)

In the 19th century Panama city was the tumultuous scene of much political disorder, and in 1903 the standard of revolt from

Colombia was successfully raised there. In the Hay-Bunau-Varilla treaty with the United States of 1903, the latter was given the right to keep order and keep the city clean, both rights being yielded in treaties of 1936 and 1955 respectively. The city became the national capital in 1903 and developed rapidly thereafter with the construction of the canal. The title to the water and sewer systems built by the United States was turned over to the government of the republic in 1942, and in 1953 their management was also transferred. In 1826, 1939, and 1956 representatives of the American republics met there to proclaim their political ideals.

(A. R. W.)

PANAMA CANAL, a high-level artificial interoceanic waterway of the lake and lock type at the Isthmus of Panama connecting the Atlantic and Pacific oceans, owned, operated and controlled by the United States under treaty, for the transit of vessels of commerce and of war of all nations on terms of equality, with tolls that are just and equitable. The Canal Zone, through which it was built, is the constitutionally acquired domain of the United States granted in perpetuity by the Republic of Panama, for the construction of the canal, and its perpetual maintenance, operation, sanitation and protection.

By using the canal, vessels plying between the Atlantic and Pacific coasts of the United States can eliminate the Cape Horn route and save a distance of about 8,000 nautical mi., while journeys between the Atlantic and Pacific coasts of the North and South American continents can be reduced by 3,000–4,000 mi.; vessels from Europe to western Asia and Australia can effect a saving of 1,000–2,000 mi. Hence the canal is of the greatest international importance, strategically and economically.

This article is divided into the following sections:

I. The Waterway
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  2. Navigation
II. Canal Zone
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III. History
  1. Panama Railroad, 1849–55
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I. THE WATERWAY

1. Description.—The Panama canal does not cross the isthmus from east to west as generally supposed, but from northwest to southeast, with the Atlantic entrance 33½ mi. N. and 27 mi. W. of the Pacific entrance. Located in one of the heavier rainfall areas of the world with its longest section formed by impounding the waters of the Chagres river valley by a dam at Gatun, its principal features include: twin-flight locks, dams and spillways at both ends of the canal; the summit-level Gatun lake; an excavated gorge across the continental divide, renamed as Gaillard cut, connecting Gatun lake with the Pacific locks; a small Miraflores lake between two sets of Pacific locks; and two terminals.

The Atlantic terminus is at Cristóbal on Limón bay, a natural harbour protected against storms from the north by east and west breakwaters. The Pacific terminus is at Balboa, a sheltered artificial harbour with its Pacific entrance channel safeguarded from silt-bearing currents by a causeway from the mainland to the fortified islands in the Bay of Panama.

The canal length from shore line to shore line is 40.27 statute miles; and from deep water to deep water, 50.72 miles. From north to south, its main parts are:

1. Atlantic sea level dredged channel of 500 ft. bottom width from deep water to Gatun locks, about 7.4 mi.

2. Gatun locks in three steps from sea level to Gatun lake, 85 ft. above sea level.

3. Gatun lake section with channels varying in width from 1,000 ft. at Gatun to 500 ft. at Gamboa where Gaillard cut begins, distance about 24 mi.

4. Gaillard cut of 300 ft. minimum bottom width to Pedro Miguel locks at the south end of the cut, distance about 8 mi.

5. Pedro Miguel locks in one step (31 ft.) to the intermediate Miraflores lake, 54 ft. above sea level.

6. Miraflores lake with channel 750 ft. wide to Miraflores locks, distance about 1 mi.

7. Miraflores locks in two steps to Pacific sea level.

8. Pacific sea level dredged section to the Bay of Panama, distance about 8.5 mi.

The controlling depth for the Atlantic dredged section from deep water to Gatun locks is 42 ft. below mean low water; from Gatun locks to Pedro Miguel, 42 ft. below the minimum Gatun lake level of 82 ft.; from Pedro Miguel locks to Miraflores, 42 ft. below the minimum Miraflores lake level of 54 ft.; and from Miraflores locks to deep water in the Pacific, 42.4 ft. below mean low water spring (maximum) tides.

The canal is equipped with modern aids to navigation. The Panama canal has had no major operational improvement since opening to traffic in 1914 with the exception of the Madden Dam and Power project, with its upstream lake to conserve water for lockages and maintenance of channel depths in Gatun lake during dry seasons and to reduce the danger of floods from the upper Chagres in wet seasons, and of the enlargement of the Gaillard cut started in 1959.

Locks.—No part of the canal attracts more attention than its massive locks. Constructed in duplicate to enable simultaneous lockages of vessels in the same or opposite direction, all locks have usable dimensions of 1,000 ft. length, 110 ft. width, and a depth to accommodate vessels drawing 40 ft. in salt water. Each lock gate has two leaves, the leaves being floatable structures 65 ft. wide by 7 ft. thick, varying in height from 47 to 82 ft., weighing from 400 to 750 tons, and operated by 25 h.p. motors through gear arrangements.

Locks are equipped with unique safety devices, notably hydraulically operated fender chains and electric towing locomotives. The fender chains protect lock gates against vessels that may get out of control when approaching locks, and are dropped into grooves to permit passage. With the exception of small craft, vessels are not permitted to pass through locks under their own power, but are required to be drawn by towing locomotives, varying in number from four to ten, depending on ship characteristics.

The time required for passage through the locks depends upon many factors, including size of vessel and its handling features. Generally, lockage intervals are 80 min. at Gatun, 40 min. at Pedro Miguel, and 60 min. at Miraflores.

Gatun Dam and Spillway.—The key structure of the Panama canal is Gatun dam, near the end of the Chagres river valley. It is about 1½ mi. long on its crest, ½ mi. wide at the base, 400 ft. wide at the water surface, 100 ft. wide at the top, and its crest is 105 ft. above sea level. It contains 22,958,069 cu.yd. of material.

Located on a natural hill of rock near the centre of the dam, Gatun spillway was designed to provide adequate control of Gatun lake levels during the maximum known discharge of the Chagres river. The dam and spillway together with Gatun locks form the northern barrier that creates Gatun lake.

Gatun Lake and Gaillard Cut.—Gatun lake, at its normal height of 85 ft., has an area of 166 sq.mi. and a shore line of 1,100 mi.; with a watershed of 1,285 sq.mi., which includes territory of the Republic of Panama. Its designed operating range is 5 ft., between water levels of 87 and 82 ft. above sea level.

Gaillard cut, formerly called Culebra cut, is an artificial extension of Gatun lake across the continental divide to Pedro Miguel locks, with its original bottom at a maximum of 40 ft. above sea level, on an alignment that passes between Gold hill and Contractors hill. Its restricted channel and rocky banks make this cut the most hazardous part of the canal. A steady growth in vessel sizes and number carrying hazardous cargo has increased the frequency of transits requiring one-way navigation in Gaillard cut.

Pacific Dams, Miraflores Lake and Spillway.—Across the south

end of Gaillard cut, a pair of one-lift (31 ft.) Pedro Miguel locks and two flanking dams to nearby hills form the southern barrier closing the upper valley of the Rio Grande and holding the Gatun lake water level. With crests 105 ft. above sea level, the east dam extends about 300 ft. to Cerro Luisa and the west extends about 1,400 feet to Cerro Paraiso. The east dam is a concrete wall, 260 ft. long, covered with earth; the west is earth and rock, containing 699,518 cu.yd. of material.

At Miraflores, a set of two-lift locks and two dams form a second barrier closing the lower valley of the Rio Grande and creating the intermediate Miraflores lake. This lake, at 54 ft. above sea level, has an area of 1.5 sq.mi. Its watershed is 38 sq.mi.

The major part of the east dam at Miraflores is the spillway, designed to handle free flow of water from Gatun lake through one chamber at Pedro Miguel in event of accident. The west dam, with crest 40 ft. wide and 70 ft. above sea level extending 2,700 ft. to Cerro Cocoli, is the second largest dam of the canal, containing about 2,388,423 cu.yd. of material.

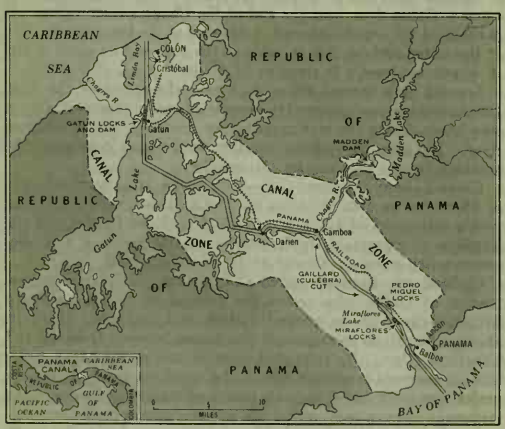
Terminal Facilities.—The Atlantic terminus affords safe anchorages in Limón bay and convenient pier berths at Cristóbal. The Pacific terminus has mooring buoy, dock and pier berths at Balboa; also an unprotected outer anchorage in the Bay of Panama. All piers are modern, 1,000 ft. long by 200 ft. wide, with enclosed sheds and railroad service, ample for storage of consignments and transhipment of cargo.

Both terminals are equipped for servicing of vessels, provisioning and repairs. The principal repair installations are on the Atlantic side near Mount Hope, with a 386-ft. dry dock. Larger marine and railway repair shops on the Pacific side are closed, with a 1,044 ft. dry dock in a stand-by status. Salvage tugs and other wrecking equipment are available.

2. Navigation.—All vessels entering or leaving a terminal port, maneuvering in Canal Zone waters, or in transit, in general, are required to take pilots, who, at all times, have charge of navigation and movement. Transits are made under rigid traffic controls. The average time required to transit is from seven to eight hours.

II. CANAL ZONE

1. Area and Tidewaters.—The Canal Zone is a strip of land and land under water 10 mi. wide with boundaries generally 5 mi. from the centre of the canal except for the western salient covering the mouth of the Chagres river, the arms of Gatun lake extending into the Republic of Panama, and Madden lake. Beginning in the Caribbean, "three marine miles" from mean low water as provided by treaty, the zone extends across the isthmus to a distance of "three marine miles" from mean low water in the Pacific, but excludes the Panamanian cities of Colón and Panama.



MAP OF THE PANAMA CANAL AND CANAL ZONE

The Canal Zone includes all of Gatun lake and surrounding shores up to the 100 ft. contour and all of Madden lake and its shores up to the 260 ft. contour. The total area of the Canal Zone is 647.29 sq.mi.—372.32 sq.mi. land, 185.52 sq.mi. fresh water, and 89.45 sq.mi. salt water, including the Atlantic and Pacific coastal waters within the three-mile limit.

The tides at the Atlantic and Pacific terminals differ in both magnitude and character. At Cristóbal on the Atlantic side they are irregular and small, with an extreme range of 3.05 ft. At Balboa on the Pacific side, they are remarkably regular with two highs and two lows every lunar day of 24 hr. and 50 min., with an extreme range of 22.7 ft.

2. Sovereignty.—Under the authority of the Panama Canal act of 1912 and in conformity with treaty, Pres. William H. Taft, by executive order of Dec. 5, 1912, declared that "all land and land under water within the limits of the Canal Zone are necessary for the construction, maintenance, operation, protection, and sanitation of the Panama Canal." Since title to all such land was acquired by the United States, the Canal Zone, in its entirety, is a United States government reservation.

The only private enterprise activities permitted within the zone are on lands rented under revocable licenses, normally to shipping interests, agriculturists and others directly connected with the canal or its operation. Areas assigned for other government purposes, as of June 30, 1963, include 136.8 sq.mi. for the armed forces, with 103.97 to the army, 22.08 to the navy and 10.75 to the air force; 5.71 to the Smithsonian institution as a wildlife preserve on Barro Colorado; 5.38 as the Madden Forest preserve and 0.96 to the Federal Aviation agency. Remaining land, largely mountain or jungle, totals 190.43 sq.mi. All areas continue subject to the civil jurisdiction of the Canal Zone government in conformity with the Canal Zone code.

3. Administration.—The Panama canal enterprise, as reorganized July 1, 1951, under public law 841, 81st congress, approved Sept. 29, 1950 (Thompson act), consists of two main units, the Panama Canal company and the Canal Zone government, with the dominant mission of the safe, convenient and economic transit of vessels. The Canal Zone is divided into two districts, the Balboa (or Pacific) subdivision and the Cristóbal (or Atlantic) subdivision.

Balboa and Cristóbal.—These subdivisions are coterminous with the Balboa and Cristóbal divisions of the U.S. district court. Their common boundary crosses the Canal Zone at right angles just northwest of Barbacoas Island. The Balboa subdivision includes all Canal Zone area lying southeasterly of this boundary, and the Cristóbal subdivision, all lying northwesterly of it.

Towns, except Gamboa, are clustered near the terminals convenient to canal and shipping activities, in which, directly or indirectly, most of the civilian population in the zone is employed. Gamboa, because it is the headquarters of dredging operations, is located north of Gaillard cut to prevent isolation of equipment from lake dumps in event of slides. All towns have the facilities of well-managed communities in the United States, with high standards of health, sanitation and education. The canal administrative centre is at Balboa Heights.

A long-felt defect in the 1903 treaty was failure to provide for adequate public crossings of the canal for the Canal Zone and Panama, both divided by the waterway. This condition was initially corrected by the United States through establishment of a toll-free ferry at Balboa in 1932 under legislation sponsored by Rep. Maurice H. Thatcher, former member of the Isthmian Canal commission for whom it was named; and finally, in 1962, pursuant to treaty, by the toll-free Thatcher Ferry bridge to replace the ferries.

The civilian population in the 1960 census including dependents of the U.S. armed forces, was 42,122, with 11,499 in the Cristóbal district and 30,623 in the Balboa district. The population of the principal communities was 3,489 for Gamboa and 3,139 for Balboa.

The Panama Canal Company.—This is a corporate instrumentality of the United States, operated under the management of its board of directors and charged with the maintenance and operation of the Panama canal and the conduct of business-type operations

AUTHENTICATED NEWS

BERTH PIERS AT CRISTÓBAL ON LIMÓN BAY, THE ATLANTIC TERMINUS OF THE PANAMA CANAL

incident thereto and to the civil government of the Canal Zone.

The basic law requires that the company be self-sustaining. Its obligations include its own operating expenses, the net cost of civil government, interest and depreciation on United States investment in the enterprise, and $430,000 of the $1,930,000 annuity paid to the Republic of Panama, the remainder being provided by the department of state, and thereby excluded in fixing tolls.

The Canal Zone Government.—This is an independent agency of the United States, administered by a governor of the Canal Zone, under the supervision of the president, or such officer of the United States as may be designated by him (secretary of the army). It performs the functions of city, county and state governments, with certain attributes of diplomatic character in connection with the Republic of Panama. The governor, who is appointed by the president and confirmed by the senate, is ex-officio a director and president of the Panama Canal company.

The judicial functions of the Canal Zone government are performed by two magistrate's courts, Balboa and Cristóbal, each presided over by a magistrate appointed by the governor; and by a United States district court of the fifth judicial circuit, consisting of two divisions, Balboa and Cristóbal, presided over by one judge appointed by the president.

4. Tolls.—The levy of tolls is subject to provisions of the Hay-Pauncefote treaty (1901), the Hay-Bunau-Varilla treaty (1903), and the Thomson-Urrutia treaty proclaimed in 1922. Exempted from transit tolls in accordance with treaty are vessels owned, operated or chartered by the government of the Republic of Panama and war vessels of the Republic of Colombia; also vessels in transit solely for repairs at Panama canal shops.

Tolls are assessed on the basis of Panama canal net tonnage of actual earning capacity, a net vessel ton being 100 cu.ft. of space. Tolls cover all normal transit charges, including pilot service. Vessels operated by the United States, including warships and auxiliaries, are assessed tolls.

Tolls in 1964 were 90 cents per net ton for merchant vessels, army and navy transports, tankers, hospital and supply ships, and yachts, when carrying passengers or cargo; 72 cents per net ton on such vessels in ballast without passengers or cargo; and 50 cents per ton of displacement for other types. The average measurement per ocean-going commercial vessel in fiscal year 1963 was 5,855 net tons and average tolls per vessel, $5,116.

Fiscal year	Number of commercial transits*	Tolls revenue	Long tons of cargo
1929 . .	6,289	$27,111,125	30,647,768
1933 . .	4,162	19,601,077	18,161,165
1939 . .	5,903	23,661,021	27,866,627
1944 . .	1,562	5,456,163	7,003,487
1950 . .	5,448	24,430,206	28,872,293
1955 . .	7,997	33,849,477	40,616,301
1960 . .	10,795	50,919,428	59,258,219
1961 . .	10,866	54,127,877	63,669,738
1962 . .	11,149	57,289,705	67,524,552
1963 . .	11,017	56,368,073	62,247,094

*Ocean-going vessels of 300 or more net tons, Panama canal measurement.
Source: *Annual Report.* Balboa Heights: Panama Canal Company, Office of the President.

The Panama Canal company is authorized to prescribe and, from time to time, change rules for the measurement of vessels and tolls, subject to requirements for six months notice, public hearings and approval by the president of the United States, whose action shall be final and conclusive.

5. Canal Traffic.—Although the Panama canal was conceived and built primarily as an artery of world trade, its traffic, except during World War II, has had an irregular but sustained growth since 1916 in the number of commercial transits and cargo tonnage. Its traffic volume is extremely sensitive to wars and depressions, and to appreciable political, economic or other upheavals in any part of the world, such as crop failures, strikes, destruction by tropical storms, development of foreign industries and closure of the Suez canal.

A significant feature of Panama canal traffic is the pattern of its trade routes, of which eight are well defined.

The lowest traffic volume after 1933 occurred in 1944, when there were 1,562 transits by ocean-going commercial vessels with 7,003,487 tons of cargo. A high point in traffic history occurred in fiscal year 1962 when, for the 11th consecutive year, new records in the number of transits, toll revenue, and tons of cargo were made. Growing numbers of commercial vessels with beams over 80 ft. were using the canal, thus emphasizing the need for increased capacity.

6. Defense.—The Panama Canal act of 1912 vests responsibility for protection of the Panama canal and Canal Zone in the governor, this protection being the normal exercise of police authority within the Canal Zone. Defense against external aggression is a function of the armed forces, for which the commander in chief, Caribbean, is responsible. These include army, navy and air force units, located in the Canal Zone and elsewhere.

The act further provides that "in time of war in which the United States shall be engaged, or when, in the opinion of the president, war is imminent," the president is authorized to vest exclusive authority and jurisdiction over the Panama canal and Canal Zone government in such officer of the army as the president may designate. During continuance of such condition, the governor of the Canal Zone is subject in all respects to the orders and directions of the designated officer of the army.

During war or emergency, elaborate security precautions are taken by both civil and military authorities, including careful examination of arriving vessels and use of specially trained security guards during transits.

III. HISTORY

The advantageous geographical location of the Central American isthmus was recognized by the early Spanish who, within a few years after the visit there by Columbus in 1502, followed with extended explorations focused on four main route areas: Tehuantepec, Nicaragua, Panama and the Darién-Atrato. Not finding a strait, they promptly conceived the idea of constructing one.

Because of lower continental divides at Panama and Nicaragua, with penetration by large valleys, these two avenues became rivals for isthmian transit. At Panama, mountainous terrain and torrential rivers, notably the Chagres, at the time presented insuperable barriers to a canal. Lake Nicaragua, 3,089 sq.mi. in area, with its then navigable San Juan river flowing into the Atlantic, reduced the magnitude of the task to cutting across the narrow strip which separated the lake from the Pacific.

Eventually, control of the Nicaragua route became a focal point of international conflict, with Great Britain and the United States in a diplomatic deadlock. This situation was prolonged by the Clayton-Bulwer treaty (1850) which deprived the United States of exclusive control over any isthmian canal that it might construct.

1. Panama Railroad, 1849–55.—When United States westward expansion in the late 1840s required better means for transit, three North Americans of vision, John Lloyd Stephens (*q.v.*),

William Henry Aspinwall, and Henry Chauncey, organized the Panama Railroad company. Chartered in 1849 by the state of New York, this company, under enormous difficulties, completed building the Panama railroad in 1855—the first transcontinental railroad of the Americas. Running from Aspinwall (Colón) close to the line of the future canal, this 47.5-mi. strategic rail link was the first concrete step toward construction of the Panama canal, giving it a tremendous advantage over Nicaragua in the choice of route.

In view of the key functions that this celebrated railroad was later to fill in Panama canal history, it is important to note a treaty of 1846 between the United States and New Granada (Colombia). This treaty was an offensive and defensive alliance aimed primarily toward securing a canal at Panama, even then recognized by Pres. James K. Polk as the most practicable route. It provided that the United States should guarantee the "perfect neutrality" of the isthmus and its free and uninterrupted transit.

2. French Project, 1879–1904.—Meanwhile, French interests under the dynamic leadership of Ferdinand de Lesseps (*q.v.*), hero of the Suez canal, decided to construct a canal across the American isthmus. An International Congress for Consideration of an Interoceanic Canal, consisting of 135 delegates, convened at Paris on May 15, 1879, to decide upon site and type. As president of the congress, De Lesseps applied the full force of his prestige and genius toward securing approval for a sea-level type of canal at Panama.

Adolphe Godin De Lépinay de Brusly, an engineer who had studied the American isthmus, protested strongly at this trend. He understood the topography at Nicaragua and how its large natural lake, 105.5 feet high, would contribute toward construction of a canal at that location. He knew the surface features at Panama—the continental divide about 10 mi. from the Pacific, the torrential Chagres river flowing into the Atlantic, and the smaller Rio Grande into the Pacific, both through valleys suitable for the formation of lakes. He emphasized the key problems at Panama as the control of the Chagres river and excavation of Culebra cut, recognized the lake idea as offering the best solution, and proposed a "practical" plan for building the Panama canal. It called for a dam at Gatun and another at Miraflores, or as close to the seas as the configuration of the land permitted, letting the waters rise to form two lakes about 80 ft. high, joining the lakes by cutting across the continental divide, and connecting them with the oceans by locks. This design, he explained, was not only best for engineering but also most advantageous for navigation.

Unfortunately for the French, De Lépinay's idea was ignored. His conception, however, and its dramatic presentation before the Paris congress of 1879, established him as an architectural and engineering genius and the originator of the plan from which the Panama canal was eventually built.

The French Panama Canal company, despite De Lépinay's timely warning, launched upon its ill-fated undertaking. Ten years later, in 1889, its effort collapsed due to a combination of bankruptcy, lack of planning and disease. In France, it resulted in a sensational financial scandal. Yet, before failing, the company, to save money and time, was forced to change its plans from sea-level to a high-level lock type.

Reorganized in 1894 as the New Panama Canal company, its officers realized that their only chance of assuring any return on the investment was to hold on until the United States could be induced to take control. Thus until 1904 they limited their activities to technical studies and such excavation as were required to protect the concession from Colombia. The total French excavation was 78,146,960 cu.yd. of material, of which 29,908,000 were later useful to the United States.

3. United States Policy, 1850–81.—With active canal endeavours temporarily checked by the Clayton-Bulwer treaty and transit facilities met by the Panama railroad, United States efforts were generally restricted to explorations. It was not until Gen. Ulysses S. Grant became president in 1869 that major interest revived, with extensive naval exploring expeditions starting in 1870 and covering the more important canal sites.

With the objective of securing the best type of canal at the best site, and at least expense, the reports of these expeditions were reviewed by the first United States Interoceanic Canal commission, 1872–76, consisting of Brig. Gen. Andrew A. Humphries, chief of U.S. army engineers; C. P. Patterson, U.S. Coast survey; and Commodore Daniel Ammen, chief of the bureau of navigation of the navy. Reporting to President Grant on Feb. 7, 1876, the commission was unanimous in recommending a Nicaragua canal starting on the Atlantic side near Greytown, following the San Juan river to Lake Nicaragua, through the lake, and thence across the land to Brito. Thus, the United States became definitely committed to the Nicaragua route, then complicated by British control of its eastern terminus through their protectorate over the Mosquito kingdom.

Viewing an isthmian canal as "virtually a part of the coastline of the United States" and alarmed by the energetic measures taken by French interests at Panama, United States leaders determined to change American policy. This attitude found expression on March 8, 1880, when the Select Committee on Interoceanic Canals of the house of representatives recommended a resolution by the congress declaring that any form of protectorate on this continent was contrary to the Monroe Doctrine (*q.v.*), that the United States asserts and maintains its right to possess and control any artificial means of isthmian transit, and that the president be requested to take steps to abrogate the Clayton-Bulwer treaty. This objective was supported by former President Grant, who, in Feb. 1881, publicly commended "an American canal, on American soil, to the American people."

4. Isthmian Canal Commission, 1899–1901.—The French failure in 1889 rendered the canal situation less acute, requiring a new crisis to dramatize the issue. This was supplied by the historic voyage of the U.S.S. "Oregon" during the Spanish-American War in 1898, which emphasized the need for an isthmian canal. The result was that Pres. William McKinley, in 1899, appointed an Isthmian Canal commission, with Rear Admiral John G. Walker, U.S.N. (ret.), as president, to investigate all canal routes, particularly Nicaragua and Panama, and to recommend the most practicable.

In its first report on Nov. 16, 1901, the commission estimated the cost of a Nicaragua canal at $189,846,062, and Panama at $144,233,358; and the value of the French holdings at $40,000,000. But as the French company was demanding $109,141,500 for its property, the total estimate for Panama was $253,374,858. Because of the excess cost for a canal at Panama, it recommended Nicaragua as the only practicable route.

5. U.S. Diplomacy, 1901–03.—Meanwhile, the United States government, under the leadership of Secretary of State John Hay, negotiated with Great Britain the Hay-Pauncefote treaty of Nov. 18, 1901, which superseded the Clayton-Bulwer treaty and recognized the exclusive right of the United States to construct, regulate and manage any Isthmian canal. It further adopted the principal points in the Convention of Constantinople (1888) for the Suez canal as rules for the operation and neutralization of the American canal. These rules provided that the canal should be free and open to vessels of commerce and of war of all nations on terms of entire equality, with tolls that were just and equitable. The United States was also authorized to protect the canal against lawlessness and disorder.

The New Panama Canal company in Paris, reacting to the commission's recommendation for Nicaragua, on Jan. 9, 1902, cabled Admiral Walker its readiness to accept the United States offer of $40,000,000 for its holdings. Thereupon the commission, in a supplementary report on Jan. 18, 1902, canceled its first recommendation and recommended Panama as the most practicable and feasible route for an Isthmian canal. Describing the previous concessions from Colombia as unsatisfactory and insufficient, the commission emphasized the necessity for obtaining in perpetuity the grant of a sufficient strip of territory across the isthmus for canal purposes. Promptly transmitted to the congress by Pres. Theodore Roosevelt, the new recommendation started a memorable debate in the congress known as the "battle of the routes." Out of it came the basic law for construction of the Panama canal approved June 28, 1902, known as the Spooner act.

This law authorized the president to acquire all French holdings including its Panama railroad stock at a cost not exceeding $40,000,000, to obtain from Colombia perpetual control of a strip of land for the maintenance, operation and protection of the Panama canal and railroad, and then, through the Isthmian canal commission, to construct the Panama canal. The type contemplated by the act was high-level, with Atlantic locks and dams at Bohio to form a Lake Bohio. Provision was also made that in event of failure to obtain an adequate treaty within a reasonable time, the president should proceed with construction of a Nicaragua canal.

In harmony with the act, Tomás Herrán, Colombian chargé d'affaires in Washington, after many months of arduous labour, succeeded in negotiating a most favourable treaty for his country —the Hay-Herrán treaty of Jan. 22, 1903, which was ratified by the United States senate on March 17, 1903.

Unfortunately, this treaty became involved politically in Bogotá. The Colombian senate, called into special session on June 20, 1903, for its ratification, rejected the treaty against urgent pleadings by Herrán in Washington and U.S. Minister Arthur M. Beaupré in Bogotá.

The Panama Revolution, 1903.—Panamanian leaders, fearing that after all Panama might still lose the canal to Nicaragua, determined to avert that possibility. A Panamanian agent was then dispatched to Washington to obtain promise of help for a plan of revolt. While no promise was given, the warship U.S.S. "Nashville" appeared at Colón on Nov. 2, 1903. On the following day an uprising occurred, Colombian troops were prevented from crossing the isthmus to put down the rebellion and independence was proclaimed under the leadership of Manuel Amador. It was recognized, first by the United States, second by France, and soon afterward by other countries.

Then followed negotiation of the second basic canal convention, the Hay-Bunau-Varilla treaty of Nov. 18, 1903, with Panama instead of Colombia. By this treaty, in harmony with the Spooner act, United States was granted in perpetuity exclusive use, occupation and control of the Canal Zone. Significantly the United States could exercise all sovereign powers to the entire exclusion of the exercise of such powers by Panama. That country was to receive $10,000,000 in cash and a $250,000 annuity to begin nine years after ratification of the agreement. The proclamation of this treaty on Feb. 26, 1904, sealed the choice of the Panama route.

A few days later, on March 8, 1904, President Roosevelt recognized the contributions of Admiral Walker by appointing him as the first chairman of the first Isthmian Canal commission for the construction of the Panama canal. One member, Maj. Gen. George W. Davis, U.S. army (ret.), was the first governor of the Canal Zone. John F. Wallace, a leading railroad engineer, not experienced in "frontier" work, was chosen as the first chief engineer.

The Canal Zone was formally acquired on May 4, 1904—a day subsequently celebrated annually in the zone as Acquisition day.

6. Building the Canal, 1904–14.—Work under the United States started haltingly. Because of public clamour to "make the dirt fly," the commission weakened in its stand for thorough and comprehensive preparation and started work without proper equipment or plans. Though valuable time was thus lost, the commission made important contributions. It organized the Canal Zone government, started sanitation under the supervision of William Crawford Gorgas (*q.v.*), and recruited the nucleus of an engineering and construction force.

Resigning on March 30, 1905, the Walker commission was succeeded by a new one headed by Theodore P. Shonts, a prominent railroad executive, with Wallace continuing as chief engineer. Though for a time conditions improved, Wallace, on June 26, 1905, suddenly resigned, throwing the working forces into confusion.

Battle of the Levels, 1904–06.—Of the difficulties of this period the gravest was increasing uncertainty as to the type of canal that should be built—the high-level lock type contemplated by the Spooner act or a canal at sea level as had been suggested by Wallace in 1904.

Fortunately, President Roosevelt selected a great railroad builder, executive and explorer, John F. Stevens, as the new chief engineer. Stevens' qualifications were unique. He had read everything available on the Panama canal since the time of Philip II, discovered Marias pass in Montana, built railroads in the Rocky mountains and supervised open mining operations in Minnesota. Thus, he had observed what occurs when the delicate balances of nature are upset, understood the hazards of cutting a ship channel through mountains, and was experienced in personnel and construction problems in undeveloped terrain.

Arriving on the isthmus on July 25, 1905, at a time of chaos, he rescued the project from possible disaster. He promptly provided housing for employees, established commissaries, adopted sanitation measures, ordered equipment and double-tracked the Panama railroad. After planning the transportation system for Culebra cut excavation and for relocation of the railroad to higher ground on the east side of the canal, moving the Atlantic locks site from Bohio

BY COURTESY OF PANAMA CANAL COMPANY

GATUN LOCKS AND PART OF DAM LOOKING SOUTH FROM THE ATLANTIC APPROACH TO GATUN LAKE

to Gatun to form Gatun lake, recruiting competent leaders and forming the organization for building the Panama canal, he found progress hampered because of delay on the decision as to type of canal, then being considered by an International Board of Consulting Engineers, of which General Davis was chairman.

In its report of Jan. 10, 1906, this board split—the majority of eight members headed by General Davis and including five Europeans, voting for sea level; and the minority, five Americans (Alfred Noble, Henry L. Abbot, Frederic P. Stearns, Joseph Ripley and Isham Randolph), voting for the lock type.

The controlling features of the lock plan recommended by the minority were a dam at Gatun creating Gatun lake 85 ft. high as the summit level and Culebra cut. Parallel flight locks were to be provided: three-lifts at Gatun, one-lift at Pedro Miguel, and two-lifts at Sosa hill, the last two sets being separated by an intermediate Sosa lake. Though of different lock arrangement, this plan was the same type as recommended in 1901 by the Walker commission.

Testifying before congressional committees in Washington in January and June 1906, and using the De Lépinay arguments of 1879, Stevens supported the high-level plan with a conviction that no one could shake, and strongly opposed the sea-level plan recommended by the majority of the International Board of Consulting Engineers. In the end, with the support of President Roosevelt, Secretary of War Taft, and the Isthmian Canal commission, the views of Stevens prevailed against strenuous opposition concerned primarily with questions of "vulnerability." Congress, by act approved June 29, 1906, adopted the high-level lake and lock plan as proposed by the minority. This was the great decision in building the Panama canal.

The transit since 1914, in both peace and war, of thousands of vessels of various types, completely establishes the wisdom of that decision. It secured for Stevens, who was mainly responsible for bringing it about, great fame as the basic architect of the Panama canal. This fact was recognized in Oct. 1962 at the time of the opening of the Thatcher Ferry bridge by the dedication of a handsome memorial honoring the great engineer.

Pacific Lock Location Question, 1906–08.—Though the high-level plan, as approved by the minority of the International Board

of Consulting Engineers, placed all Atlantic locks at Gatun it divided the Pacific locks into two sets. Stevens, early in 1906 before adoption by congress of the minority report, recognized the Pacific lock arrangement as faulty and recommended consolidation as a needed change.

Eventually, on Aug. 3, 1906, Stevens approved a plan placing all Pacific locks in three-lifts south of Miraflores with the terminal dam and locks between two hills, Cerro Aguadulce on the west side of the sea level section of the canal and Cerro de Puente on the east side, a location later recognized by Lieut. Col. George W. Goethals as offering the best site. This arrangement would have enabled lake-level navigation from the Atlantic locks to the Pacific, with a summit level anchorage at the Pacific end of the canal.

Regrettably, Stevens was under great pressure to start active construction. Advocates of the sea-level proposal, stung by their defeat in congress, and also opponents of any canal at all, were ready to take advantage of any change in the approved program as evidence of weakness in the high-level plan. Together, these two forces represented a political and economic power that could not be ignored.

Stevens' foundation investigations, necessarily made in haste, proved unsatisfactory, and he did not dare to jeopardize the project by further delay. On Aug. 23, 1906, apparently confident that this important question would rise again, he voided his plan but retained it on file, and proceeded with the approved plan for separating the Pacific locks, which he did not personally favour.

Later, after Stevens left canal service, Maj. William L. Sibert, a member of the commission with a keen appreciation of marine needs in the design of navigational works, made more extensive explorations. Finding adequate foundations, he likewise, on Jan. 31, 1908, recommended the consolidation of all Pacific locks in three-lifts at Miraflores to provide a Pacific terminal lake, but his well-reasoned proposal was not approved, and the canal was completed with two sets of Pacific locks, separated by Miraflores lake.

Construction and Completion, 1907–14.—With canal type decided, construction organization effected, and a greater part of the plant installed by July, 1906, real progress started. Thus, Stevens was able to assure the press in 1906 that the canal would be completed in 1914 and formally opened by Jan. 1, 1915.

On Jan. 30, 1907, after having brought design and construction to a point where work was in "full swing" and success a certainty, Stevens submitted his resignation to the president. Despite that action, however, Roosevelt, on Mar. 4, 1907, in recognition of his tremendous contributions, appointed him as chairman of the Isthmian Canal commission, making Stevens the first to hold the combined positions of chairman and chief engineer.

Stevens was succeeded by Lieutenant Colonel Goethals, an outstanding army engineer, who, with his associates, civilian as well as military, ably brought the project to completion substantially in accord with the Stevens plan. Such changes as were made, though important, were nonbasic. These included widening the bottom of Culebra cut from 200 ft. to 300 ft., increasing usable lock dimensions to a width of 110 ft. and length of 1,000 ft., with a depth to permit passage of ships drawing 40 ft. in salt water, rerouting the Panama railroad around Gold hill, relocation of locks from Sosa hill to Miraflores, and redesign of Gatun dam.

Other members of the Isthmian Canal commission on April 1 1907, were Maj. David D. Gaillard, Major Sibert, naval civil engineer Harry H. Rousseau, Lieut. Col. William C. Gorgas, Jackson Smith and J. C. S. Blackburn. Later changes included Lieut. Col. H. F. Hodges (1908–14) to succeed Smith, Maurice H. Thatcher (1910–13) to succeed Blackburn and Richard L. Metcalfe (1913–14) to succeed Thatcher. Gaillard died on Dec. 5, 1913, without a successor.

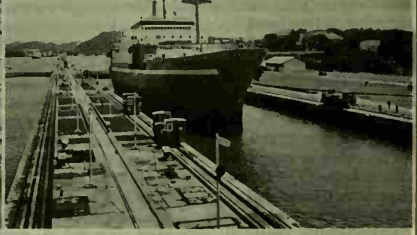
The building of the Panama canal, one of the greatest engineering feats in the world, was indeed a monumental and unprecedented achievement. Its subsequent success, in both peace and war, entitle all who, in significant manner, participated in its planning construction, sanitation and civil administration, to highest honour. The canal was opened to traffic on Aug. 15, 1914.

7. Principal Engineering and Construction Projects After 1914.—The Isthmian Canal commission, abolished on April 1 1914, was succeeded by a highly centralized permanent operating organization authorized by the Panama Canal act of 1912, known simply as The Panama Canal. Though free, under the law, to choose the governor from any source, Pres. Woodrow Wilson, in recognition of the services of Colonel Goethals, appointed him as the first governor of The Panama Canal.

The canal was launched into its era of operations under Governor Goethals, who served until late 1916 after the early slide crises. Goethals chose his principal engineer assistant as his successor and established a tradition of succession, by advancement, that lasted until 1952.

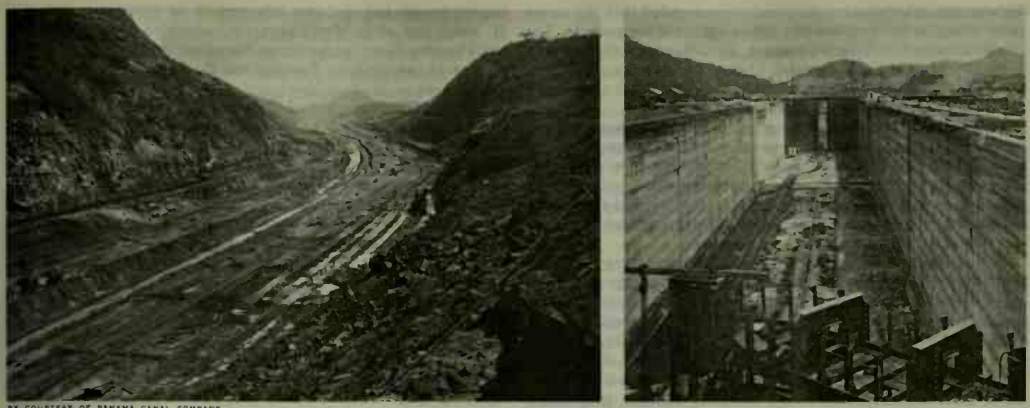
Madden Dam and Power Project, 1919–35.—Faced with the problems of an unusually dry season, 1919–20, requiring conservation of water for lockages and maintenance of channel depths, and later by a great flood in 1923, endangering the waterway, together with growing traffic, congress authorized the first important step toward increasing canal capacity, the Madden Dam and Power project. Completed in 1935, it provided more water for lockages controlled floods, improved navigation and supplied additional power.

Third Locks Project, 1939–42.—The second step toward greater capacity was for a third set of locks. Because of naval needs, in the critical period preceding World War II, congress, on administrative recommendations, authorized the Third Locks project, at a cost not to exceed $277,000,000. The proposed layout contemplated a new set of larger locks, 1,200 ft. long and 140 ft. wide with 45 ft. navigable depth, near each of the existing locks but at some distance away with the new locks joined with existing chan-



BY COURTESY OF (LEFT) PANAMA CANAL COMPANY, (RIGHT) GRACE LINE

(LEFT) MIRAFLORES BASIN LOOKING NORTH FROM THE PACIFIC APPROACH TO MIRAFLORES LOCKS, MIRAFLORES LAKE, AND PEDRO MIGUEL LOCKS (RIGHT) VESSEL PASSING THROUGH MIRAFLORES LOCKS



BY COURTESY OF PANAMA CANAL COMPANY

CONSTRUCTION OF THE PANAMA CANAL. (LEFT) GAILLARD (CULEBRA) CUT, 1910, LOOKING SOUTH WITH GOLD HILL AT LEFT AND CONTRACTORS HILL AT RIGHT; (RIGHT) PEDRO MIGUEL LOCKS, 1912, LOOKING NORTH FROM LOWER MAIN GATES OVER WEST CHAMBER

nels by means of by-pass channels. At the Atlantic end, the project duplicated existing arrangements. At the Pacific end, however, the proposed channel, in addition to duplicating its faulty layout, contained three sharp bends of 29°, 47° and 37° in succession from north to south.

Work started in 1940 and was pushed vigorously until suspended by the secretary of war in May, 1942, because of shortage of ships and materials more urgently needed elsewhere for war purposes. No excavation was accomplished at Pedro Miguel; that at Gatun and Miraflores was substantially completed. About $75,000,000 was expended.

Terminal Lake—Third Locks Plan, 1942–43.—Fortunately, suspension of work on the Third Locks project occurred while there was still time for canal officials to re-examine it in the light of needs demonstrated by war-operating experience. These studies served to emphasize that the separation of the Pacific locks and failure to provide a summit-level lake at the Pacific terminus were fundamental errors of design, with Pedro Miguel locks as the principal obstruction to optimum canal operating conditions.

Out of the studies, including an evaluation of the sea-level idea, grew what proved to be the first comprehensive proposal for the economic increase of capacity and operational improvement of the Panama canal—the Terminal Lake-Third Locks plan. It proposed the physical removal of Pedro Miguel locks, consolidation of all Pacific locks near Aguadulce, elevation of the intermediate Miraflores lake water level from 54 ft. to that of Gatun lake to create a summit-level anchorage at the Pacific end of the canal to match, as far as possible, that in the Atlantic end. It would also include raising the summit level to its highest feasible height of approximately 92 ft., enlarging Gaillard cut and constructing a set of larger locks. Essentially, this was the same plan originated by De Lépinay, and later recommended by Stevens and Sibert.

Officially submitted and publicly presented in the Canal Zone, it aroused wide interest among engineers and maritime agencies, including the secretary of the navy, who, on Sept. 7, 1943, submitted it to the president. Soon after, in 1944, it was approved in principle by the governor of The Panama Canal and recommended to the secretary of war for thorough investigation, and later, in 1945, it was approved in general before the congress by a succeeding governor for the major modification of the existing waterway in preference to completing the original Third Lock project. A 1949 congressional investigation reported that it could be accomplished at comparatively low cost.

The Terminal Lake-Third Locks plan, being an enlargement of the existing facilities that does not call for additional land or waters, is covered by current canal treaties and does not require negotiation of a new one, a paramount diplomatic consideration.

Sea Level Plan, 1945–47.—The spectacular advent of the atomic bomb in 1945 injected new elements into the canal picture. At the request of Canal Zone authorities, congress enacted public law 280, 79th congress, approved Dec. 28, 1945, authorizing the governor of The Panama Canal to make a comprehensive investigation of the means for increasing its capacity and security to meet future needs for interoceanic commerce and national defense, including consideration of canals at other locations. This was the first time the terms "security" and "national defense" had been embodied in any Panama Canal statute.

The report of the inquiry with security and national defense as paramount considerations, recommended only the sea-level plan for major canal construction, initially estimated in 1947 to cost $2,483,000,000, a figure later substantially increased. Though the report covered the Terminal Lake-Third Locks plan, which it did not recommend, it offered a relatively minor program for improvement of present installations as a preferred alternative to the major operational improvement of the existing waterway as recommended in 1943 by the secretary of the navy.

With the exception of the two canal terminals, the 1947 sea-level plan would provide a virtually new Panama canal of 60 ft. minimum depth in navigation lanes and of 600 ft. width between sloping sides at a depth of 40 ft. on a new alignment somewhat removed from the present channel. The plan also provides a tidal lock (200 ft. by 1,500 ft.) and a navigable pass at the Pacific end, many miles of flood control dams on both sides of the projected canal, diversion channels and spillways. Some of its features are not covered by current international conventions and would require a new treaty with Panama, with further concessions, attendant indemnity and increased annuity charges.

The report of the investigation failed to receive presidential approval. Transmitted to the congress on Dec. 1, 1947, without comment or recommendation, its submission, however, led to a recurrence of the 1902 and 1906 debates over route and type with almost identical arguments, but on the basis of the newer term, "security," rather than the old term, "vulnerability."

In voluminous discussions, many leading engineers, nuclear scientists and other experts challenged the assumptions on which the principal 1947 recommendations and estimates rested. The congress took no action until 1957, when an independent inquiry into the entire subject of increased facilities for interoceanic transit was authorized and a special board of consultants appointed.

Its final report of June 1960 included estimates for the Terminal Lake-Third Locks plan ($1,020,900,000) and the Sea-Level plan ($2,537,000,000) exclusive of any Panamanian indemnity. The board emphasized that the Sea-Level plan would present many constructional problems including interruption to traffic. A plan for a lake and lock canal at Nicaragua ($4,095,000,000) as an alternate route was submitted without definite recommendation

This report, otherwise inconclusive, recommended that the entire canal situation be reviewed in 1970 or earlier if warranted. The congress, on administrative request, by act approved Sept. 22, 1964 (78 Stat. 990), authorized further investigations to determine the feasibility and most suitable site for a canal at sea level between the Atlantic and Pacific oceans.

Meanwhile, the 1947 report served to focus governmental attention on administrative problems of the Panama canal.

8. Reorganization and Policy Determination.—On June 30, 1948, the Panama Railroad company was reincorporated as a federal corporation and, on Feb. 28, 1949, the house of representatives authorized an investigation into the organizational and financial aspects of the Panama canal enterprise.

All recommendations growing out of this inquiry were implemented except that for transfer of responsibility for canal supervision from the secretary of the army to the secretary of commerce, which the president delayed for further study. The resulting Act of Congress, public law 841, 81st congress, approved Sept. 26, 1950, known as the Thompson act, created the Panama Canal company and the Canal Zone government. Effective July 1, 1951, the act started major administrative changes, including a break in 1952 in the traditional selection for appointment as governor. The law requires that transit tolls be established at rates to place the canal enterprise on a self-sustaining basis, a fundamental principle in canal policy with far-reaching implications for its future. (M. DuV.)

9. Panama-U.S. Relations.—Because of the previous history of Panama as a land of endemic revolution, the framers of the 1903 treaty, in order to guarantee political stability essential for future efficient operations of the waterway, insisted on its perpetuity, sovereignty and protective clauses. Subsequent events fully substantiated the wisdom of these 1903 treaty provisions, which remain largely unchanged. The canal was no sooner opened to traffic in Aug. 1914, than the United States applied another provision of this treaty, that of obtaining additional lands. During World War I, in which Panama participated, the United States took possession of several areas of land, and in 1919 acquired a group of islands. Friction over this and other issues led to an attempt in 1926 to revise the convention of 1903, but Panama refused to sign any agreement. The attempt was renewed in Oct. 1933, when Pres. Harmodio Arias conferred in Washington with the U.S. president. Their basic agreement was refined and incorporated in four treaties, signed March 2, 1936. At the insistence of Panama, the United States was relieved of the obligation to guarantee the independence of the republic and renounced the right to acquire any additional lands and waters outside the Canal Zone. By limiting the use of the zone commissaries to persons employed on the canal and the railroad, the negotiators sought to dissipate a long-standing grievance. It was agreed that Panama was to operate port facilities at Colón and Panama city, that equal opportunities between Panamanian and American employees should be observed, and that the United States should increase the annuity from $250,000 to $430,000. Agreement was also reached on constructing a trans-isthmian highway. The weakening of the diplomatic structure was further advanced in the 1955 Eisenhower-Remón treaty, which provided for the annual U.S. payment to Panama to be increased to $1,930,000, for equal pay for equal work to Panamanians and U.S. citizens (effective 1958), and for Panamanian concerns to be placed on an equal footing with U.S. companies in contract bidding; the U.S. obtained a 15-year lease for a military base at Rio Hato. The effect of these treaties has been the withdrawal of canal activities to the limits of the Canal Zone and the curtailment of activities within the zone.

The policy of the Canal Zone authorities in the ensuing years was to improve the living conditions of the Panamanians working in the zone and to make changes in the physical features of the canal that would benefit trade in general and Panama's well-being in particular. Among the new policies designed to improve the condition of Panamanian workers were equal wages for equal work, the establishment both of a minimum wage and a labour commission to hear disputes, and the making available of health and life insurance equally to Americans and Panamanians. Capital improvements included the enlargement of Gaillard cut to 500 ft. width and 47 ft. depth (not yet completed), the building of the Thatcher Ferry bridge across the canal, the transfer of certain real estate properties to Panama, and the purchase of new towing locomotives.

But these changes lacked the emotional appeal that was attached to the display of the Panamanian flag. In 1958 and in 1959 the Canal Zone was invaded by Panamanians intent on raising their flag there, and in the latter year their attempt was turned back with injuries. President Eisenhower reviewed the Panamanian claim with sympathy, and in 1960 agreed to the raising of the Panamanian emblem at one point in the Canal Zone as evidence of titular sovereignty (never defined). From this beginning the United States made further concessions until the two flags were displayed almost equally.

A dispute over this very concession between Panamanian and U.S. students at the Balboa high school on Jan. 9, 1964, caused considerable deterioration in relations between the two countries. The subsequent mob assaults on the Canal Zone produced a number of deaths, injuries by the score, and great property damage, requiring the use of U.S. army units and a temporary replacement of civilian by military rule in the Zone. The U.S. embassy was evacuated, and many Americans left their homes for the sanctuary of the Canal Zone. Normal diplomatic relations were restored on April 3.

During the weeks of discussion the economy of Panama suffered. Trade between the Canal Zone and Panama declined; investment capital was less available; credit became tight and tourism almost ceased. On the other hand, the canal continued to operate without interruption. The enlargement of the Gaillard cut was not slowed down, the new towing locomotives began to arrive, and, of more immediate importance, the illumination of the locks promised to extend the hours of transit.

See PANAMA: *History* for further aspects of Panama-U.S. relations; *see* also references under "Panama Canal" in the Index.

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PANAMA CITY, a city of northwest Florida, U.S., and the county seat of Bay county, is 103 mi. E. of Pensacola on the northern shore of St. Andrew bay. The landlocked, deep-water harbour is on the intracoastal waterway. During World War II the city became a major shipbuilding and war industrial centre and the population grew rapidly.

Nearby military installations are Tyndall Air Force base, an air defense command base, and a United States navy mine defense laboratory. Principal products of the area are fish, paper and chemicals, including tall oil. Panama City beach, 10 mi. S. of Panama City, is largely a summer resort.

During the American Revolution the area was settled by Tories, who established indigo plantations and engaged in the lumbering and naval stores industries. Salt works on St. Andrew bay, established to serve the Confederacy, were destroyed by Union raids in 1863. Fisheries in the area were temporarily destroyed in the Civil War.

Panama City was formed in 1909, by merging a village of that name with Millville and St. Andrew, which had been a flourishing community as early as 1800. For comparative population figures *see* table in FLORIDA: *Population.* (E. C. Jo.)

PANAMA SCANDAL, the exposure of an enterprise of corruption in the French Chamber of Deputies, an episode much exploited in propaganda by the enemies of the Third Republic.

The Compagnie Universelle du Canal Interocéanique de Panama, or French Panama Canal Company, which had been sponsored originally by Ferdinand de Lesseps (*q.v.*), was facing a financial crisis in 1888. The company proposed to float a lottery loan to raise money, but this required authorization from the legislature. Authorization was obtained, with some difficulty, from the Chamber of Deputies in April and from the Senate in June 1888; but during the debates the company had been adversely criticized, and the project came to nothing. After lawsuits had been filed against its directors, the company went into liquidation in February 1889. After some delay, a judicial inquiry into its affairs was opened.

In autumn 1892 two newspapers, *La Libre Parole*, conducted by Édouard Drumont, and *La Cocarde*, which supported Gen. Boulanger (*q.v.*), began to accuse the government of complicity with the directors of the company; and the Royalist deputy Jules Delahaye, in stormy sessions of the Chamber (Nov. 19–21), declared that "more than 150" parliamentarians had taken bribes to vote for the lottery loan in 1888. A parliamentary commission of inquiry was set up; and on Nov. 28, 1892, Émile Loubet's government, which was showing little enthusiasm for the question, was forced to resign.

The bribery had been managed by three men: Baron Jacques de Reinach, a financier, who died on Nov. 19, 1892, presumably by suicide (though after exhumation his death was declared due to natural causes); and two adventurers, Léopold Émile Arton (properly Aaron) and Cornelius Hertz, who subsequently fled abroad. Some of the money involved was supposed to have been used by members of the government to combat Gen. Boulanger's agitation.

Charles Baïhaut, a former minister of public works, confessed to having received money and was sentenced in March 1893 to five years' imprisonment; the other parliamentarians were acquitted for lack of proof. Georges Clemenceau (*q.v.*), an associate of Hertz (through whom he was alleged to have received money from the British), became highly unpopular and had to retire from political life for some years.

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PAN-AMERICAN CONFERENCES, a term applied to a wide variety of inter-American meetings attended by representatives of the American states. Of these conferences the most important by the second half of the 20th century were the periodic numbered meetings of the Inter-American conference, which in 1948 succeeded the former International Conferences of American States, the first of which met in 1889–90. After 1948, when the charter of the Organization of American States was adopted at Bogotá, Colombia, the earlier occasional and less formal conferences, dealing chiefly with technical matters, became known as specialized conferences, and their programs and regulations came under the control and supervision of the Organization of American States itself, acting through one of its organs. Representation at Pan-American conferences was usually restricted to the 21 independent republics of the western hemisphere, although on occasion Canada participated in certain of the specialized conferences.

Inter-American Conferences, 1826–89.—*Political Conferences of 1826–64.*—The congress of Panama of 1826, which met from June 22 to July 15, 1826, on the initiative of Simón Bolivar, was attended by representatives of Colombia, Mexico, Peru and Central America. Colombia at that time embraced the present-day republics of Ecuador, Panama and Venezuela, as well as Colombia, and Central America included the five republics of Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua, so that 11 of the present-day states were represented. The United States was invited, and after extended debate in congress the invitation was accepted, but the delegates failed to arrive before the meeting adjourned. The principal result of the congress was a treaty of union, league and confederation, whereby the signatory states formed a defensive and offensive alliance to preserve their sovereignty and independence against foreign aggression. Contingents of troops were to come from each signatory state. At the same time an assembly of plenipotentiaries was provided for to serve as an organ of the confederation and to regulate the relations among the member states. In spite of the failure of the signatory states to ratify the treaty it remained as a symbol of continental unity, to be realized more than 100 years later.

The American congress (Congreso Americano) of Lima of 1847 met in the capital of Peru from Dec. 11, 1847, to March 1, 1848, with representatives in attendance from Bolivia, Chile, Ecuador, New Granada (Colombia) and Peru. The principal agreement reached was a treaty of union and confederation by which the contracting states agreed reciprocally to support their sovereignty and independence and to maintain their territorial integrity.

The Continental congress (Congreso Continental) of 1856, held at Santiago, Chile, with delegates representing Chile, Ecuador and Peru in attendance, also approved a treaty of alliance and confederation. The convention of Washington, D.C., in 1856, signed by representatives of Costa Rica, El Salvador, Guatemala, Mexico, New Granada, Peru and Venezuela, also contemplated joint action for mutual protection. This was not strictly speaking a conference but an agreement signed by the diplomatic representatives of the respective countries accredited to Washington, D.C., largely on their own initiative and as a result of informal conversations.

At the American congress (Congreso Americano) of Lima of 1864 (Nov. 14, 1864–March 13, 1865), there were representatives from Bolivia, Chile, Colombia, Ecuador, Guatemala, Peru and Venezuela. In a treaty of union and defensive alliance the parties agreed to defend reciprocally their independence, sovereignty and territorial integrity against foreign aggression, and in a treaty for the maintenance of peace they obligated themselves to resort to pacific means in settling differences.

These early inter-American conferences had as their principal object the common defense and mutual protection of the participating states. Instances of encroachments on the sovereignty of Central and South American states were the European interventions in the Río de la Plata between 1842 and 1850; the Mexican War of 1846, which in the eyes of most Central and South Americans was an aggression against Mexico; the filibustering expeditions of William Walker in Central America in 1855–57; the French invasion and the attempted establishment of Maximilian's empire in Mexico in 1863–67; the Spanish occupation of the Dominican Republic from 1860 to 1865; and the attempt of Spain in 1865 to reassert its sovereignty over Peru.

Juridical Congresses.—In the years following, and before the inauguration of the International Conferences of American States, several important juridical conferences were held in South America. The first of these was the American Congress of Jurists of Lima of 1877, which representatives of Argentina, Bolivia, Chile, Costa Rica, Ecuador and Venezuela attended.

The United States was invited, but declined the invitation because of the basic differences between the common law of the

United States and the civil law of Central and South America, and also because of the dual nature of the legislative system in the United States. The congress approved a treaty to establish uniform rules in matters of private international law, as well as a convention on extradition.

In 1883, at a congress held in Caracas, Venez., to commemorate the centenary of the birth of Simón Bolívar, a series of declarations on public international law was signed. This was followed by the South American law congress at Montevideo in 1888–89, at which Argentina, Bolivia, Brazil, Chile, Paraguay, Peru and Uruguay were represented. The congress resulted in the signing of treaties on international civil law; international commercial law; international penal law; the international law of procedure, literary and artistic property, trademarks and patents; and a convention on the practice of the liberal professions.

First International Conference of American States (1889–90).—The conferences held between 1826 and 1888 were inter-American in character but not continental in scope. At none of them were all the nations represented. It was not until 1889 that the Pan-American conferences and the Pan-American movement in general assumed continental proportions, embracing all the independent nations of the western hemisphere. In that year the first International Conference of American States met in Washington, D.C., on invitation of the United States government.

An attempt to initiate this continental movement had been made in 1881 when the United States government, through Secretary of State James G. Blaine, invited the other American nations to attend a congress in Washington, in Nov. 1882, "for the purpose of considering and discussing the methods of preventing war between the nations of America." This invitation was subsequently withdrawn following changes in the administration in Washington and the belief that the unfavourable international situation then prevailing in South America as a result of the War of the Pacific (*q.v.*) involving Chile, Bolivia and Peru made it an unpropitious time to hold the conference. Invitations were again extended on July 13, 1888, this time by Secretary of State Thomas F. Bayard. It was a coincidence that when the conference actually convened on Oct. 2, 1889, Blaine should again be secretary of state and preside over its deliberations.

All the countries of the western hemisphere except the Dominican Republic were represented. This conference laid the bases of the modern Pan-American movement and created, on April 14, 1890, the International Union of American Republics, operating through a permanent bureau in Washington, later designated as the Pan American Union. It approved a series of recommendations relating to rail and ocean transportation, uniformity of commercial documents, port dues, sanitary regulations, establishment of an inter-American bank, patents and trademarks, freedom of navigation of rivers serving as international boundaries and the submission to arbitration of certain classes of questions arising between the American nations.

Second International Conference of American States.—At this meeting, held at Mexico City, Oct. 22, 1901–Jan. 31, 1902, all the countries were represented. Conventions were drafted on arbitration of pecuniary claims, copyright, patents and trademarks; extradition of criminals; exchange of official, scientific, literary and industrial publications; codification of international law; practice of learned professions; rights of aliens; and also a treaty on compulsory arbitration (signed by only nine delegations). A protocol of adherence to the Hague conventions of 1899 was approved. A resolution on reorganization of the International Bureau of American Republics was also adopted, as were resolutions on measures to facilitate international commerce, sources of production and statistics.

Third International Conference of American States.—At this meeting, held at Rio de Janeiro, Braz., July 23–Aug. 27, 1906, all the American republics were represented with the exception of Haiti and Venezuela. It approved conventions on the status of naturalized citizens, pecuniary claims, patents, trademarks and copyright and the codification of international law. It recommended that the second Hague conference consider the subject of forcible collection of public debts, and it approved a series of other resolutions dealing with commercial, industrial and financial matters and problems of transportation.

Fourth International Conference of American States.—At Buenos Aires, Arg., July 12–Aug. 30, 1910, all the republics were represented except Bolivia. Conventions were signed on pecuniary claims, copyright, patents and trademarks. The International Union of American Republics was reorganized and the name of the permanent commercial bureau was changed to the Pan American Union. Recommendations were approved dealing with, among other matters, steamship and railroad transportation, consular documents and customs regulations, commercial statistics, establishment of national bibliographical bureaus and the interchange of professors and students.

Fifth International Conference of American States.—Because of World War I the conference originally scheduled for Nov. 1914 was postponed and did not convene until 1923. It was held at Santiago, Chile, from March 25 to May 3. All the countries were represented except Bolivia, Mexico and Peru. A treaty on prevention of conflicts, known as the Gondra treaty, was signed, constituting a first step in the development of inter-American peace machinery; also conventions were signed on trademarks, publicity of customs documents and uniformity of nomenclature for the classification of merchandise. The Pan American Union was reorganized and provision was made for a series of special technical conferences to consider specific problems.

Sixth International Conference of American States.—At Havana, Cuba, Jan. 16–Feb. 20, 1928, all countries were represented at the conference, which gave preferential consideration to the codification of international law and approved conventions on the status of aliens, asylum, consular agents, diplomatic officers, maritime neutrality, rights and duties of states in the event of civil strife, and treaties. It also approved a code of private international law and conventions on commercial aviation, copyright and the Pan American Union.

Seventh International Conference of American States.—At Montevideo, Urug., Dec. 3–26, 1933, all countries with the exception of Costa Rica were represented. The codification of international law was continued by the approval of conventions on extradition, political asylum and nationality. An important convention was signed on rights and duties of states, providing, among other things, that no state had the right to intervene in the internal or external affairs of another. The conference adopted a basic program of economic, commercial and tariff policy, designed to reduce trade barriers and facilitate inter-American commerce.

Inter-American Conference for the Maintenance of Peace.—In 1936 Pres. Franklin D. Roosevelt called the attention of the presidents of the American states to the peace protocols recently signed between Bolivia and Paraguay and proposed that an effort be made by representatives "seated at a common council table" to prevent such hostilities in the future. The conference met at Buenos Aires, Dec. 1–23, 1936, and adopted a treaty for the maintenance, preservation and reestablishment of peace, which embodied an agreement to consult, in the event of a threat to the peace, for the purpose of finding and adopting methods of peaceful cooperation. In spite of the vague terms of the treaty it was regarded as a sort of continentalization of the Monroe Doctrine (*q.v.*), and it became the starting point of closer political collaboration between the American states. The conference also adopted a new treaty on peaceful procedures, bringing into play the plan of consultation, as well as numerous other treaties and resolutions dealing with general principles of inter-American solidarity, the prevention of controversies, codification of international law, equality of treatment in international trade and cultural relations.

Eighth International Conference of American States.—At Lima, Peru, Dec. 9–27, 1938, all countries were represented. The Declaration of Lima, in which American republics reaffirmed their continental solidarity and their determination to defend themselves against all foreign intervention or other activity that might threaten them, was approved. The procedure of consultation among the governments in the event of a threat to the peace or security of the continent was perfected by providing for meet-

ings of the ministers of foreign affairs, and at the same time the procedure of consultation was extended to any economic, cultural, or other question which by reason of its importance might seem to justify it.

Inter-American Conference on Problems of War and Peace.—Meeting at Chapultepec in Mexico City, Feb. 21–March 8, 1945, all states being represented except Argentina, the conference was called to determine the relations of the inter-American system to the new international organization planned four months earlier at Dumbarton Oaks in Washington, D.C., to replace the League of Nations. An agreement, entitled the Act of Chapultepec, was adopted reaffirming earlier pledges of reciprocal assistance and solidarity, followed by a resolution providing for the reorganization of the inter-American system.

Numerous other resolutions were adopted, one suggesting amendments to the General International organization proposed at Dumbarton Oaks, others dealing with questions of international law, the inter-American peace system, an economic charter of America and a declaration of social principles of America. The conference laid the basis for the work of the two succeeding conferences of 1947 and 1948.

Inter-American Conference for the Maintenance of Continental Peace and Security.—Meeting at Quitandinha, near Petropolis, Braz., Aug. 15–Sept. 2, 1947, the conference at its close saw the signing at Rio de Janeiro of the important Treaty of Reciprocal Assistance, known as the Rio treaty, which put into effect the principle that an attack upon one American state should be considered as an attack upon all, justified in respect to the obligations of the United Nations charter by the provisions of art. 51 recognizing the inherent right of individual or collective self-defense until the security council of the United Nations might take measures necessary to maintain international peace and security. A hemisphere defense zone that included Greenland, the Aleutians and Bermuda, but not Hawaii or Iceland, was designated as the area in which the Rio treaty should be operative. The Rio treaty was the model upon which the later North Atlantic treaty, embodying a similar regional defense agreement for the principal North Atlantic and Mediterranean powers, was patterned (*see* NORTH ATLANTIC TREATY ORGANIZATION).

Ninth International Conference of American States.—Held at Bogotá, Colombia, March 30 to May 2, 1948, this conference was attended by representatives of the 21 republics. The assistant secretary-general of the United Nations also participated, but without a vote.

Organization of American States (OAS).—The principal work of the conference was the charter of the Organization of American States (*q.v.*), in which the regional system of the Americas, started in 1889, was given its first comprehensive constitution. The charter proclaimed the sovereign equality of the member states and banned intervention by any state in the affairs of another, except in the case of measures for the maintenance of peace and security. Part II of the charter outlined the structure of the organization, renamed the Organization of American States. Three representative bodies were created: the Inter-American conference, which was to meet every five years, as the supreme authority of the organization; the Meeting of Consultation of Foreign Ministers, which might be convoked to deal with important emergency problems, especially acts or threats of aggression; and the council of the organization, a permanent body meeting in Washington, D.C. The council was to execute tasks assigned to it by the Inter-American conference or the meeting of foreign ministers and to supervise the secretariat. It was to be assisted by three technical organs: an economic and social council, a council of jurists and a cultural council.

The central permanent agency and general secretariat of the organization was designated the Pan American Union (this name henceforth was restricted to this administrative organ) in Washington, headed by the secretary-general of the organization. Aside from its duties as a general secretariat, the Pan American Union was charged with promoting the cooperation of the American states in the fields of economic, social, juridical and cultural affairs. Other principal elements in the Organization of American States were the specialized conferences and the inter-American specialized organizations, which were to facilitate technical cooperation in economic, social and cultural fields.

Juridico-Political Matters.—Under the title of "Preservation and Defense of Democracy in America," the conference adopted a resolution strongly condemning international Communism and all other forms of totalitarianism as being incompatible with inter-American principles. The conference also adopted an American Declaration of the Rights and Duties of Man, stating that international protection of the rights of man should be the principal guide of an evolving American law, and specifying the rights and duties in detail (*see* HUMAN RIGHTS). The subject of European colonies in the Americas was placed on the agenda by Guatemala. Although action on that subject by the conference was opposed by some delegations, including those of Brazil, the Dominican Republic and the United States, the conference adopted a resolution expressing the hope that the occupation of American territories by extracontinental countries might come to an end and establishing the American Committee on Dependent Territories in Havana, Cuba, for the purpose of studying the problem and recommending solutions thereto.

Economic Matters.—The main achievement of the conference in economic matters was the drafting of an agreement on economic co-operation. Pointing to the need for expanding international trade and for general economic development as a means of raising living standards, the agreement emphasized the need for expanding co-operation in fields of technical knowledge and assigned certain responsibilities in that respect to the Inter-American Economic and Social council. The agreement reaffirmed the principles of the International Bank for Reconstruction and Development and of the International Monetary fund as important vehicles for financial co-operation, and supported the extension in appropriate cases of medium- and long-term loans from one government to another.

The agreement recognized the importance of private capital and stated that foreign capital should receive equitable treatment on a nondiscriminatory basis, provided foreign investors observed national laws and refrained from intervening in the political affairs of a country. Other subjects referred to included the improvement of social conditions, maritime transportation, stimulation of inter-American travel and methods for adjusting economic disputes among governments. Although signed by all 21 delegations, the economic agreement was weakened by the attachment of numerous reservations by several governments, leaving its validity and effectiveness in some doubt, and leading to an effort in 1957 to adopt a new agreement.

Peaceful Settlement of Disputes.—The pact of Bogotá, which was signed at the conference, set forth general principles and procedures of good offices and mediation, investigation and conciliation, adjudication and arbitration regarding international disputes. The jurisdiction of the International Court of Justice was recognized as compulsory for a wide variety of cases. Few states, however, were willing to ratify the pact, due principally to the extension of the scope of judicial settlement and arbitration into the field of political, as distinct from legal disputes.

Tenth Inter-American Conference.—This conference opened in Caracas, Venez., on March 1, 1954, and closed on March 28. It was the first meeting of that organ of the organization since the adoption of the Bogotá charter of 1948. All of the American republics were represented, with the exception of Costa Rica. Subsequently, however, the government of Costa Rica, through its representative on the council of the organization, adhered to the conclusions and signed the final act of the conference.

Issue of Communism.—After protracted debates, the so-called Declaration of Solidarity was adopted, a strong condemnation of intervention by international communism, declaring that the domination or control of the political institutions of any American state by the international communist movement, extending to the western hemisphere the political system of an extracontinental power, would constitute a threat to the sovereignty and political independence of the American states, would endanger the peace of America, and would call for a meeting of consultation to consider

the adoption of appropriate action in accordance with existing treaties. The final vote on the resolution was 17 to 1, with Guatemala opposing. Mexico and Argentina abstained.

Colonialism.—An anticolonial motion was passed by all the Latin-American delegations, with the United States abstaining.

Other Matters.—Conventions were drawn up and signed on territorial asylum, diplomatic asylum and on the promotion of inter-American cultural relations. The Convention for the Promotion of Cultural Relations, dealing with the exchange of students and professors, which was approved at the Buenos Aires conference of 1936, was revised in order to simplify the procedures used.

Special or Technical Conferences.—Because of the variety of topics on the programs of the periodic Inter-American conferences, it was not always possible for the delegates to give detailed consideration to all the subjects placed before them. Furthermore, the delegations at these diplomatic gatherings were not always equipped to deal with technical problems. Accordingly, the practice developed of referring many of these topics to special conferences, with the request either that the projects formulated or conclusions reached be reported back to a subsequent international conference or that they be transmitted directly to the governments. Generally, these specialized meetings consider a particular subject or a group of related topics, and by concentrating on one subject the delegates are in a more advantageous position to give the matter careful study and consideration.

Several of these specialized conferences have a history extending back over a considerable period. The Pan American Sanitary conferences, for example, were inaugurated in 1902 pursuant to a recommendation of the second International Conference of American States. These conferences did important work in the field of public health and sanitation. The numbers of such special or technical conferences increased greatly over the years and the subjects which they were called upon to consider covered virtually every phase of inter-American activity.

Meetings of the Ministers of Foreign Affairs.—The Declaration of Lima, signed at the eighth International Conference of American States (1938), made provision for meetings of the ministers of foreign affairs of the American republics—a new type of consultation in the system of Pan-American conferences. Earlier, at the Buenos Aires conference of 1936, the American republics had agreed to consult together whenever anything should occur that might threaten the peace of the continent; but the instrumentality by which this consultation was to be undertaken was not specified. At Lima the American republics reaffirmed their continental solidarity and declared that if the peace, security or territorial integrity of any of them should be threatened by acts of any nature they would consult together through meetings of their ministers of foreign affairs to determine the measures that should be taken.

The first such meeting of ministers of foreign affairs was held at Panama in Sept. 1939, immediately after the outbreak of the war in Europe. It resulted in the adoption of a general declaration of neutrality and the establishment of a security zone to keep the western hemisphere free of belligerent activities. In July 1940, when it appeared that European possessions in America might be transferred from those that possessed them to new occupants, a second meeting was held at Havana, where it was decided that should such a contingency arise the American republics themselves would step in and administer these possessions. In Jan. 1942, following the extension of the war to the Americas, a third meeting of consultation, held at Rio de Janeiro, recommended the severance of diplomatic and commercial relations by the American republics with the aggressor nations. A majority of the 21 republics had already either declared war on or broken off relations with the Axis powers. The recommendation was followed immediately by other severances of relations; Argentina and Chile remained the only American republics not taking that step.

The fourth meeting of consultation of foreign ministers was held at the Pan American Union in Washington, D.C., from March 26 to April 7, 1951. The three topics of the agenda dealt with political and military cooperation, internal security and emergency economic cooperation. The Inter-American Defense board was charged with the preparation of military plans for common defense of the hemisphere. Major consideration was directed to questions of an economic character, and resolutions were adopted on the production and distribution of products in short supply and utilization of necessary services to meet the requirements of the economies of the American republics and on measures to facilitate the carrying out of programs of economic development.

Following the tenth conference, held at Caracas in 1954, new threats to the peace arose in the Caribbean that made it desirable to have recourse to meetings of ministers of foreign affairs rather than the regularly scheduled conferences. The fifth meeting of consultation was held at Santiago, Chile, in 1959, not under the provisions of the Rio Treaty of Reciprocal Assistance, but under art. 39 of the charter providing for consultation "to consider problems of an urgent nature and of common interest to the American States," in this case tensions resulting from revolutionary efforts to overthrow dictatorships. The meeting drew up a Declaration of Santiago, reaffirming in strong terms the relation between human rights and representative democracy, declaring that, "the existence of anti-democratic regimes constitutes a violation of the principles on which the Organization of American States is founded and endangers peace, solidarity, and good relations in the hemisphere."

A year later, on Aug. 16, 1960, the sixth meeting of foreign ministers convened at San José, Costa Rica, in response to an appeal of Venezuela charging the Trujillo regime of the Dominican Republic with complicity in the attempted assassination of Pres. Rómulo Betancourt. The meeting called for an immediate breaking of diplomatic relations with the Trujillo regime and for a partial interruption of commerce, beginning with arms and implements of war, to be followed later by the suspension of trade in other articles by action of the OAS council. The sanctions were withdrawn by the council after the fall of the Trujillo regime.

The seventh meeting of consultation, held at San José 24 hours later under art. 39 of the charter, was directed against the intervention by a totalitarian power in the affairs of the American republics, although, for political reasons, neither Cuba nor the Soviet Union, the two parties actually condemned, was mentioned by name. Sympathy with the social reforms of the Castro government was too strong to permit the application of sanctions, and it was for that reason that the meeting had not been called under the Rio treaty, as in the case of the sixth meeting.

The eighth meeting of consultation was called in Nov. 1961 and met at Punta del Este, Urug., Jan. 22–31, 1962. The situation in Cuba had now become a greater threat to the peace, and Colombia, in calling the meeting, did not hesitate to name both Cuba and the Soviet Union. A memorandum was submitted by the Inter-American Peace committee giving specific evidence of the denial of fundamental human rights in Cuba, but a number of the delegations did not find that fact a justification for setting aside the rule of nonintervention. More important was the indictment of Cuba for having permitted the intervention of an extracontinental power and thus having jeopardized American solidarity and security. The acceptance by Cuba of armed aid from the Soviet Union and its open repudiation of the Rio treaty clearly identified Cuba with the inherently aggressive policy of the Sino-Soviet bloc. A final indictment was based upon the subversive activities of the Cuban government against legitimately constituted governments and the democratic institutions of America.

Opinion at the meeting was divided upon the issue of the exclusion of the Cuban government from participation in the inter-American system, the final vote in favour of exclusion being a bare two-thirds, on ground of its having identified itself as a Marxist-Leninist government contrary to the principles and objectives of the inter-American system. This done, the meeting voted unanimously to condemn the communist offensive in America and to adopt countermeasures to its subversive activities. At the same time the meeting created a special consultative committee on security for the purpose of advising member states on the subversive techniques of communist activities.

On Oct. 22, 1962, when Pres. John F. Kennedy demanded the removal from Cuba of missiles and of missile bases under construc-

tion, the U.S. representative on the OAS council requested the convocation of a meeting of foreign ministers under the Rio treaty to consider what action should be taken for the common defense. The council, meeting provisionally as an organ of consultation, adopted a resolution calling upon the member states to cooperate in measures to prevent Cuba from receiving military materiel from the Sino-Soviet powers. In advance of the request of the United States for a formal meeting of consultation, an informal meeting of foreign ministers had already taken place at the department of state, on Oct. 2 and 3, with the object of obtaining an exchange of views on the Cuban situation.

In addition to the meetings of consultation of foreign ministers under the Rio treaty and under art. 39 of the charter, important meetings of the Economic and Social council were held at the ministerial level, that is, with the ministers of the separate governments representing their countries on the council. A meeting held Aug. 5–17, 1961, adopted the Charter of Punta del Este, which established the Alliance for Progress to develop a program of "accelerated economic progress and broader social justice within the framework of personal dignity and political liberty." Preceding the charter was a Declaration to the Peoples of America that set forth the basic principles of the charter and the goals to be attained during the coming years. Meetings of the council at the ministerial level were held to evaluate the results of the Alliance for Progress.

In July 1964 the OAS foreign ministers met in Washington, D.C., to act upon charges that Cuba had committed an act of aggression against Venezuela by secretly shipping arms to pro-Communist forces in Venezuela in Nov. 1963. By a vote of 15 to 4 (Mexico, Chile, Uruguay and Bolivia voting against) the conference adopted diplomatic and economic sanctions against Cuba.

See also LATIN AMERICA.

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PAN-AMERICAN GAMES, a quadrennial sports event for the nations of the Western Hemisphere, is conducted in almost identical fashion to the Olympic Games (*q.v.*).

These games had their inception at a meeting called the Pan-American Congress at Buenos Aires, Arg., Aug. 28–31, 1940, to which invitations were sent to the national Olympic committees of all countries of the Western Hemisphere. Sixteen of the 21 countries invited were represented. The idea had been under consideration for several years and became a reality when it was apparent that the 1940 Olympic games, scheduled first for London and then Tokyo, would not be held. It was decided to form a Pan-American Games Organization to conduct the games every four years beginning in 1942, with the support of the International Olympic Committee but run solely by the new body, which was formed as an autonomous organization to be governed by a congress composed of delegates chosen by its members. Regular meetings were to be held every four years.

Buenos Aires was chosen as the site of the first games, to be held in the fall of 1942, the 450th anniversary of the discovery of America by Columbus. However, because of World War II, the first Pan-American Games were not held until Feb. 25 to March 9, 1951, at Buenos Aires. One hundred thousand persons were in attendance when Delfo Cabrera, Argentina's 1948 Olympic marathon champion, opened the games by circling the track, carrying the white and blue flag of his country. A total of 2,000 athletes, representing 20 Western Hemisphere nations, took part, and the program consisted of 19 sports. Argentina and the United States, which had close to half the entries, dominated the competition.

The second Pan-American Games were held in Mexico City, Mex., March 12–26, 1955, with the number of competing athletes dropped to 1,612 and the nations increased to 22. The University of Mexico's excellent facilities were used and the number of sports was increased to 24. The United States, Argentina, and Mexico dominated the competition and among them had 55% of the athletes. The site, being close to one mile above sea level, had its effects on many of the visiting athletes, but Lou Jones of the United States eliminated talk of slow performances with a world record of 45.4 sec. in the 400-m. run.

Cleveland, O., was selected (in 1955) to conduct the 1959 Pan-American Games, but eventually withdrew in favour of Chicago, Ill., with the dates, Aug. 27–Sept. 7, 1959. The U.S. swept the competition, capturing 18 of 22 men's gold medals in track and field.

The fourth Pan-American Games were held at São Paulo, Braz., on April 20–May 5, 1963. U.S. athletes won 109 gold medals, 49 silver, and 35 bronze. Of the 22 participating nations Brazil was next with 14 gold, 21 silver, and 18 bronze, followed by Canada with 10 gold, 28 silver, and 24 bronze.

Winnipeg, Can., was chosen as the site of the fifth Pan-American Games in 1967. (ED. F.; X.)

PAN-AMERICAN HIGHWAY, a network of highways connecting the capitals and principal cities of South and Central America with highways of the United States and Canada. The system was originally conceived as a single route connecting North and South America, but as the concept was expanded alternate routes were added. There is now no single road that can be identified as the Pan-American Highway; the Pan-American Highway System now includes several routes in many countries.

Each nation selects the route or routes within its borders for inclusion in the system, but by the end of 1964 neither the United States nor Canada had taken this step. Thus, the designated system begins at the U.S.–Mexican border and extends south through Central and South America.

The Pan-American Union, Washington, D.C., the general secretariat of the Organization of American States, is the official repository of the routes that make up the system. Information about the highway, including travel information and current road conditions, may be obtained from that organization.

The idea for the Pan-American Highway developed from a proposal made in the United States Congress in 1884 for the construction of a Pan-American Railway. At the first International American Conference held in Washington, D.C., in Dec. 1889, the railway project was initiated and at subsequent conferences it was further developed. At the fifth International Conference in Santiago, Chile, in 1923, it was also proposed that an automobile road conference be held to study measures for the construction of automobile highways within and between the countries of the Americas. This action is considered to be the beginning of the Pan-American Highway. Since that time the railroad project has

PAN-AMERICAN HIGHWAY SYSTEM

been abandoned and the highway project was expanded. In 1925 the Pan-American Highway Congress was established as a permanent institution and since then it has been the international organization responsible for the development of the highway. It is now a branch of the Organization of American States.

The term Inter-American Highway is frequently used interchangeably with Pan-American Highway, but the Inter-American Highway is only that part of the system beginning at Laredo, Tex., and ending at Panama City. The term had its origin in the various inter-American conferences and in United States legislation appropriating funds for its construction. While the section in Mexico was financed and constructed entirely by Mexico, the sections in Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama were constructed on a cooperative basis, with the U.S. generally contributing two-thirds of the cost and the cooperating republics, one-third. (R. E. I.)

PAN AMERICAN UNION: *see* PAN-AMERICAN CONFERENCES; AMERICAN STATES, ORGANIZATION OF.

PANATHENAEA, in ancient Athens an annual festival of great antiquity and importance (*see* ATHENA). Traditionally begun by Erichthonius and changed from Athenaea ("festival of Athena") to Panathenaea ("festival of all Athenians" or "universal festival of Athena") by Theseus, its elaboration seems to date from Pisistratus. In its developed form it was celebrated every fourth year with special splendour, probably in deliberate rivalry to the Olympic Games; its date was the third year of each Olympiad, from the 24th to the 29th of the month Hecatombaeon (about mid-August), and the great day was the 28th, traditionally Athena's birthday. The annual festival consisted solely of the sacrifices and rites proper to this season in the cult of Athena. One of these rites originally consisted in carrying a new peplos through the streets to the Acropolis to clothe the ancient carved image of the goddess; but it is probable that this rite was afterward restricted to the great quadrennial festival. The peplos was a costly, saffron-coloured garment, embroidered with scenes from the battle between the gods and giants. At least as early as the 3rd century B.C. the custom was introduced of spreading the peplos like a sail on the mast of a ship which was rolled on a machine in the procession. At the Great Panathenaea representatives of all the dependencies of Athens were present, bringing victims, and a most brilliant procession resulted. After the presentation of the peplos the hecatomb (offering of several animals) was sacrificed. The subject of the frieze of the Parthenon is this great procession. From 1937 onward part of the processional way was uncovered in the course of the American excavations of the agora.

Pericles introduced a regular musical contest in place of the recitations of rhapsodes, which were a long-standing accompaniment of the festival. This contest took place in the odeum, originally built for this purpose by Pericles himself. The order of the contests from this time onward was first the musical, then the gymnastic, then the equestrian contest. Many kinds of contest, such as the chariot race of the *apobatai* (said to have been introduced by Erichthonius), which were not in use at Olympia were practised in Athens. *Apobates* was the name given to the companion of the charioteer, who showed his skill by leaping out of the chariot and up again while the horses were going at full speed. There were in addition several minor contests between the Athenian tribes: the pyrrhic or war dance; the *euandria* or parade of crack troops; the lampadedromy or torch race; the regatta, which took place on the last day of the festival. The proceedings were under the superintendence of ten *athlothetai,* one from each tribe, the Lesser Panathenaea being managed by *hieropoioi.* In the musical contests, a golden crown was given as first prize; in the sports, a garland of leaves from the sacred olive trees of Athena and vases filled with oil from the same. Examples of Panathenaic vases can be seen in the British Museum, London, and elsewhere.

See L. R. Farnell, *The Cults of the Greek States,* i, pp. 294 ff. (1896); L. Deubner, *Attische Feste,* pp. 22 ff. (1932).

PANAY, westernmost of the Visayan Islands in the central Philippines and sixth in size. Area 4,446 sq.mi., with a mountain range near the west coast, hilly eastern portions, irregular plains along the north coast and a wide lowland on the southeast. The island is divided into four provinces: Antique on the west coast, Iloilo in the south, Aklan in the northwest and Capiz (*qq.v.*) in the northeast. Pop. (1960) 1,745,982. *See* also PHILIPPINES, REPUBLIC OF THE. (J. E. SR.)

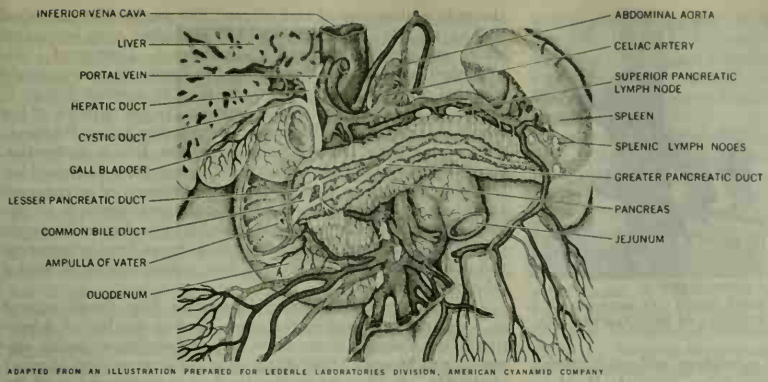
PANCEVO, a town in Vojvodina, Socialist Republic of Serbia, Yugos., and a Danube port, is 18 km. (11 mi.) ENE of Belgrade by road. Pop. (1961) 40,740. It is the administrative centre of a district, and has a high school, an academy of commerce, and two Serbian Orthodox churches with interesting icons. Pancevo is a nodal point for railway, road, and water commerce in southwest Vojvodina. Industries include the manufacture of silk, chemicals, glass, and aircraft parts. The town was first mentioned in the 12th century; freed from the Turks in 1717, it was under Austrian rule till 1918 when it was incorporated into Yugoslavia. (V. DE.)

PAN CHAO: *see* PAN KU AND PAN CHAO.

PANCH MAHALS, a district of Gujarat, India. Area 3,486 sq.mi. (9,028 sq.km.). Pop. (1961) 1,468,946. The district was united administratively with the district of Broach (*q.v.*) in 1933. In 1945 it was made into a separate district, and in 1947 the princely states of Lunawada, Baria, and Sant and some villages of Pandu-Mewas were added, while six villages were transferred to Sabarkantha District. Godhra, the district headquarters, and Dohad are the main towns. Places of interest include the Pavagadh Hill (2,700 ft. [820 m.] above sea level) with the Kali Temple on its summit and the historic Rajput fort of Champaner. The district is largely rough and wooded; the valleys produce bajra (pearl millet), maize (corn), cotton, and gram. There are rich manganese mines at Shivrajpur. The Western Railway runs through the district. (V. A. M. J.)

PANCREAS. The pancreas in man is a large digestive gland that lies in the upper part of the abdomen beneath the stomach in the curve of the duodenum, to which it is firmly attached. It is behind the peritoneum. The pancreas has an abundant blood supply and is innervated by nerve fibres from the vagus and sympathetic trunks. A large main duct (the duct of Wirsung) runs the entire length of the gland and empties into the second part of the duodenum, usually in common with the termination of the common bile duct, at what is called the ampulla of Vater. A smaller accessory pancreatic duct (the duct of Santorini) empties separately into the duodenum. These ducts collect the pancreatic juice secreted by the pancreatic glandular epithelium, or parenchyma, and convey it to the duodenum. In addition to the glandular epithelium, there are many thousands of microscopic groups of cells without ducts distributed throughout the pancreas, the islets of Langerhans. The beta cells of these islets are the source of insulin, and it is the removal or destruction of these cells that produces pancreatic diabetes. The alpha cells of the islets are thought to be the source of glucagon, a second pancreatic hormone, which in some respects has an action opposite in effect to that of insulin.

The pancreatic juice is a clear, colourless fluid, alkaline in reaction, and is made up of water in which are dissolved sodium bicarbonate, sodium chloride and three important digestive enzymes: trypsin, pancreatic lipase and pancreatic amylase. Trypsin, when activated by mixture with the intestinal juice, is a vigorous protein-splitting enzyme that facilitates the disintegration of proteins and proteoses into peptones and amino acids. Pancreatic lipase splits the fat of the food into glycerol and fatty acids, the end products of the digestion of fat. The digestive action of pancreatic lipase is greatly facilitated by the emulsifying action of the bile. Pancreatic amylase splits starches and complex sugars into glucose, which can be absorbed and utilized by the body cells. The pancreas secretes pancreatic juice continuously, but the rate of secretion is greatly increased when food is present in the small intestine. The mechanism of this stimulation is partly nervous and partly chemical. Impulses over the vagus nerves cause a secretion of pancreatic juice rich in enzymes. A profuse secretion of pancreatic juice can occur, however, even if the vagus nerves have been divided. The presence of acid chyme, or partially digested food, in the small intestine causes the elaboration of a hormone, secretin, in the lining of the small intestine and its absorption into the blood. It is carried through the general cir-



CUTAWAY DIAGRAM OF THE DUCT SYSTEM THAT LINKS THE PANCREAS WITH OTHER BODY ORGANS

culation eventually to the pancreas and liver, whose cells are then excited to greater secretory activity. Pancreatic juice secreted in response to stimulation by pancreatic secretin is poor in enzyme content. However, a second hormone, pancreozymin, is liberated from the duodenum at the same time and in a manner similar to that of pancreatic secretin. This hormone stimulates the pancreas to secrete pancreatic juice rich in enzymes.

The absence of pancreatic juice from the intestinal tract impairs the digestion and absorption of food. This is made evident by the appearance of large amounts of undigested fat and protein in the stools. The impairment, which is most marked in the case of fat digestion and absorption, varies greatly in different persons. Thus in some persons, following removal of the pancreas, there may be little disturbance in digestion or absorption, whereas in others 75% to 80% of the fat in the food appears undigested in the stools. The disturbance in protein digestion is less marked and the digestion of starch is little affected. The pancreas can be successfully removed in experimental animals and also in man. Life can be maintained in a good nutritive state, perhaps indefinitely, if the ensuing diabetes is adequately controlled by the administration of insulin, and if pancreas extracts (*i.e.*, lipocaic) are administered in adequate amounts by mouth.

Diseases of the Pancreas.—Diseases of the pancreas are fortunately not common, but when they occur they are often serious. Acute pancreatitis or acute pancreatic necrosis, as it is more accurately called, is a condition in which a large part of the pancreas becomes necrotic or gangrenous, often with extensive hemorrhage and with digestion of the pancreas by the juices of the gland itself. This disease is more likely to occur in persons who have gallstones than in others and often follows the ingestion of large amounts of food and alcoholic beverages. It may cause death within 24 to 48 hours. The cause of death is not definitely known, but is thought to be due in part to the absorption of poisonous chemical substances arising in the disintegrating pancreas. Shock, caused by loss of plasma from the blood vessels, and infection are often contributing factors. The disease is treated by repeated transfusions of blood and plasma, administration of antibiotic drugs and drainage of the common bile duct with removal of gallstones. In some cases an attack of acute pancreatitis that is not fatal may lead to the accumulation of a large amount of pancreatic juice, blood plasma and tissue debris in the pancreas itself or in the overlying tissues, forming a pancreatic pseudocyst. Such pseudocysts may become quite large and are treated by drainage in a surgical operation. Occasionally, nonfatal attacks of acute pancreatitis recur at intervals of weeks or months and produce very severe upper abdominal pain and disability. Many of these cases of relapsing pancreatitis are due to narrowing or obstruction of the pancreatic duct and can be relieved by a surgical operation that provides adequate drainage of the pancreatic juice.

Cystadenoma is a benign cystic tumour that may occur in the pancreas and reach a very large size. The cyst is usually multilocular and contains a mucilaginous fluid. These benign tumours are successfully treated by surgical excision. Cancer of the pancreas is the commonest and also the most serious tumour. When it involves the head of the pancreas, it obstructs the common bile duct and pancreatic duct and causes progressive jaundice, emaciation and impairment in digestion. Advances in surgery have made it possible, in many such cases, to remove the entire pancreas, with survival of the patient, but most of these patients later die of recurrence of the cancer in the liver and other organs.

Benign tumours (adenomas) may arise in the islets of Langerhans and produce symptoms due to the excessive manufacture of insulin and its liberation into the blood stream. Such patients display attacks of weakness or unconsciousness at progressively shorter intervals, and during these attacks examination of the blood reveals an excessively low concentration of blood sugar. The attacks can be relieved temporarily by intravenous injection of glucose, and the patient can be cured if the adenoma can be found and surgically removed. Either benign or malignant tumours arising from the islet tissues, other than beta cells, may cause an excessive secretion of gastric juice in the stomach with progressive ulceration of the mucosa, hemorrhage and perforation. When the pancreatic tumour causing these ulcers is benign and can be removed, the excessive gastric secretion stops and the patient is cured.

The animal pancreas, when used for food, is called sweetbread.

See also DIABETES MELLITUS; DIGESTION; ENDOCRINOLOGY; HORMONES, VERTEBRATE; INSULIN. *See* also references under "Pancreas" in the Index.

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PANCREATIN, also called pancreatic substance and diastase vera, is a solution made from the fresh pancreas of the hog or ox. Since it contains the pancreatic enzymes amylopsin, trypsin, and steapsin, all of which take part in the digestion and absorption of food, pancreatin may be used in medicine to treat persons with pancreatic insufficiency (*i.e.*, persons with less than normal amounts of pancreatic juice in the digestive system, as in cystic fibrosis and chronic pancreatitis). In a neutral or slightly alkaline medium and at a temperature of less than 60° C (140° F), pancreatin converts 25 times its weight of starch into sugar and 25 times its weight of protein (*e.g.*, casein) into proteoses in five minutes.

See also CHILDREN, DISEASES OF: *Cystic Fibrosis;* PANCREAS.

PANDA, the name given to two species of Asiatic mammals related to raccoons and placed with them in the family Procyonidae, order Carnivora. The bear-sized black and white panda popular in zoos is the giant panda (*Ailuropoda melanoleuca*), one of the rarest large mammals. It is known only from the mountains of Szechwan in China and the nearby parts of Tibet. Its body fur is white but its limbs, ears, and areas round the eyes are black. The giant panda inhabits bamboo forests, feeding on the young stems and leaves. There is a thumblike structure on the front foot against which the digits press in grasping bamboo stems and other food; in addition to bamboo, the giant panda feeds on the roots and leaves of herbs, and eats small animals such as mice and voles. The giant panda was discovered by Père David, a Jesuit missionary, in 1869. Although very few specimens have been brought to the West, either living or dead, the giant panda

has been exhibited in several zoos in Europe and the United States.

"Panda" without any modifier refers to the smaller, domestic cat-sized species (*Ailurus fulgens*) that ranges from the eastern Himalayas to western China. Sometimes called the common or lesser panda, it has thick fur, rich reddish-brown on the upper surface and black underneath; the face is white, with a stripe of red-brown from each eye to the corners of the mouth; there are several pale rings on the tail. Common pandas live high in the mountains among rocks and trees, which they climb with agility. They feed on fruit and other plant substances, and small animals. *See* also CARNIVORE; MAMMAL. (L. H. M.)

H. ARMSTRONG ROBERTS

GIANT PANDA (AILUROPODA MELANOLEUCA) OF SOUTHEASTERN ASIA

PANDANUS: *see* SCREW PINE.

PANDAREUS, in Greek mythology, stole a golden dog from the temple of Zeus in Cretan or Ionian Miletus, and gave him to Tantalus for safekeeping. Tantalus swore to Hermes that he knew nothing of the matter, but on the dog's discovery was punished by being crushed under Mt. Sipylus. (For a variation on the story, *see* TANTALUS.) Pandareus and his wife were killed by Zeus; their orphaned daughters were reared by the Olympian goddesses, but the Harpies stole them and gave them to the Erinyes as servants. (T. V. B.)

PANDARUS, in Greek legend, son of Lycaon, a Lycian. In the *Iliad* he breaks the truce between the Trojans and the Greeks by treacherously wounding Menelaus with an arrow, and finally he is slain by Diomedes. In the medieval tale of Troilus and Cressida he acted as the lovers' go-between; hence "pander."

PANDECTS, one name for the Digest of Justinian, a collection of passages from the writings of Roman jurists, arranged in 50 books subdivided into titles according to the subject matter. In A.D. 530 the emperor Justinian I entrusted its compilation to Tribonian, *Quaestor* of the Sacred Palace, with instructions to appoint a commission to help him. The Pandects were published in A.D. 533 and given statutory force. The rapidity with which the work was completed has suggested that much of it had been anticipated by the work of earlier Byzantine scholars. Friedrich Bluhme showed in 1818 that the arrangement of material in each title into "masses" represented a division of the work between committees of the commission according to the three principal groups of sources from which the Pandects were compiled. These masses are (1) Sabinus mass, (2) Edict mass, (3) Papinian mass, with the addition of (4) Appendix.

Early in the 19th century the term "Pandectists" was applied to the historical school of Roman law scholars in Germany who resumed the scientific study of the Pandects. The leader of the school was Friedrich Karl von Savigny (1779–1861). In the course of the century extensive treatises on the Pandects were produced, notably by Georg Friedrich Puchta, Heinrich Dernburg, and Bernhard Windscheid.

See JUSTINIAN I; ROMAN LAW: *Sources of the Law: The Law of Justinian.* (RL. P.)

PANDHARPUR, a municipal town in the Sholapur District of Maharashtra, India, stands on the right bank of the Bhima River, 38 mi. (61 km.) W of Sholapur. Pop. (1961) 45,421. It is a popular place of pilgrimage as it contains a celebrated temple dedicated to the god Vithoba, an incarnation of Vishnu, in whose honour three fairs are held annually. The one in the Hindu month of Ashadha (June–July) attracts large crowds. The town is connected by rail with Barsi and with Kurduwadi on the Central Railway. (M. R. P.)

PANDIT, VIJAYA LAKSHMI (née SWARUP KUMARI NEHRU) (1900–), Indian political leader and diplomat, one of the world's leading public women and the recipient of many honours and awards, who brought distinction, intelligence, and charm to a succession of high offices. She was born at Allahabad on Aug. 18, 1900, the daughter of Motilal Nehru, early nationalist leader, and sister of Jawaharlal Nehru (*q.v.*). Coming of a distinguished, well-to-do Kashmiri Brahman family, she was privately educated in India and abroad; and in 1921 married Ranjit S. Pandit, by whom she had three daughters. In the tradition of her family she became an active worker in the Indian nationalist movement, being three times imprisoned by the British authorities. Nevertheless, she did not neglect such opportunities as existed before independence to obtain practical experience of government and administration. She entered municipal government in Allahabad before entering the legislative assembly of the United Provinces (Uttar Pradesh) and becoming, as minister of local government and public health (1937–39), the first Indian woman to hold a cabinet portfolio.

With the coming of Indian independence, Mrs. Pandit entered on a distinguished diplomatic career, leading the Indian delegation to the United Nations (1946–48) and serving as Indian ambassador to Moscow (1947–49) and to Washington (and Mexico) (1949–51). In 1953 she became the first woman president of the UN General Assembly. From 1954 to 1961 she was Indian high commissioner in London and, concurrently, ambassador in Dublin. She was appointed governor of Maharashtra on Nov. 14, 1962.

PANDO, a department of northeastern Bolivia, bounded north and east by Brazil, west by Peru and south by the departments of Beni and La Paz. Pop. (1961 est.) 24,000. Area 24,644 sq.mi. (63,828 sq.km.). The department, formerly called the province of Vaca Diez, was established in 1938 during the administration of Gen. Germán Busch. Puerto Rico, originally designated the capital of the new department, was succeeded by Cobija, pop. (1959 est.) 2,188, because of the latter's accessibility. Pando is largely a forested region, with considerable rain, heat and humidity. The main economic resources are forest products: rubber, quinine, Brazil nuts and hardwoods. Agricultural products include rice, sugar cane, manioc, bananas and corn. Cobija may be reached by air, but otherwise transportation is by rivers: the Abuná, Ortón, Madre de Dios, Tahuamanu, Negro and Beni. The isolation, poor communication and sparse population hinder development of the region. The population is chiefly Indian and mestizo. (J. L. TR.)

PANDORA, according to Hesiod (in the *Theogony* and in *Works and Days*), the first woman (Gr., the "All-giving"). After Prometheus had stolen fire from heaven and bestowed it upon mortals, Zeus determined to counteract this blessing. He accordingly commissioned Hephaestus to fashion a woman out of earth, upon whom the gods bestowed their choicest gifts. Hephaestus gave her a human voice; Aphrodite, beauty and powers of seduction; Hermes, cunning and the art of flattery. She had or found a jar, the so-called "Pandora's box," containing all kinds of misery and evil. Zeus sent her to Epimetheus, who, forgetting the warning of his brother Prometheus to accept no present from Zeus, made her his wife. Pandora afterward opened the jar, from which all manner of evils flew out over the earth. According to the version given in Hesiod, Hope alone remained inside, the lid having been shut down before she escaped. But in a later story the jar contained not evils but blessings, which would have been preserved for the human race had they not been lost through the opening of the jar out of curiosity by man himself.

In cult Pandora was a title of Earth; at Athens she was associated with the cult of Athena, and the birth of Pandora was depicted on the base of the great statue of Athena by Phidias.

See W. A. Oldfather, "Pandora," in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. 18 (1949), which includes a lengthy bibliography; H. J. Rose, *Handbook of Greek Mythology*, p. 55 (1957). (T. V. B.; X.)

PANDULPH (PANDULF or PANDOLPHO) (d. 1226), Italian ecclesiastic, papal legate to England and bishop of Norwich, was born in Rome. He was first sent to England by Pope Innocent III in 1211 to negotiate with King John over the acceptance of Stephen Langton (*q.v.*) as archbishop of Canterbury. The failure of the negotiations resulted in John's excommunication and Pandulph's return to Italy. He was again in England in 1213 to accept the king's submission, in which John, apparently on his own

initiative, surrendered England as a papal fief. Gratified by John's humility, Pandulph used ecclesiastical censures, including excommunication, to avert a threatened French invasion of the country. Temporarily replaced by the cardinal legate Nicholas of Tusculum, Pandulph returned to England in 1215 for the conference at the meadow at Runnymede, where Magna Carta was signed. He was given the see of Norwich by John in gratitude for his services but was eclipsed in 1216 by the arrival of the cardinal legate Gualo. He regained his prominence when Gualo departed in 1218 and as papal representative was entrusted with the care of the child Henry III. He was influential during the regency. Pandulph's paramount influence in the government of England, deriving from the fact that England was a papal fief, lasted until 1220, when Cardinal Langton moved the pope to recall him in the interests of a more national policy. Pandulph retained the see of Norwich but was no longer a factor in English politics. He died at Rome on Sept. 16, 1226, but his body was removed to Norwich for burial.

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PANDYA, the name of a Tamil dynasty of the extreme south of India of unknown antiquity (they are mentioned by Greek authors; *e.g.*, by Megasthenes in the 4th century B.C.). The Byzantine emperor Julian received an embassy from a Pandya *c.* A.D. 361. The dynasty revived under Kadungon in the early 7th century A.D. and ruled from Madura or further south until the 16th century. The small but important (9th–13th century) dynasty of Pandyas of Ucchangi, a hill fort south of the Tungabhadra river, may have originated from the Madura family.

The genealogy and chronology of the family are in hopeless confusion as the kings share very few names, alternately prefixed by Jatavarman or Maravarman (or equivalents), and their numerous records are dated for the most part only in regnal years. From being Jains they became Saivites and are celebrated in the earliest Tamil poetry (the Sangam works). They ruled extensive territories, at times including the Chera (or Kerala) country, the Chola country, and Ceylon through collateral branches subject to Madura. The "Five Pandyas" flourished in the 12th to 14th centuries and after fighting with fluctuating success against neighbouring kingdoms, eventually assumed control of all the plains of the extreme south as far north as Nellore (1257). Family quarrels, however, and the sultan of Delhi's invasions from 1311 onward, culminating in the foundation of the Madura sultanate, about which Ibn Batutah writes horrifying details, weakened Pandya influence. Even after the Moslems were evicted *c.* 1370 by the king of Vijayanagar the Pandyas seldom ruled north of the Cauvery river. By 1312 control over Kerala was lost and by the mid-16th century all their territories had passed into other hands.

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PANEGYRIC, originally a speech composed for delivery at a general assembly (*panegyris*) in ancient Greece, such as the Olympic and Panathenaic festivals. Speakers often took advantage of these occasions, when Greeks of various cities were gathered together, to advocate Hellenic unity. With this end in view, and also to gratify their audience, they tended to expatiate on the former glories of Greek cities; hence came the encomiastic associations that eventually clung to the term "panegyric." The "Olympic" speeches of Gorgias and Lysias (*qq.v.*) have survived only in fragments, but the *Panegyricus* of Isocrates (*q.v.*), composed *c.* 380 B.C., perhaps for recitation at Olympia, is intact; so also is his *Panathenaicus* (*c.* 340 B.C.), in which he praised the past achievements of Athens. Akin to panegyric was the *Epitaphius*, or funeral oration, ancient and modern examples of which are to be found in Pericles' funeral speech as recorded by Thucydides, a panegyric both on the war heroes and on Athens itself, and in Abraham Lincoln's Gettysburg Address. In the 2nd century A.D., Aelius Aristides, a Greek rhetorician, combined praise of famous cities with eulogy of the reigning emperor, Marcus Aurelius. By his time the term "panegyric" had probably become specialized in this latter connection. It had been an old Roman custom to celebrate at festivals the glories of famous men of the past and to pronounce *laudationes funebres* at the funerals of eminent persons.

Another kind of eulogistic speech in Rome was the *gratiarum actio* ("thanksgiving"), delivered by a successful candidate for office. When Pliny the Younger was nominated as consul by Trajan in A.D. 100 he delivered a *gratiarum actio* which he published in considerably expanded form. It later received the title *Panegyricus*. This speech abounds in flattery of a good emperor; later panegyrists flattered good and bad emperors indiscriminately. Their speeches have survived in the collection called *XII Panegyrici Latini*, or *Veteres* (ed. by W. Baehrens, 1911), containing Pliny's speech and 11 others, in praise of the 3rd- and 4th-century emperors Maximian, Constantius, Constantine, Julian and Theodosius I. Some of the orators are anonymous; the named ones are Eumenius, Nazarius, Mamertinus and Pacatus Drepanius (*qq.v.*). Ausonius and Ennodius (*qq.v.*) also wrote Latin panegyrics, not included in this collection, to Gratian and Theodoric respectively. All these orators practise fulsomeness, insincerity and affectation; their virtues are enthusiasm, however misguided, and comparative purity of style in an age of increasing barbarism. Latin verse panegyric is also found from the Augustan age onward; its most celebrated authors were Claudian (*c.* A.D. 400) and Sidonius Apollinaris (5th century A.D.). Among modern exponents of panegyric may be mentioned Jacques Bossuet, Valentin Fléchier and Jean Baptiste Massillon, whose funeral orations in the age of Louis XIV are triumphs in this type of literature.

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PANEL, originally a small piece of cloth or parchment; this meaning persists only in certain legal terms, such as jury panel, so called from the original strip of parchment on which the names were written in early days; and in Scots law in the use of the word for an indictment or for a person or persons named in an indictment; or in the use of the word for the cloth-stuffed lining of a saddle. In architecture and furniture the word signified, originally, a small piece of thin wood enclosed in a surrounding framework. Casts of charred wooden doors taken in Pompeii as well as many ancient classic representations prove that the construction of wooden panels was well understood by the Greeks and Romans. Moreover, numerous Italian Romanesque wooden church doors of the 10th to the 12th centuries, usually of many small, nearly square panels, manifestly continue Roman types.

In much Gothic decorative work tracery forms are frequently used to divide a large surface into small recessed panels of various shapes. This decorative paneling is particularly common on tombs, screens, chancel rails and the like, in which multiplication of cusping frequently gives it great richness, especially in England. In France paneling is used with more restraint and in simpler forms, usually confined to slim, arch-headed shapes. During the late Gothic period of the 15th and 16th centuries, decorative paneling was used more lavishly throughout north Europe, and in the Perpendicular work of England large wall areas were often covered by a series of rectangular or Tudor arch-headed, sunken, tracery panels. Meanwhile, the use of structural wood paneling, at first reserved for doors, cupboards, chests and similar furniture, was spreading to wainscotting; in this development the English led. Occasionally an applied molding is used at the sides and top only of a panel with a chamfer at the bottom. The rich, interior wood paneling of the Tudor and Elizabethan periods in England often combined with linen fold decoration and sometimes with crude classic pilasters and entablatures is one of the most beautiful characteristics of those styles.

In the Renaissance of Italy paneling is of importance only in furniture such as choir stalls, etc., and in the rich coffered ceilings which cover many palace halls and church interiors. In France, on the other hand, the use of paneling grew continuously more important as the Renaissance developed and reached a climax in

the lavish paneled interiors of the Louis styles (*q.v.*). In this Louis paneling, as in work of the same date in England, the development was toward greater use of large panels made by glueing together smaller pieces of wood. As a result of industrialized building techniques, paneling is widely used in the architecture of the 20th century. (T. F. H.)

PAN-EUROPEAN MOVEMENT. There have been various attempts to express the cultural unity of Europe since the time of the Renaissance and Reformation. The Roman empire in antiquity, the unity of western Christendom under the pope and the Holy Roman empire in the middle ages created or preserved at least a semblance of unity binding together much of Europe. The Renaissance with its birth of the sovereign absolutist state and the Reformation with its division of Christianity put an end to the medieval unity of western Christendom. Since then repeated efforts have been made to restore such a unity. They were stimulated in the medieval and early modern periods by the fearful threat of Turkish-Islamic aggressive power, against which the unity of Europe for defense was sought.

Early Projects of European Unity.—Attempts to restore the medieval *res publica Christiana*, or Christian community, were undertaken on a new rational basis, their authors pleading not only for common defense but for universal peace. This was the attitude of Erasmus in his *Querela Pacis* ("Complaint of Peace") (1517) and of the "Grand Dessein," which Maximilien de Béthune, duc de Sully, the minister of Henry IV of France, outlined in his *Mémoires*. Emeric Crucé proposed in his *Le Nouveau Cynée* (1624) an organization for peace and a court of arbitration with Venice as its seat. In the following century William Penn published his brief *Essay Towards the Present and Future Peace of Europe* (1693) which voiced the pacifism of the Society of Friends. The Abbé de Saint-Pierre published in 1713 his *Projet de paix perpétuelle* ("Project of Perpetual Peace"), which Jean-Jacques Rousseau republished and condensed in 1761. The enlightened rationalism of these proposals was taken up by Immanuel Kant in his *Zum ewigen Frieden* ("On Perpetual Peace," 1795) and by Jeremy Bentham in his *Principles of International Law* (1789).

In the 19th century, the peace congress which met in Aug. 1849 in Paris with Victor Hugo as its president and Richard Cobden as its vice-president pleaded both for universal peace and for a united states of Europe. After World War I the French statesman Aristide Briand worked on proposals for a union of the European nations. Count Richard Coudenhove-Kalergi, an Austrian, in 1923 published an influential book, *Paneuropa*, urging European union; he also founded the Pan-European union, but its activities could not stem the rise of violent nationalism in Europe. The weakened state in which European democracies emerged from World War II led several private organizations to intensify a campaign for the creation of institutions for European co-operation. Some leading European statesmen, among them Winston Churchill, took an active part in this propaganda. The International Committee for the Co-ordination of European Unity Movements called a congress at The Hague, Neth., in May 1948 which proposed the convening of a European consultative assembly. This time the Pan-European movement was powerfully supported by the U.S.

Organization for European Economic Cooperation.—In the same year practical steps for a closer European integration were taken in two fields. First, a permanent Organization for European Economic Cooperation (O.E.E.C.) came into being in April 1948 as the European co-ordinating agency for the European Recovery program, with the Economic Cooperation administration (ECA) of the U.S. pressing for the fullest use and co-operative development of European resources. Secondly, Great Britain, France, Belgium, the Netherlands and Luxembourg in the same month signed a treaty at Brussels pledging co-operation in the military, economic and cultural fields for a duration of 50 years. It was the need for the defense of Europe and European civilization against the totalitarian system spread from Moscow which helped to overcome at least some of the deep-rooted loyalties to national sovereignty in the various European nations and some of the animosities between them, the result of a long past of feuds and conflicts.

NATO and the Council of Europe.—From the beginning, the Brussels pact was regarded only as a nucleus. On April 29, 1948, Louis St. Laurent, the Canadian minister for external affairs, declared that in view of "the rising tide of totalitarian communism . . . Canada and the U.S. need the assistance of the Western European democracies just as they need ours." On June 11 the U.S. senate passed a resolution, moved by Sen. Arthur H. Vandenberg, which prepared the way for the creation of the North Atlantic Treaty organization (NATO) in Washington, D.C., in April 1949. In the following month 10 European nations (Great Britain, France, Belgium, the Netherlands, Luxembourg, Denmark, Norway, Sweden, Ireland and Italy) signed in London the statute of the Council of Europe. The Council of Europe consists of two bodies: the Committee of Ministers, representing the governments, and the Consultative assembly, representing the peoples and parliaments of Europe, and intended to be a forum of ideas and a place where a stimulus could be given to democratic European initiative. Strasbourg, France, was made the permanent seat of the council.

Any European country which accepted the rule of law and of enjoyment by all persons within its jurisdiction of human rights and fundamental freedoms could join the Council of Europe. Greece, Turkey, Iceland and the Federal Republic of Germany later joined and the Saar was admitted as an observer. The first years of the existence of the Council of Europe were filled with a struggle between the assembly, which wished to develop into a European legislative body, and the European governments which were not willing to establish a supranational authority. Nevertheless, a large number of recommendations and resolutions on the most varied subjects in the economic, political, cultural, social and legal fields were made by the assembly and many of them were fully or partly implemented. Among them was the European Convention for the Protection of Human Rights and Fundamental Freedoms (*see* HUMAN RIGHTS).

European Coal and Steel Community.—A closer approach to federal instead of purely international co-operation was taken by France. On May 9, 1950, the French foreign minister Robert Schuman suggested the pooling of the coal and steel resources of the European countries and the setting up of a new high authority whose decisions would be binding on the governments concerned. On March 19, 1951, France, Italy, the Federal Republic of Germany, Belgium, the Netherlands and Luxembourg formally initialed in Paris a draft treaty to give legal effect to the Schuman plan. The treaty, valid for 50 years, came into force in June 1952 after the parliaments of the six nations involved had ratified it. The European Coal and Steel Community (E.C.S.C.) established a High Authority, to act as the executive power, and a Court of Justice, both located in Luxembourg, and an assembly, appointed by the various national parliaments or elected by direct suffrage and exercising democratic control over the High Authority. The assembly was located in Strasbourg. In Sept. 1952 British proposals for establishing close organic links between the E.C.S.C. and the nonparticipating members of the Council of Europe were adopted. The six nations forming the E.C.S.C. proceeded with plans for the creation of a European Defense Community (E.D.C.), a European army which would maintain the closest possible liaison with British forces and would be integrated with the NATO system. The six governments signed the treaty instituting the E.D.C. in Paris on May 27, 1952. The treaty also foresaw the constitution of a permanent assembly elected on a democratic basis. The E.D.C. was rejected by France in Aug. 1954 and replaced in 1955 by a Western European union (W.E.U.), including Great Britain in addition to the six E.D.C. countries.

Progress of Federal Integration.—Winston Churchill had declared in Strasbourg in Aug. 1949: "The first step has been taken, and it is the first step that counts." In the first decade of the Pan-European movement (1948–58) its realization proceeded on two levels, an organized co-operation of sovereign nations, represented by the Council of Europe, and an approach to federal integration, of which the E.C.S.C. formed the first step. At the end of 1955 Jean Monnet, the former president of E.C.S.C., founded the Action Committee for the United States of Europe.

Its purpose was to create a customs union and a common market for the six nations organized in the E.C.S.C. and also a supranational European Atomic Energy Community (EURATOM). Europe is an energy-deficit area, and therefore large-scale industrial application of the energy released by nuclear fission is of great potential importance. By 1958 the six member nations of the E.C.S.C.—Belgium, France, Germany, Italy, Luxembourg, Netherlands—had ratified the two additional treaties establishing the European Economic Community (E.E.C.) and EURATOM. It was planned that the three organizations for the economic federation of the six European nations (E.C.S.C., E.E.C. and EURATOM) should have in common a council of ministers, a European assembly and a European court of justice, supervising the activities of the three economic federations. The E.E.C. treaty also provided for a European investment bank. The single market ("European common market") without tariffs or other trade barriers foreseen for the E.E.C. was to come into full existence over a period of 12 to 15 years.

As an alternative to E.E.C. (known as the Six), Great Britain in 1959 put forward plans for the European Free Trade Association (E.F.T.A., known as the Seven) to include the European countries remaining outside E.E.C. It came into being in 1960 and included Great Britain, Austria, Denmark, Norway, Portugal, Sweden, and Switzerland. Finland became an associate member in 1961.

Integration v. Co-operation.—The six European nations united by federal institutions were also seeking, however, a wider, though looser, form of co-operation with other European nations. Seventeen western European nations, the participants in the O.E.E.C., established on Dec. 20, 1957, for example, a European Nuclear Energy agency to promote co-operative undertakings in the peacetime atomic field. A serious blow was dealt to the hopes for broadening the E.E.C. in Jan. 1963 when Pres. Charles de Gaulle of France announced his opposition to the admission of Great Britain.

The O.E.E.C., an instrument of the European Recovery program, was formed, as has been noted, primarily for European recovery, not for European union. It aimed at intensifying European trade without merging national economies. In that direction Great Britain proposed the creation of a free trade area which would embrace the six nations of the common market and other European nations, especially Great Britain and those which, like the Scandinavian countries, tended to follow the British example. Though the free trade area plan fell short of federal integration, it nevertheless went much farther than anything that had previously emerged from the O.E.E.C.

It still seemed difficult to reconcile the two different approaches toward a Pan-European movement, the one based on the co-operation of independent governments, the other on the establishment, at least in the economic field, of supranational organizations and authorities. Nevertheless the Pan-European movement had made definite progress. *See* also ECONOMIC UNION; FEDERAL GOVERNMENT; FOREIGN AID PROGRAMS; WORLD GOVERNMENT MOVEMENTS.

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PANEVEZYS (PANEVEZHIS), a district town and a major cultural and economic centre in the Lithuanian Soviet Socialist Republic, U.S.S.R., is situated about 137 km. (85 mi.) N of Kaunas by road. Pop. (1959) 41,100. It has many educational institutions and an archaeological and numismatic museum. Railways run to Siauliai and Klaipeda, Daugavpils and Riga. Panevezys is the largest milling centre in Lithuania; it also has meat-canning, sugar-refining, distilling, brewing, and flax-processing industries. Its origin dates back to the 14th century. It received the charter of a district town in 1842. In 1926 it became a cathedral town.

PANGALOS, THEODOROS (1878–1952), Greek army officer, statesman, and for seven months in 1926, dictator, was born at Salamis on Jan. 11, 1878. He studied at the Greek military academy and at St. Cyr in France and served in World War I and in the Anatolian campaign. Placed on the retired list in 1920, he was reactivated in 1922 and sat on the special court which condemned to death those supposed to have been responsible for the disaster of Smyrna (*see* GREECE: *History*). Pangalos served in 1923 as commander in chief in Thrace but in the same year entered politics. A year after the republic was proclaimed, he seized power by a *coup d'état* on June 26, 1925. His rule was erratic and irresponsible, and war with Bulgaria was only narrowly averted. He assumed dictatorial powers on Jan. 3, 1926, to put an end to the rivalry of the political parties. In April 1926 he procured his own election as president of the republic. He was deposed, however, by another *coup d'état* carried out on Aug. 22, 1926, by Gen. Georgios Kondylis. Pangalos then retired from public life, but was sentenced in April 1930 to two years' imprisonment for irregularities in connection with the building of a casino. In 1932 he was confined to Corfu. After the liberation in 1945 at the end of World War II, he reappeared in Athens and was accused of having collaborated with the Germans and the Italians, but the charges could not be substantiated. He died in Athens on Feb. 26, 1952. (B. S.-E.)

PANGASINAN, a province of central Luzon, Philippines, occupying the north end of the central plain and fronting on Lingayen Gulf on the west coast; it includes the two islands of Santiago and Cabarruyan. Area 2,021 sq.mi.; pop. (1960) 1,124,144. Most of the province consists of the alluvial lowland of the Agno River, which rises in the mountains of northern Luzon. It is one of the richest agricultural regions of the Philippines and has a heavy population of Pangasinan natives and Ilocanos from the northwest Luzon coast settled in the northern section. The chief crop is rice, much of which goes by rail to the Manila markets. Minor crops are corn (maize), mangoes and other fruits, sugarcane, tobacco and coconut, this being the northernmost important coconut-growing region. Firewood cutting from the mangrove swamps and salt making are important along the Lingayen Gulf coast. The capital is Lingayen (pop. [1960] 45,321); during World War II, U.S. forces made reoccupation landings near it. Dagupan, east of Lingayen, is a city chartered in 1947 with an area of 17.1 sq.mi.; pop. (1960) 63,191. It is the chief port and an important rail and road transport centre. There are no other large towns or cities but numerous populous municipalities are located in the northern portion of the Agno River plain. Among these are Binmaley, between Lingayen and Dagupan; Mangaldan, east of Dagupan, a rail transport and cotton textile centre; Calasiao, south of Dagupan, a rice shipping and palm-hat making centre; and the inland municipalities of Manaoag, San Carlos, and Bayambang. (J. E. SR.)

The eighth largest Philippine ethnolinguistic group, with a population of 666,003 in 1960, is also called Pangasinan. The language probably falls with those of Central Luzon though it has affinities with the Nabaloi (Ibaloi; *see* IGOROT) to the north. The Pangasinan originally occupied the whole region around Lingayen Gulf; Ilocano (*q.v.*) expansion, which still continued in the 1960s, forced them southward, so that they mainly occupy the central area of the province. In social organization the Pangasinan conform to the bilateral pattern common to the Christian lowland Philippines. They are predominantly Roman Catholic, though a minority adhere to the Philippine (Aglipayan) Independent Church, a schismatic movement from Catholicism that originated in the rebellion against Spain. There has been considerable intermarriage with the Ilocano, who in the 1960s constituted about half of the total provincial population; most of the people are bilingual. *See* also PHILIPPINES, REPUBLIC OF THE. (F. R. E.)

PAN-GERMANISM is the name of a movement aiming at the union of all people speaking German or a Germanic tongue into one political body. Sometimes the movement, which was never clearly or authoritatively defined, proclaimed the unity only

of the German-speaking population of Germany proper, of the Habsburg monarchy, of Russia (the Baltic provinces), of Switzerland, of France (Alsace) and of the Low Countries (where Dutch and Flemish were regarded as German dialects). With the peculiar position which the Rhine river acquired in German nationalism, it was stressed that the source of the Rhine (in Switzerland) and its mouth (in the Low Countries) "belonged" to Germany. Other proponents of Pan-Germanism pointed to the civilizing mission and the colonizing efforts of the medieval German empire in eastern Europe and based upon it claims for German hegemony there. Others again wished to include the Scandinavian nations in the Pan-German unity.

This latter trend was strengthened by "Nordic" racial theories, which regarded the Nordics, as represented by the Teutonic Germans and Scandinavians with their common mythology and saga world, as the most gifted and noble kind of the human species. The close tie between Nordic-Aryanism and Pan-Germanism became even more pronounced after leading German artists and scholars such as Richard Wagner and Heinrich von Treitschke embraced racialism. The famous "Nordic" or Germanic racial theory, which the French writer Comte Joseph Arthur de Gobineau (1816–82) proposed in his *Essai sur l'inegalité des races humaines* (1853–55), made little impression in western Europe but was elaborated into a system by the English-born naturalized German Houston Stewart Chamberlain (1855–1927), Richard Wagner's son-in-law and author of *Die Grundlagen des neunzehnten Jahrhunderts* (1899; Eng. trans., *The Foundations of the 19th Century*, 1911). He and other German racialists claimed every historical man of genius, including Jesus Christ, as a member of the German race.

Although Emperor William II patronized Chamberlain, official Germany adhered neither to Pan-Germanism nor to racialism until 1933. Pan-Germanism was a movement of German intellectuals, writers and scholars, but did not enter the realm of practical politics before 1914. It was first expressed during the nationalist enthusiasm of the "war of liberation" against Napoleon by such patriotic propagandists as Ernst Moritz Arndt (1769–1860) and Friedrich Ludwig Jahn (1778–1852), founder of the militant gymnastic organizations (*Turnvereine*).

The ideal Germany which they wished to build had no clearly determined historical, natural or ethnographic frontiers. This encouraged sweeping claims to many territories which had at some time or other been under the vague and ill-defined suzerainty of the Holy Roman empire or to territories where Germans had settled among non-Germanic peoples.

Half a century later, German nationalists such as the political economist Friedrich List (1789–1846), the orientalist Paul Anton de Lagarde (1827–91) and the political publicist Konstantin Frantz (1817–91) advocated the formation of a powerful European confederation in central Europe under German leadership. Such a powerful central European federation from Flanders to the Black sea and from Burgundy to the Vistula, they maintained, would be able to guarantee the peace of the entire continent.

Pan-Germanism was not organized as a movement until 1894, when Ernst Hasse, professor in Leipzig and from 1893 to 1903 a member of the *Reichstag*, reformed the *Allgemeiner Deutscher Verband* (General German league, founded in 1891) as *Alldeutscher Verband* (Pan-German league). After Hasse's death in 1908 Heinrich Class became his successor. The league inaugurated a dynamic policy in Europe and overseas under the slogan "remember that you are Germans." It defined its purpose:

(1) The Pan-German League strives to quicken the national sentiment of Germans and in particular to awaken and foster the racial and cultural homogeneity of all sections of the German people. (2) These aims imply that the League works for: (*a*) preservation of the German *Volkstum* in Europe and overseas and its support whenever it is threatened. (*b*) Settlement of all cultural, educational and school problems in ways that shall aid the German *Volkstum*. (*c*) The combatting of all forces which check the German national development. (*d*) An active policy of furthering German interests in the entire world, in particular the continuation of the German colonial movement.

In his three-volume work *Deutsche Politik* (1905–07), Hasse proposed to protect the German frontiers by a wide military glacis, settled by picked former German soldiers. "We want territory," he wrote, "even if it be inhabited by foreign peoples, so that we may shape their future in accordance with our needs."

Many writers went openly beyond the official program by demanding a close union of Germany with Austria-Hungary, the Low Countries and Switzerland and the annexation of large parts of western Russia and of the Balkans. Above all, the league was concerned with preserving the German national consciousness and loyalty to Germany of the many millions of German descent settled overseas. Although the league had hardly more than 20,000 members, its propaganda was very active and more or less coloured the thinking of large German circles. Pan-Germanism had also a wide following among the Germans in the Austrian monarchy, where Georg von Schönerer and his disciple Karl Hermann Wolf propagated Pan-German expansionism, German superiority over the Slavs and an anticapitalistic anti-Semitism, doctrines which very much influenced Adolf Hitler when he lived in Austria before World War I.

During World War I Friedrich Naumann (1860–1919), a Protestant theologian and socialist politician, published *Mitteleuropa* (1915), in which he proposed a vast German-dominated confederation from Antwerp to the Persian gulf. The treaty of Brest-Litovsk in March 1918 seemed to realize much of this Pan-German dream, only to be destroyed a few months later by the defeat of Germany on the western front. This defeat not only saved the western democracies, but also Communist Russia from the German hegemony foreshadowed in the Brest-Litovsk treaty.

Pan-Germanism did not acknowledge this defeat but strove, even during the days of the Weimar republic, to revive Pan-German nationalism and racialism. Among the various groups which propagated this faith among the masses, the National Socialist German Workers' party (Nazis) under the leadership of Hitler soon became the strongest. While the Pan-Germans before 1914 had regarded England as the main target of their hatred, Hitler turned Pan-German aspirations primarily to the east and singled out Communist Russia as the chief enemy. He propagated Pan-Germanism in its new and extremist form, in which faith in absolute Nordic racial superiority and the cult of force and violence were fused.

One of the schools supporting Pan-Germanism was that of Geopolitik, a "science" establishing a similar mystical tie between geography and history as the racial theory did in maintaining such a tie between biological "science" and man's destiny. Among the geopoliticians Karl Haushofer in Munich and Ewald Banse, the author of *Raum und Volk im Weltkriege* ("Space and Folk in the World War") (1933), were prominent. Writers such as Hans Grimm, *Volk ohne Raum* ("Folk Without Space") (1926), created a favourable moral climate in Germany for the spread of extreme Pan-Germanism. (*See* GEOPOLITICS.) Under these conditions, the feeble efforts of the Weimar government to resist the rising tide of Pan-Germanism failed, and in Jan. 1933 the government of Adolf Hitler came to power, the first German government avowedly dedicated to the realization of Pan-Germanism. Five years were needed to prepare for the task. They were used not only to arm Germany and to divide public opinion abroad, but to realize the Pan-German principles in the nation itself. In March 1938 the first open steps were taken to carry through the Pan-German program with the annexation of Austria. From then on, step followed step in an almost logical and methodical way to fulfill the whole Pan-German program.

By the beginning of 1942 this realization seemed at hand: the whole of central Europe and the Balkans, western Russia and the Ukraine were under German control—as foreshadowed in the treaty of Brest-Litovsk; but beyond it, Denmark and Norway, France and the Low Countries were occupied by the Germans, and Italy and Spain under the fascist regimes of Benito Mussolini and Francisco Franco were Germany's allies. Again, as in 1918, the German aspirations for a Pan-German empire were destroyed only a short while later by military defeat. This defeat in 1945 had much more devastating consequences for Pan-Germanism in eastern and central Europe than did that of 1918. The German settlements in eastern-central Europe were "liqui-

dated" by forced mass evacuation. Nevertheless, Pan-German sentiments again showed signs of revival in Germany in the second half of the 20th century. *See* also NATIONALISM; NATIONAL SOCIALISM.

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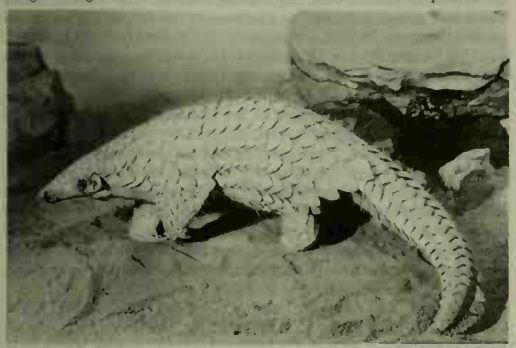
PANGOLIN (SCALY ANTEATER), any of the armoured mammals of the order Pholidota (*q.v.*). "Pangolin," from the Malayan meaning "roller," refers to the defensive habit these animals have of curling into a ball when danger threatens. Found in tropical Asia and Africa, pangolins range from one to three feet long, exclusive of the tail, which may be shorter than, or twice the length of, the rest of the body. The legs are short and the tongue long and wormlike. There are no teeth. Except for the



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INDIAN PANGOLIN (MANIS CRASSICAUDATA)

underside of the body (and excepting some African forms) the animal is covered with broad, overlapping, yellowish-brown horny scales. All species are nocturnal insect eaters. They use the curved claws on the forefeet to rip open ant and termite nests. The several distinct types of pangolin are usually grouped in a single genus, *Manis;* some authorities recognize several genera. Much remains to be known about the reproductive cycle and life span of pangolins, but it appears that one young is born at a time and is carried about by the mother for some time after birth. The life span has been estimated at a dozen years or more. By 19th-century zoologists these animals were included with the aardvarks in the order Edentata (*q.v.*).

PANHARD, RENÉ (1841–1908), French engineer and automobile manufacturer, was born at Paris in 1841 and graduated from the École centrale des arts et manufactures. In 1886 he joined with Émile Levassor, who gained control of the French rights to the Daimler patents, to form Panhard and Levassor. In 1891–92 Panhard and Levassor produced the first vehicle with an internal combustion engine mounted at the front of the chasis. The car, designed by Levassor, had a clutch and transmission to carry the power to the rear wheels. The Panhard and Levassor automobile was put on sale in 1892 and competed successfully in early races. In 1907 the firm adopted the sleeve-valve engine.

Panhard died at La Bourbole in 1908. (M. J. Bl.)

PANIC, in economics, a term used loosely to describe a variety of situations such as acute financial disturbances, widespread bank failures, feverish stock speculation followed by a market crash, or a climate of fear caused by economic crises or the anticipation of such crises. The term is applied only to the violent stage of financial convulsion and does not extend to the whole period of a downswing in the business cycle.

Up until the 19th century economic fluctuations were largely connected with shortages of goods, market expansion, and speculation. The character of these commercial crises was reflected in the nature of the panics that accompanied them. Similarly, panics in the industrialized societies of the 19th and 20th centuries reflect the increasing complexity of advanced economies and the changed character of their instability. A financial panic is often a prelude to a crisis that extends beyond commercial activities into sectors of consumption and capital goods industries.

The Tulip Craze.—One example of a speculative panic in the early modern period was the so-called tulip craze that occurred in Holland during the period 1633–37. With the development of capitalistic methods, speculation began to play a more important role, and sometimes the desire to speculate outran the possibilities supplied by economic conditions. Thus in Holland in 1633 speculators were engaged in tulip bulb transactions. By 1636 the buying of bulbs was running wild. Rare varieties of bulbs were selling for hundreds of dollars each. Everybody had joined in the tulip speculation in the expectation of high profits. The crash came early in 1637, sweeping away fortunes and leaving behind financial ruin.

The Mississippi Bubble.—Speculation in stocks also led to panics early in the history of capitalism. Stock speculation reached panic proportions in 1720 in both France and England. Largely responsible for the French speculation was a Scottish immigrant, John Law (*q.v.*), an adventurer, gambler, economic theorist, and financial wizard. Law, a friend of the regent, the Duc d'Orléans, established the Banque Générale (1716) and a year later the Louisiana Company (also known as the Company of the West) with a capital of 100,000,000 livres. It was given extensive powers over the Mississippi Valley in North America. Eventually Law monopolized the tobacco trade, controlled the African slave trade, and in 1719 his company absorbed the French East India Company, the Guinea Company, the Santo Domingo Company, and the China Company. Furthermore, he took over the collection of French taxes and the management of the mint. In effect, Law controlled French foreign trade and French finances.

The demand for the shares of Law's company increased sharply, sending the price from 500 to 18,000 livres a share, out of all proportion to earnings. By 1719 Law had issued 640,000 stock shares. The Rue Quincampoix and the Rue de Venise, where stock was traded, witnessed unbelievably wild scenes. "The roadways were jammed with people; brokers wildly signaled from near-by windows, shares and bank notes worth thousands changed hands like pennies. Stories were told of a valet trading for his master who made a fortune in side deals for himself, of beggars turned into millionaires overnight, of a hunchback who grew rich by letting traders use his back as a desk to sign papers on. All Paris was mad." (S. B. Clough and C. W. Cole, *Economic History of Europe*, p. 298. Copyright 1946 by D. C. Heath and Company, Boston.) The excessive issue of bank-notes stimulated galloping inflation with commodity prices more than doubled. In 1720, however, the "Mississippi bubble," as it was called, burst; the imaginary prosperity ended; and Law's ingenious schemes fell into pieces.

The South Sea Bubble.—During the same period England was having a similar experience. In 1711 the South Sea Company was founded to carry on trade with the South Seas and encourage fishing. (*See* SOUTH SEA BUBBLE.) The charter provided that the government stock be turned into the company in exchange for its stock. An amount of £10,000,000 of short-term national debt was taken over from the state's creditors and converted into long-term debt. The government paid interest on this debt, granted a trade monopoly to the company, and, later in 1713, the slave trade. In 1719 the South Sea Company assumed another government loan of £1,750,000, and its prospects seemed better than ever. The company paid a bonus to the bondholders in stock, which in the meantime was rapidly rising in price—from about £130 in early 1720 to £1,020 by the middle of the year. Sub-

scriptions for new companies were coming in, but many of them were often fraudulent and fantastic speculative operations, such as "improving of an art lately found out for the making of soap," trading in human hair, an air pump for the brain, and a wheel for perpetual motion. The stock market became a "roaring Hell-porch of insane and dishonest speculators."

In August the signs of a crash became apparent. The price of the South Sea shares tumbled to £390 and reached £120 in December. The "South Sea Bubble," as it was called, wiped out many companies, rocked the South Sea Company, and drove all kinds of joint stock into disrepute. It further gave rise to the Bubble Act which placed severe restrictions on the formation of joint stock companies until it was repealed in 1825.

The United States and the Panic of 1857.—In the United States economic instability before 1815 reflected the conditions of an underdeveloped economy, and the timing of crises was basically accounted for by happenings occurring outside the domestic economy. The nature of fluctuations to which the U.S. economy was subjected during the decades of the 1820s and the 1830s stemmed from the changing character of the economy itself. Domestic economic developments were beginning to play their part in determining the timing of crises, which were only aggravated or dampened by foreign influences. In the last two decades before the American Civil War economic instability assumed more of the complexity of the modern industrial crises and became more closely related to the interplay of capital investments, savings, manufacturing activity, expectations, and expanding markets. Foreign influences continued to affect the pattern of economic crises, but the main cause of domestic instability was an inadequate banking system.

The crisis of 1857 was, in a way of speaking, the first panic, at least in Europe, caused largely by economic factors. In the United States, the panic of 1857 was the outcome of a number of developments. By the spring of 1857 a pyramid of debts and speculative commitments had reached high proportions. Large investments had been sunk into railroads in regions where traffic was still insufficient to allow an adequate return on the rail bonds. The value of rail securities fell considerably; railroads defaulted on their bonds; and many banks found their assets tied up in nonliquid railroad investments. In addition, European capital had begun to flow out of the U.S. market, being attracted by higher rates in England and France resulting from an increased outflow of European specie to the Near East and Far East. In August the Ohio Life Insurance and Trust Company failed, followed by many other banks and business concerns. In October alone more than 1,400 banks went into bankruptcy and all New York banks suspended specie payments, their example soon to be followed by banks throughout the country. Unemployment rose sharply and massive workers' meetings became common. The American crisis further aggravated the European economy and panic swept the money markets of the continent. The Bank of England used its emergency powers to increase the issue of fiduciary notes.

Other Panics.—The year 1873 was another great mark in the history of economic development and panics. It marked the end of the long upward secular trend of the world economy that had begun in the late 1840s. The downward trend lasted until 1896. In June 1873 Vienna was rocked by financial difficulties and in September New York City had its second "Black Friday" (*q.v.*). Banks and stock exchanges closed and cash payments were suspended. But by November the worst of the money panic was over.

A panic occurred in England in 1890 (the Baring crisis) and in 1907 and 1921 in the U.S. But the great panic and the great crisis came in 1929. On Oct. 24 of that year, before the first hour of trading on the New York Stock Exchange was over, stock prices were tumbling. "The gigantic edifice of prices was now breaking under its own weight. Down, down, down. The roar of voices which rose from the floor of the Exchange had become a roar of panic. . . . Huge blocks of stock were thrown upon the market for whatever they would bring. The scene on the floor was chaotic." (F. L. Allen, *Only Yesterday*, Harper & Brothers, New York, 1931.) This catastrophe rocked the U.S. economy and shattered world economic relations for more than a decade.

See also references under "Panic" in the Index. (A. A. Ps.)

PANICUM, a genus of grasses (*q.v.*) comprising some 800 species, found chiefly in the warmer regions of both hemispheres, about 150 occurring in the United States. Several are important cereals, as *P. miliaceum* (common millet), cultivated for food in India and Europe; others are valuable forage plants, as *P. maximum* (guinea grass) and *P. purpurascens* (Para grass), the only grasses extensively grown for forage in tropical America. Representative North American species are *P. capillare* (common witch grass), *P. virgatum* (switch grass) and *P. texanum* (Texas millet).

See also MILLET.

PANIKKAR, KAVALAM MADHAVA (1895–1963), Indian statesman and scholar, was born in 1895 in Travancore (Kerala), India, of Nair (Nayar) parents, and was educated at the Madras Christian College and at Christ Church, Oxford, where he was placed in the first class in the modern history school. He also read for the bar at the Middle Temple and taught at Aligarh and Calcutta universities before turning to journalism as editor of the *Hindustan Times* (1925).

He entered political life in the service of the Indian princes, becoming secretary to the chancellor of the Chamber of Princes. He also served as foreign minister of Patiala and as foreign minister and subsequently chief minister of Bikaner (1944–47). After India had gained independence he was entrusted with greater responsibilities as India's ambassador to China (1948–52), Egypt (1952–53), and France (1956–59). He was also appointed to the States Reorganization Commission (1953–55) (*see* INDIA: *History*). In the last years of his life he returned to the university world, and was vice-chancellor of the University of Mysore at the time of his death there, on Dec. 10, 1963.

Panikkar wrote many books on history and politics. His interest in European influence on Asia was reflected in his studies of the Portuguese and Dutch in Malabar, and especially in his *Asia and Western Dominance* (1953). *In Two Chinas* (1955) revealed his sympathy with Communist China, where he had spent perhaps the most influential years of his diplomatic career. Writing partly in English and partly in Malayalam he was also a playwright and the author of novels (*see* MALAYALAM LITERATURE).

(KE. A. B.; X.)

PANIN, NIKITA IVANOVICH, COUNT (1718–1783), Russian statesman, one of Catherine the Great's chief diplomatic advisers, was born in Gdansk on Sept. 29 (new style; 18, old style), 1718. Having passed his childhood at Pärnu (Pernau) in Estonia, where his father was commandant, he entered the Russian Army in 1740. Rumour had it that he was a favourite of the empress Elizabeth. He was accredited as Russian minister to Denmark in 1747 but was transferred a few months later to Stockholm, where for the next 12 years he acted as the chief opponent of the pro-French party in Sweden, in accordance with the anti-French views of the Russian chancellor A. P. Bestuzhev-Ryumin. Consequently, when Russia in the 1750s turned pro-French, Panin's position became extremely difficult. Moreover, he found an enemy in Bestuzhev's supplanter, M. I. Vorontsov, and he was on the point of retiring when in 1760 he was unexpectedly appointed to supervise the education of the six-year-old grand duke Paul, son of the grand duchess Catherine. Thenceforward his influence was assured. He was on Catherine's side during the revolution of 1762 (*see* CATHERINE II, empress of Russia), but his jealousy of the influence which the Orlovs seemed likely to obtain over her predisposed him to favour the proclamation of his ward Paul as emperor, with Catherine as regent only.

Panin was the political mentor of Catherine during the first 18 years of her reign, and in 1763 he became head of the "Foreign College" or Department of Foreign Affairs. He was the inventor of the famous "Northern Accord," which aimed at an understanding between Russia, Prussia, Poland, Sweden, and perhaps Great Britain against the Franco-Austrian bloc. The idea influenced Russian policy for many years. It explains, too, Panin's tenderness toward Poland, since in his "Accord" Poland was to supply the place of Austria, whom circumstances had temporarily detached from the Russian alliance. Only when the impracticability

of the "Northern Accord" became patent did his influence begin to wane.

After 1772, when the accession of Gustavus III to the Swedish throne upset Panin's plans for Sweden, Panin became more and more subservient to Frederick II of Prussia. As to Poland, his views differed widely from those of both Frederick and Catherine. He seriously guaranteed the integrity of Polish territory, after placing Stanislaw II Poniatowski on the throne in 1764, in order that Poland, as strong as circumstances would permit, might be drawn wholly within the orbit of Russia. But he did not foresee the complications likely to arise from Russia's interference in the domestic affairs of Poland. Thus the Confederation of Bar (*q.v.*) and the ensuing Turkish War took him completely by surprise. He had to acquiesce in the first partition of Poland, and when Russia came off third best, Grigori Orlov declared that the minister who had signed such a treaty deserved death.

Panin further annoyed Catherine by meddling with the arrangements for Paul's marriage and by advocating a closer alliance with Prussia, whereas the empress was beginning to incline more and more toward Austria. Nevertheless, even after Paul's second marriage, Panin maintained his influence over his pupil, who, like himself, was now a warm admirer of the king of Prussia. As the Austrian influence increased, Panin found a fresh enemy in the Holy Roman emperor Joseph II, and his efforts to prevent a matrimonial alliance between the Russian and Austrian courts determined Catherine to get rid of a counselor of whom, for some mysterious reason, she was secretly afraid. The final rupture seems to have arisen on the question of the declaration of "the armed neutrality of the North," whereby Catherine sought to organize the protection of neutral shipping against British interference in 1780 during the War of American Independence; and in May 1781 Panin was dismissed. He died in St. Petersburg on April 11 (N.S.; March 31, O.S.), 1783. Panin was one of the most learned, accomplished, and courteous Russians of his day. Catherine called him "her encyclopaedia." He was of a most humane disposition and a friend of liberal institutions. During his residence in Sweden he had conceived a fondness for constitutional forms of government, on which later he submitted a project to Catherine.

PANIPAT, a municipal town and *tehsil* (subdivision) in the Karnal District of Punjab, India, is situated about 53 mi. (85 km.) N of Delhi on the historic highway, the Grand Trunk Road, once known as the Gate of Hindustan. Pop. (1961) 67,026. Because of its location three decisive battles were fought on the plain of Panipat: Babur's victory over Ibrahim Lodi in 1526 which established the Moguls in India; the defeat of Hemu (the Hindu general of the Afghan Adil Shah) by Akbar in 1556; and in 1761 the complete overthrow of the Marathas by Ahmad Shah Durrani. The chief monument in the town is the tomb of Kalandar, a Muslim saint. Panipat is a flourishing trade centre for wool, grains, and cotton, and is important for weaving and spinning wool. It is a junction on the Northern Railway. (O. P. B.)

PAN-ISLAMISM, the ideal embodied in the efforts of Muslim leaders during the 19th century to revive Muslim power and bring about unity. It originated partly in Islam's own realization of its decadence, but mainly as a result of European encroachments on Muslim lands in the 19th and 20th centuries. Islam's own realization of its decadence produced the Wahhabi (*q.v.*) movement, which preached going back to primitive Islam, but contact with the West also made possible the rise of such enlightened leaders as the Persian-born reformer Jamal al-Din al-Afghani, who sought to develop Islam to fit modern conditions of life. Above all he sought to achieve the unity of Islam under the aegis of a caliph who could oppose the advance of Christian powers in Muslim lands.

Importance of the Caliphate in Pan-Islamic Doctrine.—Islam (*q.v.*), in contrast to Christianity, is both Church and state; its political and legal theory are opposed to the submission of Muslim sovereignty to non-Muslim powers. The caliph, head of the Muslim State, is under legal obligation to wage jihad (holy war) should Islam fall under foreign rule. Peace between a Muslim and a non-Muslim ruler should not, in theory, last more than 10 years. Muslim submission to non-Muslim powers is regarded as an anomaly that is tolerated only under *force majeure*. When the Arab caliphate passed to Ottoman sultans in the 16th century (*see* CALIPHATE: *Later Abbasids*), the Muslims gradually began to look to the Ottoman sultan-caliph as the defender of the faith, although he lacked the legal qualification of belonging to the tribe of Quraysh (Koreish, Kuraish). The sharifian sultans of Morocco and the Mogul rulers of India refused recognition, but the rest of *dar al-Islam* (world of Islam), except perhaps the Shi'a, accepted the Ottoman caliphate. When Sultan Abdul-Hamid II formally declared himself a sultan-caliph (1876) the Mogul emperor had already submitted to British rule in 1857 and the sharifian sultan was later to fall under French domination.

Abdul-Hamid II (1876–1909) conducted such an extensive Islamic propaganda that the European powers feared political disturbances among Muslims under their control. In spite of its decline, the Ottoman Empire through Pan-Islamism enhanced its prestige in Muslim eyes and, as the leading Muslim State, was able to raise its voice on behalf of the Muslim world in the councils of Europe. Although the emissaries of Abdul-Hamid were ill-chosen, and the success of their efforts appeared slight, the Pan-Islamic movement remained as the cherished ideal of many Muslims. Before the rise of nationalism, Pan-Islamism was the dominating ideology throughout the Muslim world. If Abdul-Hamid, as caliph, was its patron, several other public figures posed as its philosophers and preachers. The most outstanding exponent of the movement was Jamal al-Din al-Afghani (*q.v.*), who preached his doctrine in several Muslim countries and finally resided in Constantinople (Istanbul) until his death. His teachings reached almost every corner of the Islamic world and were echoed in centres set up as far afield as Java, Tunisia and Shanghai. In 1903 Abdullah Suhrawardi founded the Pan-Islamic society of London, whose journal, *Pan-Islam*, used western concepts such as humanism, liberalism and socialism to characterize Islamic virtues as opposed to European vices. Attempts were made to unify the Sunni and Shi'i sects, but no great progress was achieved when a number of Ottoman and Persian jurists assembled in Najaf early in 1911 and asserted that there was no difference in principle between the two sects. The annual conferences at Mecca during the pilgrimage were cleverly used for Pan-Islamic propaganda, but perhaps the greatest practical project that impressed the Muslims, particularly pilgrims, was the Hejaz railroad, built by private funds, partly provided by Sultan Abdul-Hamid himself, that stood as a monument to the Pan-Islamic ideal.

Nationalism as a Rival Credo.—The fall of Abdul-Hamid in 1909 marked the decline of Pan-Islamism. His failure to achieve Islamic unity and to protect Islam from western encroachment prompted many a Muslim thinker, impatient with the sultan's despotism, to seek a change in the character of Muslim polity. The new generation had been influenced by western constitutionalism and nationalism (*q.v.*) and hoped that the adoption of these concepts might create a strong Ottoman state. But nationalism wrought havoc in Muslim lands; for in so composite a society as *dar al-Islam* under Ottoman rule, nationalism inevitably led to the disintegration of Muslim unity. Although the Committee of Union and Progress formally advocated Pan-Islamism at a conference held in Salonika (1911), the doctrine of nationalism proved to be incompatible with the internationalism of Islam. The Turkish nationalists, who displayed little sympathy with other Muslim countries, made an alliance with Germany that was repudiated by the Muslims in the Arab lands.

The new regimes that were set up after World War I were in the main organized on the basis of nationalism. The Ottoman empire was broken up, and the caliphial powers were at first reduced to merely spiritual powers (1922) and then the caliphate was abolished in 1924 (*see* TURKEY: *History*). The Muslim world protested against the Turkish action, since the status of the caliphate was not a problem for the Turkish nation only but for the Muslim world at large. The Indian Muslims organized the Khilafat movement, which aimed at the restoration of the caliphial powers to a supreme Muslim authority in Mecca. In 1926 two caliphate congresses were held in Cairo and Mecca in

which the need for the caliphate was affirmed, but no agreement was reached as to who should be elected caliph. The Islamic congress held in Jerusalem in 1931 did not even discuss the caliphate question. Between World Wars I and II, the Muslim countries tended to concern themselves almost exclusively with practical problems rather than with the larger issues of Islamic unity and the caliphate.

Neo-Pan-Islamism.—After World War II Islam received a certain impetus when Pakistan and Indonesia rose to independent status. A number of Arab countries such as Syria, Lebanon (whose population was at least half Muslim), and Jordan, became fully sovereign states, as did several others in Africa, such as Libya, the Sudan, Tunisia and Morocco. The sudden realization of their influence in international councils induced the Muslim States to co-ordinate their activities. Muslim conferences in Karachi in 1952 and in Mecca in 1954 resulted in establishment of a permanent council and a secretariat for organizing annual meetings to co-ordinate activities for the emancipation of Muslim countries that were still dominated by western imperialism and for raising the cultural, social and economic standards of Muslim people.

This new trend in the revival of Islam, called neo-Pan-Islamism, did not aim at the unity of all Muslim peoples under one central authority, as Jamal al-Din al-Afghani and other Muslim leaders had advocated during the 19th century, but at the co-ordination of the activities of Muslim States within the international community. The Muslim States were quite aware that it was not possible to revive either the traditional Islamic ideal of unity or the religious approach to foreign affairs, because circumstances were not favourable to the association of religion in the relations among nations. If certain religious groups insisted on a more active role for *shari'a* (religious law) in the domestic affairs of Islam, their active participation in international organizations bore witness to the fact that Muslims not only accepted secular standards in their external relations but also the integration of their countries into the larger world community. Some Muslim jurists who objected to the internal secularization of the state, and who often invoked the jihad against western encroachment on Islam, repudiated any claim that the jihad is aggressive in character. Some Muslim publicists departed so far from traditional concepts as to argue that the law governing Islam's relations with other nations, as originally expounded by Muhammad, was based on the principle of peaceful—not hostile—relations among the nations, and that its humane rules and practices can contribute to the development of the modern law of nations for the mutual benefit of Islamic and non-Islamic nations.

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PANIZZI, SIR ANTHONY (Antonio Genesio Maria Panizzi) (1797–1879), Italian patriot and man of letters, who became famous as a librarian at the British Museum, London, and also played a part in the unification of Italy, was born at Brescello, Modena, on Sept. 16, 1797. He studied law at Parma (1814–18) and became an advocate, but in 1822 was forced into exile to avoid arrest as a revolutionary. In 1823 he arrived in England, and after teaching Italian at Liverpool, became professor of Italian at University College, London (1828–37), and in 1831, an assistant librarian at the British Museum. He was appointed keeper of printed books in 1837 and principal librarian in 1856. He retired in 1866, was knighted in 1869, and died in London on April 8, 1879.

As a librarian and administrator Panizzi combined vision with meticulous attention to detail, and he was responsible for the reorganization and for the new spirit of energy and concern for scholarship which made the museum one of the world's great centres of culture. He planned and began work on the general catalogue; secured strict enforcement of the 1842 Copyright Act; drew up a report on the library's deficiencies which led to an increased grant for book purchases (1845); improved staff conditions by insisting on the museum's recognition as a branch of the civil service; and was responsible, through his friendship with Thomas Grenville, for the bequest of the Grenville library (1846). He is best remembered, however, for designing and supervising the building of the reading room, opened in May 1857.

Although he became a British citizen in 1832, Panizzi continued to further the cause of Italian liberty by friendship with such influential Liberal statesmen in England as Gladstone, Palmerston, Lord Russell, Lord Langdale, and Lord Rutherfurd, with Thiers in France, and with the Italian leaders. After the unification of Italy, he declined invitations from Garibaldi and Cavour to return as senator or as a member of the council of public instruction, preferring to continue to serve as "unofficial ambassador" in London.

Panizzi's literary works included editions of Boiardo's *Orlando innamorato* and Ariosto's *Orlando furioso* (1830–34) and of Boiardo's minor poems (1835). In his later years he was a close friend of Prosper Mérimée (*q.v.*).

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PANJABI (Punjabi) **LANGUAGE,** the language spoken by more than 17,000,000 inhabitants of the central part of the Punjab, an area now divided between India and Pakistan. The vernacular of this region was originally an old form of the modern Lahndā, a member of the outer group of Indo-Aryan languages, but it now belongs to the intermediate group, possessing most of the characteristics of the Midland language, with occasional traces of the old outer basis which become more and more prominent westward. On the west it merges into the modern Lahndā. (*See* Indo-Aryan Languages; Lahnda Language.)

The vocabulary of Panjabi is very similar to that of western Hindi (*q.v.*). Panjabi has little literature and is free from the burden of words borrowed from Persian or Sanskrit, only the commonest and simplest of such being found in it. Its vocabulary is thus almost entirely *tadbhava* (*i.e.,* evolved, as contrasted with borrowed, from Sanskrit), and, while capable of expressing all ideas, it has a charming rustic flavour, like the Lowland Scots of Burns, indicative of the national character of the sturdy peasantry that employs it.

The indigenous alphabet of the Punjab is called Laṇḍā or "clipped." It is related to the Nāgarī alphabet but is hardly legible to anyone except the original writer, and sometimes not even to him. To remedy this defect an improved form of the alphabet was devised in the 16th century by Angad, the second Sikh *guru,* for the purpose of recording the life and teachings of Nanak, founder of the Sikh religion. It was named Gurmukhī, "proceeding from the mouth of the *guru,*" and is now generally used for writing the language.

Bibliography.—See *Linguistic Survey of India,* vol. ix, pt. 1, p. 607 et seq. (1916) for a full account with specimens of the language and bibliography. *See* also T. F. Cummings and T. Grahame Bailey, *Panjabi Manual and Grammar* (1912); T. Grahame Bailey, *A Panjabi Phonetic Reader* (1914); Mohan Singh, *An Introduction to Panjabi Literature* (1949), and "Panjabi Literature" in *Writers in Free India* (1947); Harjeet Singh Gill and Henry A. Gleason, Jr., *A Reference Grammar of Panjabi,* Dept. of Health, Education and Welfare (1963). (Er. B.)

PANKHURST, EMMELINE (1858–1928), British suffragette, militant champion of votes for women, was born at Manchester on July 14, 1858, the daughter of Robert Goulden, a prosperous calico printer. At finishing school in Paris she became a friend of Noémie, daughter of the radical Henri Rochefort. In 1879 she married Richard Marsden Pankhurst, a barrister who, as a friend of John Stuart Mill, had drafted the first women's suffrage bill and later the Married Women's Property Acts of 1870 and 1882. She bore him three daughters, including Christabel (1880–1958) and Sylvia (1882–1960), and two sons. In 1895 she became a Poor Law guardian at Chorlton, Manchester. Her husband's death in 1898 left her as the breadwinner of the family, and she became registrar of births and deaths in Manchester.

But Mrs. Pankhurst's heart was in the political emancipation of women. In 1903 she founded the Women's Social and Political Union (WSPU) on nonparty lines. It first attracted attention in October 1905 when her daughter Christabel and a friend, Annie Kenney, were thrown out of a Liberal meeting for demanding an

answer from Sir Edward Grey about votes for women, and were arrested in the street charged with a technical assault on the police. Refusing to pay fines, both girls were sent to prison.

In 1906 Mrs. Pankhurst went to London and her life became bound up with that of the WSPU. Regarding the Liberal government as the main obstacle to women's suffrage, she campaigned against their candidates at elections, and her followers interrupted cabinet ministers at their meetings. With the active support of her daughters and an increasing number of feminists the WSPU rapidly grew in numbers, financial resources, and political influence. Mrs. Pankhurst and Christabel were sent to prison in October 1908 for issuing a leaflet calling on people to "rush the House of Commons." In 1910, after the introduction of a "Conciliation" bill designed to meet the views of the Liberal government on women's suffrage, Mrs. Pankhurst declared a truce, but when the government blocked its progress she resumed militant action.

A crisis came in 1912. The suffragettes had become progressively more violent and the leaders of the WSPU were charged with conspiracy. Christabel, warned in time, escaped in March to conduct the campaign from Paris. Mrs. Pankhurst and Frederick Pethick-Lawrence were sent to prison for nine months but were released in June after a hunger strike. In June 1913 she was arrested again and sentenced to three years' imprisonment. Mrs. Pankhurst now proclaimed open rebellion against the Prisoners (Temporary Discharge for Ill-Health) Act of 1913, known as the "Cat and Mouse" Act, whereby hunger-striking prisoners could be temporarily released and rearrested. She suffered this treatment many times until, at the outbreak of World War I in 1914, with Christabel, she called off the suffrage campaign. The government now released all suffragette prisoners. In February 1918 the Representation of the People Act gave the vote to a limited number of women.

Mrs. Pankhurst lived in Canada and the United States from 1919 to 1925, when she returned to England. In 1926 she was adopted as prospective Conservative candidate for an east London constituency. However, the immense strain she had imposed on herself had impaired her vitality and she died in London on June 14, 1928, a month before the passing of Stanley Baldwin's Representation of the People Act, which gave women full equality in the franchise.

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PAN KU (A.D. 32–92) **AND PAN CHAO** (*c.* A.D. 45–*c.* 115), brother and sister scholars of the Later Han dynasty of China, were probably born at Ch'ang-an (Sian), he in A.D. 32, she between 45 and 51. Their father, Pan Piao (from Fu-feng, Shensi), had begun a history of the recent Former Han dynasty; after his death in 54, Pan Ku undertook to revise and amplify it, but was imprisoned at Loyang, the capital, for tampering with the dynastic records. His twin brother, Pan Ch'ao (not to be confused with their sister), obtained an imperial audience, and after reading the writings in question the emperor gave Pan Ku an official post, eventually ordering him to complete the history.

In the following decades Pan Ku revised the sections planned by his father, the imperial annals and the biographies, and added between them a section of tables and one of treatises. The resulting *Han Shu* (literally "Han Documents"), conceived as a supplement to the *Shih Chi* of Ssu-ma Ch'ien (*see* CHINESE LITERATURE: *Ch'in and Han Dynasties*), differs from the latter work not only in chronological scope but in approach and style, its comments being more impersonal, its judgments more strictly Confucian, its prose more regular.

Among Pan Ku's shorter works, his "Rhymeprose on the Two Capitals" is notable as the model for later *fu* compositions on this subject. In 89 he accompanied the ambitious Tou Hsien on a campaign into Mongolia, where his victory inscription was carved in rock. Tou Hsien's fall from favour after returning to China involved Pan Ku, who died in prison in the year 92.

Pan Chao meantime had gained a reputation as a lady scholar and exemplary widow. Wed at 14, she never remarried after the early death of her husband Ts'ao Shou, devoting herself to literature and the education of her son. After her brother's death the emperor commissioned Pan Chao to finish his work, which she did, with some assistants, by completing the tables and the treatise on astronomy. "Aunt Ts'ao" (Ts'ao Ta-ku), as she was called, was made a lady-in-waiting to the empress and was respected as a teacher at court. Her skill in verse is seen in the "Rhymeprose on the Great Bird," prompted by an ornithological tribute sent to court in 101 by her brother Pan Ch'ao, after nearly 30 years of extraordinary military and colonial service in central Asia. In the same year her memorial to the throne enabled him at last to return to the capital. Pan Chao produced her best-known work *Lessons for Women* in 106. She died at about 70 years of age.

Biographies of the Pan family appear in the *Hou Han Shu* or "History of the Later Han," for which their own labours set the pattern, as for subsequent Chinese dynastic histories.

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PANNA, a town and district in the Rewa Division of Madhya Pradesh, India. The town, formerly capital of the princely state of Panna and now the district headquarters, lies 110 mi. (177 km.) SW of Jhansi. Pop. (1961) 16,737. It has several buildings of historical importance, including the marble-domed Temple of Swami Pran Nath (built in 1795), containing notable paintings, and the Shri Baldeoji Temple built by Maharana Pratap Singh. The town became important in 1675 when Chhatarsal, the ruler of Bundelkhand (*q.v.*), made it his capital.

PANNA DISTRICT (area 2,716 sq.mi. [7,034 sq.km.]; pop. [1961] 331,257) extends mostly over the Panna Range, a branch of the Vindhya Mountains running southwest to northeast and consisting chiefly of sandstone and Panna shales and famous for its diamond-bearing beds. The diamonds occur as pebbles in conglomerates and also in their disintegration product, a pebbly clay. The principal crops are rice, wheat, jowar, and oilseeds. The district lacks industries. (S. M. A.)

PANNONIA was the northerly of the two provinces into which Roman Illyricum was divided about A.D. 10. Bounded by the Danube on north and east, it included the Save or Sava Valley on the south, beyond which lay Dalmatia; and its western frontier, against Noricum, was a line running south from just west of Vienna, though until the late 2nd century there was also a southwestward extension toward Italy to take in Emona (Ljubljana, Yugos.). It thus extended over parts of modern Austria, Hungary, and Yugoslavia. The people were mainly Illyrian, though there were Celts in the prosperous western area which Pannonia took over from the kingdom of Noricum (*q.v.*).

Roman conquest began in 35–33 B.C., when Octavian (later the emperor Augustus) occupied Siscia (Sisak, Yugos.) and received the submission of the surrounding tribes; it was resumed in 13 B.C. by a large force under Agrippa, after whose death in the next year the work was completed by Tiberius as Augustus' legate. The keystone was the Roman capture, from the east, of Sirmium (Sremska Mitrovica, Yugos.), which gave control of the Sava Valley and led to easy occupation of the thinly populated country between the Drava and the Danube. But pacification was incomplete, and in A.D. 6 the Pannonian tribes, led by the Breuci between the Drava and the Sava, joined forces with the Dalmatians in a revolt which took Tiberius three years to subdue and was regarded as the gravest threat to Italy since Hannibal's invasion (Suetonius, *Tiberius*, 16). Pannonia then became a separate province, its normal garrison under the Julio-Claudian emperors being three legions: one was established in Tiberius' reign at Carnuntum (*q.v.*) on the Danube, with the others in the interior. Poetovio (Ptuj, Yugos.), on the Drava, was the headquarters of the Flavian Army which invaded Italy in 69, and it still housed a legion in Trajan's time.

Trajan divided the province about 106. In the west was Pannonia Superior, under a consular legate with three legions. Pannonia Inferior, under a praetorian legate with one legion at

Aquincum (the Obuda District of Budapest, on the right bank of the Danuhe) but with an abnormally large force of auxiliaries, faced the Sarmatians between the Danube and the Tisza. Pannonia was the storm centre of the Danubian wars of Marcus Aurelius (*q.v.; see* also MARCOMANNI), who died in the legionary camp at Vindobona (Vienna). Marcus settled many defeated enemies in the province, a policy followed freely in the later empire. Pannonia was held for Rome till at least the death of Theodosius I (395) but passed into the possession of the Ostrogoths and other barbarian tribes during the century which followed.

Romanization proceeded steadily, especially in the Western area. Emona became a colony probably in A.D. 14, Savaria (Szombathely, Hung.) under Claudius, and Poetovio under Trajan. Scarbantia (Sopron, Hung.) was a Flavian *municipium*. The legionary camps on the Danube developed considerable settlements nearby, some of which, notably that at Brigetio (Szöny, Hung.), became *municipia* later. Yet native religion, dress, art, and language survived in most areas in the 2nd century A.D. Still later, Pannonia was the birthplace of a series of soldier emperors, who saved the empire in the crises of the 3rd century. Its contribution to the Roman Army throughout the imperial period was extremely high.

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PANOAN, one of the major families of South American Indian languages; it has been provisionally combined with the Ge and Cariban languages to form a single phylum. In the 1960s the best-known of the Panoan-speaking tribes (the Setebo, Shipibo [Xipibo] and Conibo [*q.v.*]) lived in the Ucayali River Valley in eastern Peru. A number of other tribes of the same stock occupied an area extending from the Ucayali east into the headwaters of the Juruá and Purús rivers in western Brazil. To the south of these tribes, two smaller enclaves of Panoan-speaking peoples (one along the Beni River and its tributaries in northern Bolivia and the other in southeastern Peru) were surrounded by peoples of other linguistic affiliations. These southern tribes were quite divergent culturally from their linguistic relatives to the north. Panoan languages are listed in detail in the table found under INDIAN, LATIN-AMERICAN.

See J. H. Steward (ed.), *Handbook of South American Indians*, vol. 3 (1948); J. H. Steward and Louis C. Faron, *Native Peoples of South America* (1959). (SE. L.)

PANOFSKY, ERWIN (1892–), German-U.S. art historian, was born in Hanover, Ger., March 30, 1892. He received the degree of doctor of philosophy from the University of Freiburg in Breisgau and was professor at the University of Hamburg from 1926–33. He first went to the United States in 1931 as visiting professor at New York university, New York, and in 1935 became professor of art history at The Institute for Advanced Study, Princeton, N.J.

Cast in a lucid and entertaining prose style, his writings are distinguished for their variety of subject, critical penetration, erudition and rich allusiveness to literature, philosophy and history. Panofsky was the historian of many iconographic, stylistic and theoretical aspects of medieval and Renaissance art; he also wrote the classic account of Albrecht Dürer and a definitive history of early Netherlandish painting. Central to all his writings is the profoundly humanistic view that form and content in a work of art are indissoluble; thus art has more than mere visual meaning and is always charged with the basic attitude toward life of the civilization that produced it.

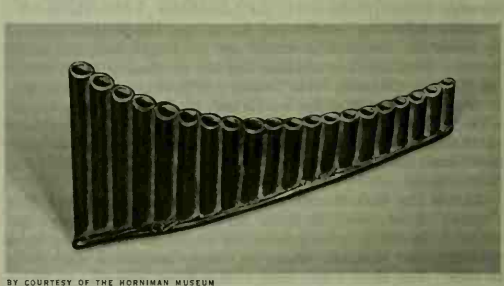
Among Panofsky's major works in English are *Studies in Iconology: Humanistic Themes in the Art of the Renaissance* (1939); *The Codex Huygens and Leonardo da Vinci's Art Theory*, Studies of the Warburg Institute, vol. xiii (1940); *Albrecht Dürer*, 2 vol. (1943), 3d ed. (1948), also republished, with full text and illustrations but without the handlist of Dürer's works, as *The Life and Art of Albrecht Dürer* (1955); (ed. and trans.) *Abbot Suger on the Abbey Church of St. Denis and Its Art Treasures* (1946); *Gothic Architecture and Scholasticism* (1951); *Early Netherlandish Painting, Its Origin and Character*, 2 vol. (1953); *Meaning in the Visual Arts* (1955), a collection of nine of Panofsky's most important articles and essays on a wide variety of subjects and, with Dora Panofsky, *Pandora's Box: the Changing Aspects of a Mythical Symbol* (1956). (RR. W. L.)

PANORAMA, the name given originally to a pictorial representation of the whole view visible from one point by an observer who in turning around looks successively to all points of the horizon. In this sense it is synonymous with cyclorama. In an ordinary landscape picture only a small part of the objects visible from one point is included. If a greater part of a landscape has to be represented, it becomes more convenient for the artist to suppose himself surrounded by a cylinder in whose centre he stands, and to project the landscape from this position onto the walls of the cylinder. In a panorama such a cylinder (the first of which were about 60 ft., but later ones as large as 130 ft. in diameter) is covered with an accurate representation in colours of a landscape, so that an observer standing in the centre of the cylinder sees the picture like an actual landscape in nature completely surround him. This gives an effect of great reality to the picture, which is skilfully aided in various ways. The observer stands on a platform representing, say, the flat roof of a house, and the space between this platform and the picture is covered with real objects which gradually blend into the picture itself. The picture is lighted from above, but a roof is spread over the central platform so that no light but that reflected from the picture reaches the eye. To make this light appear more brilliant, the passages and staircase that lead the spectator to the platform are kept nearly dark. Such panoramas, suggested by a German architectural painter named Breisig, were first executed by Robert Barker, an Edinburgh artist, who exhibited one in Edinburgh in 1788 representing a view of that city. A view of London and views of sea fights and battles of the Napoleonic wars followed. Panoramas gained less favour on the continent of Europe, until, after the Franco-German War, a panorama of the siege of Paris was exhibited in Paris. This panorama, executed by Henri Philippoteoux, French painter, included plastic objects in the foreground which strengthened the optical illusion. Paul Philippoteoux, the son of the above painter, was noted for his "Battle of Gettysburg" (1883) which was exhibited in several U.S. cities before being put on permanent exhibit at Gettysburg, Pa. Other distinguished painters of panoramas were Ludwig Braun and Anton von Werner in Germany, and De Neuville and Detaille in France.

The name panorama, or panoramic view, is also given to drawings of views from mountain peaks or other points of view. In photography a panoramic camera is one which enables a wide picture to be taken.

The term diorama (*q.v.*) refers to a comparable kind of painting in which the viewer looks through an opening at a partly translucent painting some distance away.

PANPIPE (SYRINX), a wind instrument composed of a number of cane pipes of different lengths tied or waxed together in a row. The pipes are generally closed at the bottom and are blown



BY COURTESY OF THE HORNIMAN MUSEUM

RUMANIAN PANPIPE WITH 20 TUBES, THE LONGEST MORE THAN 12 IN., ARRANGED IN A CURVE

across the top, each providing a different note of the instrument's scale. The panpipe is widespread across Neolithic and later cultures of the world, being especially important in Melanesia and aboriginal South America. Ancient Greek tradition ascribed its invention to Pan (*q.v.*) in the legend of the water nymph Syrinx. In Europe it has been mainly a shepherd's instrument and has so endured in the Pyrenees; but in Rumania it is played among the professional *lautars* (fiddlers), and some performers, such as Fanica Lucă, have achieved international fame; their panpipe, *naiu*, has between 19 and 22 pipes tuned diatonically over three octaves, semitones being made by tilting the instrument toward the lips.

(A. C. Ba.)

PANPSYCHISM, in philosophy, a term applied to any theory of nature which recognizes the existence of a psychical element throughout the objective world (Gr. *pan*, "all"; *psyche*, "soul"). In such theories not only animals and plants but even molecules and atoms are regarded as having some rudimentary kind of sensation or psychical life. Important exponents of panpsychist views have been Thomas Carlyle, G. T. Fechner, and Friedrich Paulsen. For related views *see* Hylozoism; Stoics: *Physics;* Schopenhauer, Arthur: *Metaphysics;* Entelechy.

PAN-SLAVISM. Various movements for a closer union of the peoples speaking a Slavic language were known from the beginning of the 19th century under the name of Pan-Slavism. It was generally overlooked that the affinity of language implies neither a common descent nor an affinity of cultural traditions or ways of life. Though the Slavic languages are closely related, the various peoples speaking them have been shaped by historical and religious influences in such a way that there is more similarity between some of them and their non-Slavic speaking neighbours than there is among them. One great division of the Slavs is based upon the thousand-year-old impact of religion: Russians, Serbs and Bulgarians have been Greek Orthodox; Poles, Czechs and Croats Roman Catholic. The Russians and the Balkan Slavs remained for many centuries without any close contact with the European community, while the western Slavs had their cultural and political life integrated into the general central European pattern. Only in the first half of the 19th century, under the influence of the French Revolution and of German romanticism, did Pan-Slavism start as a movement among intellectuals, scholars and poets. It had rarely any influence on practical politics, however. The various Slavic nationalities conducted their policies in accordance with what they regarded their national interests, and these policies were frequently bitterly hostile to other Slavic peoples while friendly and co-operative toward non-Slavs.

An early forerunner of Pan-Slavism was a Catholic Croat priest, Yuri Krizhanich, who in 1659 traveled to Moscow, to the "tsar of my race," to propagate Pan-Slavism and the union of the Greek and Roman Churches. He stressed the need for Slavs to emancipate themselves from the cultural and political dominion of foreigners, especially the Germans; at the same time he demanded the Europeanization of Russia and deplored its grievous oriental backwardness. Yet he was haunted by the vision of the future greatness of the Slavs. His ideas found hardly any echo at the Russian court. The great Russian rulers of the 18th century, Peter I and Catherine II, were much more interested in Europeanizing the court of St. Petersburg and the administration of their empire than in contacts with the smaller Slavic nationalities, which they used only for their imperial policy and expansion. In the 18th century Russia annexed the Slavic Ukraine and was the prime mover in the destruction of Slavic Poland.

Modern Form.—Pan-Slavism in its modern form started among the Czechs, Slovaks and Croats. The interest in folk songs and folklore, in the vernacular of the peasants and in national traditions, aroused by Johann Gottfried von Herder and the German romanticists, stimulated the interest of Slavic intellectuals in their own people and their past. Through men like Joseph Dobrovsky and Pavel Josef Safarik, Prague became a centre of research in Slavic antiquities and philology. A Slovak Lutheran pastor, Jan Kollar, who was decisively influenced by German nationalism during his student years in Jena, became famous for his cycle of poems *Slavy Dcera* (The Daughter of Slava), in which he expressed his bitter grief over the disappearance of the Slavs in the lands east of the Elbe and Saale through German aggression; he exhorted the Slavs to restore their ancient glory and to assure an even greater future by a close union of all Slavs. He regarded the Slavic languages as mere dialects of one Slavic language and pleaded for the closest cultural co-operation among the Slavs in his *Über die literarische Wechselseitigkeit zwischen den Stämmen und Mundarten der slawischen Nation* (On the Literary Mutuality of the Tribes and Dialects of the Slav Nation, 1837).

The first public manifestation of Pan-Slavism was a congress of the Slavic nationalities of the Habsburg monarchy held in Prague in June 1848. Under the chairmanship of the Czech patriotic leader and historian Frantisek Palacky, the Austrian Slavs demanded the transformation of the Habsburg monarchy into a federation of equal peoples under democratic Habsburg rule and declared the need of a strong Austrian state as protection for all the smaller nationalities of central Europe against German aggression and against the trends of Russia to establish a universal empire. These Pan-Slavs rejected Russian autocracy and looked to the West and its liberal democracy for guidance.

Their hopes for a federal transformation of the Habsburg monarchy were shattered by the concessions which Francis Joseph made in 1867 to Magyar nationalism at the expense of the Hungarian Slavs who became subject to a ruthless Magyarization policy. The Austrian Slavs now turned for protection against German and Magyar superiority to Moscow. But other Slavic peoples, the Poles and Ukrainians, suffered bitterly under Moscow's oppression. Thus, although many Russian writers and politicians were willing to propagate a Pan-Slavism under Russian leadership, Pan-Slavism suffered from the beginning from the fact that Russia itself was an oppressor of Slavs, much more cruel than Austria, and that Russia envisaged not a Slavic collaboration in freedom and equality but Russian domination over the Slavs. Some Russians even wished to impose the Russian Orthodox religion and the Russian language and culture upon the other Slavs.

Ideas of Russian Slavophiles.—While these Russian Pan-Slavs used Pan-Slavism as a vehicle for Russian expansion, another school of Russian thinkers, the Slavophiles, proclaimed the superiority of Orthodox Russian civilization over the West. Aleksei Khomyakov and Ivan Kireevski, much influenced by German romantic philosophy, believed that the Russian religion and the Russian people had developed a system of spiritual values and social relations which was being undermined by Western influences. Europe, they taught, was the creation of Roman and Teuton conquests, of Catholic rationalism and will to domination, and Protestant individualism and anarchy. These elements led to racial and class war, to the disintegration of society, to the decay of faith. Russia, on the other hand, represented an organic community, alien to the European spirit of violence and competition; Russia alone harboured the promise of social justice and of a perfect order.

These ideas were sufficiently vague and flattering to Russian *amour-propre* to be widely accepted by various currents and put into the service of Pan-Slavism. Some of the greatest Russian writers like the novelist Dostoevski and the poet Fëdor Tyutchev enthusiastically supported the wildest Pan-Slavic dreams and the most excessive glorification of Russia's mission for the leadership of mankind. Historians like Mikhail Pogodin and scientists like Nikolai Danilevski foresaw a Slavic federation under Russian leadership comprising the whole of central Europe east from a line connecting Stettin (Szczecin) on the Baltic and Trieste on the Adriatic sea, the Balkans and Constantinople; and thus creating the geographic and economic foundation for Russia's world leadership. A Pan-Slavic congress called to Moscow in 1867 expressed many of these plans and hopes.

Early 20th Century.—The Russian government, however, was on the whole cool toward these expansionist claims, although it sometimes made use of the underlying sentiments in its anti-Turkish policy. After the Russian revolution of 1905 and the beginnings of constitutional life in Russia, a new start was made with a liberal Pan-Slavic program under the leadership of the Czech statesman Karel Kramar. Pan-Slavic congresses met in

Prague and in Sofia, Bulg., but they led nowhere except to pious declarations. The reality of a bitter hostility among Poles, Ukrainians and Russians; Serbs and Bulgarians; Serbs and Croats; Czechs and Slovaks, hindered then as later any effective Slavic collaboration. In World War I Poles and Russians, Serbs and Bulgarians faced each other as deadly enemies. World War I brought the simultaneous weakening of Russia and Germany, and thereby the chance for the western Slavs, the Poles, the Czechs and the Yugoslavs to create their independent and much enlarged states. They did it in co-operation with the western democracies, but, outside of Czechoslovakia, democracy was not firmly rooted among the Slavs and was soon replaced by dictatorial regimes. Nor was there any unity among the Slavs or within the new Slavic states. In Poland the Ukrainian minority felt itself oppressed by the Poles; in Czechoslovakia the Slovaks accused the Czechs of lust for domination; in Yugoslavia Serbs, Croats and Slovenes faced each other in open hostility. In Russia the new government established in Nov. 1917 when Lenin overthrew the short-lived Russian democracy regarded Pan-Slavism as a reactionary imperialist movement. With the prevailing emphasis on internationalism and on class solidarity, a union based on common racial descent or on an affinity of language was unthinkable. Pan-Slavism seemed dead. Nobody then would have predicted its revival and intensification two decades later and the realization of most of its far-reaching aspirations.

World War II and After.—Soon after the German attack upon Soviet Russia in June 1941, a Pan-Slavic committee was founded in Moscow under Communist sponsorship, which in frequent proclamations summoned all Slavs to fight against the Germans and stressed the racial and cultural community of the Slavs as opposed to Germanism. For the first time the international class ideology was supplemented by a doctrine of racial brotherhood and solidarity. Vyacheslav Molotov, the Soviet foreign minister, had earlier justified the 1939 Soviet annexation of eastern Poland by blood ties with its inhabitants. Similarly the racial theory was used by the Soviet government for the annexation of Czechoslovakia's Carpatho-Ukraine on June 29, 1945.

As the war between Germany and the U.S.S.R. progressed, Pan-Slavism was used more and more for establishing a peace according to Soviet Russia's plans through the close integration of all Slavic nations under Moscow's leadership. Repeating the ideology of earlier Russian Pan-Slavic and Slavophile thinkers, the Communists proclaimed the Slavs as by nature inclined to "true democracy" and a perfect social order and predestined for world leadership toward an ideal peace. After the war the Communist parties in the various Slavic nations became the foremost propagandists of this new Pan-Slavism under the leadership of the U.S.S.R., the mother country of Communism and the "older brother" among the Slavic nations.

For the first time, people of Slavic descent living outside the Slavic countries as citizens of non-Slavic nations—especially Slavic immigrants in the U.S., Canada, and Latin America—were organized for the support of their Slavic "motherlands" now dominated by Communist parties. Therein, as in so many other respects, Stalinism followed the lead given by Hitlerism, when the latter organized the *Auslandsdeutsche* (people of German descent but citizens of non-German lands), to impress upon them the conviction that their primary loyalty belonged to Germany, and to transform them into agents of German national socialism. In the U.S. a Slavic congress was created to mobilize the Americans of Slavic descent for the support of the policies of the Slavic "motherland." But once the nature of Communism and Pan-Slavism was understood, these subversive activities abroad on behalf of Slavic solidarity quickly lost importance.

The Pan-Slavic committee in Moscow, under the chairmanship of Lt. Gen. Alexander Gundorov, called a meeting of all the various Pan-Slavic committees at Belgrade, Yugos., in July 1946. It decided to convene a Pan-Slavic congress in Belgrade, which was opened on Dec. 8, 1946, with an address by Marshal Tito, the Communist dictator of Yugoslavia. A central Pan-Slavic committee was elected and the Yugoslav capital was chosen as its permanent seat. At that time Tito's Yugoslavia appeared as the most promising and most faithful supporter of Stalin's Communism and Stalin's Pan-Slavism. But 18 months later, in June 1948, the open break between Tito and Stalin changed the whole situation. As the Pan-Slavism of the 19th century was frustrated by Polish opposition to Moscow's imperialism, so Yugoslav opposition to the new and more ruthless imperialism of Moscow weakened the U.S.S.R.'s Pan-Slavic propaganda, of which less and less was heard after 1948.

Danilevski had foreseen in 1869 a confederation under Russian leadership which would include all the lands controlled by Stalin east of the Elbe and the Adriatic sea in 1946. In addition, Danilevski had expected both the Dardanelles and Greece also to fall under Russian control. In 1947 only British and U.S. opposition prevented the realization of this latter expectation. Danilevski had also explained the necessity of including the non-Slavic speaking Magyars and Rumanians in this Slavic empire. Dostoevski in 1881 had stressed the need for Russia to control Asia in addition to the Slavic lands; only then would it be able to confront the sea powers. The Communist control of China was achieved by 1949. But while the most daring dreams of 19th century Russian Pan-Slavism were thus realized in the middle of the 20th century, Pan-Slavism itself receded into the background and was replaced by a theory of Russian predominance over Slavic and non-Slavic peoples alike. During Stalin's last years, all Moscow-controlled literature glorified the Russian people as the fountainhead of all cultural creativeness and the only undisputed leader in the political and social field for all peoples—for the Slavic Ukrainians and Bulgarians as well as for the non-Slavic Uzbeks and Rumanians. Pan-Slavism disappeared under Nikita Khrushchev, Stalin's successor, as did the exaggerated claims of Russian supremacy in the Communist realm.

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(H. Ko.)

PANSY (HEARTSEASE), a favourite garden flower, one of the oldest in cultivation, belonging to the genus *Viola* of the violet family (Violaceae). It has been grown for so long a period under such diverse conditions and in such a variety of forms that its origin is uncertain. The numerous handsome forms, with their striking variations of size and colour, are purely an artificial production of the gardeners and differ in a marked degree from any related wild plant now known. The pansy is generally supposed to be merely a cultivated form of *Viola tricolor*, a weed of European grain fields, the garden pansy hence being designated as *V. tricolor hortensis*.

J. HORACE MCFARLAND CO.

GIANT PANSY (VIOLA TRICOLOR HORTENSIS)

The tufted or bedding pansy, called also horned violet, is a cultivated form of *Viola cornuta*, a native of Spain and the Pyrenees Mountains. It differs from the true pansy in its tufted habit of growth and in the shape and position of its flower parts. The petals, which are obovate in form, do not overlap as in the true pansy, but stand distinctly apart. The spur on the lower petal, instead of being short and rounded, is long, slender, and sharp-pointed, whence the name horned violet. There are numerous garden forms varying greatly in colour, ranging from violet to white.

The modern varieties of the pansy consist of the show varieties and the fancy varieties, ob-

tained from Belgium and now much improved. Show varieties are subdivided according to the colour of the flowers into selfs, white grounds and yellow grounds. The fancy or Belgian pansies have various colours blended, and the petals are blotched, streaked, or edged. The bedding varieties, known as violas or tufted pansies, have been raised by crossing the pale-blue *Viola cornuta*, and also *V. lutea*, with the show pansies. The tufted pansies are hardier than the true pansies and are free-blooming sorts marked by effectiveness of colour in the mass.

The garden pansy is a short-lived perennial which must constantly be renewed. It does not like summer heat and is best raised from seed in a greenhouse or frame and used for spring-bedding effects. The tufted pansies, which stand the heat better, can be grown as garden perennials, preferably in partial shade.

See also VIOLET. (N. TR.)

PANTALONE (PANTALOON): *see* COMMEDIA DELL'ARTE.

PANTELLERIA (ISOLA DI PANTELLERIA; anc. COSSYRA), an Italian island in the Mediterranean, 62 mi. (99 km.) from Sicily and 44 mi. (70 km.) from Tunisia; it forms part of the Sicilian province of Trapani. Area 32 sq.mi. (83 sq.km.). Pop. (1961) 9,269.

Pantelleria is entirely of volcanic origin, and the highest point is an extinct crater, Magna Grande, 2,743 ft. (836 m.) above sea level. The last eruption took place in 1891, but hot mineral springs and fumaroles still testify to the presence of volcanic activity. The island is fertile but lacks fresh water. The main occupations are fishing and farming, and sweet wine and raisins are exported. The chief town, Pantelleria, is on the northwest, upon the sole harbour, which is fortified; there is also a penal colony there.

On the west coast, 2 mi. SE of the harbour, a Neolithic village was situated, with a rampart of small blocks of obsidian upon the east. Within it remains of huts were found, with pottery and tools of obsidian. To the southeast are tombs, known as *sesi*, similar to the *nuraghi* of Sardinia, consisting of round or elliptical towers with sepulchral chambers in them, built of rough blocks of lava. Fifty-seven of the tombs can still be traced. The largest is an ellipse of about 60 by 66 ft., but most of the *sesi* have a diameter of 20–25 ft. After a considerable interval, during which the island probably remained uninhabited, the Carthaginians took possession of it, occupying as their acropolis the twin hills of San Marco and Santa Teresa. The Romans occupied the island in 217 B.C. Under the empire it served as a place of banishment for prominent persons and members of the imperial family. About 700 the Christian population was annihilated by the Arabs, from whom the island was taken in 1123 by Roger II of Sicily. In 1311 a Spanish fleet under the command of Requesens won a considerable victory there, and his family became princes of Pantelleria until 1553, when the town was sacked by the Turks. Pantelleria's strategic situation in the narrow passage dividing the eastern and the western Mediterranean induced the Italian government of Benito Mussolini to fortify the island, using its rocks and caverns for the purpose. Lampedusa (*q.v.*) was made a complementary air base. In June 1943 these installations were subjected to the most intensive air assault of World War II to that date. Buildings and fortifications were practically leveled when Pantelleria surrendered to the Allies on June 11, 1943. (T. A.; X.)

PANTHEISM (Greek *pan*, "all," *Theos*, "God"), the theory that God is the All, or totality of existence. John Toland used the term pantheist and proposed the formula "What's all in all things is God" (*Pantheisticon*, part ii; 1720). The label has since been widely employed, often rather abusively. Thus Samuel Johnson said that the doctrine "confounds God with the universe." Other charges are: it makes God impersonal, blurs the distinction between creator and creatures, implies a purely "immanent" instead of a "transcendent" deity, and excludes human and divine freedom.

The appropriateness of these objections depends upon how the All, or divine totality, is conceived. Things other than God may, without exhausting it, be elements in a supreme reality which in this sense transcends them all. Nor need this total reality be impersonal—provided a person can include things inferior to himself, as a man includes cells and molecules. Likewise, free individuals might exist in a superior one; for may not our cells have some slight freedom, as they undoubtedly have a certain individuality, within ourselves? Accordingly, the criticisms mentioned refer not to the pantheistic principle itself but to some further belief, such as that God's inclusion of things is inevitable and without freedom. Thus Spinoza held that all things "follow necessarily" from the nature of God. Yet consider a man's thoughts: supposing these to be free, so that the man could have thought otherwise, still, now that he does think the thoughts, they form part of his total present reality. This shows that God's all-inclusiveness need not mean that everything is necessary. Nevertheless the best-known or, as we may term them, classical pantheists—for example, the ancient Stoics—treated the two beliefs as one. Why? We shall try to explain.

An early achievement of reason was the idea of causality, from which it was inferred (by a natural exaggeration?) that even "free" choices are entirely determined by causes. Moral freedom was seen as the absence of external constraint upon reflective but still inevitable acts. This was the Stoic view, and no Greek philosopher offered a vigorous alternative. Nor in Greek writings do we find any clear statement that God created by free fiat. Plato permits one to suppose that the divine action may be determined by the Forms which are its models for creation; the Aristotelian deity moves the world involuntarily, without troubling to notice the consequences; the Neoplatonic "emanations" from the "One" seem likewise involuntary and inevitable.

Then there was the prejudice against becoming. The Greeks discovered the idea of timeless fixity by reflection upon mathematical forms and other universals. Comparing these with restless, impermanent physical bodies, and the "souls" associated with them, they longed for the security of the unchanging. Also, it was argued, a thing changes only if it lacks something; the divine, lacking nothing, cannot change.

Thus arose the view that God acts by immutable necessity. When, however, the Jewish philosopher Philo and the Church Fathers began to speak of a free divine decree as source of all things, philosophy fell into a turmoil which still rages. For how can the eternal make free choices? That John "could have done otherwise" on Tuesday means that on Monday, or even earlier on Tuesday, he still had the capacity of doing *this*, or doing *that* instead, at the later time. However, John at the very time of performing an act is already partly constituted by the act, and he cannot have the capacity not to be what he is. Similarly, acts performed "in eternity" must constitute the eternal: how can they be free choices? This problem is shared by pantheism and theism. (The difference between them is perhaps little more than verbal, seeing that even for theism God by his infallible knowledge includes everything. We human beings may seem not to include the world we know, but this may be precisely the imperfection of our knowledge. *See* THEISM.)

Under Greek influence, the best-known or classical theists, like the pantheists, said that God was strictly eternal, and hence all his qualities were necessary and could not have been otherwise. Yet—creation was free!

And so too God must have knowledge of things as existing which might not have existed to be known; knowledge, therefore, which he might not have had. Yet—all his properties were necessary!

To soften these paradoxes, various expedients were tried by Thomas Aquinas, Gersonides, and many others, but the difficulty remained. Finally, H. Crescas, followed by Spinoza, denied divine choice, thus reverting to the Greek view. Yet if the world issues inevitably from divine perfection, then as Pope's poem has it, "Whatever is is right." But how does "right" have any meaning if nothing can ever be wrong? So necessitarian pantheism, more or less ambiguously expressed later by J. G. Fichte, Hegel, F. D. E. Schleiermacher, etc., likewise falls into paradox. Partly in consequence of this, many philosophers have rejected theism altogether. Others have accepted contingent or non-necessary qualities, and a kind of change, in God. This more constructive way out was taken in the 16th century by the school of F. Socinus. Similar doctrines were held in the 19th century by F. Schelling (in

his late writings), G. T. Fechner, J. Lequier, O. Pfleiderer; in the 20th century by B. Varisco, W. P. Montague, H. Bergson, E. S. Brightman, N. A. Berdyaev, A. N. Whitehead, M. Iqbal, and others. Most of these accept pantheism in its broad meaning (that God is All), but they hold that the world which God includes is freely chosen.

This view has been termed panentheism (Greek *en*, "in"), the term, more than the idea, being K. C. F. Krause's (1781–1832). The universe is in God, but he surpasses it in principle and could have existed with a different cosmic content.

Classical theism and classical pantheism are opposites; for while the first sees God as free to create any world or no world, the second holds that he must create and create precisely this world. As usual with extremes, there is an attractive middle position: God must create, but he need not create this world rather than any other possible one. So freedom and necessity are combined. Consistent panentheists take this position. Like most pantheists they see no merit in "freedom" not to create—a curious option which can produce value only if left unexercised.

Pantheism has taken many forms, often ambiguous or unclear, in the world's literature. Goethe was vaguely Spinozistic, as were R. W. Emerson and many other men of letters. Robinson Jeffers was a 20th-century example. The Upanishads of India are sometimes said to affirm not pantheism but "acosmism" (*q.v.*), the doctrine of "no cosmos" or world. Insofar as the cosmos was admitted—and it would not have been necessary to mention it were it simply nothing—it was conceived panentheistically. The world was in the supreme reality as divine "play," *Lila*, or free imagining (one interpretation of Sanskrit *Maya; q.v.*). But skepticism about the world's reality is not without danger, since it implies that loving one's neighbour "as oneself" may only mean taking neither self nor neighbour to be real or valuable. Taoism, much Buddhism, some Confucianism (Chu Hsi; *q.v.*), are vaguely panentheistic; there are various compromises between classical theism and panentheism, for instance in Ramanuja's pluralistic Hinduism (*see* INDIAN PHILOSOPHY: *Six Systems; Vedanta: Ramanuja's Theism*); much Russian theology (*e.g.*, Soloviev's or S. L. Frank's), like that of P. Tillich, amounts to the refusal to choose between several forms of pantheism, on the ground that "literal" correctness is impossible in theology.

How creatures can be free though in God was considered by R. H. Lotze, Berdyaev, Fechner, Whitehead, etc. The last two give the most careful solution. They deal with the problem of evil by generalizing freedom to apply to all creatures, not simply to God and man. The principles are: without freedom in some degree, no reality or value; with freedom, some risks of evil, overbalanced by opportunities for good.

A consistent pantheism admits suffering in God (passibility). According to Schelling, Fechner, J. Royce, Berdyaev, and Whitehead, the idea of a suffering God has positive religious value. To the Platonic argument that the perfect cannot change, various panentheists reply that as here used "perfect" lacks consistent meaning or religious justification. To the charge that if God includes our wicked attitudes and mistaken ideas, he must be wicked and mistaken, it has been replied that this confuses "objective" and "subjective" forms of experience (Whitehead's terms). To contain another's wicked attitude or erroneous belief as content of experience is not to adopt the attitude or the belief as one's own.

The supreme Unity has been interpreted chiefly through thought (Hegel), will (Royce), feeling (F. H. Bradley). However, since thought, will, and feeling are interdependent, must not "supreme" in one mean supreme in all? Necessitarians often stress thought or reason; yet in spite of Spinoza or B. Blanshard, it is no more rational to see that "here is a fox" necessarily implies "here is an animal," than to see that the reverse relation is without necessity. From abstract to concrete is always a leap; hence Hegel's dialectical deduction of reality from "being" and "not-being" is only pseudorational.

Spinoza, and more vaguely the Stoics, thought of the divine unity in terms of "thought" and "extension." Most pantheists since have held with Leibniz, Fechner, and C. S. Peirce that extension and matter are but aspects of mind.

If God is not the total reality, he is only the principal constituent of this reality. If, instead, we view the universe as constituent of the all-inclusive God, we gain the added advantage that "serving God" acquires a clear meaning—since we and all we influence must then "enrich the divine life itself" (Berdyaev) to the extent of the rightness of our choices.

Though rival doctrines have been endlessly discussed, panentheism, the doctrine that the creatures are in God but as free individuals in a free Individual, has been widely ignored. To evaluate this type of theism is a task for the future, since it has been shirked in the past. Classical or necessitarian pantheism, on the contrary, like classical physics, has been thoroughly discussed, and we are in a position to regard it as an oversimplification due to the Greek admiration for necessity, an admiration which even Albert Einstein still shared. But has not man become too conscious of his own free creativity to believe in a God without it?

See also DEISM; THEISM; STOICS; and biographies of philosophers referred to above.

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PANTHEON, a building for the worship of all the gods revered in a certain locality; hence a building where famous men are buried, or a structure built to commemorate a number of national heroes.

Specifically, pantheon is the name of three famous buildings, one of which is in Athens, one in Rome and one in Paris. The Athenian pantheon was constructed by the Roman emperor Hadrian. The Roman pantheon was begun by M. Vipsanius Agrippa in 27 B.C., probably as a rectangular building of ordinary temple type.

FEDERICO ARBORIO MELLA

PANTHEON IN ROME. BEGUN BY AGRIPPA (27 B.C.) AND COMPLETELY REBUILT BY HADRIAN (C. A.D. 120), IT IS NOW KNOWN AS THE CHURCH OF STA. MARIA ROTUNDA

It was completely rebuilt by Hadrian, in its present circular form (*c.* 120), the columns of the present front porch being probably those of the earlier building. Under Septimus Severus repairs and alterations were made; it is likely that at this time the rectangular coffers were cut on the inside face of the dome. The Roman pantheon is remarkable not only for its size, the dome being about 142 ft. (43.3 m.) in diameter, and for its elaborate brick construction, but also for its perfect preservation and the fact that for almost 2,000 years it has served continuously as a place of worship, having been dedicated in A.D. 609 as the church of Sta. Maria Rotunda. The gilt bronze tiles that once covered the dome were

stripped off and carried to Constantinople at an early date, and in the 17th century the bronze trusses and girders which carried the portico roof were melted and used to make Bernini's baldachin in St. Peter's at Rome. The present stucco panels and pilasters that circle the interior above the order cornice and below the spring of the dome are of late Renaissance date, and the bronze rosettes and moldings that once decorated the coffers have disappeared. Otherwise, the interior of the building exists in its exquisite original form.

The pantheon at Paris was begun in 1764 by J. G. Soufflot as the church of Ste. Geneviève. This was secularized under the Revolution and then received its present name—*panthéon*. It served as a church, also, in 1828–30 and in 1851–70. The *panthéon* at Paris bears little resemblance to the Roman example. It is a cruciform building with a high triple dome over the crossing and the four arms vaulted with lower saucer domes on pendentives.

See also references under "Pantheon" in the Index.

PANTHER, another name for the leopard (*q.v.*), also used in America as the name of the puma (*q.v.*). The panther was formerly supposed to be a distinct animal from the *pardus*, pard, the leopard. In modern times a popular distinction is often made between a larger, fiercer, or darker type of leopard, to which the name panther is given, and the smaller and more common type of leopard.

PANTOMIME. The primary meaning of *pantomimus* is "he who plays every role" or "imitator of all persons and of all things." During the Roman empire the term referred to a theatrical entertainer who by means of gestures and body movements alone acted out a mythological story while successively portraying each character in the plot. The entertainment itself was also called a pantomime. Early in the 18th century the word pantomime began to be used in England to designate dramatic ballets on mythological themes or outright harlequinades.

As representation of emotions and actions entirely by body movement and gestures, pantomime occurs in all primitive cultures (war dances, animal mimicry, sacrificial rites). The first recorded pantomimist was the legendary dancer Telestes, whom Aeschylus is said to have employed in his production of the *Seven Against Thebes* (467 B.C.).

In Rome, pantomime came into its own during the Augustan age. In 22 B.C. two pantomimists won public acclaim: Pylades of Cilicia, who specialized in tragic subjects, and Bathyllus of Alexandria, who traded in lighter fare. Both artists were *pantomimi* in the original sense of the word; *i.e.*, they acted out in dumb show a continuous fable and played all the parts in it. By changing his masks several times during a performance Pylades played the roles of Dionysus, Pentheus, Cadmus, and Agaue when he recreated the story of Dionysus' coming to Thebes. On another occasion he would now be Atalanta, and a moment later he would transform himself into Meleager. A large chorus and orchestra accompanied Pylades when he performed. The Roman pantomimist also needed the services of a writer who furnished him with a scenario; Lucan and Statius were among the authors of such *fabulae salticae*. Most Roman emperors became involved in the affairs of the leading pantomimists of the day. Later in the Christian era patristic denunciations of these dance spectacles offer ample proof of the continued thriving existence of pantomime shows.

In the meantime, the strongest defense of pantomime had come from Lucian of Samosata (*c.* A.D. 125–*c.* 190), whose dialogue *De saltatione* contains a dithyrambic praise of dumb shows. Lucian stated the qualifications expected of a first-rate pantomimist: the prerequisites were a sound knowledge of music and mythology, a prodigious memory, extraordinary sensibility, and a perfectly proportioned body that combined athletic strength and suppleness of limb. Lucian gave a long list of pantomime subjects, ranging from the origin of the world to the times of Cleopatra. Aside from Lucian there were other champions of pantomime, but no other treatise had the influence Lucian's dialogue was to have on future dancing masters, and it was the *De saltatione* that provided the inspiration for the introduction of pantomime into England. Another impetus, however, must also be considered, that of the Italian *commedia dell'arte* (*q.v.*). The strolling players of improvised comedy developed a body language that had universal significance and could be understood outside Italy, in France as well as in Poland, in Vienna as well as in St. Petersburg. Their comedies abounded in situations that had to be explained and exploited in terms of dumb show.

John Weaver, dancing master of Drury Lane, must be credited with having taken to England the idea of staging pantomimes after the manner of the Italians as well as of the ancients. According to Weaver,

> . . . the first Entertainment that appeared on the English Stage, where the Representation and Story was carried on by Dancing, Action and Motion only, was performed in Grotesque Characters, after the Manner of the Modern Italians, such as Harlequin, Scaramouch &c. and was called *The Tavern Bilkers*.

This pantomime was invented by Weaver and first performed in Drury Lane in 1702. Weaver's second attempt at reviving pantomime was made at the same theatre in 1716 when he produced *The Loves of Mars and Venus* "in imitation of the ancient Pantomimes." However, what Weaver was reviving was not the art of Pylades or Bathyllus: his Drury Lane spectacles were actual ballets in which several performers were featured, in contrast to the one-man shows of the Roman pantomimists. Yet the term pantomime persisted, and Londoners were seized by a mania for these mute entertainments, especially when they were staged by John Rich (*q.v.*) at the Lincoln's Inn Fields theatre. Rich, unable to compete with Drury Lane in the field of legitimate drama, staked his fortune on pantomime. He selected a serious classical fable and combined it with a grotesque *commedia* story about Harlequin and his beloved Columbine. Rich himself, under the stage name of Lun, danced the role of Harlequin and executed with his magic wand as many transformation scenes as the budget would allow. Later, the mythological pretext was discarded, and the pantomimes became pure harlequinades. In the 19th century Harlequin went out of fashion, and the clown of Joseph Grimaldi (*q.v.*) stepped in. In England, these pantomimes became elaborate fairy-tale fantasies written in rhyming couplets. Gradually the fairy tale was reduced to no more than a thin story line in order to make room for slapstick comedy scenes, vaudeville acts and popular songs. In the 1960s, pantomime was still the most popular form of Christmas entertainment in England, but it had become more like a series of lavishly staged vaudeville acts, although the tradition was preserved of having the "boy" (the hero of the fairy tale) played by a girl, and his mother, traditionally known as the dame, played by the male comedian.

In France, Jean Georges Noverre is often credited with establishing the pantomime, and, to be sure, in his *Lettres sur la danse* (first edition, Lyon, 1760), echoes of Lucian may be heard. But actually Noverre belongs not to the history of pantomime but rather to the history of the ballet. He reached his apogee as a choreographer when he staged his *ballets d'action* for the court of Württemberg (1760–67) on such themes as Alceste, the death of Hercules, and Medea. Lucian would have approved of these subjects but would have been disappointed by the fact that the various characters in any given myth were danced by a host of solo dancers rather than by one man. In the 19th century Parisians made pilgrimages to the obscure Théâtre des Funambules where Jean Gaspard Deburau (1796–1846) had created the character of the white-faced, white-robed, melancholy Pierrot. Deburau founded a tradition that is still alive in France: Marcel Marceau, the great pantomimist of modern times, is a true "imitator of all persons and of all things." In the hands of Marceau, pantomime again became a one-man show, Marceau being David at one moment and Goliath the next.

See also CLOWN; HARLEQUIN; THEATRE: *Mime, Pantomime, Vaudeville and Music Hall*.

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PANTUN, a Malay verse form, usually a quatrain, rhyming *abab*, as in the following example:

> Dari mana punai mēlayang;
> Dari paya turun kē-padi.
> Dari mana datang-lah sayang;
> Dari mata turun kē-hati.

The pantun, like all traditional Malay verse, is essentially a word verse, not to be divided into feet or scanned; each line contains four (rarely three) "full" words (*i.e.*, not counting particles or affixes). The first two lines (the "skin") have little or no connection in meaning with the last two lines (the "fruit" or "contents"). There is, however, a close connection in sound: just as the skin suggests, yet hides, the fruit, so do the first two lines of a pantun suggest, in sound, the content of the last two lines. As in the example quoted, there should be not only end rhyme (*"mēlayang"* with *"sayang,"* *"padi"* with *"hati"*) but as much sound correspondence between the two halves of the pantun as possible (*e.g.*, vowel correspondence between *"paya"* (line 2) and *"mata"* (line 4), often resulting in repetition (*e.g.*, "Dari mana" in lines 1 and 3). R. J. Wilkinson's free translation of the above pantun,

> The fate of the dove is to fly;
> he flies to his nest on the knoll.
> The gate of true love is the eye;
> the prize of his quest is the soul,

reproduces well the internal rhymes characteristic of a good pantun.

The pantun first occurs in Malayan literature of the 16th century, but is probably much older. In view of the theory that the Austronesian (Malayo-Polynesian) racial group came from Yunnan (in southern China), it is interesting that some of the earliest Chinese poetry, in the *Shi-King* ("The Book of Odes"), resembles the pantun. Again, as the Malays have been strongly influenced by the civilization of India, the pantun may have been influenced by the *çloka*—one of the most popular of the Sanskrit quantitative metres. However, the existence of pantunlike verse forms in Tibet (the *gtang-thung-bzhad*), Turkey (the *mani*), Norway (the *gamlestev*), Latvia (the *daina*) and Spain (the *copla*)—all, like the pantun, types of folk verse—shows that similarity of form need not indicate derivation. In fact, as a pantun-type verse is to be found not only in Malay but in many other branches of the western or Indonesian division of the Austronesian linguistic group (*e.g.*, the Batak *umpama*, the Javanese *parikan*, the Malagasi *kain-teny*), there seems no reason to suppose that the pantun is not an indigenous form.

Although considered somewhat old-fashioned (partly in reaction against the traditional Malay appreciation of a pantun more for the number of sound-correspondences between the two halves than for depth of feeling), the pantun is by no means dead. Informal parties often end with the singing of literary pantuns to a guitar, and literary pantuns appear in newspapers and periodicals.

Pantuns are sometimes linked together, with the second and fourth lines of the first verse becoming the first and third lines of the second verse, and so on. It seems to have been these linked pantuns which inspired Victor Hugo to produce a chain verse which he called *"un pantoum ou chant malais, d'une délicieuse originalité."* His example was followed by Theodore de Bainville and Leconte de Lisle. In English, Austin Dobson's poem "In Town" is a pantunlike chain verse that completes the circle by making the last line of the last verse identical with the first line of the first verse.

See W. A. Braasem, *Pantuns* (1950); R. J. Wilkinson and R. O. Winstedt, *Pantun Melayu*, 2nd ed. (1955). (CL. S.)

PAN-TURANIANISM, a movement to unite in a political and cultural union all the Turco-Tatar peoples living in Turkey, southeastern Russia, Transcaucasia, Siberia and Turkestan. The last-named area is called in Persian *Turan*, the land to the north of Iran. The name Turanian for the Turco-Tatar family of languages was first used by the Magyars of Hungary. The Hungarian language belongs to the Finno-Ugric group of languages which are related to the Turkish languages, and in the half-century before World War I some Magyars wished to base upon this affinity of languages a common front of the Turks and Magyars against the Slavs and Pan-Slavism (*q.v.*).

Of greater importance was a similar 19th- and 20th-century trend to oppose a unity of the Turks in Turkey and of the Turco-Tatar peoples of the Russian empire against the growing Russian tsarist and communist domination. In 1878 Ismail Gasprinski (1841–1914), a Crimean Turk, proclaiming the "unity in language, thought and action" of all the Turkish-speaking peoples in the Russian and Ottoman empires, started in the Russian Crimea the Turkish newspaper *Tercüman*. In 1911 Yussuf Aktshura Oghlu founded in Constantinople (Istanbul) a similar paper, *Türk Yurdu* ("The Turkish Homeland"). At the same time prominent Turkish writers such as Ziya Gökalp (1875–1924) and Halidé Edib Adivar (1883–1964), author of the novel *Yeni Turan* ("The New Turan," 1912), glorified the common legendary past and the future of the Turkish race. For Gökalp, "the Fatherland of the Turks is not Turkey, it is not Turkestan, it is the far-flung and everlasting land—Turan." The Pan-Turanian writers hoped for the rebirth of heroic types of Attila and Genghis Khan evolved into civilized men. Their symbol was a she-wolf (*Bozkurt*), regarded as the mother of the race and worshiped before the conversion to Islam.

During the years 1913–18 when Turkey was involved in a bitter struggle with Russia, Pan-Turanian propaganda was officially promoted by the Ottoman government. In the 1920s and 1930s Kemal Atatürk's realism de-emphasized the movement and confined Turkish nationalism to Turkey itself. World War II, with its revival of Pan-Slavism under Stalin and its Russian threat to Turkey, brought a renewed, though slight, interest in Pan-Turanianism among some Turks. The demand for a federation of Turanian states continued after World War II among the Turkish-speaking Islamic peoples in the U.S.S.R. Emigré groups of these peoples living in Turkey, Germany and Pakistan carried on an active propaganda for the realization, in some form, of the Pan-Turanian ideal. *See* also TURKS OR TURKIC PEOPLES; TURKEY; KAZAKH SOVIET SOCIALIST REPUBLIC; UZBEKISTAN and other articles concerning the Turkish-speaking areas of the U.S.S.R.; NATIONALISM.

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PANYASSIS, of Halicarnassus, one of the later Greek epic poets, uncle or cousin of Herodotus, flourished *c.* 470 B.C. He was put to death by the tyrant Lygdamis (*c.* 454). His chief poems, extant in fragments only, were the *Heracleias* in 14 books, describing the adventures of Heracles in various parts of the world, and the *Ionica* in elegiacs, giving an account of the founding and settlement of the Ionic colonies in Asia Minor. Although Panyassis was not much esteemed in his own time, Quintilian records that by some later critics he was ranked second to Homer.

See G. Kinkel, *Epicorum Graecorum fragmenta* (1877). *See* also Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. 18, col. 871–922 (1949).

PAOLA-TARXIEN, a township of Malta, lying ¾ mi. SE of the head of Marsa Creek and about 2½ mi. from Valletta by road. Pop. (1956) 20,000. The town (or rather, suburb) was formed by amalgamation of two earlier centres as a continuously built-up area. Paola (Pawla, Paula) mainly houses workers from the adjacent dockyard (by far the largest single group) and modern Tarxien (Tarshien, Tarshin) fulfills a similar function. Tarxien (or Hal Tarxien) is, however, famous for its remarkably well-preserved Neolithic monuments (*see* MALTA: *Archaeology*). (W. B. FR.)

PAOLI, PASQUALE (1725–1807), Corsican statesman and patriot, was born on April 26, 1725, at Stretta di Morosaglia in the district of Rostino. His father, Giacinto Paoli, was a leader

of rebellions against the Genoese from 1735 until 1739, when he went into exile at Naples. There Pasquale studied under the economist Antonio Genovesi and served with distinction as standard-bearer in a regiment formed for Corsican refugees.

Returning to Corsica in 1755, Pasquale Paoli was chosen "general" of the people, that is, political and military leader of the nationalists. In a series of rapid campaigns he overcame a rival faction allied with the Genoese. Having confined the Genoese to the coastal towns by his military operations, he proceeded to organize Corsica as an independent state. The constitution that he created and successfully put into practice was more democratic than any known in his time; the legislative assemblies were elected by all male Corsicans of 25 years old and over; and the executive *consiglio supremo*, over which he presided, was composed of nine elected members. He encouraged mining, built a navy, and founded a university at his mountain capital, Corte.

In 1756 Genoa and France concluded a treaty whereby the French were to garrison the Corsican coastal towns. The French and the Corsican nationalists avoided hostilities, however; and though the French, having withdrawn in 1759, returned in 1764, Paoli was able to capture some forts which had remained in Genoese hands and finally, in 1767, to conquer the island of Capraia also. Genoa then despaired of subjugating the Corsican people and, in May 1768, sold Corsica to France. In June the French Army invaded the island.

After a year's courageous resistance the Corsican nationalists were decisively defeated at Ponte Nuovo (May 1769). Paoli took refuge in England. For the next 20 years he lived as an exile, much respected in London intellectual society and befriended by James Boswell, Dr. Johnson, and other celebrities.

With the French Revolution, Paoli could return to Corsica by virtue of the amnesty to political exiles. He arrived on July 17, 1790, with full powers from the Constituent Assembly to reorganize Corsica as a *département* of France. Enthusiastically acclaimed by the population, he was appointed president of the Administrative Council and commander of the National Guard. But he was opposed to the extremism of the Revolution and had little sympathy with the new regime. Blaming him for the failure of a French expedition to Sardinia, the Convention in Paris ordered his arrest (April 1793) and sent a commission to Corsica to investigate his conduct. Paoli then convened a national assembly at Corte, thus declaring a state of rebellion against the French government, whereupon the commissioners set up their own administration at Bastia. Napoleon Bonaparte, siding with the minority loyal to France, was driven off the island by the Paolists.

Paoli, outlawed by the Convention (July 17, 1793), appealed for British protection. In February 1794 Admiral Lord Hood reached Corsica, and by August the British had captured the three towns held by French Republican troops. Meanwhile in June a national assembly, with Paoli presiding, had accepted the constitution of a Corsican kingdom for George III of Great Britain. The British, however, appointed not Paoli but Sir Gilbert Elliot (later earl of Minto) as viceroy, and Elliot chose C. A. Pozzo di Borgo as his chief counselor. Deeply offended, Paoli withdrew from public life. As his presence was considered responsible for unrest, Elliot arranged for him to be invited to London in 1795.

Paoli's departure merely exasperated his supporters in Corsica, while the opposite faction, encouraged by Bonaparte's victories in Italy, instigated local riots; and in 1796, the British, seeing their Mediterranean position threatened by the Franco-Spanish alliance, evacuated Corsica. Paoli received a pension from the British government until his death on Feb. 5, 1807.

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(D. CA.)

PAOLO, GIOVANNI DI: *see* GIOVANNI DI PAOLO.

PAOLO VERONESE: *see* VERONESE, PAOLO.

PAOTING (CH'ING-YÜAN, TSINGYUAN), capital of Hopeh province, China, is 90 mi. (145 km.) S.W. of Peking on the Peking-Hankow railway. It is on the Ta-ch'ing ho (Tatsing river) at the head of small-boat navigation. A very old district centre near the western margin of the North China plain, the city repeatedly has been a provincial political capital. It is an important regional trade and railroad centre, and also has light and handicraft industry. The population (1953) was 197,000. (J. E. SR.)

PAO-T'OU (PAOTOW), industrial city of the Inner Mongolian Autonomous Region, China, on the Yellow river, 230 mi. (370 km.) W. of Peking. Pao-t'ou owed its initial importance as a trade centre to the construction of the Peking–Pao-t'ou railroad in the 1920s. The city became a collecting and distributing centre of a large part of Suiyüan province, shipping wool and hides to processing plants on the coast, and importing tea, cloth and other necessities. Pao-t'ou was occupied by the Japanese from 1937 to 1945.

Under the Communist regime, after 1949, Pao-t'ou was selected as the site of one of China's three huge steel plants, the two others being at An-shan and Wu-han. Construction on the steel plant and associated industries began in the mid-1950s and soon transformed the former placid caravan centre into a bustling industrial site. Railroad lines were laid to the Pai-yün-o-po iron mine, 90 mi. (145 km.) to the north, and the coking-coal mines of Shih-kuai-kou (Shihkwaikow), just northeast of Pao-t'ou. The main Peking–Pao-t'ou railroad was extended to Lan-chou (Lanchow) in 1958. In 1954, the city, together with all Suiyüan province, passed to Inner Mongolia. Pao-t'ou's population was 149,400 by the 1953 census, but spurred by industrial construction and expansion it had increased to an estimated 650,000 by 1958. (T. SD.)

PÁPA, a town of Veszprém *megye* (county), northwest Hungary, lies on a low plateau 25 mi. (40 km.) S.S.W. of Győr on the south bank of the Tapolca, a small tributary of the Rába (Raab). Pop. (1960) 25,629 (mun.). The plateau soils, lying between the Rába plain marshes and the Bakony hills, are fertile and noted for grain and beet growing. Pápa had once a great reputation for its schools, and the library of the Protestant theological college is well known. Its castle was built by the Esterházy family in the late 18th century. The town has tobacco and cotton spinning factories. It is also an intersection point of roads, a centre for truck farming and a railway junction. (H. G. S.)

PAPACY, the headship of the Roman Catholic Church as represented in the persons of the successive popes, or bishops of Rome. The papacy is the only institution that has existed continuously from the early Roman empire. Its activities, its influence and its claims have varied and developed and have been challenged and combated; its fortunes and prestige have waxed and waned many times. Local yet world-wide, it has always based its pronouncements upon tradition while it has taken its colour from the present; flexible in choice of means, in all the changes of social and political sentiment it has remained uncompromisingly monarchical. There have been many great and saintly popes, many nonentities and not a few worthless or bad; but the office has always been greater than the man, and it survives. In addition to the historical survey below, *see* ROMAN CATHOLIC CHURCH; VATICAN, THE; and the biographies of individual popes.

(M. D. K.)

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I. THE FIRST SIX CENTURIES

1. St. Peter.—The history of the papacy begins at the point when Jesus left his apostles. St. Peter, by virtue of the words spoken to him by Christ (*Tu es Petrus* . . . , "You are Peter," etc., Matt. xvi, 18–19; cf. John xxi, 15) and as a natural consequence of the role that he had already begun to play among his colleagues, can be seen to occupy a pre-eminent place from the beginning. Peter, James "the brother of the Lord" and John "the beloved disciple" are called "the pillars of the church" in the Acts of the Apostles. But if James, as "brother" of Jesus, appears to be the leader of the Jerusalem Christians, it is nevertheless Peter whose influence predominates in the newborn church; Peter is the head of the church.

Peter is seen as taking the initiative and as the person to whom all questions that arise are addressed. It was Peter who introduced the first uncircumcised member into the Christian community, namely the centurion Cornelius. Though subsequently Peter's temporary abstention from sitting down at table with the gentile Christians at Antioch showed him less resolute than St. Paul, he soon let Paul reconvince him of Christian freedom; and Paul's very anxiety to persuade Peter shows that he recognized the weight of Peter's authority in the government of the church.

Further, Peter's first journey to Antioch, the details of which are unknown, is evidence of a missionary activity far beyond the original Palestinian limits of Christianity; and we are entitled to infer from his letters to the faithful of Pontus, of Bithynia, of Cappadocia and of Macedonia (as interpreted by Origen, whose observations have been preserved in Eusebius) that his apostolate took him not only to Antioch but into these regions as well. There is even better evidence for his having visited Corinth. Dionysius, bishop of Corinth in the 2nd century, states expressly that his see owed its origin to the apostles Peter and Paul.

Both apostles died as martyrs in Rome, during the persecution under Nero. There is no reason, however, to suppose that they had been working there together or that their martyrdoms took place at precisely the same time.

Though his having been in Rome is in Peter's case even less explicitly attested than in Paul's, the evidence is nevertheless such as cannot seriously be called in question. That the Prince of the Apostles was in fact in Rome seems to be established beyond all reasonable doubt (*see* PETER, SAINT). His stay in Rome may not have been very long, if he did not arrive there until near the close of his career; but it was enough to fix the centre of the Christian Church in what was then the capital of the Roman empire.

It is not known how long Peter had been in Rome when the first persecution of the young church broke out. In A.D. 64, when several quarters of the city were destroyed in a great fire, public opinion almost unanimously (and perhaps rightly) suspected the emperor Nero of having started the conflagration in order to clear the ground for an extension of his palace. To divert this suspicion, Nero formed the idea of blaming the Christians, who could be represented as the enemies of humanity because of their austere way of life. All who could be found ("a vast multitude") were put to death with atrocious tortures, and Peter was one of the victims.

2. Peter's Early Successors.—Of Peter's first two successors only the names are known, Linus and Anacletus. The third, however, stands out more clearly. This was St. Clement, whose letter to the Christians of Corinth, written to settle a controversy among them, is still extant. While its tone is one of charity rather than of authority, this letter shows that the bishop of Rome considered himself empowered to intervene in the affairs of another community; and the fact that his letter was soon regarded as having almost canonical status is evidence of the Roman bishop's prestige throughout the whole of Christendom.

TABLE I.—*Popes of the 1st and 2nd Centuries**

?–?	Peter (d. between A.D. 64 and 67)	125–136	Telesphorus
		136–140	Hyginus
67– 76 or 67– 79	Linus	140–155	Pius I
76– 88 or 79– 91	Anacletus	155–166	Anicetus
88– 97 or 92–101	Clement I	166–175	Soter
97–105 or 101–105	Evaristus	175–189	Eleutherius
105–115 or 109–119	Alexander I	189–199	Victor I
115–125	Sixtus I (Xystus)		

*The dates given in this table are not entirely certain.

Little is known of the first successors of St. Clement, though we are better informed on the series of bishops of the Roman Church than on that of any other. While their dates remain uncertain, it is known that Clement was followed in turn by Evaristus, by Alexander I, by Sixtus I (Xystus) and by Telesphorus (all bearing names of Greek origin), during the reigns of the emperors Nerva, Trajan and Hadrian. Telesphorus is rather better known than the others because of his martyrdom, which took place either in Hadrian's reign or under Antoninus Pius. The next bishop, Hyginus, and his successor Pius I were put to death under Antoninus. Anicetus, who succeeded Pius, received the visit of St. Polycarp, bishop of Smyrna, who visited Rome in the middle of the 2nd century. The next pontificate, that of Soter, was succeeded by that of Eleutherius, who had been deacon under Anicetus and who became pope in succession to Soter before the death of the emperor Marcus Aurelius Antoninus (180). It was during this pontificate that St. Irenaeus went to Rome as the delegate of the church of Lyons, which in this period was much respected for the number of its martyrs; and Eleutherius was requested to give a ruling on the question of Montanism, with regard to which the Lyons Christians asked him to show mercy to the erring while not compromising with error. His pontificate lasted until 189, nine years after the accession of the emperor Commodus; but it was only after Victor I (189–199) had succeeded Eleutherius as pope that Commodus granted a pardon to the Christian convicts in the Sardinian mines. This was the beginning of an improvement, precarious but never-

theless undeniable, in the church's relations with the state under the last of the Antonine emperors.

Under Victor the activity of the Roman see became prominent to an extent hitherto apparently unprecedented but for St. Clement's intervention in the affairs of Corinth. His pontificate, indeed, may be regarded as typical of certain aspects of papal history. Greek ceased to be the single official language of the Roman Church, and Latin began gradually to take its place. Victor himself, who seems to have been of African origin, wrote in Latin; and this shows the progress made by Latin in the Roman Christian community, which had previously been Greek or oriental rather than Latin in complexion. The spread of Latin influence, moreover, is to be discerned also in the development of ecclesiastical organization; a number of synods met in Rome to deal with the problem of the heretic Theodotus and with the controversy about Easter. In short, this pontificate constitutes an epoch, and it is true to say that with Victor I, far more than with any of his predecessors, the actions of the bishop of Rome were the actions of a pope.

3. The Schism of Hippolytus.—The next pope, Zephyrinus (*c.* 199–217), and his successor Calixtus I (Callistus), who is thought to have formerly been his chief deacon, were confronted with the opposition of the priest St. Hippolytus (*q.v.*), the first member of the Roman clergy to produce a theologico-philosophical work on dogma. Hippolytus was a passionate champion of the doctrine of the Logos, emphasizing the distinction of the Persons of the Trinity in contrast with the "modalist" view, which stressed the unity of the Godhead (*see* MONARCHIANISM). Blaming Zephyrinus for not declaring himself in favour of the Logos doctrine as then formulated, Hippolytus started a schism; and on the death of Zephyrinus he and Calixtus were rival candidates for the succession. Hippolytus, unwilling to submit to Calixtus, found himself with no choice but to set himself up as an antipope. His reputation as a scholar and his literary talent were assets to his cause, yet the church preferred Calixtus, a mere freedman of far less education, but a good spokesman of the faith, a strong character and an able administrator. It was Calixtus who moved the official burial ground of the Roman Christians from the vicinity of the Via Salaria to that of the Via Appia, to the site known subsequently as "the Cemetery of Calixtus" (though he was himself not buried there) and eventually as "the Cemetery" without further epithet.

The schism of Hippolytus lasted for several years but came to an end when persecution brought the opposing leaders together. Under an edict of the emperor Maximinus (Gaius Julius Verus Maximinus), both Hippolytus and the second successor of Calixtus, Pontianus, were deported to Sardinia. There a reconciliation took place, and Hippolytus was honoured as a martyr.

Calixtus, however, had previously had to face another charge, on the ground of his alleged laxity, insofar as he had mitigated the rigour of penitential discipline. On this point Hippolytus had the support of Tertullian, but the Roman inclination to mercy eventually prevailed throughout the church. Arguments have been advanced to indicate that it was in the course of this controversy that the bishop of Rome first claimed primacy of jurisdiction over the other bishops, the claim having been suggested to Calixtus by Tertullian's protest against his use of the words *Tu es Petrus* as a justification for assuming authority over the church. But the memory of the apostle Peter had been kept continuously alive in Rome, and the Roman see would not have needed an African theologian to apprise it of the special Petrine authority it enjoyed. The fact that such men as Hippolytus and Tertullian made forceful attacks on Roman bishops accused of laxity in the defense of doctrine or of morality constitutes a tribute to the authority which those bishops exercised.

Calixtus died in *222*, in the reign of the emperor Alexander Severus, during a period of peace between church and state (though he is reckoned among the martyr popes). He was buried on the Via Aurelia, far from the official cemetery, perhaps near the spot where he lost his life in some riot. The pontificate of his successor, Urban I, according to the *Liber Pontificalis*, was marked by the institution of the 25 presbyteral *tituli*, that is, of the 25 principal churches in Rome; but since there is no corroboration of this statement from any other source, it remains open to doubt.

Urban's successor Pontianus, together with Hippolytus, was condemned to the mines of Sardinia; they both died there after making their peace, Hippolytus exhorting his supporters to unite with the rest of the faithful. Their bodies were brought to Rome and buried there, Pontianus' in the Cemetery of Calixtus, in the popes' crypt, Hippolytus' on the Via Tiburtina. Anteros, elected to the papacy while the deported Pontianus was still alive (235), was himself soon prosecuted and sentenced to death; Pontianus survived him for a time before succumbing to the strain of work in the Sardinian mines.

4. Papal Authority in the Last Years of Persecution.—The next pope, Fabian, had a longer pontificate, which lasted until his martyrdom in 250 in the course of the persecution under the emperor Decius. He too is important in the early history of the papacy. Now that there was no longer any trace of the Hippolytan schism, the second successor of Pontianus was free to work undisturbed at the development of Roman Christianity as an organic body. The *Liber Pontificalis* credits him with the institution of the seven diaconates between which the ecclesiastical administration of the city was divided, together with the seven subdiaconates auxiliary to them. Two events, moreover, which took place under Fabian provide further evidence of the Roman see's pre-eminent authority in the church: (*1*) when the bishop of Lambaese (modern Lambessa), in Africa, professed doctrines which an African council found to be heretical, his teachings were censured not only by his metropolitan, the bishop of Carthage, but also by Pope Fabian, in a stern letter; and (*2*) when Origen was accused of heterodoxy and found guilty by his bishop, Demetrius of Alexandria, he sent a memorandum on his doctrine to Fabian in order to clear himself.

The election of a successor to Fabian was delayed for 14 months because of the Decian persecution; and when it took place the election gave rise to a schism. While the majority of the votes were for the priest Cornelius, a minority of the faithful declared itself in favour of another priest, Novatian. Novatian (*q.v.*) had a high reputation as a learned theologian and was an uncompromising champion of rigorism in church discipline who refused to admit the *lapsi* (*i.e.*, those who had lapsed from Christian practice during the persecution) to the sacrament of penance. A synod convened by Cornelius in 251 was attended by about 60 bishops, and sentence of excommunication was passed on Novatian and his adherents.

TABLE II.—*The Papacy From Zephyrinus to Miltiades*

c. 199–217	Zephyrinus	254–257	Stephen I
217–218–222	Calixtus I	257–258	Sixtus II
217–218–235	*Hippolytus, antipope*	259–268	Dionysius
222–230	Urban I	269–274	Felix I
230–235	Pontianus (d. in exile)	275–283*	Eutychianus
235–236	Anteros	283–296*	Gaius
236–250	Fabian	296*–304	Marcellinus
251–253	Cornelius	*c.* 308–*c.* 309	Marcellus I
251	*Novatian, antipope, expelled (d. c. 258)*	(*c.* 309–310)	Eusebius
253–254	Lucius I	311–314	Miltiades

*Dates uncertain.

In his struggle with the extremists Cornelius had the support of St. Cyprian, bishop of Carthage, himself confronted with an analogous but converse problem in his own diocese, where he had to resist a movement toward extreme laxism. Their mutual support enabled Cornelius and Cyprian to prevail over their opponents (though the Novatianists remained for a long time in schism). The friendship of Cornelius and Cyprian is still remembered, and they are joined liturgically in a single feast. When the emperor Gallus inaugurated a new persecution, Cornelius was sent into exile, where he died in 253.

The next pontificate, that of Lucius I, did not last long and this pope also had to go into exile. His successor was Stephen I, under whom occurred some important differences between Rome and Carthage, not without dramatic incident. Two Spanish bishops had lapsed, during the Decian persecution, to the extent of obtaining certificates of having made sacrifice to the pagan

gods, and had therefore been deposed by their colleagues; but when they appealed to Stephen (a step which seems to indicate that such a procedure of appeal was recognized as normal), the pope acquitted them. The rest of the Spanish episcopate, however, was not ready to yield its point and raised the matter at the Council of Africa, at which St. Cyprian was presiding. Cyprian, who exercised considerable influence throughout the church in the west, confirmed the sentence of deposition. Stephen does not appear to have persisted in upholding the accused.

Shortly afterward, Martianus, bishop of Arles, who shared Novatian's rigorist opinions, was denounced as a schismatic by the Gallic bishops, who addressed their charges to Rome and to Carthage simultaneously. Cyprian wrote at once to Stephen, inviting him to instruct the Gallic bishops to depose Martianus and at the same time asking the pope to inform him of the name of the new bishop of Arles, so that the African bishops might know with whom they were to have relations. This implies that the only lawful bishop was he who was in communion with the *ecclesia principalis*, as Cyprian calls Rome (*Letter* lix).

A serious difference of opinion, however, was soon to arise between Pope Stephen on the one hand and the African episcopate and several Asian churches on the other. Rome and the majority of the other churches held that it was not necessary for converted heretics to be rebaptized and that all that was required for them was confirmation by the laying on of hands and anointing with chrism, whereas the Africans and the Syrians rebaptized. Cyprian having solemnly affirmed the rightness of rebaptism in a letter to the pope, Stephen replied that the Roman usage was the only lawful one and that all the churches should conform to it if they wished to remain in communion with Rome. Cyprian, and with him Firmilian of Caesarea in Cappadocia, took the view that unity of faith did not preclude diversity of usage and insisted on their own view of the matter in question, declaring at the same time that they did not want to sever relations with Rome. The dilemma was resolved by Stephen's death, in Aug. 257. (*See* also CYPRIAN, SAINT.)

His successor, Sixtus II, was of a more conciliatory disposition. Encouraged by a letter sent to Stephen a short time previously by Dionysius of Corinth, he resumed relations with Cyprian and with Firmilian. His pontificate came to a sudden end with his martyrdom under the emperor Valerian in 258, and the next pope, whose name was Dionysius, sent a friendly message, together with a charitable contribution from Rome, to the Cappadocian Christians when their country was suffering from the effects of a Persian invasion (259).

The Roman Church's claim to governing in matters of faith received a further strengthening during Dionysius' pontificate. The bishop of Alexandria, whose name was also Dionysius, wrote a letter stressing the distinctness of the Persons of the Trinity to such an extent as almost to give the appearance of tritheism and unmistakably subordinating the Son to the Father. Protests and appeals against this doctrine were addressed to the bishop of Rome, and Pope Dionysius took immediate cognizance of the matter, which became known as "the affair of the two Dionysii." He condemned both the modalists, who denied that there was any real distinction between the Persons, and those who acknowledged three separate hypostases and considered the Logos to be a creature. The Roman bishop spoke here as arbiter in matters of faith, and the bishop of what was then the most important Eastern Church accepted his decision without questioning his competence to pronounce judgment. (*See* also DIONYSIUS, SAINT, the Great, of Alexandria.)

Pope Dionysius died in Dec. 268. His successor Felix I received an acknowledgment of his authority from the emperor himself. The occasion was the claim of Paul of Samosata, bishop of the important see of Antioch, to retain his bishopric even though he had been deposed by a council in view of his antitrinitarian heresy. The emperor Aurelian, having been asked to decide the question of legal ownership, gave his verdict that the rightful bishop and legal proprietor of the bishop's residence was the one recognized by the bishops of Rome and of Italy (272).

The immediate successor of Felix was Eutychianus, whose successor was Gaius; but very little is known of these two popes, even the dates of their pontificates being uncertain. The next pope, Marcellinus, became bishop of Rome in 291 or in 296 and witnessed the end of a long period of tranquillity in a renewal of bloodshed under the emperor Diocletian. This was the last official persecution of the Christians in Rome; and its aftermath was a long crisis in the government of the church. Marcellinus apparently died a martyr's death in Oct. 304, but may have shown some temporary weakness beforehand; the result was that the church felt ill at ease after his death. Moreover, the persecution delayed the election of his successor till *c.* 308, when Marcellus I became pope. Consciences however were still troubled, agitation spread and Marcellus had to go into exile. The appointment of Eusebius (*c.* 309–310) as pope failed to restore tranquillity and he too was soon exiled. Only with the election of Miltiades (Melchiades) in July 311 was peace restored.

Throughout this early period, now drawing to its close, the bishop of Rome, despite trouble from within and from outside the church, had consistently exercised the role of principal representative of the Christian Church. Whenever persecution had broken out, the first blows had been aimed at him; and on the other hand he had also received impressive marks of recognition, for instance from Aurelian.

Furthermore, the fact that the leaders of Christianity, men such as Polycarp, Irenaeus and Origen, paid him visits and conversely that the Roman Church sent letters on doctrinal or disciplinary matters to the other churches bears witness to the special authority of the Roman see as acknowledged by Christendom in its entirety, an authority experienced rather than formulated, actual rather than theoretical, unaffected, moreover, by the individual character of those in whom it was personified.

5. The Christian Empire and the Arian Crisis.—Two months before the accession of Miltiades, an edict of the emperor Galerius had put an end to the persecution of the Christians; next, Maxentius restored to Miltiades the church property that had been confiscated in the course of the persecution; and these measures were soon confirmed and amplified by the emperor Constantine, in the measure known traditionally, though inaccurately, as the Edict of Milan. Constantine, indeed, promptly changed the whole imperial policy toward the church from one of toleration to one of positive favour. (*See* CONSTANTINE.) At the same time, however, internal dissension broke out again within the church. The Donatists adopted an attitude of intransigence like that of Novatian and his followers and refused to absolve the *lapsi* of the late persecution. (*See* DONATISTS.) Schism resulted; and to put an end to it Constantine called on Miltiades to settle the question. Miltiades held a council in the Lateran palace, which the empress had just presented to him, and the Donatists were condemned (313). On their refusal to submit, Constantine summoned a larger assembly of churchmen to Arles (*see* ARLES, SYNOD OF). This council also failed to end the dispute; its concluding letter to the pope, however, is yet another striking proof of the authority that he was felt to exercise. This pope was not Miltiades but his successor Silvester I, whose long pontificate saw the beginnings of the Christian Roman empire as Constantine showered favour after favour upon the church. This meant, however, that the church's independence was often endangered. Thus neither Constantine nor his immediate successors gave any official recognition to the Roman bishop's primacy of authority over the whole church; and during the Arian crisis the popes were only rarely accorded a pre-eminent role in affairs. There were, however, a few incidents of some significance.

Silvester sent two legates to the Council of Nicaea (325), where they were treated with great honour and respect, though they did not preside at its debates. The next pope, Marcus, reigned for less than a year, but his successor Julius I reigned for 16 years, during which he made his personality felt. During the prosecution of Athanasius by the Arians, he acted decisively. At the Council of Rome (340) he insisted that the bishop of Alexandria was still in communion with him; and subsequently he maintained the same view in a letter to the eastern churches, in which, moreover, he showed himself well aware of his primacy of jurisdiction.

At the Council of Sardica (342, or perhaps 343), the Western bishops, with whom the Eastern bishops had just broken off relations, recognized the supreme authority of the bishop of Rome. The canons of the council acknowledged that it was within his power to annul any decision of the entire Catholic episcopate. (*See* COUNCIL: *Councils to the 9th Century: Councils Between 325 and 381.*) These canons, it is true, were rarely applied in practice, as the Eastern bishops, even when the schism was over, were reluctant to submit to Roman authority in matters of discipline. In the West, however, the popes did not confine themselves to declaring that a verdict ought to be reconsidered but exercised positive jurisdiction, as in the past. For instance, when the two Arian bishops Ursacius of Singidunum (modern Belgrade) and Valens of Mursa (modern Osijek, Yugos.) retracted their errors, the pope received them back into communion, thus abrogating, on his own authority, the sentence of deposition that the Council of Sardica had passed against them.

The glory of the papacy was somewhat diminished under the next pope, Liberius. Liberius persisted for a long time in the defense of Athanasius against the emperor Constantius, who wanted him to condemn the Alexandrian bishop. But after being exiled (355) to a place far distant from Rome, where Felix was made bishop instead, Liberius lost heart and agreed to sign certain formulas which, without disavowing the Nicene formula, nevertheless emasculated it; and he also agreed to sever relations with Athanasius (for which he was to incur the reproaches both of Athanasius and of St. Hilary of Poitiers). Nonetheless, he was joyfully received by the Christian community on his return to Rome, while Felix had to flee to Porto, outside the city boundaries. Constantius, however, decreed that the two bishops should rule the Roman community jointly; but his orders were disregarded. The prestige of Liberius was nevertheless impaired, and he was not invited to the great council which met at Rimini in 359 to put an end to the Arian crisis; but this temporary humiliation served to prevent the papacy's being involved in the council's rather shameful capitulation to imperial despotism and in its compromise with heresy. In 362, with his authority strengthened anew, Liberius received a delegation of Eastern bishops and prevailed upon them to profess the Nicene faith and to anathematize the formulary of Rimini. The letters that he gave to them for 64 other Eastern bishops were entirely in accord with the program of reconciliation that Athanasius was advocating. The eclipse of the papacy was over, but the curious phenomenon of the simultaneous occupation of the Roman see by two bishops lasted until 365, when Felix, who moreover had never returned to the city, died. Liberius did not long survive him, dying in 366.

6. Damasus and His Successors, to 422.—The confusion arising from these years of crisis was not at once allayed. The successor to Liberius was the deacon Damasus, who had rejoined his party after a period of allegiance to Felix; but a party of extremists objected to him and nominated another deacon, Ursinus. The result was another schism in the Roman Church, which continued for several years. Only after the secular power had intervened, in the person of the emperor Valentinian I, did Ursinus give up the struggle.

Nonetheless, despite these disorders, the organic development of the Roman Church continued. More places of worship were opened, and the number of priests rose from 46 in the middle of the 3rd century to 70 at the end of the 4th (the number of deacons remained limited to 7, though the patrimony of the church, of which they had charge, had been very much increased). Damasus I, who took a particular interest in the upkeep of religious buildings, made himself responsible for the restoration of the catacombs (to which pilgrimages were then beginning to be made) and had metrical inscriptions put up in them. The words were of his own composition and not of very high poetic quality; but the workmanship of the engraving was excellent, so that the Damasian inscriptions have become famous. His intellectual preoccupations found further expression in the interest that he took in the pontifical archives and in St. Jerome's exegetical work. In many respects he was a great pope, reviving the traditions of Miltiades and of Julius I; and in the termination of the Arian crisis he played a very important part. Though the personal authority of St. Ambrose (*q.v.*) and his rank as bishop of Milan (at that time the seat of the imperial government in the West) seemed sometimes to overshadow the influence of the apostolic see or "chair" (*sedes apostolica*, as he himself called it), Damasus nevertheless secured Rome's position in the church—particularly, however, in the Western half of the empire. The synodal letter of the Council of Rome of 378 shows how Rome's jurisdiction extended over the whole of the Western church, as based on an established tradition of authority.

Siricius, who succeeded Damasus, does not seem to have been so great a man as his predecessor, but this makes the extent of his administrative activity all the more notable. He conferred on the bishop of Thessalonica powers which made him virtually papal vicar in eastern Illyria; he intervened at the Council of Toledo to arrange for the reconciliation of the penitent Priscillianist heretics of Spain with the church; he wrote likewise to the bishop of Tarragona on the reconciliation of converted Arians; and he stated the rules of church discipline on accession to holy orders when the Gallic bishops asked for his advice on the subject. These papal decisions are accompanied by the threat of sanctions against those who contravene them; and the letters of Siricius constitute the first decretals, whereby the Roman bishop made laws, as a sovereign, for the whole church in the West.

If he did not do the same for the church in the East, he nevertheless believed himself to be entitled to intervene in its affairs. For instance, it was his instructions to Theophilus, bishop of Alexandria, and to the Council of Caesarea (393) that made possible the termination of the long-standing schism of Antioch (a product of the Arian controversy). Likewise, his arbitration was invoked, in 394, in a dispute within the Arabian church, on the subject of the bishopric of Bostra (modern Bozrah, Syria). It is well worth emphasizing here that it was to the pope that Syria and Arabia looked for a final judgment, despite the misunderstandings that were already dividing Rome and the East. It is equally important to note that the pope did not owe his primacy, as some writers have suggested, to the well-known rescript of the emperor Gratian. Gratian in fact proclaimed the authority of the Roman bishop in reply to a letter from the synod of 378; but the misnamed *Decretum Gelasianum* or "Gelasian decree," which really represents a motion voted by the Council of Rome in 382, proves that the church, less than five years after Gratian's rescript, held the primacy of Rome to be of divine, not of imperial, institution.

The following pontificate, that of Anastasius I, was short and uneventful. Pope Innocent I, Anastasius' successor, saw the sack of Rome by the Goths under Alaric; yet he maintained a firm hold on the church despite public calamities. He gave untroubled answers to the questions on matters of discipline that the Italian, Gallic and Spanish bishops addressed to him; he confirmed the privileges that his predecessor Siricius had bestowed on the bishop of Thessalonica, through whom papal control was thus exercised over the churches of Dacia and of Achaea; and when the emperor Arcadius, by an abuse of his power, deposed John Chrysostom from the see of Constantinople, he announced that he would remain in communion with the wrongfully deposed patriarch and, in fact, refused communion to his successor throughout John's lifetime.

Finally, when the Pelagian heresy began to spread in Africa, the pope, notified by the synods of Carthage and of Mileve, condemned its sponsors, Pelagius and Celestius. On the reception of the letters from the apostolic see, St. Augustine preached a sermon in which he used the words: "The rescripts have arrived. The case is closed [*Causa finita est*]."

The church was less fortunate in the pontificate of Innocent's successor, Zosimus. The new pope allowed himself to encourage the ambitions of an intriguing megalomaniac, Patroclus, bishop of Arles, to the extent of appointing him as his vicar in Gaul on the ground of an alleged historical primacy of his see. This ill-inspired decision provoked a crisis in which all the churches of southern Gaul were shaken; and Proculus, the highly respected bishop of Marseilles, was pronounced deposed from his see, a

sentence that was not carried out. Furthermore, when the Pelagians appealed to him to reverse Innocent I's decision, Zosimus seemed for a time to be ready to reconsider the matter; eventually, however, he confirmed the existing judgment. Even so, he disturbed the African episcopate by espousing the cause of a disreputable priest called Apiarius, who had been excommunicated by his bishop. This case too was unsettled when Zosimus—to the great relief of Africa and of Gaul alike—died.

His death, however, was followed by the troubles of a double election. Boniface I, a saintly man, prevailed eventually over his rival Eulalius, with the support of the imperial court at Ravenna. He had then (1) to settle the affair of Apiarius, who was cleared of the sentence of excommunication but obliged to leave his diocese; (2) to deal with another African case, that of the bishop of Fessala, who was appealing against a sentence of the synod of Hippo (after inclining somewhat in the opposite direction, Rome seems eventually to have confirmed the sentence); and (3) to curb the pretensions of the bishop of Arles, who considered that the decision of Zosimus authorized him to ordain a bishop outside his own province. What was perhaps more important, Boniface had also to stand up against the Eastern emperor Theodosius II, who, in a rescript of July 421, had tried to deprive the bishop of Thessalonica of his privileges as papal vicar in Illyria. Boniface's forceful protest, addressed to the Western emperor Honorius, promptly secured the withdrawal of this measure. Not long after this the pope died.

7. The Nestorian Question.—Boniface was succeeded by Celestine I, formerly a deacon, whose pontificate began with a repercussion of the Apiarius affair. Apiarius, having made himself objectionable in the city to which he had been transferred, had been forthwith excommunicated; he had then appealed again to Rome. Celestine agreed to hear his case, but the pope's intervention was resented by the African bishops. Order was restored in the West when Apiarius frankly admitted his own unworthiness. In the East, however, the stage was being set for a tragedy in which the pope, in the interests of doctrine no less than of discipline, was bound to take an active role.

The recently elected patriarch of Constantinople, Nestorius (*q.v.*), had advanced the doctrine that Mary ought not to be called "Mother of God" (*Theotokos*) but only "Mother of the Christ." This appeared, at least, to imply a denial of the truly divine nature of Jesus; and an impassioned outcry was raised in consequence. Celestine convened a council in Rome in 430, and this council instructed Cyril, the patriarch of Alexandria, to draw up an indictment of Nestorius and, in the event of his refusing to retract his doctrine, to depose him. This, under Cyril's influence, was what the Council of Ephesus (431) in fact proceeded to do; and its work received the approbation of the pope, whose legate proclaimed his primacy over the universal church in terms that were to be echoed 14 centuries later, at the first Vatican council. Celestine's letters to the bishops of the council, to the emperor Theodosius II and to the successor of Nestorius serve to emphasize the fact that the measures against Nestorius had received pontifical approbation.

Unfortunately, however, the council had opened without waiting for the arrival of certain Eastern bishops, the most important of them being John of Antioch, whose see was ranked next after that of Alexandria in the East; and these bishops, whose attitude toward the rather ambiguous teaching of Nestorius was less severe than Cyril's, refused to associate themselves with the sentence passed against Nestorius in their absence and claimed, instead, to depose Cyril, on the ground that his condemnation of Nestorian doctrine amounted to a denial of the human nature of Christ, which, they said, was reduced by Cyril to a mere appearance of human nature. Cyril therefore excommunicated John of Antioch. This gave rise to a new schism, which was still unhealed when Celestine died (July 432). In 433, however, a reconciliation was effected between the Antiochene bishop and the Alexandrian, as a result of negotiations in which the tribune Aristolaus, representing the emperor, and Acacius of Berea, the senior Eastern bishop, had mingled persuasion with threats of force.

Under Celestine's successor, Sixtus III, relations between Rome and the East were on the whole undisturbed, though a minor incident took place in 437, when a Constantinopolitan synod tried to encroach on the rights of the Holy See in Illyria and on those of the patriarch of Antioch in the East. Sixtus had to remind the Illyrian bishops of their obligations toward his vicar in Thessalonica and drew the attention of Proclus of Constantinople to established precedents.

8. Leo I, the Early Monophysites and Chalcedon.—The successor of Sixtus was Leo I, rightly called the Great, whose pontificate saw the primatial authority of the Roman see even more strikingly reinforced in consequence of a new doctrinal crisis. This crisis had its roots in the preceding one; its solution was a fitting culmination to the new pope's manifold achievement, which left a lasting mark on the church.

The range of Leo's activity in the West can be indicated by the following summary. In Rome itself he denounced the Manichaean heresy, which a number of secret adherents were maintaining. In the field of practical politics he persuaded Attila, who was terrorizing northern Italy, to halt his march on Rome at the Mincio; and when Gaiseric, king of the Vandals, occupied the Eternal City, Leo's intercession saved it from sack. In Gaul he restored the organization of the church on its proper basis, checking the ambitious but otherwise meritorious Bishop Hilary's attempt to revive the primacy of his see of Arles, but recognizing his successor Ravennius as pontifical vicar. In Spain he took measures against the Priscillianist heresy. For want of a council, the bishops of the Spanish provinces of Tarraconensis, Lusitania, Baetica and Carthaginiensis were required to sign a formulary of Catholic belief. He also sent messages to the African bishops, who were undergoing a savage persecution at the hands of the Vandals. In Illyria, the vicarial powers of the bishop of Thessalonica were reaffirmed. But the great victory of the papacy under Leo consisted in his exercising his *magisterium* ("teaching authority") in matters of faith not merely with the consent of the Eastern bishops but at their invitation.

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POPE LEO I. MINIATURE FROM A 10TH-CENTURY MENOLOGION OF THE BYZANTINE EMPEROR BASIL II. IN THE VATICAN LIBRARY

Eutyches (*q.v.*), an archimandrite of Constantinople, in extreme reaction against Nestorianism, had maintained that Christ as God incarnate had not two natures but only a single nature (hence the name, "Monophysitism," given to this heresy; *see* MONOPHYSITES). When Flavian, bishop of Constantinople, took action against Eutyches, controversy ensued, and the emperor Theodosius II summoned a council to meet at Ephesus (449) to settle the question. Leo sent representatives to this council and also wrote a statement of Catholic Christological doctrine in a letter, known as the *Tome*, which he addressed to Flavian. The council, however, fell under the influence of Dioscorus, patriarch of Alexandria, who supported the Monophysites; and it deposed Flavian and other bishops for refusing to come to terms with the heresy. This conduct earned the council the name of "robber synod" or *lotrocinium*. On the appeal of the deposed bishops, Leo procured the annulment of the acts of the *latrocinium* by the Council of Chalcedon (451), where the *Tome* was triumphantly received (*see* COUNCIL). The Eastern bishops, though they were often quite ready to do without the Holy See so long as they had no positive need of it, yet had prompt recourse to it whenever adverse circum-

stances reminded them of the advantages to be gained from its intervention. They did not, however, regard questions of discipline and questions of dogma in the same light. The 28th canon of Chalcedon, in fact, on the basis of a canon of the Council of Constantinople of 381, departed from ancient tradition so far as to accord to the bishop of Constantinople, as bishop of the new capital of the empire, a rank immediately after the pope and a status nearly equal to his. Leo refused to give his approval to this canon.

The Monophysite heresy was to raise its head again not long after Chalcedon, causing relations between Rome and the Eastern patriarchates once again to deteriorate. For 20 years, however, there was to be no urgent call for Roman intervention in the East. Thus Leo's successor Hilarius had a peaceful pontificate, occupied only with the further co-ordination of ecclesiastical affairs in Gaul. His aim was to revive (without actually using that expression) the primacy of the see of Arles, the bishops of which had already been made pontifical vicars by his predecessors; but the bishop of the time, Leontius, showed himself to be in no hurry to assume the role designed for him, which, moreover, the prevailing quiet seemed to render somewhat supererogatory.

TABLE III.—*The Papacy From 314 to 590*

314–335	Silvester I	483–492	Felix III
336 (Jan.–Oct.)	Marcus	492–496	Gelasius I
337–352	Julius I	496–498	Anastasius II
352–366	Liberius	498–514	Symmachus
355–365	*Felix II, antipope*	*498–c. 505*	*Laurentius, antipope*
366–384	Damasus I	514–523	Hormisdas
366–367	*Ursinus, antipope*	523–526	John I
384–399	Siricius	526–530	Felix IV
399–401	Anastasius I	530–532	Boniface II
401–417	Innocent I	*530 (autumn)*	*Dioscorus, rival pope*
417–418	Zosimus	533–535	John II
418–422	Boniface I	535–536	Agapetus I
418–419	*Eulalius, antipope*	536–537	Silverius (deposed)
422–432	Celestine I	537–555	Vigilius
432–440	Sixtus III	555–561	Pelagius I
440–461	Leo I	561–574	John III
461–468	Hilarius	574–579	Benedict I
468–483	Simplicius	579–590	Pelagius II

9. The End of the Western Empire.—The next pope, Simplicius, had to turn his attention to the East again. The bishopric of Antioch was disputed between partisans and opponents of the Council of Chalcedon, and the Monophysite Peter Mongus managed to make himself bishop of Alexandria. Simplicius wrote to the emperor Zeno and to Acacius, bishop of Constantinople, demanding the removal of Peter, but without success. In the West, meanwhile, he pursued the co-ordinating policy of his predecessors by extending the regime of the vicariate to Spain; the bishop of Seville became the pope's representative in the Iberian peninsula. At the same time his pontificate saw the disappearance of the Western Roman empire. The boy emperor Romulus Augustulus was deposed in 476; no successor to him was nominated; and when the barbarian *patricius* ("patrician") Odoacer, the real master of Italy, sent the imperial insignia to Constantinople, the Eastern emperor seemed to have become the sole rightful sovereign of the Roman world. This elimination of the imperial power in the West served perforce to enhance the prestige of the papacy throughout that half of the world, where it had begun to emerge as the focus of authority ever since Constantine had left Rome for Constantinople.

This development made the choice of every new pope a matter of even greater importance than it had been in the past, when rivalries, conflicts and even schisms calling for imperial intervention had sufficiently demonstrated how much was at stake. Simplicius then had desired to see the procedure of election regulated; and after that pope's death Odoacer's representative announced to the assembly of Roman senators and clergy that his master should be consulted about the choice of the next pontiff, who moreover should be required to pledge himself not to alienate any part of the church's patrimony (now grown to a considerable amount of property), of which the pope was to be regarded as administrator. Such were the circumstances of the election of the new pope, Felix III, who came of an old Roman family. The East, however, was still the field in which the strength of the papacy was to be most severely tested.

10. The Acacian Schism.—Reaction against the legislation of Chalcedon had come to a head, and the patriarch Acacius of Constantinople and the emperor Zeno could together find no better means of allaying the agitation than to promulgate an "edict of unification," the so-called Henoticon (482), which, without explicitly abandoning the canons of Chalcedon, reverted to the Cyrillian theological formulas, omitted all reference to the two natures of Christ and, by implication, made the *Tome* of Leo a thing of the past. The pope could not allow the patriarch of Constantinople, supported by the emperor, to arrogate to himself the right of superseding the Council of Chalcedon. He therefore demanded an explanation of these proceedings and, when Acacius failed to provide one, pronounced sentence of deposition and excommunication (484) against him. This meant another schism, which was to last nearly 35 years (484–518).

Felix III died in 492, leaving unchanged the situation that had arisen from his condemnation of Acacius. His successor Gelasius I, who was of African origin, likewise failed to restore the union of Rome and the East but yet has an honoured place in the history of the papacy. He had an exalted idea of his mission and of the authority with which he was invested by it; and his tone, in his correspondence with the emperors, anticipates that of the medieval popes in their contest with the heads of the Holy Roman empire. He wrote, in fact, on several occasions to Zeno's successor Anastasius I in the hope of persuading him to disavow Acacius and the Henoticon, reinforcing his letters with treatises on points of doctrine; but all to no avail. He showed himself no less energetic in his resistance to the Roman aristocracy, a number of whom still clung to the old pagan traditions. When some of these Romans tried to revive the festival of the Lupercalia, the pope expressly forbade Christians to take part in it. Gelasius, who died in 496, is remembered as a strong man whose personality enhanced the prestige of the apostolic see.

The following pope, Anastasius II, used conciliatory language in the letter that he sent to the emperor—his namesake—to notify him of his accession. Indeed the tension between Rome and Constantinople appeared for a moment to have been eased to such a degree that some of the Roman clergy became alarmed at what they took to be a weakness on the part of the pope. Barely two years later the pope died (498), before any new development had taken place in Rome's relations with the East.

Suspicion, however, had been aroused in Rome, and the consequences were serious. On the pope's death two parties forthwith confronted one another: the one under the archpriest Laurentius, who favoured Anastasius' policy of conciliation; the other, which was the larger, under the deacon Symmachus. The latter was upheld as the rightful pope by the Ostrogothic king Theodoric, who was then master of Italy; but the partisans of Laurentius would not abandon their case and brought charges of moral indignity against Symmachus. Theodoric, who was moreover an Arian, claimed the right of judging the issue, but Symmachus would not acknowledge this right. The result was that the Roman Church was troubled by schismatic division for about ten years, though Symmachus was never dispossessed of his see; and these circumstances did nothing to promote reunion with the East. Though the last years of his pontificate were calmer, peace had still not been wholly restored in Rome when Symmachus died (514). The lamentable schism between the two halves of the universal church likewise remained.

11. Reunion of East and West.—Symmachus was succeeded by one of his deacons, Hormisdas, who had the double satisfaction of seeing both the remnant of schism eliminated in Rome and the reunion of Eastern and Western Christendom brought about.

The pope's first approach to the emperor met with no success; but when Justin I had taken the place of Anastasius I on the imperial throne, the situation changed altogether. Justin was personally in favour of accepting the canons of Chalcedon explicitly; and Christian opinion in Constantinople, weary of the prolonged schism, supported him in this view. He therefore welcomed the formulas drawn up by Hormisdas, which contained the words: "We desire in all things to adhere to the communion of the Apostolic See, wherein the whole and true solidity of the Christian faith resides, wherein religion is ever preserved immaculate."

The pontifical enactment condemned Nestorius, Eutyches and Acacius and reaffirmed the faith as professed in the *Tome* of Leo. Thus ended the Acacian schism.

12. Theodoric.—The reunion of Rome and the East and the restoration of peace between pope and emperor was a great achievement, but it had an unfortunate repercussion in the West: it put an end to friendly relations between the pope and the Ostrogothic king Theodoric, who was now no longer needed by the pope to support him against the emperor and who was bound to regard with mistrust the *rapprochement* between Rome and Constantinople.

Theodoric's hostility was made clear when Justin decided to deprive his Arian subjects of the use of their churches. On the death of Hormisdas (523), Theodoric forced the new pope, John I, to go to Constantinople to persuade the emperor to withdraw his edict. This was the first visit of a pope to Constantinople; John received a splendid welcome, and the edict was withdrawn at his request. The pope, however, of course refrained from asking that persons newly converted from Arianism should be sent back into heresy, as Theodoric had desired; and on his return to Rome he was thrown into prison, where he died in 526. Within four months the Arian king died also.

Theodoric's support probably helped to bring about the election of John's successor, Felix IV; but the election received general approbation, and Felix' short pontificate was a peaceful one. The next two pontificates, that of Boniface II and that of John II (the first pope to take a new name on his accession), were likewise short and for the most part uneventful, though Boniface was at first confronted with a rival pope, Dioscorus. The aftermath of the Monophysite crisis was however still to be felt. In Constantinople some of the Acoemeti, a group of monks who were reacting against tendencies represented by the so-called "Scythian" group, took up a Nestorian position and refused to accept the term *Theotokos*. Justin's successor, the emperor Justinian I, whose lasting concern with theology arose from personal interest on the one hand and from recognition of its political importance on the other, accordingly invited the pope to condemn these Acoemeti (534). John had no choice but to comply with his demand.

13. The Affair of the "Three Chapters."—Yet more trouble was to arise from the persistence of Monophysitism. The emperor was anxious to win the adherence of the Monophysites at any price; his wife, the empress Theodora, had the interests of the Monophysites at heart; and in the resultant crisis the papacy was to undergo one of its most exacting trials. In the short pontificate of Agapetus I good relations were maintained between papacy and empire. Sent to Constantinople by the Ostrogothic king Theodahad to dissuade Justinian from attempting the reconquest of Italy, the pope refused to enter into communion with the newly elected patriarch Anthimus, who had entered into communion with Severus, the notoriously Monophysite patriarch of Antioch; and on the withdrawal of Anthimus another patriarch was installed in his place. A council assembled in Constantinople then declared both Anthimus and Severus officially deposed. By this time, however, Agapetus was dead; and the two following popes had to face the terrible difficulties that almost immediately ensued.

Silverius, who spent only a short time on the pontifical throne, seems to have been the victim of Theodora's resentment. Refusing her request to reinstate Anthimus as patriarch of Constantinople, he was accused of having collaborated with the Goths against the Byzantine general Belisarius, who had just reconquered Italy for the emperor. Brutally driven from his see, Silverius was deported first to Asia, then to the island of Palmarola; and the deacon Vigilius, whom the Byzantine court expected to be more accommodating, was made pope in his place.

Vigilius had to sustain an attack that was pressed hard against him. At the instigation of Theodore Ascidas, bishop of Caesarea in Cappadocia, and in pursuance of his desire to satisfy the Monophysites, Justinian demanded the condemnation (1) of the writings and of the person of Theodore of Mopsuestia; (2) of Theodoret of Cyrrhus' writings against Cyril of Alexandria; and (3) of the *Letter to Maris* of Ibas, bishop of Edessa. All three of these writers were suspected of Nestorianism, and there was indeed ground for the suspicion; but it was open to question whether it was right to anathematize men who had died at peace with the church and whose writings had not been condemned by the Council of Chalcedon. The ensuing controversy is known as that of the "Three Chapters," a name that may originally have referred to Justinian's three condemnatory propositions but is here taken as applying to the three groups of writings condemned. The Eastern bishops, then, agreed to the anathematization proposed; and Vigilius, summoned to Constantinople, published a *judicatum* ("verdict") censuring the "Three Chapters." This, however, caused such an outcry in the West, where some bishops actually broke away from communion with the pope, that Justinian decided to convene a general council; meanwhile things should remain as they had been before. Nevertheless, without waiting for the council to assemble, Justinian repeated his condemnation of the "Three Chapters"; whereupon Vigilius decided to sever relations with him. For his personal safety Vigilius took refuge first in a sanctuary in Constantinople, then at Chalcedon; and from Chalcedon he issued censures against Theodore Ascidas, against the patriarch Mennas and against certain other bishops who shared their views. The council, however, opened without the pope and confirmed the sentence passed against the "Three Chapters." The pope's *constitutum* ("resolution") of May 14, 553, withheld ratification of this measure but that was not his last word. Comforting himself with the thought that neither Theodore of Mopsuestia, Theodoret nor Ibas had been altogether beyond reproach, Vigilius succumbed to lassitude, to homesickness, to the appeals of the Romans for his return and to the ill treatment meted out to him by Justinian. He signed a second *constitutum* (Feb. 23, 554) which revoked the first and gave pontifical approbation to the council's verdict.

This act of weakness, extorted in circumstances that might be held to invalidate it, in fact did no more to impair the purity of the faith than the weakness of Liberius had done 200 years before; but its consequences were no less serious. A number of Western bishops felt that a blow had been dealt against the Council of Chalcedon and, in Africa and in Illyria especially, broke away from communion with Rome, grouping themselves round the metropolitan of Aquileia, to whom they gave the title of patriarch. This "schism of Aquileia" was to last well into the following century.

14. Temporal Power and the Protection of Italy.—The moral authority of the papacy, then, had suffered a considerable setback, and Justinian's "pragmatic sanction" of 554 may have been intended as a measure of compensation for it. By this act the emperor acknowledged, confirmed and increased the temporal power of the pope, who was henceforth to have a voice in the nomination of the governors of the Italian provinces of the empire and to participate in the control of their finances. The pope became the official protector of the civil population against the depredations of the military, against extortion by the tax collectors and against abuse of power by the administration.

The successor of Vigilius was Pelagius I, who made resolute use of the pope's new rights, organizing the temporal government of the territory over which he was actually sovereign and setting the papacy on the road to real political power. This power was to grow so rapidly that Gregory the Great could write, a few years later: "I should like to know whether the pope, in this world, is a spiritual leader or a temporal king."

The papacy was thus faced with new problems. Conditions were no longer the same as they had been while the pope and the Constantinopolitan emperor were opponents. In this latter part of the 6th century the pope was to be concerned more with vigilance against the danger of barbarian invasion and with the protection of the peoples of Italy than with his function as spiritual head of the universal church.

The pontificate of Pelagius' successor John III saw the invasion of the Lombards, who overran the northern half of the Italian peninsula, captured Ravenna and threatened both Rome and Naples. In the face of such a danger, it was doubtful whether much real help could be expected from Constantinople, distant as it was and now weak itself. Yet the emperors persisted in their claim to

be the guardians of the papacy. When John III died, Rome had to wait for ten months before the emperor ratified the election of the new pope, Benedict I, whose consecration had therefore to be deferred all that time.

Pelagius II succeeded Benedict in 579. Under him the papacy began to look in a new direction for a safeguard against the new danger that was threatening both the Holy See and the Italian peoples, for whom the popes now felt themselves more than ever responsible.

The supreme shepherd of the church in the latter half of the 6th century could hardly have hoped for anything more fortunate than the conversion of the Visigothic rulers of Spain from Arianism to Catholicism, which in fact took place during Pelagius' pontificate. But Pelagius also saw that the Lombard danger was assuming ever more threatening proportions. He decided, therefore, to turn to the Franks, who had been Catholics since the time of Clovis. In a letter to the bishop of Auxerre he declared that it was the duty of the Franks, as true believers, to defend Rome and Italy against the "deathly race" of the Lombards. The emperor, himself of little use as a protector, was persuaded by Gregory, the pope's *apocrisiarius* ("nuncio") at Constantinople, to give his consent to Rome's appeal to the Franks, to whom, moreover, subsidies were granted. Halted in their advance, the Lombards took up a defensive position.

When the Franks withdrew and the Lombards became threatening again, Pelagius made another appeal to the emperor. The exarch Smaragdus, imperial representative in Italy, then set himself to renew the understanding with the Franks, whose support now seemed essential to the independence of the papacy. This understanding was afterward to be even closer.

The papacy, however, had undergone many changes of fortune, faced many external dangers, experienced several schisms, felt the abuse of imperial power and been subjected to frustration, to coercion, to acts of war and to the effects of desertion; and its prestige had not escaped unimpaired. In Pelagius' time, though the reigning emperor Maurice was himself well disposed and reasonable in his attitude toward Rome, a dispute arose with regard to the claim of the bishop of Constantinople to the title of ecumenical patriarch, which his predecessors had assumed at the time of the schism of Acacius and which seemed to make him the equal of the pope, if not his superior, since the pope had never claimed that title. Pelagius protested, but Maurice did nothing to make the patriarch John the Faster drop the title, and the pope died without getting satisfaction on the matter.

Gregory, Pelagius' *apocrisiarius* at Constantinople, was elected to succeed him (590). As Leo I in the 5th century, so likewise was Gregory to win the title of "the Great," as one who had not only restored the ancient authority of Peter's see but added new splendour to it. His election constitutes an epoch in the history of the church. (J. ZR.)

II. THE MEDIEVAL PAPACY (590–1304)

1. Gregory the Great and His Successors.—St. Gregory I was one of the most important popes in the history of the papacy. He is also of unusual interest because he is, with St. Leo the Great, the first pope of whose correspondence more than fragments have been preserved. His letters concern all areas of papal influence and furnish a historical basis for a judgment of papal action.

As metropolitan of the Roman ecclesiastical province, Gregory summoned his suffragan bishops to three councils, in 591, 595 and 601. He also kept under close observation the elections of the bishops immediately subject to him. As bishop of Rome he showed an interest in the spiritual welfare of both laymen and clerics; his homilies on the Gospels and his initiatives in the field of the liturgy are the abiding proofs of this. By the year 600, the Roman Church had become one of the great property owners in Italy, and Gregory's correspondence shows how he administered these holdings.

During the second half of the 6th century the Lombards (*q.v.*) had taken over large sections of Italy, and by 592 they were at the gates of Rome. The representative of the empire had fled as they approached, leaving Gregory to organize the defense. In 593 the pope succeeded in buying off the Lombards by agreeing to pay an annual tribute. Although in this Gregory and those of his successors who were forced to take similar action did not aim at separating themselves from due dependence on the emperor, the result was that the people of Rome and the surrounding regions could not but look to the popes as their real protectors and rulers.

In the correspondence of St. Gregory, his action on the church as a whole is also visible. As patriarch of the West, he was the immediate ecclesiastical superior of the archbishops of Milan, Ravenna and Aquileia in Italy; of all those of Greece, the western Balkans, Spain and Gaul; and of all those of Africa outside the patriarchate of Alexandria. In many instances the invasions of the Germanic tribes had disrupted relations between these prelates and Rome. Gregory tried to re-establish communications, and this brought him into relationship also with the Visigothic rulers of Spain and the Merovingian rulers of Gaul.

Gregory had occasion to demand the rights which were his as universal primate. In addition to protesting the assumption by John the Faster, patriarch of Constantinople, of the title of ecumenical patriarch, Gregory dared to oppose the emperor Maurice when he forbade soldiers and officials to enter the clergy or the monasteries. Gregory also showed interest in the missions, his most important step in this area being that which led to the departure in 596 of 40 missionaries for England.

Gregory's attitude toward the emperor was similar to that of most of the popes of the 6th, 7th and early 8th centuries. He had served for a time as papal representative at Constantinople under his predecessor, Pelagius II, and seems to have accepted the domination of the church by the empire without question. The election

TABLE IV.—*The Papacy From 590 to 752*

590–604	Gregory I	678–681	Agatho
604–606	Sabinian	682–683	Leo II†
607 (Feb.–Nov.)	Boniface III	684–685	Benedict II‡
608–615	Boniface IV	685–686	John V
615–618	Deusdedit (otherwise called Adeodatus I)	686–687	Conon
		687 (Sept.)	*Theodore and Paschal, rival antipopes*
619–625	Boniface V	687–701	Sergius I
625–638	Honorius I	701–705	John VI
640	Severinus*	705–707	John VII
640–642	John IV	708 (Jan.–Feb.)	Sisinnius
642–649	Theodore I	708–715	Constantine
649–655	Martin I (d. in exile)	715–731	Gregory II
654–657	Eugenius I	731–741	Gregory III
657–672	Vitalian	741–752	Zacharias
672–676	Adeodatus (II)	752 (March)	Stephen II (d. unconsecrated)
676–678	Donus		

*Elected in 638; consecrated 640. †Elected in 681. ‡Elected in 683.

that made him pope was, as Justinian the Great had made it, subject to ratification by the emperor. Gregory, who feared the burden of the papacy, wrote to the emperor Maurice asking him not to approve. But Maurice approved and Gregory reluctantly assumed the papal office.

The short reigns of Sabinian and Boniface III were followed by that of St. Boniface IV, during which a controversy on the question of Easter arose between St. Columban, Irish missionary to the continent, and the bishops of Gaul. Columban defended his position in a letter to the pope and apparently received the approbation of Boniface.

2. Monothelite Controversy.—After short reigns by Deusdedit, about whom little is known, and Boniface V, remembered chiefly for his assistance to the Christian mission in England, came that of Honorius I, who modeled his pontificate on that of Gregory the Great. He too pushed the evangelization of the Anglo-Saxons, bestowing the pallium on Honorius of Canterbury and Paulinus of York. He also strove to advance the conversion of the Lombards. Praised in his day as a distinguished pontiff, Honorius was subsequently much damaged by his intervention in the Monothelite controversy, when he approved a formula similar to the heresy. (*See* MONOTHELITES.) This later led to sharp dispute on his orthodoxy, on the meaning of papal infallibility and on the relationship between the popes and general councils. Honorius was condemned by the sixth general council (Constantinople, 680–681), a condemnation accepted by Pope Leo II (682) in the sense that "Honorius did not brighten the apostolic see by teachings in accord with apostolic tradition but by unholy betrayal allowed the immaculate faith

to be stained." Honorius' questionable orthodoxy was brought up again at the first Vatican council (1869–70) by opponents of papal infallibility. His defenders deny that the statements of Honorius on this question were official, binding the whole church, and maintain that his teaching was imprudent rather than heretical.

The successors of Honorius refused to accept his doctrine on the question and condemned Monothelitism, a position that caused strained relations between Rome and Constantinople for several decades. Pope Severinus' refusal to accept the Monothelite *Ecthesis* (638) of the emperor Heraclius (*q.v.*) led the emperor to refuse to ratify his election for almost two years; John IV condemned the doctrine; and Theodore I was engaged in disputes on the subject. But it was St. Martin I who was the real victim of the Monothelite controversy. After his election but before he had received the approbation of the emperor, Martin issued in the Lateran synod of 649 a condemnation of the heresy. The emperor Constans II immediately ordered his arrest; he was taken to Constantinople (654), condemned for treason and exiled to the Crimea, where he died after the election of his successor, St. Eugenius I. Eugenius, in spite of pressure from Constans, refused to recognize the Monothelite patriarch of Constantinople. His successor, St. Vitalian, was more conciliatory toward the emperor. Adeodatus took little part in the struggle, which was finally brought to a close by the third Council of Constantinople (680–681) during the reigns of the emperor Constantine IV and Pope Agatho.

3. End of the 7th Century.—The last pope of the century, St. Sergius I, ruled 14 years. After Pope Conon's death (687), the Roman populace proceeded to enthrone two popes, the archdeacon Paschal and the archpriest Theodore. The higher clergy, however, with the support of the army, resisted these attempts and elected Sergius, who soon received the submission of his rivals, the only antipopes of the century. Sergius, however, had to pay to the representative of the Eastern emperor the sum Paschal had promised in case he obtained the papal throne.

When the emperor Justinian II demanded the approbation of the Trullan synod of 692—convoked by the imperial government and unattended by any papal representative—whose decrees accentuated the growing difference between Eastern and Western practice and would have placed Constantinople on a level with Rome ecclesiastically, Sergius refused. He was saved from the fate of Martin I only by the intervention of the Roman populace. Sergius was also interested in the kingdom of the Franks: at the request of Pepin II of Heristal he consecrated St. Willibrord archbishop of the Frisians (695). Sergius had occasion likewise to deal at times with the Anglo-Saxon heptarchy: he baptized Caedwalla, king of the West Saxons, and ordered St. Wilfrid of York restored to his see; he also seems to have approved Brihtwald (Beorhtweald) as archbishop of Canterbury and primate of all Britain.

Gregory I, Honorius I and Sergius I were the important popes of the 7th century, Gregory far surpassing the other two. The papacy was oriented toward Constantinople, whose emperors, while they had the right to ratify the election of the popes, were not able to impose their ecclesiastical policies on Rome, as the troubles of the century show. The power of Constantinople, indeed, was on the decline—partly because of the challenge of the Muslims—and a new Christian power was coming into its own in the Frankish kingdom. Culturally, socially, politically, ritually and, at times, in religious matters, East and West spoke quite different languages; the easterners were contemptuously referred to as Greeks; and it was in the 7th and early in the 8th century that *Romanitas* acquired the suggestion of antithesis to Byzantinism or Grecism which was to become such a vital element in the making of Latin Christendom. *Latinitas* and *Romanitas* came to signify the same thing, denoting on the one hand a religious attachment to the Church of Rome and on the other a kind of historic superiority to Constantinople, an upstart city without historic roots.

At the same time, the frequent pilgrimages to Rome of young and virile western potentates (especially of the English), the missionary work undertaken by the Anglo-Saxons and the genuine veneration of the deeply religious Germanic nations for St. Peter and for his vicar could not but demonstrate to the papacy that, while the East exhibited all the characteristic features of Caesaropapism and hence hostility toward the Roman Church, the West was demonstrative in its manifestation of loyalty to the see of Peter.

Harsh and unjust taxes levied by the imperial regime in Italy, a corrupt officialdom and an ineffective administration increased the popular resentment. As a result of the moribund regime in Italy the popes had steadily assumed a leading role in the affairs of the peninsula. Rome as a historic and ecclesiastical centre came more and more to the fore; it became the rallying focal point.

4. Early 8th Century.—The popes of the early years of the 8th century, still dominated by Constantinople, were often at odds with the emperors. John VI, because of Italian military support, was able to maintain his position despite the emperor Tiberius III and his exarch Theophylact. John VII, who improved papal relations with the Lombards, endeavoured to maintain peace with the emperor Justinian II, who had regained the throne and was again seeking the confirmation of the Trullan synod, by returning the council's decrees without decision. Pope Constantine was summoned to the East but was received with flattering honours at Nicomedia, and the conferences that followed passed off amicably. Justinian II was again overthrown by Philippicus, a Monothelite, in 711. Constantine rejected the Monothelite heresy and was saved from further trouble when the emperor Anastasius II restored orthodoxy in 713.

The pontificate of St. Gregory II launched the troubled period that ended in papal independence from the East. The event that initiated this development was the iconoclastic decree of the emperor Leo III the Isaurian (726). (*See* also BYZANTINE EMPIRE; ICONOCLASTIC CONTROVERSY.) Imperial taxation of papal properties in Sicily was also of some importance in the widening rupture. Papal protests against the Isaurian emperor, who had stopped the Muslim advance in the East as Charles Martel was to do in the West, led to a rising in the duchy of Rome. Although Pope Gregory II wished to maintain the *status quo*, Rome and other cities refused to deal with the emperor, considering themselves subjects of the Holy See; Gregory accepted a kind of sovereignty. His fear of Constantinople and of the Lombards led him to appeal to the Frankish leader Charles Martel for help. The appeal was vain, but it pointed to the future.

Gregory III, succeeding Gregory II, after an attempt to reach an understanding condemned iconoclasm. The emperor Leo III retaliated by confiscating the property of the Roman Church in his domains. Probably also during his reign the churches of southern Italy, Sicily, the western Balkans and Greece were removed from the jurisdiction of the Roman patriarchate and subjected to Constantinople. In his troubles with the Lombard king Liudprand, Gregory III, like his predecessor, appealed (739) to Charles Martel, who again gave no military aid but was able to act as mediator between the pontiff and the Lombards.

St. Gregory III's pontificate has been described as one of the most critical in the history of the papacy. The iconoclasm of the emperor undermined the papal position in the empire while the rise of Frankish power seemed to offer hope of security for the throne of St. Peter. The popes, however, cannot be said to have been responsible for the revolution. Rather, the emperor Leo III, by his policies, forced them to look elsewhere for support.

Zacharias initiated a policy of conciliation with the Lombard kingdom in Italy while endeavouring to turn its rulers from the conquest of the Byzantine exarchate of Ravenna, showing himself in this a friend of the empire. (*See* RAVENNA, EXARCHATE OF.) He had also announced his election to the emperor Constantine V, Copronymus, with whom he was able to maintain friendly relations because during his early years Constantine was more concerned with securing his imperial position than with promoting iconoclasm.

5. The Carolingians and the States of the Church.—Pope Zacharias, who had supported the activities of St. Boniface in reforming the Frankish church, was on terms of cordial friendship with the Frankish kingdom. In 750 an embassy arrived from Pepin the Short, son of Charles Martel, to ask Zacharias if it was right that men who had no royal power (*i.e.*, the puppet Merovingian kings) should have the royal title. Zacharias replied that he who exercised royal power (in this case, the Carolingian mayors of

the palace) should also be called king. As a result of this decision Pepin during the winter of 751–752 had himself proclaimed king and relegated the last of the Merovingians, Childeric III, to a monastery. Pepin had scrupled to take away from the last descendant of Clovis his last possession, an empty title. Zacharias freed the prince from this scruple. (For the history of the supplanting of the Merovingian dynasty, *see* CAROLINGIANS; MEROVINGIANS; MAYOR OF THE PALACE.) Whether or not the reply of the pope was influenced by his own position is not known; but in the duchy of Rome and to a lesser degree in some of the other Byzantine possessions in Italy, Zacharias (like the mayors of the palace) held the power while the distant emperor had the title.

Under Stephen II (III) the course of events led rapidly toward papal independence from Constantinople. The Lombards took over most of the Byzantine possessions in Italy, Ravenna falling *c.* 751. Their aim was now to make Rome the Lombard capital. Since the emperor Constantine V could do nothing to prevent them, Stephen II crossed the Alps, the first pope to do so, and prevailed upon Pepin the Short to come to his assistance in 754 or 755 and again in 756 (when he anointed Pepin as king). Pepin, moreover, gave the territories he won from the Lombards to the pope and thus laid the foundation of the States of the Church; Stephen II was the first pope to be also a temporal sovereign. The role of protector of the papacy had passed to the Frankish ruler. Paul I, Stephen's brother and successor, informed Pepin of his election, as his predecessors had informed the emperor, but did not ask for authorization to be consecrated.

Few episodes in history have given rise to more discussion than the so-called Donation of Pepin, and few episodes can have been of more momentous consequence than the creation of the papal state. The papacy had freed itself from the shackles of the imperial regime at Constantinople and emerged as a nearly independent entity. The constitutional change was accompanied by the introduction of a number of institutional changes in the second half of the 8th century. The decree of the Lateran council of 769, by which an attempt was made to regulate the election of the pope by confining it to the Roman clergy and excluding the laity, was to be the model for the later and more permanent procedure. The dating of papal documents according to imperial years was abandoned. The popes began to strike their own coins.

6. The Western Empire and Emancipated Papacy.—The brief reign of the antipope Constantine II showed that the papacy, having become a throne, was now coveted by temporal rulers. Toto, duke of Nepi, thrust his brother Constantine, a layman, into the papal office. With the Lombards' help, Constantine was dethroned and cruelly treated. But when the Lombards tried to enthrone their own man, Philip, he too was ejected. Stephen III (IV) notified Charlemagne and Carloman, the sons and successors of Pepin, of his election and tried to prevent an alliance between the Frankish and Lombard kingdoms. Unsuccessful, he accepted an alliance with the Lombards (771) that led to the murder of the leaders of the Frankish party in Rome.

The next two popes, Adrian I and St. Leo III, together ruled 44 years and were the pontiffs of the time of Charlemagne. Adrian I was elected with the support of the Frankish party at Rome. Learned, eloquent and of impressive presence, he did not disappoint the high hopes placed in him. In dealing with his puissant protector, however, he had need of much forbearance.

At the beginning of Adrian's pontificate, Desiderius, the Lombard king, while protesting friendship, attacked the papal possessions. Adrian turned to Charlemagne for help. Charlemagne's expedition of 773–774 put an end to the Lombard kingdom and Charlemagne confirmed (774) the Donation of Pepin. Adrian remained faithful to his alliance with the Frankish ruler, who in return exacted submission to his policies, going so far as to interfere in the government of the States of the Church and to accept appeals from papal subjects. Despite this, Adrian I was increasingly aware of his independence. Theologically, however, the understanding was better with Constantinople than it was with Aachen. Adrian confirmed the decisions of the seventh ecumenical council (Nicaea, 787), which condemned iconoclasm. The Council of Frankfurt, called in 794 by Charlemagne, rejected Nicaea without,

ALINARI

POPE LEO III (LEFT) RECEIVING FROM ST. PETER (CENTRE) THE PALLIUM SIGNIFYING SPIRITUAL POWER, WHILE CHARLEMAGNE (RIGHT) RECEIVES THE STANDARD, SIGNIFYING SECULAR POWER. FROM AN 8TH-CENTURY MOSAIC IN THE BASILICA OF ST. JOHN LATERAN, ROME

it is true, fully comprehending its decrees; the faulty Latin translation indicated that icons were to be worshiped. (*See* COUNCIL.) Despite this and other disagreements, however, the pope and king represented for over 22 years the medieval ideal of union of church and state in a united Christendom.

Adrian I died Dec. 25, 795, St. Leo III was consecrated Dec. 27. He informed Charlemagne of his election, sent him the keys of St. Peter's tomb and the flag of Rome, and asked him to send a representative to receive the oath of fidelity of the Romans. The Frankish sovereign replied with benevolence and outlined a program for the pope. Though Charlemagne recognized the church of Rome as superior to all other churches, he considered himself Christendom's head, to whom the pope had to listen, even in matters theological. Leo III, who saw in Charlemagne another Constantine, accepted his domination with better grace than Adrian I had done. This is perhaps explained in part by the circumstances of Leo's reign.

During his early years, Leo III seriously offended some members of the curia, notably the supporters of Adrian I. In the spring of 799, he was assaulted and was half dead when rescued. Leo went for help to Charlemagne, at Paderborn. Letters, in the meantime, had reached the king accusing the pope of grave crimes—adultery and perjury among others. Charlemagne sent the pope back to Rome accompanied by ecclesiastics who were to investigate the charges. At an assembly convoked by the king at St. Peter's in Rome, Leo cleared himself by asserting his innocence in a solemn oath on Dec. 23, 800.

Two days later the coronation of Charlemagne as Roman emperor took place in St. Peter's. Historians disagree about the circumstances of the coronation. It is impossible to accept the tale that it took Charlemagne by surprise and even displeased him. In any event, the coronation symbolized the severance of the empire, which was now two empires. And the papacy was allied with the Western.

The coronation of Charlemagne as "emperor of the Romans" by Pope Leo III can be regarded as the final step in the achievement of independence by the papacy. Charlemagne had not only vastly increased the Frankish territory by military conquest but had also crushed all further resistance on the part of the Lombards by incorporating their kingdom into his own. He was one of those medieval rulers to whom Christianity was a motivating force in all his governmental actions; and hand in hand with this went his profound devotion to the Roman Church as the see of St. Peter in matters of doctrine.

Nevertheless, while the coronation can be regarded as concluding the process of papal emancipation, the papal interpretation of it, according to which, since there was only one emperor of the Romans, the Eastern empire could no longer be in legitimate existence, did not meet with Charlemagne's approval; it would have involved him in a serious conflict with Byzantium, with which he wished to live in amity. Charlemagne therefore gave the coronation a purely religious meaning. He came to hold himself as an emperor of the Roman Christians, since to him *imperium Romanum* and *imperium Christianum* were the same thing. Although from a practical standpoint this Christmas episode had little effect on the contemporary scene, it nevertheless set a powerful historical precedent which later was endowed with an importance quite out of proportion to the actual result. (For the history of the period, *see* further CHARLEMAGNE; HOLY ROMAN EMPIRE.)

When Charlemagne died in 814, the old hatred of the Roman nobility against Leo III reasserted itself. He had a number of conspirators executed but submitted an account of this action to Charlemagne's son and successor Louis I the Pious. Leo died not long afterward on June 12, 816.

TABLE V.—*The Papacy From 752 to 900*

752–757	Stephen II (III)	*855*	*Anastasius Bibliothecarius of San Marcello, antipope*
757–767	Paul I	858–867	Nicholas I
767–768	*Constantine II, antipope*	867–872	Adrian II
768 (July)	*Philip, antipope*	872–882	John VIII
768–772	Stephen III (IV)	882–884	Marinus I (miscalled Martin II)
772–795	Adrian I	884–885	Adrian III
795–816	Leo III	885–891	Stephen V (VI)
816–817	Stephen IV (V)	891–896	Formosus
817–824	Paschal I	896 (April)	Boniface VI
824–827	Eugenius II	896–897	Stephen VI (VII)
827 (Aug.–Sept.)	Valentinus	897 (Aug.–Nov.)	Romanus
827–844	Gregory IV	897 (Nov.–Dec.)	Theodore II
844 (Jan.)	*John, antipope*	898–900	John IX
844–847	Sergius II		
847–855	Leo IV		
855–858	Benedict III		

7. Early 9th Century.—The short reign of Stephen IV (V) is remarkable for the deference shown by the pope to the emperor Louis I the Pious. Stephen IV had the Roman people take an oath of fidelity to Louis, informed the emperor of his election and asked to meet him in Gaul. Equally important, however, is the fact that at Reims in Oct. 816 Stephen crowned Louis and his consort as emperor and empress; at this time also occurred the first anointing of the emperor by the pope. The role of the papacy as the agency which made emperors—symbolized by the coronation and anointing—became one of its most treasured prerogatives. It was a role that also suited the Western kings, to whom the title of Roman emperor gave an immeasurably enhanced standing. The Franks as successors of the Roman Caesars was a theme that conveniently bridged the gulf between religious Romanism (adherence and loyalty to the Roman Church) and political Romanism (the resuscitation, rebirth and continuation of the ancient Roman empire). Much of the papal edifice was erected upon this ground. The emperor made by the pope was, according to the papal theory of government, a lieutenant, an assistant, the secular arm.

Naturally enough, the papal role in the making of emperors was not accepted by the Eastern emperors, who, crowned as they were by their own patriarchs, considered the papal power as confined to things ecclesiastical; but, as later conflicts between papacy and Western empire were to show, the corollaries of the papal claim were not always acceptable to the Western emperors either. The Western emperors, indeed, in contrast with the Byzantines, found themselves in an inescapable dilemma. On the one hand, it was axiomatic for them that only the pope could validly confer universal (Roman) imperial power; on the other hand, they disputed the implicit superiority of the popes, maintaining a theory of the papacy which resembled that upheld by the Byzantines.

Three months after his return to Rome from Reims, Stephen died. The reign of his successor, St. Paschal I, was marked by the same submissiveness to Louis, who confirmed the donations of his father and grandfather to the Holy See. Paschal crowned Louis I's oldest son, Lothair I, as co-emperor in 823. This was the first occasion on which a sword was handed to the emperor by the pope during the coronation ceremony as a symbol of that physical power which was to suppress evil.

When leaders of the Frankish party at the curia were killed, Paschal was required to clear himself by an oath. Eugenius II, Paschal's successor, was elected with the support of the Roman nobility and the Frankish party in the curia and in spite of the opposition of the Roman populace. He too sent word of his election to Louis I, who dispatched Lothair I to remedy the disorders which had occurred under Paschal I. According to the *Constitutio Romana* issued by Lothair in 824, imperial sovereignty over the papacy was affirmed; a pope after his election but before his consecration would in the future swear fealty to the emperor. Gregory IV, elected after the very brief pontificate of Valentinus, awaited the approval of the imperial representative before his consecration. He gained in independence, however, when Louis I and his sons chose him as arbiter in their disputes. Unfortunately Gregory was not able to maintain peace in the imperial family, and his support of Lothair helped the latter in his deposition of Louis the Pious (833), a deposition that was reversed a year later. During Gregory's reign the Saracens of Africa and Spain became a serious menace to Italy, and the Normans began sending formidable forces into the empire. These troubles, while they increased the independence of the States of the Church, also rendered them far less secure.

Sergius II was elected to succeed Gregory by the Roman nobility against the wishes of the populace, which enthroned an antipope, John. Sergius did not await approbation but had to submit his election to Louis II, son of Lothair I, and agree that no one could become pope without the emperor's consent. Sergius, who was dominated by his brother Benedict, bishop of Albano, lived in a time of disaster. In 846 the Saracens advanced to the walls of Rome, pillaged St. Peter's and St. Paul's and retired with much booty.

St. Leo IV did not await imperial approbation for his election. He constructed a high wall around the part of Rome on the right bank of the Tiber, henceforth known as the Leonine city. Leo defeated the Saracens in a naval battle in 849 and fortified Civitavecchia. He crowned Louis II co-emperor in 850. After the death of Leo and the election of Benedict III, Anastasius Bibliothecarius, one of the most learned men of the age, excommunicated during the pontificate of Leo, tried to capture the papal throne with the aid of Louis II. The resistance of the Romans was so vigorous, however, that the imperial government had to recognize Benedict. His policy of peace brought a relaxation of tensions.

The legend that a woman reigned as pope between Leo IV and Benedict III has no foundation in fact and has long been discredited. (*See* JOAN, POPE.)

8. Nicholas the Great.—St. Nicholas I is one of only three popes styled "the Great." He ranks with Leo the Great and Gregory the Great in his conception of the prerogatives of the Roman pontiff. Nicholas had been elected as the candidate of the emperor Louis II but as pope showed himself quite independent. He reacted against Carolingian domination in ecclesiastical matters: it was the pope's duty, not that of the emperor, to settle doctrinal disputes, and he claimed the right to legislate for the whole of Christendom. In Nicholas' view the pope was also the supreme judge. Major disputes, especially those involving bishops, were to be judged by him, and he could accept appeals from lesser ecclesiastical courts; this was illustrated by his reinstating Rothad of Soissons, deposed by Hincmar (*q.v.*) of Reims. Nicholas carried out these principles in the case of the divorce of Lothair II, king of Lorraine (brother to the emperor Louis II), in which

the pope not only treated the monarch as his ecclesiastical subject but deposed the archbishops of Cologne and Trier who had supported the divorce. He also made use of his conception of the papal plenitude of power against John, archbishop of Ravenna, and against Photius, whose election as patriarch of Constantinople violated the canons. Photius refused to submit and took occasion from the efforts of Nicholas I to attach the Bulgarians to the Roman patriarchate, to declare the pope deposed (867). (*See* further NICHOLAS; PHOTIUS.)

The short pontificate of Nicholas I was the most important of the Carolingian period and prepared the way for the reform popes of the 11th century.

9. Late 9th Century.—Adrian II could not maintain the position to which Nicholas I had elevated the papacy. Lacking continuity and decision, he was rebuffed by Charles II the Bald and Hincmar of Reims. Because of a change in rulers, however, Constantinople yielded to him; Photius, who had been condemned by a Roman council (869), was likewise condemned by a council held in Constantinople (869–870). Adrian was not able to keep Bulgaria in his immediate resort, but he won for the Western church the Slavs evangelized by Cyril and Methodius, by making Methodius his legate and permitting the use of Slavic in the liturgy. (*See* also CYRIL AND METHODIUS, SAINTS.)

The pontificate of his successor, John VIII, a man of talent and energy, was one of misfortune. John devoted himself to the defense of Italy against the Saracens without much assistance from the emperors Louis II, Charles the Bald and Charles III the Fat. He was harassed by the future pope Formosus and other members of his entourage. John unwisely sanctioned the second installation of Photius as patriarch of Constantinople and, against the desires of the German bishops, protected St. Methodius and repeated the sanction of the liturgical use of the Slavic language.

The last 18 years of the 9th century were years of short pontificates and much intrigue. The reign of Marinus I is remarkable chiefly for the fact that Marinus apparently had been a bishop before his accession to the papacy; this was unusual because the church of the time was loath to allow a bishop to move from a minor see to a more important one. Stephen V (VI) was consecrated before receiving the approval of Charles the Fat, who was angered but in time gave in (and was himself deposed not long afterward). The pope preferred Arnulf (*q.v.*) of the East Franks as emperor, but circumstances forced him to crown Guy of Spoleto (891). During this pontificate the opponents of the Slavs were able to bring about the prohibition of the Slavic liturgy.

Formosus, the stormiest petrel in papal history, had been before his accession bishop of Porto, legate to Bulgaria and object of laicization by John VIII. As pope he, like Stephen V, was a partisan of Arnulf but was obliged to crown Lambert of Spoleto, Guy's son, as co-emperor. When, however, Arnulf crossed the Alps and made himself master of northern Italy, Formosus abandoned the Spoletans and crowned Arnulf emperor (896). Shortly afterward the newly crowned emperor was stricken with paralysis and Formosus died. But even in death he was to be the cause of dissension. Boniface VI reigned only a fortnight and his successor Stephen VI (VII) was a partisan of Lambert of Spoleto, who now gained control of northern Italy. Under Stephen VI members of the curia disinterred the body of the hated Formosus and instituted a trial of his cadaver. Formosus' person was condemned, his election as pope and his ordinations were declared null and he was degraded posthumously from the priestly order. His corpse was then thrown into the grave of strangers, whence the people dragged it to cast it into the Tiber. This ghastly procedure led to a revolt and to the imprisonment and strangulation of Stephen. Romanus reigned for about two months and was succeeded by Theodore II, who, during a 20-day pontificate, gave Formosus, whose body had been recovered, a solemn funeral and revalidated his ordinations. John IX, whose election was disputed by the future Sergius III, confirmed the acts of Theodore in favour of Formosus.

The trial of a dead pope casts a shadow over the last years of the 9th century and over the early decades of the 10th. But the whole period was far from brilliant in papal history. The subservience of most of the 9th-century popes to the Carolingian emperors was not in the best traditions of the West. Nicholas I was the sole pontiff who was able to enforce the principles of Leo I.

10. 10th Century.—The 10th century was a difficult one for the papacy, which, with the extinction of the Carolingian house, was dominated first by the Roman nobility and later by the German emperors. So thorough was this subjection that throughout the century most of the popes were appointed, though the appearance of elections was maintained. In the first half of the century the house of Theophylact—represented first by Theophylact, a nobleman and governor of Ravenna, and his wife, Theodora, and her daughters, Theodora and Marozia, and later by Marozia's son Alberic—were in command. Later the emperors Otto I, II and III were dominant, with some competition from the Crescentii.

Benedict IV, during his brief reign, crowned the emperor Louis III (901). Leo V, about whom little is known, reigned for about two months in 903 and was driven out by the antipope Christopher, who in turn was deposed in 904 by Sergius III, who earlier had disputed the election with John IX. Leo and Christopher were presumably murdered. Theophylact became master of the wardrobe and virtual dictator of the papal administration.

Sergius again declared the ordinations of Formosus invalid. His successors, Anastasius III and Lando, reigned for slightly more than two years, subject to Theophylact. John X, another anti-Formosan, organized the defense of Italy against the Saracens and even led the papal troops in battle (916). He fell out of favour with Marozia, now the head of the Theophylact clan, who imprisoned and probably killed him. Pope John XI, said to have been the son of Marozia and Sergius III, was a tool of his mother until 933, when Alberic II, his brother, took the power away from Marozia and imprisoned both her and the pope. From that time till his death in 954, Alberic chose the popes. His choices, Marinus II and Agapetus II, were both men of value. They favoured, for example, the rise of the abbey of Cluny, and indeed St. Odo, abbot of Cluny, was called to Rome to help with reform.

Before his death Alberic made the Romans swear to elect his son, Octavian, when Agapetus died. In 955 this promise was fulfilled and the young man became John XII. His conduct as pope was scandalous and his politics unsuccessful. In Feb. 962 he crowned the German king Otto I Holy Roman emperor and obtained from him a confirmation and extension of the temporal powers of the papacy, the so-called Ottonian privilege (*Privilegium Ottonianum*). But a proviso to the Ottonian privilege gave the emperor power of ratification over papal elections.

TABLE VI.—*Popes of the 10th Century*

900–903	Benedict IV	946–955	Agapetus II
903 (July–Sept.)	Leo V	955–964	John XII (deposed Dec. 963)
903–904	*Christopher, antipope*	963–965	Leo VIII*
904–911	Sergius III	964–966	Benedict V* (deposed June 964)
911–913	Anastasius III	965–972	John XIII
913–914	Lando	973–974	Benedict VI
914–928	John X	*974 (June–July)*	*Boniface VII, antipope (expelled)*
928 (May–Dec.)	Leo VI	974–983	Benedict VII
929–931	Stephen VII (VIII)	983–984	John XIV (deposed)
931–935	John XI	*984–955*	*Boniface VII returned)*
936–939	Leo VII	985–996	John XV
939–942	Stephen VIII (IX)	996–999	Gregory V
942–946	Marinus II (miscalled Martin III)	*997–998*	*John XVI, antipope*

*Rival popes, one or other of whom may be regarded as an antipope.

The pope and the emperor soon quarreled. Otto had John deposed and replaced by Leo VIII (Dec. 963). When Otto's duties took him away from Rome, John again obtained control of the city and took vengeance on his foes. Leo fled (Feb. 964). John died (May) before Otto I returned to Rome, and the Romans immediately elected Benedict V. Otto had Benedict deposed and sent into exile while he restored Leo VIII (June). (*See* also OTTO I the Great.)

John XIII owed his office to Otto I, who in 966 had to rescue him from the Romans. John crowned Otto II as co-emperor in 967 and his Greek wife Theophanu as co-empress in 972. Benedict VI awaited the approval of Otto I before receiving consecration and was a protégé of the emperor. When Otto II succeeded his father in 973, Benedict was overthrown and murdered (974) by

order of Crescentius I (*see* CRESCENTII), a son of the younger Theodora, who installed the murderer as antipope under the name of Boniface VII. But the envoy of Otto II expelled Boniface and presided at the election of Benedict VII, who showed himself the devoted servant of the emperor. When Benedict died, Otto made his Italian chancellor pope under the name of John XIV. Otto died soon afterward and Crescentius II recalled Boniface VII, who imprisoned and presumably murdered John XIV. Boniface, the murderer of two popes, died suddenly the following year (985), and his corpse was mutilated by the populace. John XV, the candidate of Crescentius II, carried out the first solemn canonization in history, that of St. Ulrich of Augsburg (993). He eventually appealed to Otto III against Crescentius but died before the emperor could intervene.

Otto III named as John XV's successor the first German pope, his 23-year-old cousin Bruno, who took the name Gregory V and immediately crowned the emperor (May 21, 996). When Otto was called back to Germany, Crescentius stirred up a revolt and Gregory had to flee Rome. An antipope, John XVI, was installed but Otto returned (998) and a reign of terror ensued. John XVI was treated with savage brutality and deposed; Crescentius was decapitated. Gregory V died after a short reign and Otto chose as his successor Gerbert of Aurillac, a Frenchman, a learned man and a devoted servant of the emperor, who took the name Silvester II. The first French pope's reign was also brief; in history he is remembered chiefly for his many accomplishments before ascending the papal throne. (*See* also OTTO III.)

11. 11th Century.—With the death of Otto III the power in Rome passed to Crescentius III, who made John XVII pope. After six months he was succeeded by John XVIII, whose activities were confined by Crescentius to the spiritual sphere. Crescentius died in 1012 and the counts of Tusculum, descendants of Alberic II, took over in Rome. Benedict VIII, of this family, succeeded Sergius IV, the last appointee of the Crescentii. Benedict crowned Henry II as emperor (1014) and defeated the Saracens when they attacked northern Italy but was unable to prevail against the Greeks, who were still powerful in southern Italy. Both pope and emperor were zealous in the cause of ecclesiastical reform. When Benedict VIII died his brother Romano, a layman, seized the papal throne, receiving all the orders in a single day and taking the name of John XIX. He crowned Conrad II emperor in 1027. Neither Conrad II nor John was interested in reform.

TABLE VII.—*Popes of the 11th Century*

999–1003	Silvester II	1047–48	Benedict IX (restored)
1003 (June–Dec.)	John XVII	1048 (July–Aug.)	Damasus II
1004–09	John XVIII	1049–54	Leo IX
1009–12	Sergius IV	1055–57	Victor II
1012–24	Benedict VIII	1057–58	Stephen IX (X)
1012 (May–Dec.)	*Gregory, antipope*	*1058–59*	*Benedict X, antipope*
1024–32	John XIX	1059–61	Nicholas II
1032–45	Benedict IX (resigned)	1061–73	Alexander II
1045 (Jan.–March)	Silvester III	*1061–72*	*Honorius II (Peter Cadalus), antipope*
1045 (April–May)	Benedict IX (deposed)	1073–85	Gregory VII
1045–46	Gregory VI	*1080, 1084–1100*	*Clement III (Guibert of Ravenna), antipope*
1046–47	Clement II	1086–87	Victor III
		1088–99	Urban II

Benedict IX, who figures in the official list of the popes three times, was another member of the house of Tusculum and probably in his 30s when he first ascended the papal throne. His conduct as pope eventually led to a revolt. Benedict fled and was replaced (Jan. 1045) by Silvester III. Benedict returned, however, expelled Silvester and sold the papacy (May) to John Gratian, who took the name Gregory VI. At this juncture the German king, Henry III, came to Italy, and at the synod of Sutri (Dec. 1046) caused Silvester, Gregory and Benedict to be deposed and imposed Suidger, bishop of Bamberg, as Clement II. Clement at once crowned Henry with the imperial crown. But Clement died in Oct. 1047 and Benedict IX for the third time returned to the papal throne, on which he was able to maintain himself until the following year when Henry III imposed the bishop of Brixen as Damasus II. Damasus, however, lived less than a month as pope. Henry then nominated his relative Bruno, who took the name Leo IX.

Leo had been bishop of Toul for more than 20 years and had given proof of prudence and wisdom; his nomination by Henry was ratified by the unanimous consent of the Romans. As early as April 1049, Leo held a synod at Rome in which he condemned simony and the marriage of priests. Similar synods were held by him at Pavia, Reims and Mainz in 1049. Leo renewed the Roman curia by introducing exceptionally able men into its ranks. He was unable to avoid the break with Constantinople (1054), though he tried to get the help of the Eastern emperor in his struggle with the Normans, against whom he led a papal army in person. Though he was captured and held prisoner by the Normans, an important step in the strengthening of the papacy was taken when they swore fidelity to him. Leo IX, who is honoured as a saint, had the merit of putting the papacy at the head of the reform movement in the church. On one point, however, he failed to take a firm stand, viz., on lay investiture.

Victor II, who had been bishop of Eichstädt, was nominated in Sept. 1054 by Henry III and enthroned in April 1055. He continued the reform in the manner of Leo IX. Henry III died in Oct. 1056 and Victor II followed him to the grave in July 1057.

The combination of the premature death of Henry III with the fact that his successor, Henry IV, was but a minor and with the ascendancy in the Roman curia of highly gifted men resulted in the first concrete steps directed against imperial domination of the church. Cardinal Frederick of Lorraine was elected pope in Aug. 1057 without consultation with the civil power. He took the name Stephen IX (X) and sent Hildebrand, the future Gregory VII, to notify the empress-regent, Agnes. A beginning in the effort to free the papacy from imperial control was thus made.

After Stephen IX's early death, the Roman nobility, eager to secure control of the papacy, brought about the election of an antipope, Benedict X, who maintained himself for nine months. Through the efforts of Hildebrand and the empress-regent, Gerard, bishop of Florence, was elected as Nicholas II. In a Lateran synod of 1059, Nicholas not only condemned clerical marriage and other abuses but by a decree, of which two versions have come down, expressly forbade lay investiture of bishops and of abbots, stipulated that the election of the pope must proceed "canonically" (*i.e.*, with imperial influence excluded) and established the composition of the electoral body. (*See* also CONCLAVE.) This electoral body was subsequently to become the College of Cardinals, in whose hands alone the choice of the vicar of St. Peter lay. (*See* further NICHOLAS: *Nicholas II.*)

Nicholas II's decree is of prime importance for the medieval centralization of the Latin church and for the contest between empire and papacy which it began. Nicholas was also the first pope to rely on the power of the Normans in southern Italy. He favoured the Patarines, a popular party in Milan dedicated to reforming the corrupt, aristocratic higher clergy of the city. It was the decree on papal elections, however, which gave this brief pontificate importance.

Through the efforts of Hildebrand and the reform party, Anselm, bishop of Lucca, one of the founders of the Patarines, was elected as Alexander II. The partisans of Benedict X, however, with imperial support, proceeded to elect Peter Cadalus of Parma as antipope under the name Honorius II. It was not until 1064 that Alexander II was recognized by the empire. Alexander renewed the decrees against simony (for which he deposed the bishop of Milan) and marriage of the clergy, prohibited attendance at the Mass of an incontinent priest and again forbade lay investiture. In 1066 he blessed the invasion of England by William I the Conqueror. Although approving of the aims of the Patarine party, Alexander had to restrain its excesses in Milan and Florence.

12. Curial Changes and Canon Law.—Many changes took place in the Roman curia during the 1050s and 1060s. The residence of the popes, the Lateran palace, was reconstituted; old offices merged into new ones or decayed altogether; the chancery (the pope's secretariat) with its numerous special officers, the financial departments, the judicial tribunals, etc., were put on a new footing. A feature previously reserved to royal courts now also entered into the service of the curia, namely feudalism. Nicholas II enfeoffed the Normans in 1059, the beginning of a long line of feudal contracts concluded between the curia and kings, princes,

etc., so that by the end of the 12th century the papacy had more feudal vassals than any other European power. In these contracts St. Peter, acting through the pope, was envisaged in the role of a feudal lord giving protection to his vassals, who enjoyed certain privileges in return for military services or money payments.

It was also at this time that the breach with Constantinople (1054) became final, as a result of the abortive mission of the Burgundian Cardinal Humbert. Himself one of the great driving spirits in the Roman curia, Humbert was also the author of an influential collection of decrees, the first collection of canon law in the later medieval sense. Its characteristic feature, as also that of the subsequent collections, was its orientation on the primacy of the Roman Church. The attention given to law in this same period is noteworthy. Hildebrand as a member of the curia, long before he became pope as Gregory VII, appreciated the vital importance for governmental and constitutional purposes of a fixed body of law; for how else, if not by law, was the whole church to be governed? The new movement, necessitated by the ascendancy of the papacy itself, reached its preliminary conclusion in the middle years of the 12th century with the publication of Gratian's *Decretum*. (*See* CANON LAW.)

13. Gregory VII.—After the death of Alexander II, Gregory VII was elected. As Hildebrand he had been the leader of the reform party. Bringing to the service of ecclesiastical renewal unusual powers of government and extraordinary tenacity, he began his work for the revival of the church by forbidding not only simony and incontinence of the clergy but also lay investiture, which, since it subjected the church to the secular power, had been forbidden also by his two immediate predecessors. Gregory's insistence on this prohibition led to violent opposition, especially in Germany where the emperor Henry IV even had the pope declared deposed. On Henry's challenging his authority, Gregory excommunicated him. Henry was obliged to seek absolution from the pontiff at Canossa in 1077. "He came," wrote Gregory,

> with a small escort, showing neither hostility nor boldness, to the town of Canossa where we were staying. And having laid aside all the trappings of royalty, with bare feet, clad in wool, he continued for three days to stand before the gate of the castle. Nor did he desist from imploring with many tears the aid and consolation of apostolic mercy until he had moved all who were present there . . . to such pity and deep compassion that, interceding for him with many petitions and tears, all wondered at the unaccustomed hardness of our heart. . . . Finally we loosed the bond of excommunication and received him back into communion.

Canossa has often been looked upon as the symbol of the subjection of the lay to clerical power. Others, however, have seen in it a victory for Henry IV, who did not live up to his promises and eventually forced Gregory into exile at Salerno where he died in 1085 while an antipope, Guibert of Parma, ruled at Rome as Clement III. Gregory's action, however, inaugurated a program which was carried out and eventually led to liberty of the church.

St. Gregory VII promoted the spiritual regeneration of Christendom by measures increasing the centralization of the Latin church. He endeavoured to establish closer relations between Rome and the episcopacy of the West by obliging archbishops to come personally to Rome to receive the pallium. He transferred some kinds of ecclesiastical litigation from archiepiscopal to Roman courts. He supervised the election of bishops and demanded an account of their administration. Gregory also looked to the Normans of southern Italy for support against the empire. It was, however, his courageous struggle against lay investiture which has led not a few historians to look upon him as the greatest of the popes. (For details of the struggle between Gregory and Henry, *see* GREGORY: *Gregory VII;* HENRY: *Henry IV.*)

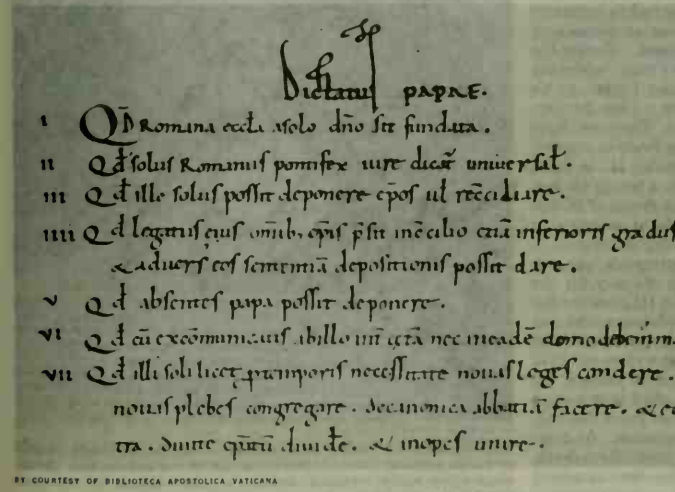
14. End of the 11th Century.—Victor III, Gregory's successor, spent the greater part of his short reign in making up his mind whether or not to function as pope. His successor, Urban II, had always been a partisan of reform, and his aims were those of Gregory VII. In 1089 he promulgated canons against simony, lay investiture and clerical marriage. Urban II initiated the medieval crusades, which further enhanced papal power and made Western Christendom conscious of papal leadership. (*See* CRUSADES: *Causes.*)

The history of the 11th-century papacy falls into two parts. The first period is one of decadence due to the domination of the civil power. The accession of the emperor Henry IV while still a child gave the church a chance to shake off the shackles of lay imperial control, and in the ensuing struggle St. Gregory VII is the greatest name.

15. 12th Century.—Paschal II, like his immediate predecessor Urban II, had been a Cluniac monk and had distinguished himself by zeal for reform. His reign was marked by inconclusive struggles with the emperors Henry IV and Henry V over lay investiture, for which Henry I of England at this time substituted the feudal oath. Gelasius II, after a brief reign, died at Cluny, where Guy, archbishop of Vienne, was elected and took the name Calixtus II. He was able to bring to a close the long struggle over lay investiture by the Concordat of Worms (1122), which secured peace between the church and the empire for 35 years. (*See* also HENRY: *Henry V.*) Calixtus summoned the first Lateran council (1123), which ratified the concordat and promulgated a number of reforming canons.

At Rome the rival houses of Frangipani and Pierleoni were struggling for control of the papacy. Honorius II, who became pope with the aid of the Frangipani—there was some dispute about the election but Celestine II, who had also been elected, resigned in Honorius' favour—was unsuccessful in his attempt to prevent the establishment of a Norman kingdom in southern Italy.

Innocent II's reign was troubled for years by the schism of Anacletus II. Innocent made peace with the Normans, who in return acknowledged that their possessions in Sicily and southern Italy were papal fiefs. During this reign another source of confusion arose. For half a century the cities of northern and southern Italy had been trying to rid themselves of the yoke of feudal masters. (*See* COMMUNE [MEDIEVAL]: *Italy.*) Innocent


Dictatus papae.

I Quod Romana ecclesia solo domino fundata.

II Quod solus Romanus pontifex iure dicatur universalis.

III Quod ille solus possit deponere episcopos vel reconciliare.

IIII Quod legatus eius omnibus episcopis presit in concilio etiam inferioris gradus. Et quod contra eos sententiam depositionis possit dare.

V Quod absentes papa possit deponere.

VI Quod cum excommunicatis ab illo inter cetera nec in eadem domo debemus manere.

VII Quod illi soli licet pro temporis necessitate novas leges condere. Novas plebes congregare. De canonica abbatiam facere. Et econtra. Diuites egenum dimittere. Et inopes imperes.

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FIRST SEVEN OF THE "27 SENTENCES" OF GREGORY VII'S DICTATUS PAPAE

II had trouble with insurgents in Tivoli who wanted to organize a republic. In Rome itself the ancient senate was revived and the Romans refused to submit to the pope. Innocent II in the second Council of the Lateran (1139) took a further step toward Roman centralization of the church when he made the first reservation of an excommunication to the Holy See—that incurred by violence against a monk or cleric.

During the short pontificates of Celestine II and Lucius II, the crisis brought on by the communes persisted. Lucius II was

TABLE VIII.—*Popes of the 12th Century*

1099–1118	Paschal II	1144–45	Lucius II
1100	*Theoderic of Santa Rufina, antipope*	1145–53	Eugenius III
		1153–54	Anastasius IV
1102 (Feb.–March)	*Albert of Sabina, antipope*	1154–59	Adrian IV
1105–11	*Silvester IV (Maginulf), antipope*	1159–81	Alexander III
		1159–64	*Victor IV (Octavian of Monticelli), antipope*
1118–19	Gelasius II	*1164–68*	*Paschal III (Guido of Crema), antipope*
1118–21	*Gregory VIII (Maurice of Braga), antipope*	*1168–78*	*Calixtus III (John of Struma), antipope*
1119–24	Calixtus II	*1179–80*	*Innocent III (Lando of Sezza), antipope*
1124–30	Honorius II		
1124 (Dec.)	*Celestine II (Theobald), antipope*	1181–85	Lucius III
		1185–87	Urban III
1130–43	Innocent II	1187 (Oct.–Dec.)	Gregory VIII
1130–38	*Anacletus II (Pierleone), antipope*	1187–91	Clement III
		1191–98	Celestine III
1138 (March–May)	*Victor IV (Gregory), antipope*	1198–1216	Innocent III
1143–44	Celestine II		

wounded while spurring on papal troops in the struggle against the revolutionaries and died of his wounds. His successor, Eugenius III, a disciple of St. Bernard of Clairvaux, found Rome in a state of anarchy, and his whole reign was troubled by the revolutionaries who made their leader, Arnold (*q.v.*) of Brescia, the real ruler of the city. Eugenius was also the pope of the lamentable second crusade. Anastasius IV, elderly at the time of his election, reigned only a year and a half and was succeeded by Adrian IV (Nicholas Breakspear), the sole English pope. The Romans immediately summoned him to renounce his temporal power, but Adrian was able to maintain himself. When Frederick I Barbarossa came to Italy, Adrian exacted full homage before crowning him emperor (1155). Frederick broke the power of the Roman commune temporarily, and Arnold of Brescia was executed. Adrian IV renewed the peace with the Normans of southern Italy. His claim that the emperor held his crown as a *beneficium* from the pope precipitated the quarrel between Frederick Barbarossa and the Holy See which was to trouble the following pontificate. (*See* also FREDERICK I.)

Against Alexander III Frederick set up antipopes (Victor IV, Paschal III, Calixtus III, Innocent III) and maintained his schism for 17 years. In the end, however, the emperor had to surrender in the peace of Venice (1177), almost as famous an instance of the subjection of civil to clerical power as Canossa. During the schism Alexander III lived much of the time in France, where the actions of the archbishop of Canterbury, Thomas Becket, in his struggle with King Henry II, embarrassed him. (*See* BECKET, THOMAS [A]; CLARENDON, CONSTITUTIONS OF.) The pope, however, was firm in imposing penance on Henry for Becket's murder. The third Lateran council, assembled by Alexander III in 1179, vested the exclusive right of electing the pope in a two-thirds majority of all the cardinals, an improvement on the decree of Nicholas II of 1059. Alexander also withdrew the right of canonization from the bishops, a further step in the centralization process.

Lucius III, with the consent of Frederick Barbarossa, promulgated a decree against heretics which prepared the way for the medieval Inquisition. During the reign of Urban III occurred the marriage of Henry VI, Barbarossa's son, with Constance, who was nearest in line to the crown of Sicily, a marriage that opened the way for Hohenstaufen domination of southern as well as northern Italy. It was resented by Urban as an attempt to encircle the papacy. Gregory VIII, a friend of the emperor, died after a reign of two months. Clement III espoused a policy of peace not only with the emperor but also with the Roman commune. As a result he was able to return to Rome and remain there till his death. During this reign the unsuccessful third crusade—the crusade of the kings—took place.

Celestine III was 85 at the time of his election. His indecision allowed Henry VI to unite Sicily to the German empire. (*See* also HENRY: *Henry VI.*)

16. Innocent III and His Successors.—The 13th century opens with the pontificate of Innocent III, one of the most gifted men ever to rule as pope. (*See* INNOCENT: *Innocent III.*) The popes, following the principles of Gregory VII, had by this time become the nonpolitical presidents and effective heads of Western Christendom. Since the papal blessing was the surest way to guarantee title to temporal rule, the local princes found it expedient to submit to the popes. The early death of the emperor Henry VI gave Innocent III a relatively free hand in dealing with the empire; indeed, he was able to enforce his policies throughout western Europe. The fourth Lateran council (1215), the high point of Innocent's reign, stressed the solidarity of the Christian peoples, condemned heresy and introduced the episcopal Inquisition. (*See* also COUNCIL: *Councils of the Western Church: Fourth Lateran Council [1215].*)

The religious complexion of the 13th century would have been radically different but for Innocent III. Itinerant preaching and apostolic poverty, hitherto regarded as sure signs of heresy, were given a legitimate standing—a policy that led to the recognition of the mendicant orders, notably the Franciscans and the Dominicans under Honorius III. Some successful attempts were made to bring heretical sects back into the church; but severe measures were taken against those sects (for example the Albigenses) which the pope was unable to bring back. (*See* CATHARI.) The Lateran council enjoined annual oral confession to the parish priest. The episcopate was firmly controlled, as the papacy intervened more and more in the filling of vacant sees; and the Lateran council limited the power of bishops in granting indulgences.

Papal legislation reached unprecedented heights, giving a great impetus to canon law scholarship; and litigation at the papal tribunal was encouraged. The pope intervened on several occasions in the affairs of kings (notably in the matrimonial affairs of Philip II Augustus of France, of Peter II of Aragon and of Alfonso IX of León); and the case of John of England provides an example of the use of interdict over a whole country together with personal excommunication in order to bring pressure on a recalcitrant prince. The papal state, meanwhile, had been re-established; and

BY COURTESY OF THE VATICAN MUSEUMS

POPE INNOCENT III, FROM A 13TH-CENTURY FRESCO IN THE LOWER CHURCH OF SACRO SPECO AT SUBIACO, ITALY. CRADLE OF THE BENEDICTINE ORDER; INSCRIPTION BELOW STRESSES INNOCENT'S MANY FAVOURS TO THE BENEDICTINES

the relations between the papacy and Sicily were clarified. Furthermore, Bulgaria (1204) and England (1213) were made feudal dependencies of the papacy, and papal suzerainty over Portugal was reaffirmed.

In the complicated conflict between the papacy and the two claimants to the imperial throne, Frederick II and Otto IV, the pope showed his diplomatic superiority. In the midst of the conflict the fourth crusade was launched. When the crusaders captured Constantinople (1204), a Latin patriarchate was erected and for a short time the Roman primacy over Constantinople became a reality.

Innocent III died suddenly in 1216. His successor, Honorius III, long before his accession, had centralized papal finance and made the papacy a financial power. In general he continued the policies of his predecessor, though less vigorously. He crowned Frederick II, whose tutor he had been, as emperor (1220).

Gregory IX, a nephew of Innocent III and a friend of St. Francis of Assisi, brought the medieval Inquisition under papal control, a move which restricted the power of the bishops considerably in

TABLE IX.—*Popes of the 13th Century*

1198–1216	Innocent III	1276 (Jan.–June)	Innocent V
1216–27	Honorius III	1276 (July–Aug.)	Adrian V
1227–41	Gregory IX	1276–77	John XXI
1241 (Oct.–Nov.)	Celestine IV	1277–80	Nicholas III
1243–54	Innocent IV	1281–85	Martin IV
1254–61	Alexander IV	1285–87	Honorius IV
1261–64	Urban IV	1288–92	Nicholas IV
1265–68	Clement IV	1294 (July–Dec.)	Celestine V (resigned)
1271–76	Gregory X	1294–1303	Boniface VIII

matters concerning the faith, another and very important step in the centralizing process. Politically Gregory IX's reign was a struggle against the emperor Frederick II, who was besieging Rome when the aged pontiff died. (*See* further GREGORY: *Gregory IX;* FREDERICK II.)

After the brief (less than a month) pontificate of Celestine IV, Innocent IV succeeded to the papal throne. A distinguished canonist, Innocent IV pursued the policies of Innocent III with unequaled rigour. His struggle with Frederick II was one of the bitterest in papal history. Innocent also approved the use of torture by the papal Inquisition. He showed great interest in the missions and considered a union between the Mongols and the Christians against the Muslims. (For his pontificate, *see* further INNOCENT: *Innocent IV.*) Alexander IV, his successor, was of the family of Innocent III and Gregory IX and like them a friend of the religious orders, but he lacked the decision of those great men. He failed to keep the Hohenstaufen Manfred from the kingship of Sicily, though he pronounced the coronation void.

Urban IV, a Frenchman of humble origins, offered the crown of Sicily to Charles of Anjou, youngest brother of Louis IX of France, and under Clement IV, another Frenchman, agreement was reached on this momentous step. Charles had arrived in Italy with an army (1266) and was taking over southern Italy and Sicily from Manfred. Clement IV opposed Conradin, the last of the Hohenstaufen, when he in his turn invaded Italy in 1267. Charles of Anjou (Charles I of Naples) defeated and executed Conradin (1268). (*See* also CHARLES I of Naples; CONRADIN.) This was the end of the great Hohenstaufen family which had long been a source of dissension in the west and with which the papacy had battled for over 100 years. If it was a victory for the papacy, it was not without lamentable consequences. In Germany, where there was to be no recognized emperor for more than a score of years, it meant independence for a multitude of small states—a source of German weakness for centuries. In Italy it meant freedom from Germany but opened the way to other foreign aggressors. The papacy itself was seriously weakened and its temporal power was in the future to be, more often than not, merely nominal.

After the death of Clement IV (1268), the Holy See was vacant for nearly three years while opponents and adherents of Charles in the College of Cardinals quarreled. Gregory X, finally elected in 1271, succeeded in restoring the empire by promoting the election of Rudolf I of Habsburg, though he kept peace with Charles. Gregory, by means of the 14th ecumenical council at Lyons in 1274, effected an ephemeral reconciliation with the Greek Church. This council, considering the three-year papal vacancy so recently ended, also added an important element to the legislation on the election of the pope: To prevent long vacancies, the cardinals would in the future be enclosed together in a portion of the papal palace; there was to be no communication with those outside; if after three days an election had not resulted, food was to be diminished; after five additional days, the cardinals would receive only bread, wine and water. (*See* also CONCLAVE: *Institution of the Conclave.*)

The next four popes together reigned only four years, but during this time one of them (Adrian V) suppressed, as too rigorous, the legislation on the conclave. This again led to long vacancies—nine months after the death of Honorius IV, two years after Nicholas IV. These four popes endeavoured to keep the balance between Rudolf of Habsburg and Charles of Anjou, and Nicholas III was able to curb the ambitions of the Angevin. (*See* NICHOLAS: *Nicholas III.*) Under his successor, however, Martin IV (a Frenchman who owed his election to pressure from Charles), the Angevin house again dominated the papacy. Charles, now master of Sicily and southern Italy, was dreaming of extending his domain to the east. In 1282, however, the Sicilians revolted and installed Peter III of Aragon as king (*see* VESPERS, SICILIAN), and futile attempts to remove Peter and reinstate Charles occupied Martin's reign thereafter.

Honorius IV and Nicholas IV were concerned with trying to procure the return of the house of Anjou to Sicily, supplanting the Aragonese. Nicholas IV, the first Franciscan pope, laboured unsuccessfully to launch another crusade, and during his pontificate the Palestinian fortress of Acre, the last Christian stronghold, fell to the Muslims. (*See* further NICHOLAS: *Nicholas IV.*)

The long vacancy which followed Nicholas' death—attributable partly to rivalry between the Orsini and the Colonna factions among the cardinals—ended with the election of a holy hermit, Peter of Morrone, who took the name Celestine V. Celestine, who was over 80 at the time of his election and extremely reluctant to ascend the throne, immediately fell under the influence of the house of Anjou. His lack of experience in government and his arbitrary ways led to clashes with the cardinals. Celestine wisely resigned after a reign of less than six months, but not before he had restored the legislation of 1274 on the conclave which, with some changes, has remained in effect till the present day. (*See* also CELESTINE: *St. Celestine V.*)

17. Boniface VIII.—Boniface VIII had had a part in the abdication of Celestine V and after his election put his aged predecessor into protective custody. Boniface, of the Caetani family, was soon engaged in a bitter struggle with the powerful Colonna family, rivals of the Caetani, whose fortresses he razed to the ground. (*See* also CAETANI; COLONNA.) Much of his reign, too, was taken up with unsuccessful struggles with Philip IV the Fair of France, with whom the Colonna allied themselves. In 1302 Boniface issued his bull *Unam sanctam*, a resounding assertion of papal supremacy which led the French king to demand his trial as a heretic. When the pope was about to reply with an excommunication, Philip sent his agent Guillaume de Nogaret to arrest him. But Nogaret was anticipated by Sciarra Colonna, who broke into the Caetani palace at Anagni where Boniface was staying. Boniface met his angry opponents seated on his throne, clad in the papal robes, his tiara on his head and exclaiming, "I desire to die for Christ's faith and his Church." Nogaret probably prevented Colonna from slaying the pope. Rescued after two days, Boniface was conducted to Rome where he died, a broken man. (*See* further BONIFACE: *Boniface VIII;* NOGARET, GUILLAUME DE.) Blessed Benedict XI, his successor, lived long enough to make peace with France.

The scene at Anagni is often contrasted with the humiliation of the emperor Henry IV at Canossa. Not only did Philip IV the Fair not suffer for the outrage perpetrated on the pontiff but he was in a sense to capture the papacy itself: the "Babylonian captivity" of Avignon was approaching. Boniface VIII's pontificate thus marks the end of a long period which saw the rise of the papacy to at times dazzling heights.

This growth can be explained by the Christocentric character of

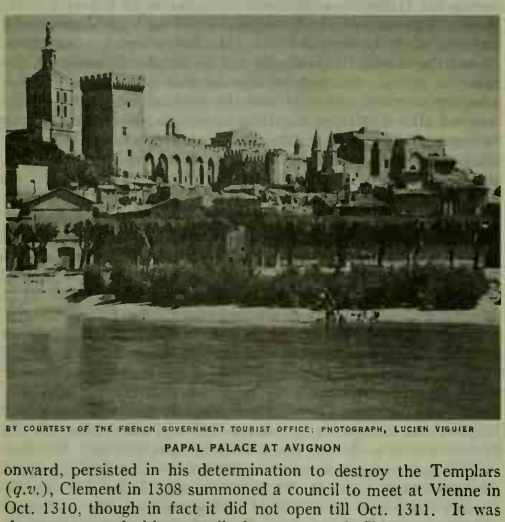
medieval society, which the papal standpoint held to be indivisible. Society at large, like the individual, was considered one indivisible whole which could not be carved up into different compartments. Only under this presupposition could the papacy with its insistence on the directing force of its divinely instituted monarchy govern the undivided whole of Western Christendom. Considering man and society, that is, the church, as one whole, the papacy was bound to act as it did in virtually all spheres of human activity and to direct man and society along the path to the eventual goal. The debt which medieval Europe owed to the papacy was very great. In the middle ages it was the only highly developed and stable institution, and as such it gave to the world, by virtue of its government, a sense of unity, order and purpose.

(E. A. R.)

III. THE PAPACY IN AVIGNON

Boniface VIII had not had time to excommunicate Philip IV of France for his resistance to the bull *Unam sanctam*. But the threat of the French monarchy to denounce him to a general council was hanging over him at his death and may have influenced the conclave of 1303 to elect Benedict XI, who had been absent from the curia during the later stages of the dispute between Boniface and Philip. Benedict, however, died within a year. The conclave that met at Perugia in 1304 let nearly 11 months pass before electing Bertrand de Got, archbishop of Bordeaux, who took the name Clement V.

1. Clement V and the Move to Avignon.—Bordeaux was in the territory held by the English king, and a considerable number of the cardinals created by Clement were to be Aquitanians. But the pope chose Lyons to be the place of his coronation (Nov. 1305), with a view to conciliating Philip IV, who was still pressing for the condemnation of Boniface. Then, as Philip, from 1307



BY COURTESY OF THE FRENCH GOVERNMENT TOURIST OFFICE; PHOTOGRAPH, LUCIEN VIGUIER

PAPAL PALACE AT AVIGNON

onward, persisted in his determination to destroy the Templars (*q.v.*), Clement in 1308 summoned a council to meet at Vienne in Oct. 1310, though in fact it did not open till Oct. 1311. It was the prospect of this council that prompted Clement to select Avignon for his residence. He arrived there on March 9, 1309.

Avignon, a possession of the Angevin counts of Provence and kings of Naples, stood on the Rhône adjacent to the Comtat-Venaissin (which had been in possession of the popes since 1274). Midway between France and Italy, on a great trade route, the town guarded the southernmost of the rare bridges over the Rhône, and it was reasonably near to the sea. Avignon, indeed, was a more suitable centre for church administration than Rome, if history was forgotten and the existing balance of power in Europe taken principally into account; for neither Rome nor Italy was safe for prolonged sojourn, and politically France now bulked largest.

In view of this French predominance Clement V had at first supported the election of Henry of Luxembourg as German king (Henry VII) in 1308; but as the result of the Council of Vienne and of French pressure in favour of Robert, the Angevin king of Naples, he came round to the anti-imperial side, of which the main organizer was Florence. Thus when, in 1313, Henry prepared for war against Robert, Clement threatened Henry with excommunication. With his ally Frederick III of Sicily, Henry might have conquered the Angevin had he not succumbed to fever (Aug. 1313); whereupon Clement, claiming to rule while the empire was vacant, gave Robert the title of imperial vicar in Italy. Robert, however, spent his treasure and forces upon assaults on Sicily, lost control of the Romagna and never made much impression in Lombardy, where the Visconti and the Scaligeri lorded it in Milan and Verona respectively.

Clement died in April 1314. An adroit but timid and physically ailing pontiff, he had been obliged to consent to the destruction of the Templars (whom he himself dissolved, so as not to leave their extinction to Philip IV) and to erase from the papal registers all apostolic letters against Philip IV and his agents. Only in the war of Ferrara (1309) against the Venetians had he had any success. He had moreover falsified Dante's highest hopes, turning upon his earlier welcome to the emperor and yielding to France; yet he left a notable memorial of himself by adding the Clementinae to the existing body of canon law. He was a confirmed nepotist and appears to have had a large secret treasure. His private resources and the funds of the apostolic camera he treated as a single unit, which he kept under the control of his family and on which he drew in order to make substantial presents to his relatives.

2. John XXII.—Clement's successor, elected after an interval of two years and three months, was John XXII, another Frenchman, who left a permanent mark upon the later medieval papacy. Formerly chancellor of the Angevin Charles II of Naples, John touched the political and intellectual life of Europe at many points. He presented a firm and insensitive front to the Franciscan zealots who mingled poetry and prophesying with their determination to follow the naked Christ and to make the moderates of the order follow their example. In this, as in his doctrine of the Beatific Vision, John aroused a great deal of theological antagonism and was unfortunate in having as his opponents such men as Michael of Cesena (general of the Franciscan order) and William Ockham. In 1322 he revoked the bull *Exiit qui seminat* (1279) of Nicholas III, which, by declaring the possessions of the Franciscans to be the property of the papacy, had enabled the order to claim total poverty while its "use" of the papal property was sanctioned; and by the bull *Cum inter nonnullos* (1323) he declared the Franciscan doctrine that Christ and his apostles lived in absolute poverty to be heretical. As a result Michael of Cesena, Ockham and others took refuge with John's enemy Louis IV the Bavarian. At Munich a new factory of antipapal argument and propaganda came into being, encouraged by the revolutionary thinking of Marsilius of Padua, who looked upon the church as the *pars sacerdotalis* ("priestly department") of the state. The intellectual attack on John was pressed by Ockham, whose polemical works are dominated by the thought that the papacy under John did not possess the *magisterium* in Christian teaching but was emitting views that were plainly heretical.

John entered into a fierce quarrel with the empire and began a long series of military and diplomatic actions in Italy to uproot Ghibellinism (the antipapal imperial party; *see* GUELPHS AND GHIBELLINES) and prepare the way for a return to Rome. At the imperial election of Oct. 1314, five electors had chosen the Wittelsbach candidate Louis the Bavarian, while the remaining four voted for Frederick of Habsburg, duke of Austria. John, on becoming pope, viewed with alarm the possibility of a new imperial intervention in Italy and thought it safest to keep the empire vacant (as Clement had done) until he should have decided the issue between the two claimants; meanwhile he maintained Robert of Naples as imperial vicar in Italy.

Louis the Bavarian's victory over Frederick of Habsburg at Mühldorf (1322) was alarming to John, and his suspicions were

confirmed by the fact that Louis sent a vicar to Italy to help the Ghibellines in Milan and Verona. In Oct. 1323 he declared Louis guilty of acting as king of the Romans before his election was confirmed by the pope and of helping heretics by aiding the Visconti of Milan. Louis was ordered within three months to surrender his title, and his subjects were to renounce him under pain of excommunication and forfeiture. The German ruler retorted (Jan. 1324) by declaring the independence of the empire and the sufficiency of his election and coronation to make him king of the Romans without papal approval. On March 23, 1324, John excommunicated Louis.

In the course of his Italian expedition (1327–30) Louis reached Rome and was crowned emperor by four laymen syndics of the Roman people, headed by Sciarra Colonna; and an antipope, Nicholas V (Pietro Rainalducci), was elected in May 1328. But the expedition achieved little else, since John continued to insist on the nullity of an election unconfirmed by the papacy. (*See* also Louis IV the Bavarian.) There could be no settlement of the quarrel while John was alive; and after his death indignation with his policy provoked the German princes to declare at Rense that the chosen of the electors was king of the Romans without need of papal confirmation (1338).

The pope found the Ghibellines of northern Italy no less intractable. The Visconti and the Scaligeri (Della Scala) remained unmoved by excommunication, and John had to send the warrior legate Bertrand du Pouget to retrieve the situation. He also appealed to Philip V of France, who authorized Philip of Valois (the future Philip VI of France) to descend into Italy (1320); but Philip, instead of fighting Galeazzo Visconti, parleyed with him. Later, Philip excused himself to the French king on the ground that neither John nor Robert of Anjou, who was pledged to help him, had sent him any money. The Visconti seized Vercelli (1321) and Cremona (1322), and the pope tried without success to tempt Frederick of Austria to rescue the position. Despite the Ghibelline recovery, the legate was successful in forming a Guelph nucleus in Parma, Modena, Reggio and Bologna. It was suggested that a new north Italian kingdom might be constituted for John of Bohemia, Henry VII's son, who in 1330 went to Italy to help the Brescians against Mastino della Scala. But the Italian powers took fright. Guelph and Ghibelline alike formed, in 1332, the league of Ferrara to expel the invader, and the papal and legatine forces were twice defeated in 1333, at Ferrara and at Argenta. John of Bohemia left Italy and the legate, against whom Bologna revolted in 1334, had to make his escape to Avignon.

The 14 years of warfare had cost John XXII more than half the revenues of his pontificate. But he had at least asserted the power of the church in northern Italy, even if unsuccessfully. His general administration contributed substantially to the development of the papal bureaucracy. Under his rule the court of Rome became fixed at Avignon. The episcopal palace where John lived was a powerfully defended place; the atmosphere of security guaranteed the untroubled working of the monarchical centralization.

3. Administration, Finance and Development at Avignon.—The Avignonese system, complicated as it grew to be, was founded upon two simple administrative acts: a petition to the pope and the papal reply, in the form of a grant of some licence, dispensation or favour in the shape of office or benefice. The recipient was willing (and obliged) to pay the fees laid down, both to the chancery and to other authorized agents. The commonest form of petition was for the papal collation of a benefice (*q.v.*), whether a canonry with or without a prebend or a "church" (*i.e.*, parish church) or other emolument. But the issue of letters of provision did not necessarily imply that the petitioner got the benefice for which he asked. The executors of the provisions (generally clerks of the diocese named) might find that the benefice was already filled or that obstacles were encountered against which litigation had to be commenced. Hence the growth and volume of lawsuits in the curia; hence, perhaps, the increasing vogue of expectatives (grants of benefices sooner or later to fall vacant) and the increasing reliance of the curia on the chief owners of ecclesiastical patronage, the diocesans and the religious houses, to provide for papal nominees when benefices in their gift fell vacant.

At the same time the popes steadily increased the categories of reservations, from those benefices which fell vacant by their holders' dying within a given distance of the Roman curia. John XXII saw the need of advance by stages. In the constitution *Ex debito* of 1316 he extended reservation to several categories of benefices over and above those which were *vacantes in curia* (*i.e.*, those of which the holder had died in Rome). The constitution *Execrabilis* (1317), forbidding a clerk to hold more than one living with the cure of souls, placed in the hands of the Roman curia the collation of the benefice that the pluralist clerk was forced to resign.

At Avignon the plenitude of power was asserted not so much politically as administratively, and petitioning became a skilled technique, for the system of granting benefices was regulated by the delicately adjusted rules of the apostolic chancery.

The livings or offices, whether conferred in consistory (appointments in collegiate churches) or by ordinary process of assented petition, involved, in addition to the fees, payments to the apostolic camera and to the *camera cardinalium*, called *servitia* ("services") and annates (*q.v.*) respectively. The latter were paid on simple benefices; the higher benefices involved both the "great" and the "little" *servitia*. Gathered locally by papal collectors, the payments were frequently advanced by papal merchants who satisfied the needs of the pope and cardinals for ready money and retained the papal grant until they had secured from the grantee binding agreements to pay (*obligationes*), approved by the curia.

This development of papal finance and, in particular, the help of the *mercatores domini Papae* ("papal merchants") enabled John XXII to finance his military enterprises in Italy. The chamberlain Gasbert de Laval (1319–47) acted both as administrator and as a diplomatic counselor and was responsible for many of these developments. The system of collectories, areas into which Christendom was divided for the collection of papal duties, was promoted by him; it did not, however, function till the middle of the 14th century.

In addition to the expansion of the chancery and of the exchequer and the growth of the papal *palatium* or law court, the papal penitentiary dealt with those ecclesiastical offenses the absolution of which was reserved to the Holy See and, through its local penitentiars, exercised the power of binding and loosing vested in the pope.

The whole edifice was kept together by the collaboration of the cardinals, who had come to be the pope's sole counselors when seated with him in consistory, and during the Avignonese period the aristocratic theory of their necessary co-operation and consent in all major papal acts undoubtedly developed.

TABLE X.—*Popes of the 14th Century, to 1378*

1303–04	Benedict XI, in Rome	1334–42	Benedict XII, in Avignon
1305–14	Clement V, to Avignon 1309	1342–52	Clement VI, in Avignon
1316–34	John XXII, in Avignon	1352–62	Innocent VI, in Avignon
1328–30	*Nicholas V (Pietro Rainalducci), antipope in Italy (resigned)*	1362–70	Urban V, in Rome 1367–70
		1370–78	Gregory XI, to Rome 1377

On his death John XXII was succeeded by Benedict XII, a French theologian devoted to the reform of the religious orders. The bull *Summi magistri* (1336) dealt in its 39 chapters with all the main aspects of the religious life of the Order of St. Benedict, its government, the regime of the convents, its temporal possessions and its studies. The pope was also much concerned to remedy abuses in the secular clergy. In view of his reforming activity it is not surprising that Benedict was the object of calumny. He was accused of avarice, of egoism, of prejudice, of dislike of the cardinals and of hatred of the mendicants.

Strangely enough, the rigorous Benedict began the erection of a papal palace separate from the bishop's residence at Avignon. No longer was the see of Avignon kept vacant and administered by the bishop of Marseilles. Round the court of the old episco-

pal palace he constructed a building that resembled both a monastery and a fortress, yet one suitable for the expanding curia; and in 1339 he transferred to it the papal archives which had been at Assisi since the pontificate of Benedict XI.

It was the French Benedictine Clement VI who in June 1348 took the step of purchasing Avignon for 80,000 florins from Joan I of Naples. He also built on to Benedict's palace a second, less austere, more fitted to his grandiose conception of the papacy. Already in Benedict's time Sienese artists, in particular Simone Martini, had been brought to decorate the churches at Avignon. Clement charged Matteo Giovannelli of Viterbo and Lippo Memmi with the decoration of chapels in the new palace and had his own apartments lined with tapestries from the north. The galleries and halls were filled with ornaments and rich furniture; new plants and strange animals appeared in the gardens; and Hebrew manuscripts and translations from the Arabic were added to the library. The influence of humanism was making itself felt.

4. Clement VI and Innocent VI.—Clement VI, a clear-headed, Renaissance type of pontiff, was confronted by three problems: the crusade; the failure of the Florentine bankers; and the state of the Italian possessions of the Holy See. The Anglo-French struggle was likely to be long (it became the Hundred Years' War) and to hamper attempts to relieve the last Christian states left in the east, the kingdoms of Lesser Armenia and of Cyprus. Clement thought of the crusade as the pope's first duty and made himself responsible for an expedition that was successful in taking Smyrna (1344); later, to Clement's indignation, the Latins of the East traded the place for a precarious peace with the Turks and for guarantees against piracy.

Finance, because of the Florentine bankruptcies, was an acute problem. Clement had to look outside Florence for his bankers, and on certain occasions had to employ 11 banks to send his military commanders in Italy sums varying from 20,000 to 40,000 florins. But these were failures of mechanism rather than of revenue itself; the pontiff was able to lend the king of France no less than 600,000 florins from the secret account. All that could be got was needed to meet the situation in Italy. The papal territories in Romagna and the Marches were disputed by the noble Italian families, while the patrimony was menaced by Giovanni di Vico, the prefect of Rome. Clement's nephew Astorge de.Durfort was sent to re-establish the authority of the Holy See in the Romagna.

Clement was also concerned with Naples and with affairs in Rome itself. In Naples he strove to ensure that justice was done to Queen Joan, who was suspected of the murder of her husband, Andrew of Hungary. In Rome he at first supported (1343) the popular leader Cola di Rienzo (*q.v.*) in his attempt to create an orderly bourgeois state based upon the ancient Roman republic; but when after 1347 Cola's plans went beyond the establishment of order and the suppression of the nobles and displayed a dangerous revivalism embodying a federation of Italy in which all Italians must be Roman citizens, Clement became alarmed and refused any more support.

The next pontificate, that of Innocent VI, saw the Italian campaigns of Gil Álvarez Carrillo de Albornoz (*q.v.*), the fighting cardinal who revived the papal state and made possible the return of the pope to Rome. Sent as legate to the Romagna and to the march of Ancona, he quickly dealt with Giovanni di Vico (1354) and reduced the whole patrimony and Umbria to order. In 1355 the Malatesta family surrendered and received back some of their dominions as papal vicars. The duchy of Spoleto and the march of Ancona were both recovered in 1355. In 1357 Cesena was captured. Further success was for the time undermined by the intrigues at Avignon of Bernabò Visconti, who was trying to secure Bologna. In 1363 Bernabò was defeated, but Urban V decided not to break up the Visconti state. Had he done so, the later threat of Visconti domination over the city-states of Tuscany and central Italy might have been avoided.

5. The Return to Rome.—The last two pontiffs in the undisputed Avignon line, Urban V, a French Benedictine, and Gregory XI, the last French pope, were neither politicians nor administrators but intellectuals. Both were men of great piety, and Urban was generally accounted an austere saint. It was he who took the decision, in 1365, to bring the curia back to Rome. He was greatly concerned to reunite the Eastern and Western churches and hoped to enter into conversations with the patriarch of Constantinople. He could not do this so well from Avignon as from Rome. Leaving Avignon on April 30, 1367, and reaching Rome on Oct. 16, Urban installed himself in the Vatican; but he was not to remain long there. When the Anglo-French war flared up again, the pope thought it best to return to Avignon, where negotiations could be more easily undertaken with the warring kings. On Sept. 27, 1370, Urban was back at Avignon.

Gregory XI had reached the conclusion that, in order to conduct negotiations with the Eastern church and to maintain the papal territories, consolidation by Albornoz and residence at Rome were necessary. But by proposing to go at a time when the apostolic treasury was almost empty, while also a large proportion of the personnel of the papal civil service was southern French by origin, Gregory aroused a good deal of criticism.

He delayed his departure, however, while he tried to bring about a truce in the Anglo-French struggle and then to convert it into a definite peace. But events in the east, particularly the conquest of Lesser Armenia by the Mamelukes (1375), were pressing. On top of these happenings came the attempt of Florence to organize a league against the pope and at the expense of papal territory. In the War of the Eight Saints (1375; called after the magistrates deputed by Florence to conduct the campaign) Florence secured the revolt of Bologna and other papal towns. The ecclesiastical territories would have been lost had it not been for the vigorous action of Gregory and of his legate, Robert of Geneva (later the antipope Clement VII). The move to Rome (Jan. 1377), was essentially sound and can even be said to have saved the papal state. Gregory, however, did not live to see the result.

IV. THE GREAT SCHISM, 1378–1417

1. Two Popes.—The double election of 1378 and the consequent schism had disastrous effects upon the church. Historians now regard Urban VI's election as canonical, in spite of the threatening behaviour of the Roman populace demanding "a Roman or at least an Italian." It was only when Urban showed himself bitter and hostile to the cardinals and to the bishops at the curia that 13 French cardinals, fearing that the majority in the Sacred College would be turned against them by a new promotion of Italians to the purple, left Rome and retired to Anagni. There they denounced the election of Urban as "null, because it was not made freely, but under fear." At Fondi on Sept. 20, 1378, they elected Robert of Geneva to be pope as Clement VII. For 39 years after these events there were to be two (and later, for a time, three) rival popes, each with his own following, his own college of cardinals and his own administrative offices.

Neither France nor England decided immediately with whom to sympathize. By the end of 1378, however, France had declared in favour of Clement VII; England took the opposite side. Scotland, Savoy and, for a time, Portugal followed the French example; and after further delays Castile, Aragon and eventually Navarre also declared for Clement VII. Urban VI, on the other hand, was supported by the house of Luxembourg (kings of Bohemia and Holy Roman emperors), Poland, Hungary, the county of Flanders, northern and central Italy and, from 1381, Portugal. Clement hoped to dislodge Urban from the Vatican with the help of the French mercenaries who were occupying the castle of Sant' Angelo; but the castle fell in April 1379, and Clement had to retire to Naples. There Queen Joan I was willing to recognize him, but the populace supported the pope born in their own city, Urban. Clement left Naples in May and entered Avignon on June 20, 1379.

With the divided papacy the church entered upon a prolonged crisis. The confusion, particularly in territories uncertain which pope to obey, was profound, and the dual nature of the papacy gave opportunity, to both England and France, to prolong the antagonism and the party divisions of the Hundred Years' War. To France especially the schism offered the opportunity of intervening in Italian politics and, in particular, of gaining a foothold in the kingdom of Naples, where the younger Angevin line of France

opposed the claims of the Hungarian branch of the family. There were two great expeditions (1382–84, 1390) by French armies to conquer and hold the kingdom. In 1392–93 the Avignonese papacy put forward, in the interest of Louis, duc d'Orléans (brother of Charles VI of France and son-in-law of Gian Galeazzo Visconti), the project of a kingdom of Adria, on the lines of the kingdom formerly suggested by John XXII for John of Bohemia. Such active Italian intervention cost money and involved both pontiffs, the Avignonese most of all, in continuous efforts to apply the fiscal and revenue-collecting methods of earlier Avignonese popes. It was undoubtedly the sharp financial practice of Boniface IX, who succeeded Urban in 1389, that alienated English opinion from the Roman pontiff. Yet neither pope could afford an estrangement with the kingdoms of his obedience, and royal propaganda was met, as far as Urban VI was concerned, by papal compliance.

On the other hand the Avignonese pope was less ready for concession. Benedict XIII, the successor of Clement VII, had promised before his election, in 1394, to resign the papacy if in the interests of the unity of the church this became necessary. When the French king demanded this, Benedict demurred and fell back upon a theory of the plenitude much like that of Boniface VIII. He denied to the University of Paris (which was then advocating "the way of cession"), to the court or to the cardinals sympathetic with the French king any sort of right to demand his resignation; and this attitude was at the root of the two withdrawals of obedience by the French. On their first withdrawal of obedience (1398), the French besieged Benedict in Avignon; but after his escape to Provence they reacknowledged him as pope (1403).

Later, the collapse of the plan for negotiations between him and the Roman pope in 1408 was followed by a second French declaration of neutrality toward the rivals. Benedict, however, who was eventually driven to take refuge in the island of Peñiscola, off the coast of Valencia, never abandoned his claim. Finally deposed by the Council of Constance he lived on, fiercely maintaining his own status, until 1424.

Boniface left the papal state in Italy even stronger than it had been under Albornoz, but his successor, Innocent VII, was less qualified to deal with an enemy such as Ladislas of Durazzo. Even before the conclave had elected the new pope, Ladislas entered Rome, forced the pope to receive a popular government under a treaty highly advantageous to himself, and made him accept the sinister condition that he would not end the schism until Ladislas' right to the crown of Naples was conceded. In Aug. 1406 Ladislas made peace and was created papal vicar of Campania and Maritima, in return for which he undertook to pay Innocent 20,000 florins.

TABLE XI.—*The Great Schism*

Years	Roman line	Avignonese and Aragonese schismatics	Conciliar opposition (Pisa and Bologna)
1378–89	Urban VI		
1378–94		*Clement VII (Robert of Geneva)*	
1389–1404	Boniface IX		
1394–1423		*Benedict XIII (Pedro de Luna)*	
1404–06	Innocent VII		
1406–15	Gregory XII (resigned)		
1409–10			*Alexander V*
1410–15			*John XXIII (deposed)*
1417–31	Martin V		
1423–29		*Clement VIII (Gil Sánchez Muñoz) (resigned)*	
1425–30		*Benedict XIV (Bernard Garnier), counter-antipope*	

Innocent died in Nov. 1406 and Gregory XII was elected. This nervous, greedy man, who thought only of his relations and took no heed of spiritual duties or his temporal responsibilities, may be judged by the bull which he addressed to the cardinals (Aug. 29, 1407), asking them to approve the donation of various lands of the church to his brother and to his nephews, not in vicariate but in fee. He was intending to give up Faenza, Forlì and Orvieto, and the proposal suggests that he had no hope of keeping the temporal power in existence. In 1408, when Ladislas moved on Rome and thence to Viterbo and to Orvieto, there was nobody to stop him. He could be temporarily pacified, but not bought off, by grants of church lands; and Gregory made him extensive concessions with little hope of stemming the tide.

By the autumn of 1408 Gregory's pathetic position in Italy and his failure to concert resignation with Benedict XIII (who was consistently intransigent) had convinced the cardinals that the "way of the council" was the only hope for the church. Their efforts were strongly supported by the Gallican church and by the rulers of France, England, Bohemia and Hungary. The result was the Council of Pisa, which assembled in 1409. Unity and reform were its two objects. Neither was secured. Determination to make a speedy end of the schism soon led to the election of Alexander V; but since the council merely declared the two existing pontiffs schismatic without persuading them to resign, the result was a condominium of three representatives of St. Peter. Nor was reform in the church brought any nearer.

For nearly five years after the Council of Pisa there was—with the exception of the abortive Council of Rome (1412)—a pause in the activity of general councils. In 1410 Alexander died and was succeeded by a most unspiritual figure of great ability, John XXIII, who, as Baldassare Cossa, cardinal legate in Bologna, had been a most successful opponent of rebellious *condottieri* and had organized the fighting strength of the best mercenary captains against Ladislas of Durazzo. The league against Ladislas reached its high-water mark in 1410; but the departure of Louis of Anjou for Provence after the successful action of Roccasecca (May 1411) left John inadequately protected. His only possible resort was King Sigismund of Hungary, whom, after the death of Rupert of the Palatinate (May 1410), he had recognized as king of the Romans. Ladislas not long afterward lost one of his best captains to the pope and was then willing to make peace, which was signed at San Felice in June 1412. Ladislas promised to repudiate Gregory in favour of John, while the pope abandoned the Angevins and Sigismund. The pope took Ladislas and his *condottiere* Muzio Attendolo Sforza into his service and promised them large territorial concessions and extremely large sums of money. In May 1413, however, the perfidious Ladislas moved against Rome. John had to seek refuge in the suburbs of Florence.

2. The Council of Constance.—The protection of Sigismund, for what it was worth, meant for John XXIII agreement to appear at the general council, on which Sigismund had set his heart; and John's position grew weaker as Ladislas deployed his forces northward and threatened Tuscany. But in Aug. 1414 the king died. John, seeing the chance of escape from the council, immediately attempted to form a league with Florence and Venice to keep the representatives out of Italy. To the cardinals he protested that, rather than go to the council, he must go to Rome and recover the States of the Church. The cardinals told him that he could do this by legates or deputies; the council he was bound to attend. The assembly, fixed for Constance, opened in the late autumn of 1414.

Representation at the council was almost universal, and its composition was very heterogeneous. With many different purposes and cross-purposes seeking fulfillment, questions of internal organization, particularly the order of business and the method of voting, assumed immediate and fundamental importance. If heads were counted, the reactionary party might win and John XXIII might simply remove his opponents and ignore the question of reform. Such an outcome was hardly in keeping with the plans of the French leaders Pierre d'Ailly and Guillaume Fillastre. Their program was essentially that expressed in D'Ailly's *Capita agendorum*, which called for a complete reformation in head and in members of the church; and they were not to be satisfied with the restoration of unity in the person of a suspected libertine. Hence, when the English delegation, led by Robert Hallam (Hallum) and supported by the Germans, suggested that the system in vogue in the universities should be adopted and that voting should be by nations, the French fell in with the plan and the papalist Italians were outnumbered. This deprived the cardinals of effective influence. Envisaging the result, John XXIII publicly professed his willingness, on conditions, to quit the papal

chair; but in March 1415 he secretly escaped from Constance.

The unequal battle between the cardinals, anxious to preserve their right of election, and the conciliar liberals, determined to procure John's abdication, continued until John was finally deposed. More of layman than a cleric, John had yet made brilliant promotions to the cardinalate, and the charges against him at his trial were, in the main, fantastic. Shortly afterward Gregory XII resigned; and in July 1417, after prolonged efforts to secure his voluntary abdication, Benedict XIII was at length pronounced schismatic and heretical. Unity was eventually achieved by the election of Martin V in Nov. 1417. (*See* also CONSTANCE, COUNCIL OF; COUNCIL.)

By a majority in the council, reform was left to the new pope, and certain specified recommendations were made to him. Martin V, however, was content to pass the inadequate decrees of March 1418 and to make a series of concordats with the principal powers, involving for the most part his recognition of the actual status of papal finance in the various countries, together with certain modifications in favour of national demands for the reform of abuses in the central bureaucracy. The fact was that in their relations with the Avignonese papacy the principal countries of Europe had evolved a technique of mutual agreement and compromise which their rulers did not wish to upset.

V. THE RENAISSANCE PAPACY

A. EARLY RENAISSANCE, 1417–92

Martin V's chief problem was to assert his authority over the *condottieri* who, under pretext of serving the church, were making free with its lands in Italy. His proposal (Jan. 1418) that the rule of the lands and cities of the church should in future be given to cardinals or to other ecclesiastics and that the papal vicariate of such lands should not be granted for more than three years was accepted by the Council of Constance; but in these territories he had to establish himself by diplomacy rather than by force, and places like Bologna made stiff bargains. His chief difficulty was the *condottiere* Braccio (*q.v.*) da Montone; and it was not until after Braccio had been defeated in the battle of Aquila (June 1424) that Martin could make headway in central Italy.

In non-Italian affairs likewise the pope, strongly supported by his cardinals, set himself to advance the interests of the Holy See and to retrieve the authority of the curia in the church as a whole. He did his utmost to render abortive the Council of Pavia (1423–24), later transferred to Siena, which he refused to attend in person and which he was able ultimately to get dissolved on the ground of its insufficiently representative character and because churchmen present had no security from attack by the townsfolk and others. Against the English government, however, he asserted to the full his determination to get rid of the Statute of Provisors of 1390 (*see* PROVISION), even to the extent of suspending (1427) Archbishop Henry Chichele from his office as legate. In the Spanish kingdoms he similarly emphasized the rights of the church against the crown. He was a restorer of the papal supremacy in all matters ecclesiastical.

1. Basel and Ferrara-Florence.—Eugenius IV succeeded Martin in 1431. Devout but of no international experience and often of faulty judgment, Eugenius had to steer the papacy through the crisis of the rebellious Council of Basel; and his pontificate also saw the reconciliation of France and Burgundy (Arras, 1435) and the Pragmatic Sanction of Bourges (1438). He was also the pope under whom a short-lived union of the Greek and Latin churches took place (1439) at the Council of Ferrara-Florence. Eugenius had none of the gifts to guide difficult business to a successful issue; but he had a certain obstinate dignity, and if he could be swayed by disingenuous persons, his own character was simple enough. Above all, he was well served by his cardinals, particularly by the great Niccolò Albergati (1375–1443), on whom Martin V had much relied.

Eugenius' chief victory was over the Council of Basel, which he first allowed to be summoned, then, on hearing that his legate Giuliano Cesarini was proposing to invite the Hussites (*q.v.*) and Bohemian religious radicals to state their case, dissolved. Eugenius was forced, through the desertion of the cardinals, to recognize the assembly once more (1433), but he made use of its blunders. Important among these were (1) the determination of the French radicals to secure upon French soil a meeting place for the prospective council which was to seek unity of the Greek and Latin churches and (2) the council's assertion of its right to grant indulgences. But even more serious was the council's interference in matters with which it had no concern. These considerations led Eugenius in 1437 to break with the fathers at Basel, to repudiate the decrees of the assembly and finally, in September, to order its removal to Ferrara. In 1439 the diehard fathers still at Basel replied by the citation and "deposition" of the pope and the election of Amadeus VIII of Savoy as Felix V. (*See* BASEL, COUNCIL OF.)

Meanwhile in 1438 Eugenius secured the holding of his new council at Ferrara-Florence attended by the Greek emperor John VIII (Palaeologus) and many Orthodox prelates; and in 1439, at Florence, whither this council had been transferred, the Greeks accepted the Catholic doctrine of the procession of the Holy Spirit, the use of either leavened or unleavened bread in the Eucharist and the headship over all Christendom of the Roman pontiff. (*See* FERRARA-FLORENCE, COUNCIL OF.) This resounding victory, though it never became a generally accepted fact, enabled Eugenius to defy the Basel assembly during its last phase (1439–48) and hence bring to an end the conciliar movement and establish papal supremacy. But some work of value had already been effected by the council. A compromise, involving the *Compactata* of Prague (1433), had been arranged with the Bohemians at Jihlava (Iglau) in 1436; and reforming decrees had been passed which forbade reservations as unauthorized by canon law and which abolished annates and limited the number of cardinals. Some of the more important of these recommendations were accepted by Charles VII of France and embodied in the highly Gallican Pragmatic Sanction of Bourges, which declared the rights of the French church and disallowed papal appointments to vacant benefices.

2. Humanism and Italian Politics.—Eugenius died in Feb. 1447. It has been observed that he was outside the chief interests, intellectual and moral, which were moving Italy. His successor, however, was the humanist Nicholas V. A man of peace and moderate views, strong in the desire for reform while maintaining the prestige of the Holy See, Nicholas concluded the concordat of Vienna with the German king Frederick III in 1448, extending the basis of Martin V's concordat of Constance to regulate the relations of the pope with the German church. He also dealt reasonably with Felix V when he abdicated (1449), restored Louis Aleman to the cardinalate of which Eugenius had deprived him as a partisan of Felix, and recognized three of Felix' creations. His

TABLE XII.—*The Papacy From 1431 to 1492*

1431–47	Eugenius IV	1455–58	Calixtus III
1439–49	*Felix V (Amadeus of Savoy), antipope*	1458–64	Pius II
		1464–71	Paul II
1447–55	Nicholas V	1471–84	Sixtus IV
		1484–92	Innocent VIII

chief concern was the restoration of the buildings of Rome and the increase of the books and treasures in the Vatican. The jubilee of 1450 provided the funds to carry out the proposed restorations; but the visit of Frederick III and his imperial coronation (the last in Rome) in 1452 gave the pope the best opportunity for his aesthetic antiquarianism, and he used the occasion to the full.

The political league between pope and emperor proved, however, a failure, nor would Frederick give any help with the crusade which the pope was preparing. The diet of Frankfurt (1454) was more occupied in reforming the empire than with crusading. Amid these disappointments Nicholas died in 1455. His claim to distinction rests on his building in Rome, on his virtual foundation of the Vatican library, on the welcome he gave to scholars from Constantinople and on his patronage of Italian humanists.

The short pontificate of the first Borgia pontiff, Calixtus III, is notable mainly for the pope's abortive crusade against the Turks. The papal fleet, dispatched from Ostia, won a few islands in the Aegean from the Turks and brought help to the Hospitallers in

Rhodes. One promotion of great importance was made: Aeneas Silvius, who had consistently fought the electoral opposition to the emperor in Germany, was raised to the purple in 1456. Aeneas had always appreciated that the strength of the electors' opposition lay in their ability to use the decrees of Constance and of Basel and the concordat of 1448 as weapons against any close *rapprochement* of Frederick III with Rome. He therefore had an answer to all complaints from Germany; and it was perhaps his arguments and promises, together with the legation of Nicholas of Cusa in Germany, that prevented the empire from sliding into a quasi-independence of Rome.

An orator and a humanist, Aeneas had done so much for the papacy in Germany through his letters and his personality, and had so many contacts with the influential of Europe, that at the conclave of 1458 he received the majority of votes. To Pius II (as he called himself) it was left to abolish all traces of the conciliar regime. The bull *Execrabilis et in pristinis temporibus inauditus* (1460) condemned any appeals to a future general council (though for the time being it did not stop people from making them); Louis XI was urged to abolish the Pragmatic Sanction and did so; and in 1462 the *Compactata* of Prague were denounced by the pope. Into the crusade Pius flung himself with all the ardour of his incomparable pen and, in the end, by personal example that led to his death. Yet his more important work had been done in Germany, and it was his knowledge of the German (highly separatist) mind that showed him how to support Nicholas of Cusa, bishop of Brixen, against Sigismund of the Tirol, how to bribe the electors and how to win Frederick III for the papacy.

Pius' eloquence and his love of pageantry should not obscure the fact that he was invariably in earnest; and he had an astonishing flair for publicity and the manipulation of opinion. Yet at the end of his time it was clear that the papacy, if it had great prestige and high diplomatic ability and had the money to build and to decorate, was now being grouped as one of the European concert of powers having *auctoritas* ("authority") rather than *potentia* ("power"). More than that, it was as an Italian principate that the world of diplomacy saw it.

The cardinals at any rate showed suspicion of a *princeps* or actual potentate. Before electing a successor to Pius II, they framed a series of regulations for the guidance of the college and for the control of papal policy, including the provision that they were to be consulted on appointments to the more important posts. The new pope, Paul II, would have none of these restrictions; and while he was prepared to take advice on necessary reforms, he followed his own judgment in making changes within the papal court. In 1464 he ordered a drastic purge of the College of Abbreviators; and when the humanist Platina (one of them) objected, he imprisoned him till he came to a better mind. Deeply concerned with the well-being of Rome, Paul lived in the palace of San Marco, where he could see and enjoy the Roman carnival. Not isolated in the Vatican, he dwelt among the people of Rome, a friend to the magistrates and a patron of artists and scholars.

In external relations he was as suspicious of Bohemian Utraquism as Eugenius IV had been (*see* HUSSITES). He condemned George of Poděbrady, king of Bohemia, as a heretic (Dec. 1466); and further, diverting possible forces from the crusade against the Turks, he turned Matthias of Hungary against the Bohemian king. This was not to the taste of Frederick III, who, if he did not like George of Poděbrady, disliked and feared Matthias more. But the last visit which a Holy Roman emperor ever paid to Rome was not successful in changing Paul's determination to ally himself with the Hungarian king and to crush the Bohemian. Paul and George died both in the same year, 1471.

Paul II promulgated, with the consent of the citizens, new statutes for the city of Rome. A churchman and a disciplinarian, he fell out with the Roman Academy, which, after the dissolution of the College of Abbreviators, had become the national resort of aggrieved scholars and humanists; and by condemning them and subjecting Platina to torture, he prepared the way for a denigratory biography of himself, in which he was represented as hating literature and literary men. Paul was medieval in his literary sympathies, had little time for frivolity and disliked panegyrics. Literature apart, he was a magnificent builder and art collector. Implication in Italian wars he was determined to avoid.

Wholly different was the aim of his successor Sixtus IV, never a man of the crusade nor a curial politician. Though he sent a papal force against the Turks, at heart he had the aggrandizement of the papal state and the embellishment of its capital as his objectives. His agents were the members of his own family (he was Francesco della Rovere, from Savona in Liguria), whom he enriched on a scale hitherto unknown. If his nephew the Franciscan Pietro Riario was all glitter and extravagance, two other nephews, Cardinal Giuliano della Rovere and Girolamo Riario (brother of Pietro), were men of demonic energy who involved him, sometimes outwardly protesting, in the disputes and turmoils of Italian politics—most acutely of all in the conspiracy formed with their help by the Pazzi (banking rivals of the Medici) against Lorenzo de' Medici (1478). Here Girolamo's agents did not stop at murder; Giuliano de' Medici was killed in the attack, which took place in the cathedral of Florence during High Mass. Yet the pope was able to find reason to justify his excommunication of Lorenzo. War followed, and Lorenzo had to seek a peace through the papacy's ally, Naples, in 1480.

Apart from plunging into the feuds of the great Roman families, Savelli, Colonna and Orsini, the pope committed himself, more scandalously, to the aggression of Venice against Ercole I of Ferrara (1482). Venice, however, soon appeared to be a dangerous rival to the papal state and was laid under an interdict by Sixtus (1483). In Rome, Girolamo Riario was openly on the side of the Orsini, but victory over the Colonna was hard to achieve, and before he had won it Sixtus died. (*See* also SIXTUS: *Sixtus IV.*)

Sixtus IV was a superb patron of architects, painters, sculptors and scholars and a great builder and a restorer of churches. His principal monument is the Sistine chapel in the Vatican; but he also built the fine hospital of Santo Spirito. Under him the papacy became an Italian principality, observing the rules and conduct that were to find favour with Niccolò Machiavelli and acting upon "reason of state" backed by clerical censure as well as by force; but the example had been set by Boniface VIII and Martin V.

Such popes, while not devoid of nepotism, were free from the weakness and pliability that marred the pontificate of Innocent VIII. Giovanni Battista Cibò, cardinal priest of Santa Cecilia and bishop of Molfetta, emerged as pope from a simoniacal election, managed by Cardinal Giuliano della Rovere, under whose domination he remained continuously. The diarist J. Burchard reports that Cibò won his election by signing petitions for favours which were brought to him in his cell the night before. In earlier years, before he entered the priesthood, Cibò had had two illegitimate children, one of whom, Franceschetto, was now to appear publicly at papal functions.

Cardinal Giuliano, who hated the Aragonese dynasty, was not slow to support Innocent in his quarrel with Ferdinand I (Don Ferrante) of Naples; but the war that followed Innocent's demand for tribute from his fief and Ferdinand's counterdemand for Benevento, Terracina and the territory of his father cost the papacy Aquila and subjected it to extreme insults and to the loss of most of its remaining political prestige. The only offset for Innocent was his gaining possession of the Turkish prince Jem, brother of the sultan Bayazid II, from his custodians, the Knights of St. John. Jem was an important hostage for the good behaviour of the sultan, affording the pope time to hold the congress of Rome (June 3, 1490) and to plan the organization of the crusade, which was to be a five-year affair. This might have been carried through but for the death of Matthias and the ensuing civil war in Hungary.

(E. F. J.; X.)

B. The 16th Century

1. The Approach to the Protestant Revolution.—Alexander VI, Julius II, Leo X and Clement VII appeared to their contemporaries primarily as Renaissance princes preoccupied with Italian politics, the patronage and enjoyment of Renaissance culture and the advancement of their families. Julius II (the former Cardinal Giuliano della Rovere) alone performed a creative work.

By reconstituting the papal states through the recovery of territories seized by the Venetians and through the reabsorption of the conquests of Alexander VI's son Cesare Borgia (*q.v.*), he assured a firm territorial and economic basis for the papacy in the new age of nationalism. It was he who inaugurated the construction of the modern city of Rome and began the long-contemplated erection of a new St. Peter's, entrusting this to Bramante and the decoration of the Vatican to Michelangelo and to Raphael.

But, though a greater personality in every way than his successors, he was no more capable than Leo X or Clement VII of giving Catholicism a much-needed spiritual and intellectual lead. Julius' military successes and Leo's spendthrift magnificence, together with their liberal but superficial patronage of the scholars, artists and philosophers of Renaissance humanism, might give temporary splendour and an appearance of enlightened tolerance to the papacy but were no adequate substitutes for a serious attempt to meet the moral and doctrinal needs of Christendom. The easy lives of the popes and their lavish affection for their relatives caused grievous scandal, and it is ironic that it should have fallen to an Alexander VI to condemn the excesses of a Savonarola.

Moreover the existence of the papal states inevitably involved the papacy in the chronic warfare which ravaged Italy from the French invasion of 1494 to the peace of Câteau-Cambrésis in 1559 and which formed part of the wider European struggle between the Habsburg and Valois dynasties. Anxious, as ever, to prevent Milan and Naples from falling together into the hands of a single power—especially, Germanic hands—the papacy was constrained to see both fall to the Habsburgs, masters also in Spain and seated on the imperial throne. Alexander VI cultivated mostly the French alliance, but Julius II contrived the expulsion of the French from Milan. With France again temporarily victorious in Italy after the battle of Marignano (1515), Leo X decided to make his peace. Meeting Francis I at Bologna, he began the negotiations that resulted in the concordat (1516). But Clement VII's alliance with the French against the emperor Charles V after the latter's victory over Francis at Pavia in 1525 led to the barbarous sack of Rome by imperial troops in 1527.

This event marked the end of an era in Rome and opened the way for the reassessment of values and the reform of the papal curia, for which the ground had been prepared by the founding of new religious orders and the influence of the members of the Roman Oratory of Divine Love. The numerous organs of the

TABLE XIII.—*The 16th-Century Popes*

1492–1503	Alexander VI	1555–59	Paul IV
1503 (Sept.–Oct.)	Pius III	1559–65	Pius IV
1503–13	Julius II	1566–72	Pius V
1513–21	Leo X	1572–85	Gregory XIII
1522–23	Adrian VI	1585–90	Sixtus V
1523–34	Clement VII	1590 (Sept.)	Urban VII
1534–49	Paul III	1590–91	Gregory XIV
1550–55	Julius III	1591 (Oct.–Dec.)	Innocent IX
1555 (April)	Marcellus II	1592–1605	Clement VIII

curia formed a centrally controlled bureaucracy unparalleled in size, now almost completely Italian in personnel and a prey to all the abuses—ranging from mere obstructive delay to widespread corruption—that 16th-century social and economic conditions made almost inevitable in such a system. The curia was also a great financial centre to which money came from all parts and was handled by up-to-date Italian banking methods. This gave scandal in that, though much curial business was purely administrative or legal, much also came close to the substance of religion, such as the traffic in ecclesiastical benefices, the management of offerings for indulgences and, above all, the countless dispensations which continually hindered reform and frustrated the good purposes of the provisions of canon law. Furthermore, the taxation of churches throughout Europe and the enormous fees involved in ecclesiastical promotions generated bitter resentment, especially in Germany. Nevertheless the popes, like other contemporary potentates, were unsystematic and extravagant in finance and lived largely from hand to mouth on borrowings and pawnings.

Except perhaps for the Dutchman Adrian VI, whose good intentions had little time to develop their potentialities, the popes gravely underestimated the depth and the dangers of their unpopularity in Germany, though they continued to fear the less dangerous bogey of a new conciliar movement. But Julius II not only met the feeble challenge of the schismatic Council of Pisa (1511–12) but trumped it with the fifth general Council of the Lateran (1512–17; completed by Leo X), a mainly Italian assembly whose good intentions produced little positive result. Roman theologians like Cajetan (Tommaso de Vio) meanwhile restated the loftiest theories of papal supremacy both in church and in state and the popes themselves remained fully conscious of a leading function in Christendom. All continually urged the union of warring Christian princes against the advancing Turks. Alexander VI in 1493 drew a line to demarcate the Atlantic conquests of Spain from those of Portugal (*see* TORDESILLAS, TREATY OF); and Paul III was soon to pronounce that American Indians had souls. Popes still ratified treaties and received the "obedience" of new sovereigns.

The Protestant revolution (*see* REFORMATION), first set in motion by Martin Luther and Huldreich Zwingli in Germany and Switzerland, found the papacy psychologically unprepared for a radical and permanent rejection of its authority. The combined results of dissolvent Renaissance criticism, of exasperation with the Roman curia and with the lives of the popes, of the successful action of German and Swiss towns and princes in taking independent control of refashioned ecclesiastical organizations and, above all, of the attraction of the new religious outlook turning around justification by faith alone produced a situation which left the papacy expostulating but impotent.

Yet all over Europe control over the church had recently been passing, either tacitly or explicitly (by specific agreement with, or privilege from, the papacy), into the hands of the secular power. But the actions of German, Swiss and Scandinavian authorities in setting up new state-controlled churches with Protestant beliefs overstepped the limits of possible papal toleration and grievously disappointed whatever trust in princes the popes had inherited from the middle ages. It was probably decisive that in the 1520s, while events were still fluid in Germany, both emperor and popes were preoccupied with Italian politics. By 1530, when Charles V (*q.v.*), after his coronation by Clement VII at Bologna (the last imperial coronation by a pope), again gave his attention to Germany, it was too late. The German and Swiss Protestant organizations had become vested spiritual and political interests too strong for easy upset. Then came the Reformation parliament in England, with legislation in restraint of appeals to Rome and of the payment of annates (*see* ENGLISH HISTORY). In 1533, shortly before his death, Clement VII accelerated the English schism by finally pronouncing Henry VIII's marriage with Catherine of Aragon to be valid. The Act of Supremacy followed, making the king of England head of the English church.

2. The Council of Trent.—In the ensuing years the pressure of the Catholic reformers and the rapid advance of Protestantism in its various forms forced the papacy to devote more serious attention to church affairs. Paul III, Julius III, Paul IV and Pius IV all worked, with varying intensity, toward the restoration of the primacy of the spiritual in the activities of their office, though with all of them the marks of the Renaissance papacy persisted in different ways. Paul III excommunicated Henry VIII (1538) but aimed at political neutrality between Habsburg and Valois. He introduced into the College of Cardinals the leaven of a group of zealous and virtuous reformers and set up a series of commissions to inquire into abuses. These reported with great frankness, and the slow, difficult process of curial reform was inaugurated. It was Paul who in 1540 approved the foundation of the Society of Jesus, destined to be of inestimable value to the papacy; and in 1542 he refounded the Roman Inquisition with a jurisdiction theoretically universal, though in practice confined to Italy. He also convened the Council of Trent which had ten sessions (1545–47; including two at Bologna) during his pontificate, six (1551–52) under Julius III and nine (1562–63) under Pius IV.

This council was of prime importance in papal history. (*See* TRENT, COUNCIL OF; COUNCIL: *Councils of the Western Church: Council of Trent* [*1545–63*].) It was not the universal, uncom-

GIRAUDON

"COUNCIL OF TRENT" BY AN UNKNOWN 16TH CENTURY PAINTER. IN THE LOUVRE, PARIS

mitted, general council of all Christians desired by Protestants but an assembly of those continuing to acknowledge the papal headship, in which there was always a large Italian majority and only relatively small representations of other nations. Within these terms, however, it was a great co-operative achievement that clarified the whole field of Catholic doctrine, rejecting all the principal Protestant theses, and established fresh norms of discipline regulating every aspect of church life. This achievement was largely due to the supervisory control of the papacy, which emerged stronger, reinvigorated and much more self-assured from a hazardous enterprise on which it had embarked with considerable apprehension. Though the council made no pronouncement on the papal power, the challenge of the innumerable problems involved in its assembly, program and management drew new strengths and initiatives out of the papacy which served to restore and to push to even greater lengths its ecclesiastical leadership and control.

No effective revival of 15th-century conciliar principles occurred. A declaration that each bishop's diocesan jurisdiction came immediately from Christ, rather than mediately through the pope, was avoided. The reform of the curia was not forcibly taken out of Rome's own hands. Reforms were not permitted to be made indiscriminately without reference to relevant doctrine. Proposals, disliked in Rome, for radical changes in liturgy and discipline put forward by more liberal Catholic reformers or urged by Catholic princes for the appeasement of overmighty Protestant subjects (whose existence created novel and harassing political difficulties) were successfully resisted.

The Council of Trent witnessed a crisis in the problem of the nature and extent of the powers of the state in matters of Catholic reform. The emperor and other Catholic rulers desired to control the program and policy of the council according to what was politically convenient to themselves and to do so not only through their accredited ambassadors but also through the bishops of their territories, whom they tended to regard as forming national delegations which should press the views of their political superior. Thus the political background to the sessions under Paul and Julius was occupied by the rise and fall of Charles V's hopes of achieving the submission of the German Protestants either by force or by concessions or by a mixture of both; the French, on the other hand, desired only the maintenance of the concordat of 1516 and the maximum harrassing of Charles by his Protestant vassals. During the sessions under Pius IV, Charles's imperial successor Ferdinand wished only to safeguard the hard-won, if unsatisfactory, stalemate of the peace of Augsburg (1555), which had legitimized the Lutheran states on the principle *Cujus regio, ejus religio* ("the ruler's own religion determines the religion of the state").

It was the French who, worried in their turn by the Calvinist movement, then chiefly pressed for the wide concessions and changes after which many Germans, too, still hankered; while the Spaniards opposed concession of any kind. It was a remarkable and far-reaching achievement of papal diplomacy to have preserved not only unity but uniformity and to have prevented the establishment of differing, quasi-autonomous, national Catholic settlements which would perhaps have involved, in Germany and in France, such points as a married clergy, lay communion under both kinds and altered and vernacular liturgies.

Paul IV alone in this series of popes deliberately rejected the conciliar method—though Marcellus II (1555) would probably have done so too had he lived. A man of deep personal piety, Paul believed that he could effect reform in Rome better without a council; and indeed his thunderbolts, though sometimes overcharged and occasionally misdirected (as when aimed at the cardinals Reginald Pole and Giovanni Morone), had a permanent effect on ecclesiastical conditions in Rome. But his excessive violence in orthodoxy and in reform was carried over into politics. He succumbed disastrously to the evil counsels of his unworthy nephews and to his consuming hatred of Spain and of the Habsburgs, for which he would have jeopardized even the Marian restoration of Catholicism in England. His attempt to drive the Spaniards from Naples in 1557 collapsed in a humiliating disaster when his French ally withdrew. Only Spanish restraint averted another sack of Rome like that of 1527. Paul even refused to recognize the abdication of the emperor Charles V and the election of Ferdinand as his imperial successor, as having been effected without papal approval; and the following pope, the diplomatic, conciliatory and easygoing Pius IV, had tacitly to withdraw from this unrealistic position. In Paul IV's violent politics, as in the nepotism, the ease of life and the self-indulgent cultivated tastes of Paul III, Julius III and Pius IV, the papacy had still not wholly cast itself free from its immediate past.

3. The Counter-Reformation, 1566–1605.—The 40 years following Pius IV's death were the zenith of the reformed papacy. With the Tridentine achievement behind them and peace restored to Europe and to Italy at Câteau-Cambrésis in 1559, a succession of energetic pontiffs of blameless lives devoted their whole attention to the spiritual restoration of Catholicism, to the reform of the church's administration and to the fight against Protestantism. Pius V, a former inquisitor of great severity, inaugurated and typified this period (he was canonized in 1712). Of its three other important popes—Gregory XIII, Sixtus V and Clement VIII—Sixtus, a remarkable and forceful man, is the outstanding figure. Rome was again a centre of holiness. The spiritual influence of the Jesuits and of St. Philip Neri was deeply felt throughout the city; and there were few in the Roman court who did not make at least some show of conformity with the new piety.

Spiritual and Intellectual Activity.—The papacy was now setting the pace throughout the church of its obedience. Its active, central control had been renewed through the Council of Trent and on this now depended the completion and enforcement of the council's work. In the hurry of its termination the council had en-

trusted to Rome a number of unfinished matters. Roman commissions drew up and published the Tridentine creed (1564) and catechism (1566), a new breviary (1568), a new missal (1570), the Sixtine and Clementine editions of the Vulgate (1590 and 1592) and a new version (1564) of the *Index Librorum Prohibitorum* (of which the *Index* of 1596 was a revised edition). The successful enforcement of the rule that diocesan bishops should visit Rome periodically to submit reports strengthened the ties binding them to the pope. National seminaries in Rome made for the spread of Roman influences and ways. The Roman Inquisition was sharpened, and its activities ensured the practical disappearance of Protestantism and of open skepticism from Italy.

The Counter-Reformation papacy recognized no necessity either to understand (save for purposes of confutation) or to tolerate beliefs incompatible with the Tridentine creed. It censured both individuals and governments who tried to do either. The censorship of new publications and the control of reading were strictly applied, wherever practicable, in the Catholic world in the interests of rigid orthodoxy. Yet within the limits allowed by orthodoxy and within the scope of current ecclesiastical-philosophic ideas, the papacy genuinely strove to further learning and to improve the educational level of the clergy.

The Vatican library and press were liberally promoted. In 1578 the Roman catacombs began to be rediscovered; and this, together with the historical work of the Oratorian Caesar Baronius (*Annales Ecclesiastici*, 1588–1607) replying to the Lutheran *Centuriae Magdeburgenses*, stimulated research into early Christian history. Gregory XIII's reform of the Julian calendar (1582) was in time accepted throughout most of the world; and the Copernican thesis was apparently not yet suspect.

There was still room, however, for controversies on divine grace. In 1567 and 1579 Rome censured the theories of the Louvain theologian Michael Baius; but the more serious conflict that arose in the 1590s between Jesuits represented by Luis de Molina and Dominicans represented by Domingo Bañez much harassed Clement VIII and was eventually suppressed without solution by Paul V. The papacy was also much concerned at the continuance in France of Gallican views on ecclesiastical authority and church history. In the forms of art and literature a new Tridentine puritanism imposed itself; nevertheless, a flourishing artistic and musical life was maintained in Rome, and much of the humanistic spirit retained a permanent foothold within the church.

Administration.—In church government, while the medieval inheritance of the old curial organs still survived, unchanged essentially though somewhat reformed, the papacy now perfected for its wider and more intensive tasks a new equipment of a more modern character.

First, the cardinals, who in 1500 had formed a smallish body, predominantly aristocratic, potentially turbulent and fitfully asserting claims to a real participation in the papal authority, had by 1600 much increased both in numbers and in moral quality; and those resident in Rome had been transformed into a body of ecclesiastical civil servants performing in organized boards known as congregations (in addition to the full weekly consistory) a mass of varied ecclesiastical business. Sixtus V in 1586 established the numbers of the college at 70 and in 1588 set up the organization of 15 permanent congregations, thus reducing to a system that still prevails in principle (*see* CURIA ROMANA) the practice of special cardinalitial committees that had been growing throughout the century. This new bureaucracy further buttressed the papal supremacy; the cardinals might still elect the pope, but they were now much more completely his servants.

Second, there was the rise of the papal secretary of state. This new official bypassed and eventually atrophied the older secretariates of the curia in all important affairs. By the second half of the century the secretary was almost always a papal nephew with whom the existing pontiff could have relations of trust and intimacy. This new and more justifiable form of nepotism—of which St. Charles Borromeo, nephew of Pius IV, was neither the first nor perhaps the most influential example—lasted until late into the 17th century and produced many able first ministers.

Third, the diplomatic representation of the papacy by nuncios (*see* NUNCIO) at the courts of the Catholic secular powers was systematized by Gregory XIII and the scope of their concern widened to include religious as well as political matters. Important factors in the Counter-Reformation, their main task was to promote acceptance and implementation of the reform decrees of Trent by political and ecclesiastical authorities alike.

Gregory XIII was also the first pope to see the world-wide missionary activity of the Roman communion, both inside and outside Europe, as a whole—though the special missionary congregation *de Propaganda Fide* ("for the propagation of the faith") was not founded until 1622. This period also saw some successful Uniate movements, the largest being the submission to Rome, by the union of Brest (Brest-Litovsk) in 1596, of a number of Ruthenian dioceses in Poland; while Uniate colleges (Maronite and others) appeared in Rome.

The Papacy and European Politics.—Despite the slow turn of the tide in Germany from the pontificate of Gregory XIII onward, and despite all the intensification of Catholic propaganda methods (both of suasion and of force, whether concealed or open), the Counter-Reformation papacy failed to win back England or Scotland, Russia or Scandinavia or the bulk of Protestant Germany and Switzerland. It failed also to prevent either the Calvinizing of the United Provinces of the northern Netherlands after their break from Spain or the privileged toleration finally accorded to French Calvinism by the Edict of Nantes (*q.v.*) in 1598.

The papacy still regarded the capture of the monarch as the trump card in the technique of national conversion and maintained its full political claims in respect of heretical rulers. Pius V's bull of 1570 denying the right of the excommunicated Elizabeth I to rule in England and the successive papal denunciations of the validity of Henry I of Navarre's claim to the French throne were eventually recognized to have been mistakes, but not to have been *ultra vires;* and the Jesuit Robert Bellarmine's theory of indirect papal power in temporal matters led to the inclusion of his book *De controversiis* in the *Index* of 1590 (which however was revised after Sixtus V's death). English Catholics were forbidden to take an oath of allegiance declaring the papal deposing power to be heretical. Political theories which justified armed revolt against declared heretical "tyrants" (or even the violent removal of them) found support in Rome.

The Council of Trent did not end friction between pope and Catholic sovereigns. The co-operation of the latter was essential to the Counter-Reformation, but they still claimed a considerable and unwelcome independence in church affairs. Neither Valois nor Bourbon sovereign in France would withdraw toleration from Calvinism; and their concern to defend the "Gallican liberties" of the crown made them unwilling to "receive" the new ecclesiastical discipline of Trent officially as the law of the land. Philip II of Spain, though he was the right arm of the Counter-Reformation, was a constant irritant by his overbearing claims and pretensions; and Clement VIII welcomed the revival of an independent counterbalancing Catholic France under the former heretic Henry IV. This enabled him to modify the Spanish ascendancy among the cardinals and had a corresponding effect in future conclaves.

By 1605 the papal states, enlarged by Clement VIII's incorporation of the duchy of Ferrara in 1598, had become more firmly consolidated and now formed the economic support of the papacy. The peace of Câteau-Cambrésis had led to some economic revival in Italy. The exploitation of the resources of the states—customs duties, profits from the manufacture of alum (a papal monopoly) and direct taxation—together with a developed system of public loans, known as *monti di pietà*, had replaced the older sources of papal revenue drawn from all over Christendom. The papal states were squeezed to supply the finances required for the multifarious needs of the Counter-Reformation popes, including the great building activities of Sixtus V. Sixtus' energetic action freed Rome and the Campagna only temporarily from endemic banditry, but his provision of a new water supply was more permanent, and his employment of Domenico Fontana to complete the dome of St. Peter's, his many other new buildings, his obelisks, his fountains and his adornment of Rome in general accelerated the transformation of the medieval into the baroque city.

In 1605 the papacy had neither dropped out of European public life nor yet fully resigned itself to the loss of northern and much of central Europe. Its spirit and its organization had been notably renewed, in some ways even modernized. The naval league that defeated the Turks at Lepanto in 1571 had been organized by Pius V. But the counterattack on Protestantism, except for the coming Thirty Years' War, had all but reached its limits, and the 17th century was to bring fresh problems.

Rome was now increasingly remote from the intellectual and material forces at work in nations such as England and the Netherlands that were to influence so deeply the future course of history; and the papacy's attitude even toward Catholic France was not always understanding. Coming to move more and more in a closed world, the popes were losing the universal role that they had once been acknowledged to hold in Christendom. Yet with the geographically vast American accessions to Catholicism and the spread of Catholic missions throughout the globe the papacy was beginning again, in a new sense, to become a world power. (H. O. E.)

VI. THE 17TH AND 18TH CENTURIES

1. Paul V.—During the pontificate of Clement VIII, who died in 1605, the secular authorities of the kingdom of Naples and of the Venetian republic had constantly violated ecclesiastical rights, without provoking retaliation from Rome. For the sake of Christian peace, Clement, who was a statesman, had held his hand while remonstrating vigorously and even issuing a few threats; but the French ambassador to Venice, Philippe Canaye, who felt that the doge and senate were trading on the pope's forbearance, had surmised that under a *pape plus brusque* there might be serious trouble. The utterance was prophetic. One of the first public acts of Paul V, who succeeded after the 26-day reign of Leo XI, was to excommunicate the recalcitrant minister of Naples for his breach of the *privilegium fori* (the right of ecclesiastics to be judged in criminal cases by their own order).

After some months of protest against even worse offenses by the proud republic of the north, Paul launched an interdict against the whole Venetian territory, with little effect except to stiffen the resistance. A compromise peace was eventually patched up, but it had become plain to the Holy See that the day for interdicts and depositions had passed, and they were never again used as a weapon of compulsion against a sovereign state. When Paul forbade the Catholics of England to take the new oath of allegiance which James I imposed on them after the Gunpowder plot, many Catholics accepted the dire consequences of refusal, but a small vociferous party maintained that the oath did not contravene any doctrine of the faith and might safely be taken. That, however, was hardly the point when an express order had been issued by the supreme spiritual authority of the church.

The one real blot on this good and zealous pope's administration was his excessive fondness for display, which wasted funds that could have been better employed on the objects dearest to his heart; viz., a crusade against the aggressive Turks in eastern Europe and the salvaging of the faith in Austria, Poland, Hungary and the German states. His contention with Venice had taught him caution, and he feared nothing more than an open breach of the peace of Augsburg, though that measure had been so little favourable to Catholic claims. He endeavoured with all his might to maintain peace between the dedicated rivals, France and the Habsburg powers, and his closing days were rendered happy by the news of the emperor Ferdinand II's victory over the Calvinists of Bohemia in the battle of White Mountain (Nov. 8, 1620).

2. The Thirty Years' War and the Peace of Westphalia.—The pontificate of Paul's successor Gregory XV was made memorable by the foundation in 1622 of the congregation *de Propaganda Fide*, for the spreading of the Catholic faith in heathen lands and in missionary countries such as England. Through this congregation the church was enabled to recover in distant lands much of the ground that had been lost through the Protestant revolution in Europe. Under Gregory also the church won some notable successes in Bohemia, Moravia and Hungary through the tireless diplomatic and apostolic efforts of such men as the nuncio Carlo Carafa, the cardinal archbishop Péter Pázmány and the members of religious orders, especially the Capuchins and Jesuits.

The College of the Propaganda, distinct from the congregation, was founded in 1627 by the next pope, Urban VIII, to train missionaries of all nationalities for all parts of the world and is still known as the Urbanum. It was possibly the best thing that he did in the whole of his long and ineffective reign. As Maffeo Barberini, nuncio in Paris, he had been extremely successful, acquiring the full confidence of the French court; but as pope he added little except a profusion of baroque art to the dignity and prestige of the Holy See. He squandered on his arrogant and worthless nephews vast wealth that should have gone to the support of the poor, of hardly tried missionaries beyond the seas and of the Catholic cause in Europe, imperiled by the diplomatic unscrupulousness of Cardinal Richelieu and by the military genius of Gustavus II (Adolphus) of Sweden. He tried to maintain an uneasy neutrality between the two mighty contenders of the Thirty Years' War, France and its Protestant allies on the one side and the house of Habsburg in Spain and in Germany on the other, on the ground that he must not endanger his common fatherhood of the warring parties, so as no longer to be able to heal their differences. The result of his refusal to align himself unequivocally with the devoutly Catholic emperor Ferdinand II was that the French under Richelieu and his successor Mazarin eventually prevailed, without having any reason to be grateful to the papacy.

The chief reason for the pope's hesitation was the presence of Spanish power north and south of the papal states, whereby the Holy See's independence was constantly menaced. This situation explains and, on the whole, justifies papal policy during the period, for the Holy See had a long memory and was determined, as far as in it lay, not to be again the mere puppet or chaplain of Caesar. If Urban VIII and his successors clung covetously to every square yard of their hereditary states, even to the extent of going to war for their integrity, it was because, in those times of aggressive nationalism and absolutism, they could never be sure where Caesar, in the shape of a Spanish or a French king or a Holy Roman emperor, would be content to stop, unless barred on a frontier by troops as sturdy as his own. That Catholic France should be allied with the Protestant princes and acting in collusion with the Turks does not seem as shocking to us as it necessarily was to the popes of that period; and Richelieu also demonstrated, by his tolerance of the defeated Huguenots as a religious minority, that unity of faith was no longer to be considered a necessity of national power and prosperity—a lesson which England took very much longer to learn.

The concern of the popes to prevent a permanent Spanish occupation of the Valtellina (*q.v.*) was actuated by the fear that it would serve as a channel of reinforcement for the Spanish Habsburgs in Milan by the Austrian Habsburgs in the Tirol north of the Alps. Under Gregory XV papal troops had taken possession of the valley, but Urban VIII was not able to maintain the position, and the Calvinist Grisons eventually assumed control.

By the peace of Westphalia, signed in 1648, the Catholic Church in the empire lost a great deal of territory through the cession of ecclesiastical estates to the Protestants. For this policy the new emperor, Ferdinand III, was responsible. It was plain that Austria had lost the war, and Ferdinand, advised by his able minister Maximilian von Trauttmannsdorf, a paler version of Richelieu, determined to save what he could of his hereditary dominions by sacrificing those of the church. The new pope, Innocent X, protested in the most vigorous terms against the clauses of the peace which alienated Catholic lands, but nothing that he could say or do had the least effect. This was symptomatic of the great change which had come over the political scene. Until then the Holy See had maintained, in spite of the Protestant revolution, some measure of its medieval prestige as a unifying centre of the nations; but Richelieu, Mazarin and Trauttmannsdorf, all three Catholics, had destroyed that precious office of mediatorship, and the popes were no longer to be consulted by the nations in the making of war or peace.

Apart from the fact that he was dominated by his rich sister-in-law, the extraordinary and most objectionable Olimpia Maidalchini, Innocent X gave evidence of every quality of a good ruler

and showed, in spite of his advanced age, a remarkable determination to see that his states were justly and wisely administered and that crime, even in high places, did not go unpunished. When the bishop of Castro was assassinated at the instigation of the duke of Parma, the pope sent his troops to raze that town to the ground. After the most careful consideration he condemned five propositions extracted from the *Augustinus* of Cornelius Otto Jansen, whose followers in France, led by Jean Duvergier de Hauranne (*q.v.*), abbé de St. Cyran, strenuously contended that the book did not contain them. There followed a century of acrid controversy which did much harm to the church in France and other countries. (*See* JANSENISM.)

The secularization of politics brought to a head by the peace of Westphalia had the result of increasing the spiritual power of the papacy within the church. The tendency toward centralization of all the church's activities in Rome, observable for centuries past, was given a new impetus by the claims of the secular states, Catholic as well as Protestant, to regulate all ecclesiastical affairs within their dominions. The establishment of the various congregations in Rome to help the Holy See in the government of the universal church, the gradual supersession of cardinal nephews by officially appointed secretaries of state, the overhauling and increasing of the nunciature service and the closer linking of the universal episcopate with Rome by means of the compulsory visits *ad limina apostolorum*—all these measures gave new vitality and strength to the papacy, precisely at the time when its importance in world affairs seemed to have been finally eclipsed.

Even a pope such as the vigorous Innocent X's indolent successor, Alexander VII, who was personally a fine character and had been an excellent nuncio, contributed to the process by leaving more and more of the administration to the congregations, with the result that the secretariate, so often in the past the perquisite of self-seeking, avaricious cardinal nephews, became increasingly important. Two well-loved popes of deeply spiritual mind, Clement IX and Clement X, did their best to rouse Europe to the menace of the Turks, again on the march, but could achieve very little because of Louis XIV's understanding with the Porte.

3. Innocent XI, the Turks and Louis XIV.—In 1676 a pope succeeded who was also a saint and a statesman, the incomparable Innocent XI. "In manner gentle, in temper tolerant, in mood humane, in outlook broad and comprehending, he nevertheless possessed and exercised an inflexible will and an imperturbable daring" (Sir Winston Churchill, *A History of the English-Speaking Peoples*, vol. ii, *The New World*, Cassell, London, 1956).

Innocent needed all his qualities to deal with the pretensions of the absolutist Louis XIV, who could command the most powerful army in the western world to support his claims. The pope was not in the least hostile to France and bent all his energies to persuade Louis to put the interests of the Christian west above his national ambitions by entering into an alliance with the emperor Leopold I against the Turks. But his pleadings fell on deaf ears; Louis had already assured the Porte of his benevolent neutrality should the sultan decide to attack the emperor.

French influence was also very strong in Poland and caused John III (Jan Sobieski) to hesitate before throwing in his lot with the sorely pressed Leopold, who had to contend not only with the Turks, already in possession of part of Hungary, but with the insurgent Hungarian Calvinists. In fact, it was the Calvinists, under their brilliant leader Imre Thököly, who appealed to the grand vizier, Kara Mustafa, to launch his hordes against the Habsburg power. Soon they were under the walls of Vienna, where one of the most famous sieges in history took place in 1683. By dint of constant appeals and immense subsidies, Innocent, through his indefatigable nuncio in Warsaw, Obizzo Pallavicini, persuaded the reluctant Sobieski to move to the rescue. Sobieski was slow in coming and, but for the intervention of Charles of Lorraine, Vienna must have fallen. When the siege was raised, Sobieski claimed all the glory for himself; but the real architect of the Christian victory was Innocent XI.

Innocent, who came of a banking family, inherited an insolvent papal treasury; by dint of the most rigid economies, wise taxation and complete avoidance of the ostentation to which some of his predecessors had been addicted, he not only balanced his budgets but also accumulated, by appeals to the Catholic powers and to the episcopate, vast sums for the common good of Christendom. His stand against the pretensions of Louis XIV was no less staunch and admirable, even if he had to leave it to his successors Alexander VIII and Innocent XII to make peace with the Grand Monarque, who helped by withdrawing from Avignon in 1689 and by abrogating, in 1693, the Gallican articles of 1682. (*See* GALLICANISM.) Only then did the Holy See consent to institute canonically the 35 French bishops appointed irregularly and as a defiant measure by the king. Innocent XI saw more clearly than any of his predecessors that Protestantism had to be tolerated for the sake of general peace, and he expostulated strongly against the persecution of the Huguenots (*q.v.*) by Louis XIV after the revocation, in 1685, of the Edict of Nantes. (*See* also INNOCENT: *Blessed Innocent XI.*)

BY COURTESY OF THE VATICAN MUSEUMS

POPE INNOCENT XI. SKETCH IN RED CHALK BY HIS CONTEMPORARY GIOVANNI BERNINI. IN THE GALLERIA CORSINI, ROME

Innocent XII, the last pope of the 17th century, is notable as having put an end to the nepotism which had spoiled the good intentions of so many of his predecessors. In 1692 he issued a bull making it unlawful for any subsequent pope to bestow the cardinalate on more than one of his relatives or to give any of them a benefice bringing in more than a modest revenue. For himself, he said, his nephews were the poor people of Rome.

4. Clement XI.—The 21-year reign of Clement XI, a pope worthy of a better fate, was made wretched by the War of the Spanish Succession. When the dying Charles II, last of the Spanish Habsburgs, nominated Louis XIV's grandson Philip of Anjou (Philip V) as his successor, the pope was in no position to repudiate this creation of a Bourbon dynasty in Spain, but his recognition of Philip as king inevitably antagonized the emperor Leopold I, who accused him of having gone over to the French side in the endless contest between Bourbon and Habsburg. This accusation was not true, for Clement's only desire was to avert war by peaceful mediation or, if he could not do so, to save Italy from the calamity. He failed disastrously in both aims. French troops occupied Mantua, the key to upper Italy, but were ousted from that strong position by the genius of the imperial general Prince Eugène of Savoy. After that, the struggle between the emperor (who fought to make his son, the archduke Charles, king of Spain and Naples) and Louis XIV turned into a great coalition war, almost a world war.

Leopold I died in 1705 and was succeeded by his son Joseph I, who proved even more hostile to the unfortunate pope, crushed between the upper and the nether millstones. In Vienna there was no forgiveness for his recognition of the Bourbon king in Spain, though he determinedly refused to invest Philip as king of Naples. Imperial troops invaded the papal states, conquered Naples and compelled the holy father, who feared another sack of Rome, to promise recognition of the archduke Charles as king of Spain. Thereupon Philip V expelled the papal nuncio from Madrid and broke off diplomatic relations with the pope. The peace of Utrecht (1713–14) and the peace of Rastatt (1714) resulted in heavy diplomatic defeat for the Holy See, whose age-old rights of suzerainty in Naples, Sicily, Parma and Piacenza were disregarded.

Perhaps the most important of the unhappy Clement's acts was his bull *Unigenitus* (Sept. 8, 1713) against the Jansenists, whose resistance to it was, however, much encouraged by the example of opposition set by the cardinal archbishop of Paris, Louis Antoine de Noailles. (*See* JANSENISM.) Much less wise was his condemnation of the Chinese and Malabar rites in 1704 (*see* RITES CONTROVERSY), a measure which, through the bungling of his legate in China, C. T. Maillard de Tournon (whom he created

cardinal in 1707), led to a persecution of the Chinese Christians and to the ruin of many flourishing missions. The pope himself was a noble character, dogged by misfortune but never despairing, a tireless worker, abounding in charity, who heard confessions in St. Peter's like any priest and did not disdain to go into the pulpit.

5. 18th-Century Secularism.—Innocent XIII was handicapped by ill-health and showed very little of the quality of his great predecessor Innocent III, whose name he took and to whose family, the Conti, he belonged. Under French pressure he raised to the cardinalate that morally questionable person Guillaume Dubois, archbishop of Cambrai and prime minister of the French crown. In 1723 the Jansenists in Holland went into open schism by electing Cornelius Steenoven archbishop of Utrecht without the authority of the Holy See.

Innocent's successor, very much against his will, was the devout, unworldly Dominican archbishop of Benevento, Pierfrancesco Orsini, who took the name Benedict XIII. In spite of Benedict's exemplary personal qualities and zeal for reform, his reign was disgraced by the venal conduct of his principal confidant, the rapacious cardinal Niccolò Coscia; and Benedict's inexperience in secular affairs led him to make concessions which were promptly exploited in the sphere of politics.

The sensitiveness of professedly Catholic governments at that period of ever-expanding skepticism and irreligion was well illustrated by the ludicrous outcry that they made when the pope, in 1728, extended the feast of Gregory VII to the universal church, as though the mild, conciliatory Benedict were thereby reasserting

TABLE XIV.—*The Papacy From 1605 to 1800*

1605 (April)	Leo XI	1691–1700	Innocent XII
1605–21	Paul V	1700–21	Clement XI
1621–23	Gregory XV	1721–24	Innocent XIII
1623–44	Urban VIII	1724–30	Benedict XIII
1644–55	Innocent X	1730–40	Clement XII
1655–67	Alexander VII	1740–58	Benedict XIV
1667–69	Clement IX	1758–69	Clement XIII
1670–76	Clement X	1769–74	Clement XIV
1676–89	Innocent XI	1775–99	Pius VI (d. in exile)
1689–91	Alexander VIII		

the claims to depose monarchs and deprive them of their kingdoms which seven centuries earlier Hildebrand had successfully maintained. The perfectly objective account of Gregory's struggle with the emperor Henry IV, in the second nocturn of the new office, was regarded as an attempt against the sovereignty of princes and an incitement of their subjects to rebellion. The *signoria* of Venice and the *parlements* and Jansenists of France protested in violent terms. The viceroy of Naples proposed to the emperor that the printers of the offending nocturn should be cast into prison, and the senate of Palermo forbade the office under a penalty of 1,000 scudi. Not to be outdone, the Dutch government, "in order to safeguard the reformed religion," forbade Catholic priests within its jurisdiction to recite the office of St. Gregory under a penalty of 1,000 florins. The pope declared all the decrees of the secular powers against the office to be null and void.

The happiest event of his reign was the restoration of Comacchio (1725). This fortified commune, 30 mi. S.E. of Ferrara, had been retained by the emperor after the War of the Spanish Succession and was considered by the popes to be necessary for the defense of their states. After Benedict XIII's death in 1730 there were riots in Rome directed against his favourite Cardinal Coscia and that man's followers, who had seriously depleted the papal treasury by their depredations.

The next pope, Clement XII, whose parents had belonged to two of the wealthiest families in Florence, partially restored the situation by contributions from his own ample funds, by making Coscia disgorge his ill-gotten booty and by various financial measures, including a public lottery and the issue of paper money. The new pope was an affable man of spotless reputation, but his age (he was 78 years old at his election), his gout and a weakness of the eyes resulting in total blindness shortly after his election all militated against his being able to do much for the church in that age of spreading rationalism and skepticism. (For the philosophical climate of the period, *see* ENLIGHTENMENT and other articles referred to there.)

From the outset of his pontificate, the pope had to struggle with the pretensions of Charles Emmanuel of Sardinia and with serious trouble over those ill-omened duchies Parma and Piacenza, which, though held by the Farnese as fiefs of the Holy See since 1545, became bones of contention between Bourbon Spain and Habsburg Austria on the extinction of the male line of the Farnese dukes in 1731. With England as mediator, the rival Catholic powers composed their differences without resort to war, but the protests of the pope were completely ignored in the arrangement. The Gallicanism of France had crossed the Pyrenees to Spain with the Bourbon king—to become in its new home, under the leadership of Gaspar Molina, bishop of Málaga, even more affronting to the papacy than in the land of its origin. In the kingdom of Naples, which Don Carlos (the future Charles III of Spain) had seized from the Habsburgs in 1734, the ruling power behind the throne was the violently anticlerical Bernardo Tanucci. The best-remembered act of Clement XII was his constitution of April 28, 1738, condemning Freemasonry under heavy ecclesiastical penalties; and his most endearing act was restoration (1740) of complete independence to the little republic of San Marino, which the cardinal Giulio Alberoni, of his own initiative, had in 1739 annexed to the papal states.

It was at this nadir of the Holy See's political influence that Prospero Lambertini became pope as Benedict XIV. He was the most genial, witty and learned of all occupants of the papacy, as well as one of the kindest and most compassionate. Before his election he had played a decisive part in settling the manifold differences of the Holy See with the encroaching Catholic powers, and as pope he directed all his great ability and energy to the restoration and maintenance of peace with those same suspicious and aggressive governments. Even the courts of Turin and Naples, which had defied his predecessor and grievously afflicted the church, came, however sulkily, to some kind of understanding with the new pope, who showed himself conciliatory almost to a fault. In Spain the difficulties were even greater, because of the baleful influence of Molina, the bishop of Málaga, whom Clement XII had made a cardinal in a pathetic attempt to mitigate his antipapal hostility. Still stranger was it to find a strong Gallican in Philip V's Jesuit confessor, an impetuous Frenchman who had convinced himself that Benedict was meditating some drastic coup against his order. The coup was being prepared, surely enough, but not by Benedict XIV. The concordat which the pope eventually signed with Spain (1753) has been heavily criticized as giving away far too much and as greatly encouraging the caesaropapism of the Spanish court, but it may well have been his only way of preventing a complete schism. During the War of the Austrian Succession, Benedict had to endure the devastation of his defenseless states by the armies of both contending parties because he tried to remain neutral. He said that he could write a treatise on "The Martyrdom of Neutrality."

The pope had the defects of his shining qualities. His love of literature and learning and his charming geniality and broad-mindedness led him into a friendly correspondence with the leader of the anti-Christian movement, Voltaire, on whom he bestowed two gold medals. He promoted schemers such as the cardinal Domenico Passionei whose dearest object in life, assisted enthusiastically by a group of hidden or open Jansenists, was the destruction of the Society of Jesus. The bull *Ex quo singulari* (1742) put an end to the century-old controversy on the Chinese rites by forbidding to Christian converts certain observances which the Jesuits, on the testimony of the Chinese emperor, had maintained to be of purely social significance. That spelled the eclipse of many bright hopes for the conversion of China; and it was followed in 1744 by another bull, *Omnium sollicitudinum*, dealing similarly with the Malabar rites. On the other hand, oriental Catholics nearer home received great support from the Holy Father, who encouraged them to maintain their own rites: "We desire most intensely," he declared, "that all should be Catholics, but not that all should be Latins."

As proof that the church in that age of rampant secularism and skepticism retained its indestructible vitality, there arose two new religious families, the Passionists and the Redemptorists, which

the pope had the happiness of approving. But almost his last act on earth, the appointment of the cardinal Francisco de Saldanha, a creature of the marquês de Pombal, to report on the Jesuits of Portugal, played straight into the hands of the Jesuits' enemies.

6. The Suppression of the Jesuits.—Clement XIII spent his pontificate in an almost unbroken fight against the godless forces of the times and did everything in his power to save the doomed Society of Jesus from its confederated foes, Bourbon absolutists, Jansenists, *philosophes*, Freemasons. During his reign, the Jesuits were expelled successively from Portugal (1759), from France and the French dominions (1764), from Spain and the Spanish dominions (1767), from Naples, Sicily and Parma (1768). All their property was confiscated and their flourishing missions in India and in the far east and in North and South America were ruined. The pope received the destitute exiles into his states, but their enemies had not finished with them. In Jan. 1769 the ambassadors of Spain, Naples and France appeared in turn before the Holy Father and demanded the complete suppression of the Society of Jesus throughout the world. At that point the tormented pope had a stroke and died. (*See* also JESUS, SOCIETY OF.)

The conclave from which the gentle, peaceable Franciscan friar Giovanni Vincenzo Antonio Ganganelli emerged as Clement XIV was subjected to pressure and interference such as had not been paralleled for ages; and the unfortunate man, who by an irony of history had been created cardinal by Clement XIII because he was supposed to be friendly toward the Jesuits, never had a chance of proving his friendship. Terrified lest France and Spain should resort to open schism, he issued on Aug. 16, 1773, a brief, *Dominus ac Redemptor* (dated July 21), dissolving the order which from its beginnings had dedicated itself to the service of the Holy See.

7. Pius VI.—Clement survived the destroyed society by less than 14 months and was succeeded by Pius VI, a throwback to some of the ostentatious and irresponsible Renaissance popes, who might be charged with having fiddled while Rome burned. He was not the man to deal with the Febronianism of the emperor Joseph II (*see* GALLICANISM: *Febronianism* and *Josephinism*) nor with the cataclysm that ensued from the French Revolution of 1789. The destruction of his temporal authority by the armies of the Revolution in 1798 and his death in captivity in the following year presaged a new epoch for the papacy. (J. P. Bk.)

VII. THE 19TH AND 20TH CENTURIES

A. From Napoleon to the Revolutions of 1848

1. Pius VII.—When the Benedictine bishop Barnabà Gregorio Chiaramonti emerged as pope from the prolonged and rather undignified conclave at Venice, his election could be interpreted as a reaction against the pressure of political elements (mainly pro-Austrian) in favour of a candidate whose major interest was known to be in the religious aspect of contemporary problems. With a mental acuteness that enabled him to cling tenaciously to the essential points while sacrificing matters of detail Pius VII, notwithstanding his respect for tradition, promptly showed his readiness to reach a compromise with the Revolution insofar as was compatible with the church's principles. Overriding the shocked opposition of some members of his entourage, he made a bold decision and negotiated the celebrated concordat of 1801 with the first consul of the French republic, Napoleon Bonaparte. In the belief that it was of vital importance for Rome to come to terms with the republic, both for religion's sake and because of the international significance of such a reconciliation, Pius not only stood sponsor, in a moral sense, for the child of the Revolution but also, in return for certain substantial advantages, waived the claim that Catholicism should be recognized as the state religion. Giving his official blessing to the liquidation of the pre-Revolutionary church in France, he renounced the ecclesiastical property that had been secularized, set himself to a far-reaching reorganization of the provincial and diocesan structure of the church and called on the surviving bishops to resign their sees.

This last concession was altogether without canonical precedents; and by inducing Pius to agree to it Napoleon struck a heavy blow at the Gallican tradition, since the pope, however well aware he may have been of the extent of his powers over the bishops, had never previously dared to assert them so drastically in practice. Moreover, the fact that a concordat was signed was in itself a victory for the papacy. Whereas in the 18th century it had been either disregarded or treated as a foreign power against which the national episcopate could be brought into play, the papacy now became an ally whose influence over the clergy of the Catholic world was acknowledged and whose co-operation would be sought in settling the religious questions that the state had formerly tried to settle by unilateral action.

The prestige accruing to the papacy from the concordat was to be augmented when Pius and Napoleon (whom he had consecrated as emperor in 1804) came into conflict. The cause of the quarrel was political rather than religious; viz., the pope's refusal to incorporate the papal states within Napoleon's continental system of blockade against England. The emperor thereupon annexed what was left of the states of the church (1809). When Pius retorted by excommunicating him, he had him arrested and tried to reduce his position to that of a high ecclesiastical official of the empire. These rough measures, which at one moment came very near to success, had two results: in the first place, they aroused a deep feeling of esteem and respect for the victim among Catholics, particularly among Catholics north of the Alps, where for centuries few had cared much about a pontiff who never left the vicinity of Rome; and second, they served to align the pope with the powers that were eventually to be victorious against Napoleon, even though at the time of the pope's arrest these powers showed little concern for him.

On the one hand, then, Pius VII and his secretary of state, Ercole Consalvi (*q.v.*), who was a man of genius, had adopted an understanding attitude toward the France of the Revolution and so had been able to re-establish, within a few months of the beginning of this pontificate, a power that had been seriously threatened; on the other, the moral authority of the papacy, enhanced as it was by the pope's subsequent resistance to Napoleon, was to be seconded in the work of restoring the church after Waterloo.

In reaction against Napoleon, numbers of European statesmen came to think that an independent spiritual power vested in the person of the pope constituted a valuable guarantee. This view, together with the principle of legitimism, caused the papal states to be restored by the congress of Vienna; and Consalvi's diplomatic ability succeeded in securing complete restoration except for Avignon and the Comtat-Venaissin. Yet this success carried with it the germs of trouble for the popes. Their subjects, particularly those in the Legations (Bologna, Ferrara, Ravenna and Forlì) which had been annexed to France for 20 years, had acquired a taste for modern administrative methods and now felt misgivings at the re-establishment, even in part only, of the archaic proce-

PICTORIAL PARADE

ELECTION OF THE POPE TAKES PLACE IN THE SISTINE CHAPEL, IN THE VATICAN PALACE, SHOWN WITH THE CANOPIED THRONES OF THE CARDINALS PLACED ALONG THE SIDE WALLS

dure of pre-Revolutionary times. Consalvi, who had moreover to struggle against opposition within the curia, tried to modernize the administration, the judicial procedure and the financial system of the states by means of the constitution of 1816. The progressives, however, were disappointed in their hopes.

While it was principally Consalvi who was responsible for the reorganization of the papal states, Pius VII concerned himself with the ecclesiastical and religious aspects of the restoration. In the period following 1815 it was generally accepted that the church was the best safeguard of monarchy; and Pius took advantage of this opinion and of his own personal ascendancy to continue his policy of concordats. This policy enabled him, at the cost of a few concessions to the spirit of the age, to counteract the tendency toward state control of the church (to which all contemporary governments were inclined) and to get himself implicitly recognized as the real head of the universal church. Further, in view of what had happened in France, he could insist on more favourable conditions in his concordats. In other respects he showed himself capable of profiting from circumstances. In France and in Spain he co-operated with the counterrevolution; in Austria and in Germany, however, where the spirit of the emperor Joseph II was still vigorous, he did not scruple to appeal to new ideas of liberty; and in the Protestant countries he called for toleration.

With papal encouragement, the religious orders took up the task of reorganizing themselves; and in 1814 Pius restored the Society of Jesus, which in later years was to be one of the papacy's most active partners in the work of ecclesiastical centralization. Different from many of his predecessors of the 18th century, whose interest was principally in administration and politics, Pius VII showed a great concern for doctrine and issued stern condemnations of the enemies of the church, especially against Freemasonry, in which he saw the embodiment of the revolutionary and anti-Christian philosophy of the 18th century. He remained true to the tradition of the humanist popes, however, in his interest in educational reform, in the improvements that he introduced into the Vatican library and the pontifical museums and in his desire to make Rome a centre of the arts.

2. Leo XII.—In their efforts to adapt the papacy to the political, intellectual and social conditions of the modern world, Pius VII and Consalvi had come up against the opposition of the *zelanti; i.e.*, those churchmen who stood for political reaction and objected to any concession that might be made to modern aspirations. This party was well represented in the higher clergy and in the curia, and the election of Annibale Sermattei della Genga as pope, under the name of Leo XII, constituted a victory for it.

Their next success was the abandonment, in the papal states, of the reforming policy of Consalvi. Authoritarianism was reinstated. This reaction, however, provoked in the *bourgeoisie* a strong resentment against "government by priests"; and though Leo's financial policy, by reducing expenditure, made it possible to reduce taxation, the precarious economic situation of the state remained unchanged, while the pope forfeited the affection of those who had profited from the abuses that he removed.

In matters of doctrine Leo took a number of measures calculated to prevent the infiltration of liberal ideas and to strengthen the efficiency of the Inquisition. On the other hand, in his relations with foreign governments, after some clumsy moves inspired by the intransigence of the *zelanti*, he soon came to appreciate the need for appeasement and moderation in view of the new outbreak of liberal propaganda, the revival of Gallicanism and the persistence of Josephinism.

3. Pius VIII.—The reactionary Leo XII was succeeded by Pius VIII, a disciple of Pius VII and of Consalvi, who reigned, however, for only 20 months. In strictly ecclesiastical matters Pius showed himself generally broad-minded and conciliatory, though not at the expense of principle; and in the administration of the papal states he both mitigated the authoritarian regime and showed wisdom in his social and economic policy (though he did not succeed in allaying the increasing discontent and agitation). In foreign policy, however, he gave a free hand to his secretary of state, the old cardinal Giuseppe Albani, who was wholly devoted to the Austria of the Holy Alliance. This caused him to be represented as having aligned himself altogether with the absolutist governments and as hostile to the Polish, Irish and Belgian risings of 1830 (the Belgian alliance of Catholics and liberals against the enlightened despotism of King William I of the Netherlands was regarded as "monstrous" by the Vatican). Yet Pius made no difficulties about recognizing the July monarchy in France.

4. Gregory XVI.—Historians used once to represent Gregory XVI (a former Camaldolese monk, Bartolomeo Alberto Cappellari) as a typical example of a reactionary and narrow-minded pope; but this view is now disputed. Gregory indeed showed little sympathy for Italian nationalism or for his subjects' desire to see the administration of the papal states modernized; his monastic austerity moreover made him seek to isolate himself, while his rough manner made him seem even more intransigent than in fact he was. But even so his political and administrative record is less black than it has been painted by the early historians of the Risorgimento; and we must also recognize in this scholarly man an enlightened patron of the arts and of archaeology. Moreover, in religious matters his intelligent and carefully considered measures proved beneficial to the church in more than one respect.

A former monk, Gregory naturally favoured the religious orders. He supported the inauguration of several new congregations, restored the Benedictines and the Dominicans in France and protected the exempt orders from encroachments by the bishops. This last-named line of action reflects the long-established papal policy of maintaining the Holy See's rights against all surviving traces of Gallicanism and Febronianism; and the pontiff before his election had already made himself the spokesman of Ultramontanism in his book *Il trionfo della Santa Sede* (1799).

Having once been prefect of the congregation *de Propaganda Fide*, Gregory was a great missionary pope. In the Revolutionary and Napoleonic periods Catholic missions had suffered a serious setback, and everything now needed to be reorganized. The effort that had been begun in the last years of Pius VII was systematically encouraged and extended; and since 1826, when he became cardinal, Cappellari had been working for centralization of the missionary enterprises. Gregory moreover did not flinch from bold innovations. For example, he envisaged a native clergy and even a native episcopate in the missionary countries (this however had no immediate result).

In Portugal, Spain, Switzerland, Prussia and Russia various politicoreligious disputes confronted the papacy under Gregory. The pope's underlying policy was to oppose any attempt at restricting the rights of the church, whether inspired by caesaropapism, as in Russia and in Prussia, or by liberalism, as in Switzerland. Yet on several occasions he showed himself ready to come to terms. For instance, after obtaining satisfaction on the matter of principle he agreed to the removal of the Ultramontane archbishop of Cologne, K. A. von Droste zu Vischering, whom the Prussian government had arrested in 1837; and in 1845 he consented to a partial dissolution of the Jesuits in France. This same spirit was made especially evident in his attitude toward the young republics in South America (the bull *Sollicitudo ecclesiarum* of Aug. 7, 1831, declared that where there was a change of regime the Holy See would treat with the *de facto* government) and toward Belgium (where the revolution of 1830 had led to a liberal constitution). Thus it was that, despite his dislike of liberalism and of the revolutionary spirit, Gregory was prepared to negotiate with governments born of insurrection and refrained from condemning those Catholics who throughout Europe were appealing to liberal principles to secure their religious rights from their governments. Here Gregory appears not as a reactionary pope but as one who was ready for what the future held; yet he felt no enthusiasm for these compromises, which he did his best to limit.

In matters of principle Gregory was indeed uncompromising. Rationalist naturalism he condemned in all its forms, together with fideism. The most famous of his pronouncements in this field is the encyclical *Mirari vos* (Aug. 15, 1832) against certain ideas that H. F. R. de Lamennais (*q.v.*) and the newspaper *L'Avenir* had been putting forward; viz., the separation of church and state, liberty of conscience and the freedom of the press. Gregory was opposed to liberalism not only because he regarded it as a mani-

festation of indifference to doctrine but also because his feeling for authority prompted him to defend kings even against rightful claims by their subjects and, ultimately, because from the moment of his accession he was haunted by the fear of seeing his own dominions eaten away by liberal ideas.

In fact at the very beginning of his pontificate there had been a revolt in the Romagna and in Umbria. Foreign intervention had been required to restore order, and as a consequence of this intervention Gregory had had to promise reforms (stipulated in the memorandum presented by the powers in May 1831). These reforms, though not very generally recognized, were numerous (particularly while Tommaso Bernetti was secretary of state) and for the most part reasonable and beneficial; but they still proved inadequate to the situation, mainly because they were limited to the administrative field and never extended to the political. Opposition therefore became rife, and repressive measures, designed to stifle it, only made it more bitter. Discontent was also further exasperated by the wholly negative attitude of Gregory and of his new secretary of state, Luigi Lambruschini (a partisan of the old order who had taken Bernetti's place in 1836), toward Italian nationalism and patriotic feeling against the influence of Austria in the peninsula. Though his understanding with Metternich was not nearly so close as his detractors thought, Gregory showed no sympathy whatever for the cause of Italian unity, even when thinkers such as Vincenzo Gioberti and the "Neo-Guelphs" proposed a federal union under the presidency of the pope himself.

B. The Advance of Democracy and Rationalism

1. Pius IX.—Pius IX reigned longer than any former pope, and his pontificate was one of crisis and of new departure both from the political and from the religious point of view.

The Revolution of 1848 and the Roman Question.—Giovanni Maria Mastai-Ferretti was elected pope, in opposition to the rival candidature of Lambruschini, by cardinals who were anxious about the liberal and national agitation then rife in the states of the church. Pius was thought at first to be far readier than in fact he was to come to terms with the movement for Italian unification and for constitutionalism; many, indeed, hoped that he would put himself at its head. For some months this myth of a "liberal pope" won him immense popularity; then it was brought to an end in the crucial period of 1848.

It first became clear that, though he sincerely wanted to improve the lot of his subjects by administrative reform, Pius IX could not bring himself to reform the constitution. Any concession that his priestly monarchy might make to the laity, he feared, would be a limitation of the Holy See's spiritual independence. His allocution of April 29, 1848, showed that, however much he sympathized with the Italian aspirations, he would never agree to play an active role in the war of independence against Austria, as this would seem to him incompatible with his duty as spiritual father of all the faithful. Economic difficulties combined with the pope's lack of political adroitness to precipitate a crisis. Rioting broke out, and on Nov. 24–25 Pius had to flee to Gaeta. In Feb. 1849 a republic was proclaimed in Rome, but this republic lasted only for a short time. The European powers upheld the pope, who was reinstated on his throne thanks to the French expeditionary force.

The ensuing work of restoration was reactionary and ill conducted, and the presence of foreign troops increased popular resentment at it. It was thus not difficult for Cavour to exploit this situation in order to advance his plans for uniting Italy under the aegis of Piedmont. After patiently undermining the authority of the papal government he seized the opportunity presented by the Franco-Austrian War of 1859 to annex the Romagna (March 1860) and then, on the defeat of the small pontifical army at Castelfidardo (Sept. 18), the Marches and Umbria. For the next ten years Napoleon III extended sufficient protection to enable the pope to retain Rome and the Roman Campagna. Then the Franco-German War broke out, and on Sept. 20, 1870, the Italians occupied Rome. Pius IX, who regarded himself less as a deposed sovereign than as the tenant of a property for which he had to answer to the church, refused to bow before the *fait accompli*. Rejecting the Italian offer of a "law of guarantees," he assumed the role of a prisoner in the Vatican. (*See* also Italy: *History*.)

FELICI

POPE PIUS IX

The Direction of the Church.—At the very moment when the disappearance of the papal states removed it from the field of European diplomacy, the papacy was about to emerge as a world power with which every politician would have to reckon. This development, of which Pius IX's successors were to reap the benefit, was the result partly of missionary activity (which throughout this 32-year pontificate kept abreast of the colonial expansion of Europe overseas) and partly of the large-scale immigration of Catholics to Canada, then to Australia and, above all, to the United States, where promising new churches grew up. In Europe, meanwhile, the position of the church in the traditionally Catholic countries was being apparently consolidated by concordats that sometimes gave it very favourable terms (*e.g.*, the Austrian concordat of 1855); and the churches that had survived precariously since the Reformation in Protestant countries were reconstituted. This was the case in England, where Pius restored the hierarchy in 1850; in the Netherlands likewise in 1853; and most markedly in Germany, where the *Kulturkampf* (*see* Germany: *History*) served to show how vigorous the Catholic Church had become in a few years through its increasing reliance on the Holy See.

Expanding in numbers, the church was yet closing its ranks ever more firmly round the person of the Holy Father. One of the most striking features of this pontificate is the continuous advance toward centralization and uniformity within the church, a movement that was to determine the character of Catholicism till the time of Pope John XXIII and Paul VI, 100 years later. The first Vatican council (1869–70), by its solemn definition of the infallibility of the pope when he speaks *ex cathedra* and of his primacy of jurisdiction over the entire church, marked the end of all that was left of particularism in the local churches. (*See* Infallibility.) From 1850 this policy was pursued in a number of ways, not without meeting with considerable opposition not only from the eastern patriarchates but also in France and in Germany (as can be seen from the size of the minority at the council and from the fact of the Old Catholic schism in Germany following the proclamation of the dogma). In any case, the decisive factor in the rapid and conclusive victory of Ultramontanism (*q.v.*) was the personality of Pius himself and the immense influence that he had won over laity and clergy alike. This expressed itself,

particularly in France, in the unprecedented phenomenon of "devotion to the pope."

Though successful in the long run, the ecclesiastical policy of Pius IX and his successors had certain unfortunate consequences. While the church, at his death, was numerically stronger and more firmly bound together than ever before, it was dangerously isolated in the face of the general hostility of national governments and public opinion. The victories of Catholicism during his pontificate were largely due to the progress of Ultramontanism and to the church's alliance with counterrevolutionary governments; but the very success of Ultramontanism provoked a reaction of resentment in these governments when they saw the national clergies escaping from their grasp; and at the same time the partisans of democracy, who were becoming every year more influential, could not forgive the church for having lent all its support to conservatism since 1848. Pius, ill-advised by his counselors, failed to adapt the church to the changes in politics and society that were coming into being in the second half of the 19th century.

Doctrinal and Spiritual Achievements.—Pius IX failed also to provide that stimulus on the intellectual plane which was required to counteract the advance of rationalism and positivism. He allowed the church's attitude to science to be determined by narrow-minded persons who, rigidly adhering to supposed tradition, thought their duty fulfilled if they simply anathematized any new tendency that at a first glance seemed contrary to the faith.

Yet Pius made important contributions to doctrine. He defined two new dogmas, that of the Immaculate Conception of the Virgin (1854) and that of papal infallibility (1870); and his encyclicals, though hardly original in content, following as they do on those of Gregory XVI, nevertheless constitute a far more systematic and wider-reaching corpus than Gregory's. The encyclical *Quanta cura* (Dec. 8, 1864) and the controversial *Syllabus* that accompanied it deserve special mention in this corpus, to which the decrees of the first Vatican council should have put the finishing touch. This council, however, which opened on Dec. 8, 1869, was interrupted by the outbreak of the Italian war in July 1870; and most of its sessions were consumed in long and passionate deliberations on the question of infallibility. In April, nevertheless, the important constitution *Dei Filius* had been approved, on the relation between reason and faith. Typical of the positive aspect of Pius IX's work, this represents a resolute attempt to eradicate the last traces of the naturalistic deism of the Enlightenment and to reassert the basic premises of revealed truth as the core of Christian thought. (*See* VATICAN COUNCILS; COUNCIL.)

TABLE XV.—*Popes of the 19th and 20th Centuries*

1800–23	Pius VII	1903–14	Pius X
1823–29	Leo XII	1914–22	Benedict XV
1829–30	Pius VIII	1922–39	Pius XI
1831–46	Gregory XVI	1939–58	Pius XII
1846–78	Pius IX	1958–63	John XXIII
1878–1903	Leo XIII	1963–	Paul VI

Together with this vast doctrinal enterprise, a considerable effort was made to enrich religious life; and this, indeed, was the major achievement of Pius IX's pontificate. While national traditions had to be sacrificed, the training of the clergy was made more thorough and there was a lasting increase in popular devotion. This achievement has often been belittled as superficial, but that it was not so is proved by the great revival of Catholic activity and by the expansion of the religious congregations. While local organizations and the Society of Jesus must be given the credit for some of these results, Pius himself played a large part in the achievement. (*See* further PIUS: *Pius IX.*)

2. Leo XIII.—In former times the Romans had been prompt to divide candidates for the papal crown into three classes: scholars, politicians and *zelanti*. Vincenzo Gioacchino Pecci, however, who became pope as Leo XIII, seemed to fulfill all three roles. As an intellectual he was in touch with scientific progress; as a diplomat he understood politics; and as a shepherd of souls he cared for the inner life of the church and for the spread of missionary work.

Continuity and Innovation.—Both in his own time and in later historical works an exaggerated contrast used to be drawn between the pontificates of Leo XIII and Pius IX. In many important respects, however, there is an obvious continuity from the one to the other. Leo not only maintained the devotional practices that Pius had favoured (the cult of the Sacred Heart and devotions to the Blessed Virgin, the rosary in particular) but also showed himself to be no less vigorous an opponent of rationalism and secularism, against which he was quite ready to have recourse to the *Syllabus*—to the deep disappointment of those who had hoped for a liberal papacy. Likewise he disappointed those who had expected a reversal of the Ultramontane tendencies that had prevailed under Pius. Leo in fact systematically encouraged Ultramontanism by accelerating the process of centralizing the great religious orders; by promoting pilgrimages to Rome; by constantly exerting his authority over the national hierarchies; by personally intervening in the politicoreligious disputes of several countries in order to indicate to the laity or to the clergy what line they were to follow; and by increasing the power of the nuncios, whom he sought to establish as the pope's commissioners to the local episcopates.

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POPE LEO XIII (APRIL 1878)

Finally, on the Roman question, while ready to compromise on ways and means and to declare himself satisfied with very little territory, Leo refused to abandon temporal sovereignty as a principle, as he could not see how the Holy See and the church could remain independent without it. Aware that no satisfactory situation could be reached by direct negotiation with Italy, he tried (without success) to make the question an international one, looking first to Germany, which was the dominant European power in the period following 1870, and subsequently to France.

In other respects, however, there is no doubt that Leo XIII's pontificate was characterized by a new spirit: in the first place, the pope was anxious to put a stop to the belief that the church was necessarily opposed to modern aspirations; second, he stimulated Catholic initiative with regard to social work; third, he sought to open the way to a *rapprochement* with other Christian churches; and, finally, he showed himself ready to conciliate foreign governments, being willing to temporize rather than to break off relations and, unlike Pius IX, refraining from strongly worded protest even when he found himself forced to disagree.

Doctrinal Guidance.—Leo XIII's encyclical *Aeterni Patris* (1879) gave a decisive stimulus to the revival of Thomism, which, however, he hoped to see reconciled with scientific progress. Another encyclical, *Providentissimus Deus* (1893), defined in a fairly broad-minded manner the principles on which Catholics should expound the doctrine of the divine inspiration of the Bible in the light of modern discoveries. He called upon Catholic historians to write objectively, and his opening of the Vatican archives to historians without regard to creed led to the establishment of a number of foreign historical institutes in Rome.

Not the least remarkable of Leo's encyclicals were those in which he gave a positive statement of the ideal of the Christian state (*Immortale Dei*, 1885; *Libertas Praestantissimum*, 1888). In these, he recognized that the concrete institutions of the *ancien régime* were no longer feasible and recommended that church and state live together in peace within the framework of modern society, acknowledging the new regime of toleration as provisionally admissible. Similarly, the encyclical *Rerum novarum* (1891), though rather cautious in its approach and not very fruitful in its immediate results, showed that the papacy had taken cognizance of the working-class question and sought to take a hand in its solution by defining "social Catholicism" for the first time. Leo's interest in the social problem is partly to be explained by his desire to win the masses for the church so as to be able to reckon

the support of this "real population" against the anticlerical policies often adopted by the *bourgeoisie* or "legal population." Of like inspiration were the papacy's efforts to organize the laity (notably through the Opera dei Congressi, the central body for Catholic social work in Italy).

Whereas Pius IX had wanted to latinize the rites and to standardize the discipline of the Uniate patriarchates, Leo XIII on the contrary declared that Eastern traditions were to be respected (*cf.* the encyclical *Orientalium dignitas*, 1894) and founded new seminaries in which the future clergy of the East could learn the spirit of Rome. His expectation that this would do much to promote the return of the schismatic churches to his fold was, however, disappointed, as also were the hopes that he had entertained of a *rapprochement* with the Church of England, for which Lord Halifax and the abbé Fernand Portal had been working. On the question of the validity of Anglican orders Leo had finally to give a negative reply (1896).

Foreign Relations.—In his dealings with foreign governments, Leo showed a strong preference for proceeding along diplomatic channels. His aim was to win the friendship of governments for the church by letting them appreciate the value of the church's moral support against revolutionary activity and by inducing Catholics to withdraw their obedience from lost causes (Carlism in Spain, monarchism in France); and he hoped that the church would receive substantial favours in return for services rendered. Thus, where Pius IX had been on the defensive, Leo adopted an active policy and won, indeed, some unmistakable successes: relations were resumed with Bismarck's Germany; disputes with Switzerland and with most of the South American republics were smoothed over; tension was eased in Russia; and much greater cordiality was established not only with Catholic Spain and Austria but also with the Protestant powers.

Yet in certain essential respects Leo's pontificate was a failure. Attempts to conciliate Italy came to nothing. The hope of winning German support for a solution of the Roman question was frustrated when Germany, Italy and Austria signed the triple alliance. The new policy adopted when Mariano Rampolla became secretary of state in 1887, namely that of seeking the friendship of the democracies, the United States and, particularly, France, was no less disappointing. Moreover, Leo's whole French policy, based as it was on the new collaboration of Catholics with republicanism, was made bankrupt when many refused to follow the pope's directives and when the flood of anticlericalism grew so strong as to threaten the proper functioning of the concordat. These reverses, which served to keep the Roman question unsolved, prevented the Holy See from playing the part to which it aspired in the international field. Nonetheless, Leo's policy enabled the church and the papacy to recover a considerable amount of their moral authority and, as a result, to gain a real political power. The growth of the Holy See's prestige in the course of this "glorious pontificate" can be measured by the number of new diplomatic missions established at the Vatican and by the volume of congratulation that reached the old pope on the occasion of his four jubilees. (*See* further Leo: *Leo XIII.*)

3. Pius X.—As Austria vetoed the election of Cardinal Rampolla, Giuseppe Melchiorre Sarto became pope as Pius X on Aug. 4, 1903. His was a mind quite different from that of Leo XIII. He had always hated "the political priest"; he had no liking for diplomatic maneuvers and little sympathy for liberal tendencies in the intellectual field; and he had an instinctive mistrust of popular government. Years of work as a parish priest had made him very conscious of the pastoral duties of the church and inclined him to consider every problem from the religious point of view; all who had come into contact with him thought of him as a saint. As Leo's policy of co-operation with secular governments seemed to him to have ended in failure, Pius decided to concentrate his attention on the problems of the apostolate and to make the defense of Catholic religion the keynote of his pontificate.

A Conservative Pope.—Opinions differ widely on the means by which Pius went about his purpose and on the spirit that actuated him and his advisers (the chief of whom was the Spanish cardinal Raphael Merry del Val). Three aspects of his policy in particular have aroused bitter controversy: the repression of modernism; the reaction against the "Christian democrats"; and his attitude toward the separation of church and state in France.

Even before he became pope, Sarto had been alarmed at the dangers that might be inherent in the reforming movement known as modernism, a movement most marked in France and in Italy. The modernist tendency seemed to be to sacrifice certain essential traditional values in order to reach a premature accommodation with modern ideologies. Pius settled the question by putting a series of books on the *Index*, by issuing the decree *Lamentabili* and the encyclical *Pascendi* (both 1907) and finally by reorganizing the commission on the Bible and imposing rigorous control over all churchmen whose duty it was to teach philosophy and theology. Pius did not intend that these measures should put a stop to all intellectual life within the church; but his lack of personal acquaintance with critical methods made it impossible for him to distinguish precisely between the justifiable, the controversial and the objectionable elements in the new theories; and moreover, particularly after 1910, he was rather too open to pressure from the "Integralist" or extreme reactionary party in the curia. Most of the blame that the antimodernist reaction has incurred was called forth by disagreeable incidents in these last four years of Pius X's pontificate, when the activities of Umberto Benigni's *Sodalitium Pianum* were often far from praiseworthy. (*See* also Modernism, Roman Catholic.)

At first sight it seems even more paradoxical that a pope whose own antecedents had been among the people and who all his life championed the cause of the poor should have led the reaction against Christian democracy. What he found intolerable, however, was that some Catholics should make their social work a matter independent of the hierarchy and conduct it in an increasingly political direction. Accordingly he began his pontificate with a radical reorganization of the Opera dei Congressi in Italy and disavowed and then formally condemned both the Italian priest Romolo Murri's "Popular Action" movement and, in 1910, Marc Sangnier's *Sillon* group in France. Some intervention on the part of the higher authority in the church was justified insofar as the Italian groups were making certain concessions to modernism and the French were too outspoken on matters of doctrine; but the pope's choice of measures, together with the rather favourable attitude that he adopted toward *L'Action française* (*see* Maurras, Charles; Daudet, Léon), showed that the Vatican for the time being was drawing away from democratic ideas and inclining rather toward paternalism as a means of solving social questions.

All the factors contributing to the break between the papacy and the French government, which culminated in the law of 1905 separating church and state in France, were already on the scene at Pius X's accession; the break, in fact, was inevitable. Pius, indeed, saw the advantage of making the church of France wholly independent of the state, particularly where the choice of bishops was concerned. Most of the French bishops, however, would have been willing to try out open-mindedly the new legislation on *associations cultuelles* (associations for religious worship), which safeguarded all that could still be preserved of the church's material interests; and there was general surprise when Pius rejected the compromise offered. In his view no departure could be admitted from the principle that the church's position must not be determined by unilateral action on the part of a government; and he may also have been misinformed on the new spirit active in the French government's policy since the fall of Émile Combes.

The break with France, increased tension with Russia about religious affairs in Poland, and some clashes with the United States combined to promote Austrian and German influence in the Vatican to such a degree that Pius has sometimes been called "the pope of the triple alliance." Yet his relations with the court of Vienna and, especially, with the German empire were not untroubled. For instance, there was the incident of the *Borromäus-Enzyklika* (1910), when great resentment was shown at the pope's slighting references to the Protestants in his encyclical on the occasion of the tercentenary of St. Charles Borromeo's canonization; there was the question of the antimodernist oath required from university professors; and there was the controversy about mixed trade

unions, in which the Vatican made clear its preference for unions organized on a strictly confessional basis.

The Pope as Reformer.—Whatever the final judgment on Pius X's defensive strategy may be, it would be unhistorical to represent his pontificate as one of defense and nothing more.

In the first place, there was an improvement in the papacy's relations with the Italian government. On the one hand, the facts of the Roman question came to be viewed in a more realistic light; on the other, the fear of socialism served to draw Catholics and liberal conservatives together. There was thus a gradual mitigation of the *non expedit*, which in the 1870s and 1880s had been developed into a prohibition against Catholics taking part in Italian political life; the so-called Gentiloni pact of 1913 established seven conditions on which Catholics might vote for candidates at elections. Second, Pius, who seemed so old-fashioned to his contemporaries, was in fact a great reformer. Clearsighted and enterprising, he envisaged the reconstitution of Christian society as requiring not only the unequivocal disavowal of erroneous attitudes but also a positive effort toward adaptation and initiative in pursuing the essentially pastoral work of the church, to enhance its inner life and make the best use of its strength.

The teaching of the catechism, preaching and the education of the clergy (this last being one of his major preoccupations) were all objects of improvement or reform under Pius X; and some of his directives, though outmoded by later social developments, nevertheless mark him as one of the forerunners of Catholic Action, that is, the organization of the laity for special and direct collaboration in the apostolic work of the church (*cf.* the encyclical *Il fermo proposito*, 1905). Most important in the context of reform, however, were: (1) his eucharistic decrees, which eased the regulations governing daily communion, facilitated the communion of the sick and insistently enjoined that children should begin to communicate on attaining the age of reason; (2) his liturgical reforms, namely the revival of Gregorian plainsong and the recasting of the breviary and of the missal; (3) his decision, taken at the very beginning of his pontificate and despite numerous objections, to adapt and systematize the canon law, which led to the publication of the new code in 1917 (to take effect in the following year); and (4) his reorganization of the curia, through the constitution *Sapienti consilio* (1908), which modernized the central administration of the church and its method of operation and enabled the Roman congregations to deal more effectively with the heavy task of centralization.

C. The War and Interwar Periods

1. Benedict XV.—In view no doubt of the international situation the conclave of 1914 chose a clever diplomat, Giacomo della Chiesa, a former pupil of Leo XIII and of Rampolla, as Pius X's successor. The political isolation in which he found the Holy See, as a result of his predecessor's strategy of defensive withdrawal and intransigence, made it difficult for Benedict XV to play an effective role in the world crisis. Many people were disappointed by the strictly neutral attitude that he adopted in World War I and by his abstention from condemning any action of the belligerents. The Western Allies were bitterly indignant at his efforts to prevent the spread of a conflict that set Catholic against Catholic and at his attempt at mediation in 1917, which was a complete failure; but his conduct was to be attributed not so much to German influence in the Vatican as to his fear lest Orthodox Russia should receive any accession of power and, eventually, to his anxious desire to save central Europe from plunging into a chaos that could bring no good either to the church or to Europe in general (it must be remembered also that, while he considered the violation of Belgian neutrality to be legally indefensible, he shared the opinion of Pius X and, particularly, of Merry del Val that Austria's action against Serbia was legitimate).

In 1919, then, though its work for prisoners of war and its relief services for war victims had been universally appreciated, the Holy See had no such prestige among the nations as it had had under Leo XIII; Benedict was excluded from the peace negotiations, despite the efforts of papal diplomacy.

While it was mainly his activity in international affairs that attracted the attention of the external world to Benedict, his constructive work within the church itself was of considerable importance, even though his pontificate did not last long enough for him to bring to maturity several fruitful undertakings from which his successor was to benefit. He promptly put a stop to the maneuvers of the Integralists; he enhanced the competence of the Unione Popolare (an organization formed in 1906 to unite Italian Catholics of all classes in pursuance of the aims of the encyclical *Il fermo proposito*), thus marking a new stage in the development of Catholic Action; and he sought concordats with the new states brought into being by the treaty of Versailles.

Of greater significance were his directives on missionary activity and his attitude to the Eastern Churches. His apostolic letter *Maximum illud* (1919) not only tried to dissociate missionary activity from imperialism and from colonialism by warning missionaries against showing "indiscreet zeal" for their own native country's interests, but also urged the pressing need for establishing an indigenous priesthood; and his wish to help the Uniate churches to develop in accordance with their individual traditions was expressed on several occasions (for instance through the foundation of the Pontifical Institute for Oriental Studies in 1917 and through the pope's support for the metropolitan of Galicia, Archbishop Andrzej Szeptycki, against the pressure brought to bear by the Latin Catholic Poles). By such means it was Benedict's intention to encourage the return of the schismatic churches of the East to the Catholic fold at a time when the collapse of imperial Russia and the political changes in the near east gave rise to a renewal of speculation on the problem.

2. Pius XI.—On Feb. 6, 1922, a successor to Benedict XV was elected in the person of Achille Ratti, a scholar who had been prefect of the Ambrosian library in Milan and then of the Vatican library, but one who had also had the opportunity, as nuncio in Poland, of displaying his energy, his organizing ability and his grasp of the complexities of 20th-century politics.

A learned humanist, Pius XI made it his business to ensure that the world should have a better knowledge of the scientific resources and the artistic treasures of the Vatican. He took an interest in the development of the positive sciences and organized the Pontifical Academy of Science (1936), to which he admitted non-Catholic scientists; and he both founded new research establishments or institutes of higher education (for instance the Pontifical Institute of Christian Archaeology; 1925) and expanded those already in existence (such as the Gregorian university and the College of the Propaganda). He was particularly concerned to raise the level of education in the clergy (*see* his constitution *Deus scientiarum Dominus*, 1931) and took charge of the Congregation for Seminaries and Universities in 1938. The intellectual prestige of Catholicism was enhanced by his sympathetic attitude toward science.

FELICI

POPE PIUS XI

The Christian Reconstruction of the World.—In pursuance of the program outlined in his first encyclical (*Urbi arcano Dei*, Dec. 23, 1922), Pius XI worked unremittingly to construct a new "Christendom" in the hope that, after the outward forms of the old order had been relinquished, its spirit might be revived.

Pope between two world wars, Pius had as his motto *Pax Christi in regno Christi* ("the peace of Christ in the Kingdom of Christ") and continually preached peace to the nations, reminding them of the basic conditions of peace in the Christian sense. He had no great faith in the League of Nations but gave what support he could to statesmen working to promote international co-operation.

to halt the armaments race and to dispel the threat of war.

Pius was concerned to warn Catholics against excessive nationalism and was distressed at the fascination exercised over so many French Catholics by *L'Action française*. His condemnation of the latter (1926) was clumsily launched and sternly and severely carried out, with the result that great resentment was felt in certain French circles; but it had the fortunate effect of clarifying the situation once and for all and of releasing the forces that were to be canalized in Christian social activity and Catholic Action. The strength of the reaction against *L'Action française* must be considered in the light of that newspaper's anti-Christian doctrine.

Pius XI wished to make his pontificate one of reaction against the increasing materialism of modern life. This preoccupation was the source of his insistence on Christian education (the encyclical *Divini illius magistri*, 1929) and of his vigorous restatement of Catholic teaching on marriage and on the family (the encyclical *Casti connubi*, 1930); and it is in this light also that his interpretation of the new Feast of Christ the King, as expounded in the encyclical *Quas primas* (1925), is to be understood. Likewise the same intention is manifest in Pius XI's unceasing efforts to organize the laity, first in Italy and then throughout the whole church, so that every Catholic should do his best to bring Christian principles into action in the institutions of society and in private life. Calling for "specialized movements," he was impelled to give particular encouragement to the Jeunesse Ouvrière Catholique, the "Jocists" (a Christian youth organization for the working classes), in view of the progressive dechristianization of labour. These views also underlie his encyclical *Quadragesimo anno* (1931).

In addition, however, to a pressing concern with the religious life of both clergy and laity, Pius also followed the example set by Leo XIII and already repeated by Benedict XV of trying to establish the papacy on the international political scene and of increasing the number of his diplomatic contacts with foreign governments. In this respect he was able to profit from the trend of contemporary politics, which led governments away from the liberal ideal of separation and toward a desire for the collaboration of the papacy as an international moral force. While the Vatican had still to face some powerful adversaries in Mexico, Czechoslovakia, republican Spain and the totalitarian states, it enjoyed excellent relations with the Anglo-Saxon world (in which Catholicism made steady progress) and found itself on better terms with the French republic (where anticlericalism was on the decline); and its negotiations with the new states formed after World War I met with a general measure of success.

Pius showed a preference for the concordat as the best formula for establishing his relations with foreign states, and more than 20 such agreements were concluded in the course of his pontificate, with the object of introducing the fundamental principles of the code of canon law into the legislation of the several states, or at least of gaining official recognition for the rights of the church.

Missionary Activity and Ecclesiastical Reunion.—Pius outdid his predecessors in support of overseas missions. He required every religious order to take an active part in this work, with the result that the number of missionaries doubled in the course of his pontificate; he promoted international missionary activity; and he encouraged the study of missionary subjects. Above all, he followed Benedict XV's example of denationalizing the missions, stressing the need for adapting methods to local traditions and the crucial importance of building up a native clergy. The encyclical *Rerum ecclesiae* and the consecration of the first Chinese bishops in 1926 were events of capital significance.

The same concern to distinguish the cause of the church from that of the Western world can be seen in Pius XI's solicitude for the Eastern Churches. He encouraged historians and liturgiologists to study the Christian East, reacted strongly against attempts to latinize the Uniate rites and inaugurated the work of codifying Eastern canon law. Furthermore, in the first years of his pontificate, he tried, though unsuccessfully, to extend Catholic influence into the U.S.S.R. (in these efforts the titular bishop of Ilium, Michel d'Herbigny, was closely associated with him). He had the satisfaction of seeing the Christians of the Syro-Malankarese (in southern India) reunited with Rome in 1930. On the other hand, though at first the Vatican had shown itself well-disposed toward the Malines conversations (between the Belgian cardinal Désiré Joseph Mercier, Lord Halifax and other Catholic and Anglican churchmen), it soon assumed a sterner attitude toward Protestantism, and the encyclical *Mortalium animos* (1928) was completely negative in its response to the "ecumenical movement."

The Lateran Agreements.—Pius XI, as a historian, was aware of the element of contingency present in ecclesiastical institutions, and so he was even readier than his two immediate predecessors to seek a compromise solution of the Roman question. Negotiations with Mussolini, conducted on the papal side by the cardinal secretary of state Pietro Gasparri and the lawyer Francesco Pacelli, were begun in great secrecy in 1926 and resulted in the signature of a threefold agreement—political, financial and religious—on Feb. 11, 1929.

Pius recognized the kingdom of Italy, with Rome as its capital. Italy in return recognized papal sovereignty over a minute territory of 44 ha. (the Vatican City), thus securing for the pope the full independence on which Leo XIII and his successors had always insisted; and the payment of an indemnity was a further point. In addition, several apostolic palaces, basilicas and ecclesiastical institutes were granted extraterritorial privileges and exemption from Italian taxes. Together with these political and financial agreements went a concordat between Italy and the Holy See. The pope recognized that the treaties and the concordat, though not connected with one another in law, were so connected in fact (*simul stabunt, simul cadent*, "they will stand together or fall together") and regarded the concessions made by Italy in the sphere of religion as compensation for the Holy See's abandonment of obsolete political claims.

The spectacular reconciliation of Italy and the Vatican did not eliminate all possibility of clashes. The first took place in 1931, on the subject of Catholic Action and youth movements; and from 1938 the Italo-German alliance gave rise to more lasting differences. On the whole, however, relations remained quite good.

The Struggle Against Totalitarian Ideologies.—The fascist systems that emerged in Europe between World Wars I and II had certain characteristics which were not without appeal to the church. They were based, for instance, on ideas of authority, of order and of hierarchy; they advocated a corporative structure for society; they upheld the family; and they were opposed to Freemasonry and to communism. In 1930, moreover, it was communism that Rome regarded as the church's most dangerous enemy. It is thus not surprising that Pius XI should have been ready to establish good relations with fascist Italy and should have signed a concordat with Hitler in 1933, by which he hoped to alleviate the difficulties confronting German Catholics.

But within a few years he saw how the leading fascist regimes were accentuating their anti-Christian tendencies (excessive nationalism, pagan state worship and racial prejudice); and he then came forward unreservedly against totalitarianism, whether of the left or of the right, to defend the rights of the individual human being. This new phase of his pontificate had a climax in 1937, when he published two encyclicals, *Divini Redemptoris* against atheistic communism and *Mit brennender Sorge* against naziism.

Thereafter Pius continually insisted on the great principles of morality that should underlie all political and social life; and since these principles were no longer at variance (as in Pius IX's time) with popular aspirations or with the immediate aims of other governments, but rather in line with much contemporary feeling, whether hopeful or fearful, the result was a new accession of moral authority to the Holy See and, also, a marked *rapprochement* between it and the western democracies.

3. Pius XII.—Eugenio Pacelli, who was elected pope on March 2, 1939, had in 1930 succeeded Cardinal Gasparri as secretary of state. He was the first pope for centuries to have held this office and it had given him wide diplomatic experience. From the outset he was faced with the prospect of World War II, and the first years of his pontificate were occupied mainly by the concerns to which that war gave rise.

The Papacy and World War II.—Since 1914 a change had taken place in the papacy's relations with the rest of the world. The

KARSH OF OTTAWA—RAPHO GUILLUMETTE

POPE PIUS XII

Holy See was becoming officially recognized by an increasing number of governments. Pius XII was in a far better position for effective action in the critical situations created by the spread of hostilities. He was careful, however, never to commit the Holy See to either of the belligerent camps, nor to join any ideological crusade, whether against communism or against naziism. He took as his motto *Opus justitiae pax* and in May 1939 began negotiations for peace which he continued throughout the war. He defined the church's principles with regard to international order, condemning aggressive war, denouncing extreme nationalism and emphasizing the natural moral law which should govern international relations. He upheld the rights of minorities and of individuals and pointed out the economic inequalities between nations as one of the chief causes of war. At the same time Pius XII organized the Pontifical Relief commission to aid all victims of the war and in May 1945 created an International Committee of Catholic Charities to co-ordinate relief efforts.

The Problems of Peace.—The papacy emerged from the war with very much more influence in international affairs. In non-political fields, too, the Holy See could play a larger part through the newly created, nongovernmental international organizations, especially branches of the United Nations. Pius XII had particular influence on the Economic and Social council of the UN.

From 1945 Pius delivered speeches, broadcasts and writings at a rate unprecedented in papal history, determining how Christian morality was to be applied in practice. In accordance with current trends in the relations between the church and the social order, he underlined the need for toleration in a manner markedly different from that of the syllabus of Pius IX (1864). He called for disarmament and criticized the rise of totalitarian states, though at the same time recognizing that force was necessary to back law. In communism he saw one of the chief dangers to the church, and on July 13, 1949, issued a decree excommunicating those who "enlist in or show favour to the Communist party." This followed a series of acts of persecution in eastern European countries, among which was the sentencing to life imprisonment of Joseph Cardinal Mindszenty in Hungary. Pius adopted a very cautious attitude toward attempts by some of the clergy in countries under Soviet regimes, especially in Poland, at peaceful co-existence with their Communist rulers. However, anxious to remain above the ideological conflict, he emphasized the rights of the worker in the sphere of industrial relations and took certain standpoints which caused a section of U.S. public opinion to brand him a neutralist. On the whole, nonetheless, Pius XII maintained excellent relations with countries in the western hemisphere. He could do nothing to prevent the liquidation of the Uniate churches of the Ukraine and of Transylvania, nor the expulsion of the Chinese missions. Further problems were posed by the lack of clergy in Latin America, by political advancement in the underdeveloped countries and by the need for protection of the holy places in Jerusalem. In 1950 Pius instituted a Holy Year of prayer and penance to encourage active work for peace.

Pastoral Affairs.—The theme of Pius XII's pontificate in pastoral matters was the adaptation of the laws of the church to the conditions of the modern age. During the war, in 1943, he published two encyclicals of doctrinal importance, *Mystici corporis* on the nature of the church and *Divino afflante spiritu* on biblical studies, which together embodied the results of 25 years' progress in Catholic theology and exegesis. In 1950 he defined the dogma of the Assumption and proclaimed 1954 as a Marian year to commemorate the 100th anniversary of the definition of the dogma of the Immaculate Conception. Pius showed interest in the liturgical movement (encyclical *Mediator Dei*, 1947), especially its pastoral aspects. In response to requests from the bishops in certain countries he permitted some use of the vernacular in the administration of the sacraments. He restored the liturgy of Holy Week, modified the law regarding the eucharistic fast and introduced evening Mass.

Anxious to put through a number of reforms as quickly as possible, Pius XII, an authoritarian by temperament, did not hesitate to deal personally, apart from the help of certain intimate advisers, with those matters closest to his heart, bypassing the normal procedure. One of his innovations was to reduce the Italian majority in the college of cardinals to a minority (in 1953 he created 24 new cardinals) and to increase the number of foreign ecclesiastics in the Roman curia. Pius took steps to make the religious orders more effective in the apostolate, and authorized the meeting, in Rome, of the first world congresses on the apostolate of the laity (1951 and 1957). In his encyclicals *Evangelii praecones* (1951) and *Fidei donum* (1957), and other pronouncements on Catholic missions, he sought to hasten the establishment of local churches in mission territories under their own bishops (the number of native bishops rose from 48 to 139). He went further than his predecessors when he prudently but actively encouraged the ecumenical activity of Catholics (instruction of Dec. 20, 1949).

From 1950 onward, Pius XII, and possibly to an even greater extent his immediate advisers, judged it expedient to adopt a more cautious attitude. Warnings were issued simultaneously against the dangers of hasty compromise in doctrinal, political, social and pastoral issues. In the first category were the encyclical *Humani generis* (1950), various pronouncements on moral questions and the addition of several works to the index of prohibited books. In the social and political sphere he repudiated the "progressive Catholics" who wanted to collaborate with the Communists, and made less encouraging pronouncements on the workers' undertakings. On the pastoral level he initiated greater reserve toward relations with non-Catholics and brought to an end the French experiments with worker-priests. These men, who had been evangelizing the labouring classes through sharing their work and living conditions, were in danger of being affected by the current revolutionary trends and by a too secularized pattern of living. This more cautious attitude on Pius' part during the last years of his pontificate caused some uneasiness, particularly in the affair of the worker-priests, which had repercussions beyond the Catholic Church; but it did not jeopardize the steady move forward in readjustment to conditions after World War II.

Pius XII died on Oct. 9, 1958.

4. John XXIII.—Angelo Giuseppe Cardinal Roncalli, patriarch of Venice, was elected pope on Oct. 28, 1958, when aged nearly

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POPE JOHN XXIII (MARCH 1963)

77. He at once broke with recent precedent by his simple manner of life, his frequent visits outside the Vatican and his delight in human contact. He announced his intention of governing his diocese of Rome in person, for which purpose he summoned in Jan. 1960 the first synod since the Council of Trent. He brought the number of cardinals up to 85 (including one Japanese, one from the Philippines and the first African), instead of keeping to the traditional 70. Although he at first caused uneasiness by placing in positions of confidence men who opposed progress, he showed a new orientation by tacitly accepting the "opening to the left" in Italy and especially by his less negative attitude to eastern European Communist countries. On Jan. 25, 1959, he announced his intention of summoning a council; his planning for it, despite the resistance of the conservative curia, showed his desire to counteract excessive centralization by involving the episcopate throughout the world in the responsibilities of the Holy See, as well as his concern to reform the pastoral work of the church in the hope of encouraging the reunion of Christendom. This hope he furthered by founding a secretariat for Christian unity, by receiving in friendly manner persons from other Christian denominations and by inviting non-Catholic observers to the council. The first session of the second Vatican council (Oct. 11–Dec. 8, 1962) revealed to what extent these hopes were shared by the majority of the Roman Catholic Church, and encouraged the belief that the age of the Counter-Reformation was coming to an end (*see* VATICAN COUNCILS). This belief was reinforced by the encyclical *Pacem in terris* (1963), which emphasized not only the papal support for the forces of peace (notably the United Nations) but possibly even more the pope's appeal for co-operation between all men, including unbelievers. The encyclical showed an optimism and confidence regarding the possibility of safeguarding human liberty that was in striking contrast to the centuries of papal reticence on the subject of modern man. This liberal attitude toward the non-Christian world, including Communists, which aroused the anxiety of the conservatives, was instrumental, together with his transparent goodness, in creating the universal popularity he enjoyed.

After John's death on June 3, 1963, the speedy election of Paul VI indicated that his brief pontificate was not a mere interregnum but the beginning of a new era in the history of the Roman Catholic Church.

5. Paul VI.—Giovanni Battista Cardinal Montini, archbishop of Milan, was elected pope on June 21, 1963, the second day of the conclave. He continued his predecessor's work by recalling the second Vatican council in the autumn of 1963 for its second session, at which decrees were passed on reforming the liturgy and on the church's use of modern means of communication. In Sept. 1964 the pope convened the third session of the council and on Nov. 21 promulgated the constitution *De Ecclesia*, a 30,000-word document on the nature and function of the church, a central thesis of which is that the bishops collectively share with the pope in the government of the church.

On Sept. 21, 1963, the pope summoned the Roman curia and proposed certain principles for its reform. These included: membership on a larger, supranational, instead of predominantly Italian, basis; a "more accurate ecumenical preparation" of its members; the abandonment of outdated temporal prerogatives and external forms; the transfer of certain of the curia's powers to the bishops. The pontiff also suggested the possibility of forming an international "senate" of bishops to meet regularly in Rome with the care of, and responsibility for, the church government in union with the pope. Promulgation of the constitution *De Ecclesia* a year later was regarded as making the creation of such a senate more likely.

In his first encyclical letter, *Ecclesiam Suam*, dated Aug. 6, 1964, Pope Paul reaffirmed and amplified points made in his opening discourse to the second session of the Vatican council: the self-awareness of the church as a living and evolving historical reality, which requires restudying of its structure and especially of the function of the bishops and of their relationship to the pope in the life of the church; the reform of the church; the reunion of all Christians; and the dialogue of the church with the contemporary world.

On Jan. 4–6, 1964, Paul broke a long-standing precedent by leaving the Vatican to make a pilgrimage to the Holy Land, where in a dramatic gesture he manifested his solicitude for reunion with

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POPE PAUL VI (1964)

Oriental Christians by meeting with the ecumenical patriarch Athenagoras, spiritual leader of the Eastern Orthodox Churches; the two men embraced each other fraternally. In Dec. 1964 the pope undertook another trip, the longest ever made by a pope, when he went to Bombay, India, to attend the International Eucharistic Congress.

See also references under "Papacy" in the Index. (RR. A.)

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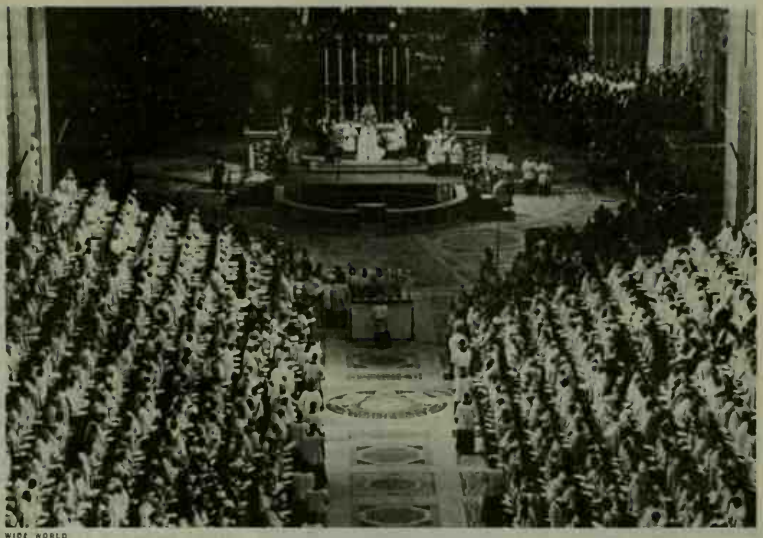

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PAPAGO, an American Indian tribe numbering about 11,000 and located in 73 villages on three reservations in southern Arizona and scattered through northwestern Sonora, Mex.; in 1960 nearly all lived in the U.S. Their language, closely similar to Arizona Pima and to Tepehuan in northern Mexico, belongs to the Piman group of the Uto-Aztecan family. Agriculturalists who used floodwater farming since about A.D. 1, they continued to raise maize, beans and squash after the coming of Europeans. By mid-20th century most income was derived from raising cattle that were introduced by Jesuit missionaries, and from off-reservation wage work.

In 1937 Papago formed a tribal council under the United States Indian Reorganization Act, the first tribal organization in their history. First missionized by Eusebio Kino (1687), the Papago were under Jesuit influence until 1767. After the expulsion of the Jesuits, Franciscan missionaries took over. The largest churches in Papago territory, such as San Xavier del Bac Mission near Tucson, Ariz., were built by Franciscans. A majority of villages maintained chapels dedicated to the Jesuit, Saint Francis Xavier; and a few villages had active Presbyterian churches in the 1960s. Nevertheless many villages maintained the annual ceremony celebrating the ripening of the giant cactus (saguaro) fruit and the coming of the summer rains. Much of the earlier culture has survived, particularly village organization, music, and religious ceremonials. In the aboriginal religion, songs as a source of supernatural power are important, especially for curing disease. The women make white coiled baskets with black geometric designs. The Papago carried out unsuccessful revolts against Spanish domination in 1695 and 1751. In the 19th century they allied themselves with the U.S. government against the Apache; relations with the government have been uniformly peaceful. *See* also PIMA.

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PAPAGOS, ALEXANDROS (1883–1955), Greek army officer and statesman, prime minister in the last three years of his life, was born in Athens on Dec. 9, 1883. He studied at the military academies of Athens and Brussels and was commissioned in 1906, serving in the Balkan Wars of 1912–13 and in the Anatolian campaign of 1919–22. He was promoted to the rank of major general in 1927 and became a corps commander in 1935. In the latter year he was appointed minister of war and played a leading part in the restoration of the monarchy. Papagos was appointed chief of staff in 1936 and at the time of the Italian attack on Greece (Oct. 28, 1940) he was commander in chief. He succeeded in stemming the attack and driving the Italians back into Albania. When British forces arrived in Greece in the spring of 1941 and the Germans attacked (April 6, 1941) Papagos was unable to hold the line in the north, perhaps because of misunderstanding with the British, and Greece was granted an armistice on April 23. Papagos was eventually taken as a hostage to Germany. Liberated in 1945, he was recalled to active service in the Greek army and promoted to the rank of general in 1947. As commander in chief from Jan. 28, 1949, he was responsible for the final victory over the Communist rebels in the Grammos-Vitsi campaign. He was appointed field marshal on Oct. 28, 1949.

The troubles of the 1930s and World War II had deprived Greece of outstanding political figures. Because Papagos' success against the Italians and the Communist rebels had made him a leader without equal in Greece, in May 1951 he was persuaded to enter politics. He resigned his military offices and formed a new party called the Greek Rally (*Ellinikos Synagermos*), which at the elections of Nov. 16, 1952, swept the country. Papagos became prime minister and provided Greece with the first stable government that it had known since World War II. He died in Athens on Oct. 4, 1955. He published his own account of *The Battle of Greece, 1940–41* (English translation, 1949).

(B. S.-E.)

PAPAL STATES (STATES OF THE CHURCH) were the lands over which the popes, as heads of the Roman Church, had temporal sovereignty; in particular they were those in Italy, with which this article is concerned.

From the 4th century A.D. onward the Roman Church was the recognized proprietor of extensive estates throughout and even beyond Italy, but it held these *patrimonia* in the manner of a landowning corporation, under the Roman empire, not in that of a sovereign ruler. By the middle of the 8th century, however, the Lombards had overrun most of Italy. The Duchy of Rome was then still theoretically dependent on the Byzantine or East Roman Empire; but the Byzantines could not protect the duchy, within which the bishops of Rome, supported by their clergy, exercised an authority counterbalancing that of the local barons and their army. When Pope Stephen II (III) appealed for help against the Lombards to the Frankish ruler Pepin III the Short, Pepin in 754 made the famous and controversial Donation, whereby he undertook to "restore" to the Roman Church and to the "Republic of the Romans" numerous lands of which they had been despoiled, regardless of the fact that these lands ought juridically to have been restored to the Exarchate of Ravenna (*q.v.*). The Lombard king Aistulf, by the Treaty of Pavia in 756, ceded (1) Comacchio and Ravenna; (2) the country from Forlì to Senigallia and Jesi between the Apennines and the Adriatic; and (3) Gubbio in the Apennines, linking the northeastern territories with the Duchy of Rome by way of Perugia. This cession, which comprised less than what the Donation of Pepin had adumbrated, was the beginning of the temporal power of the papacy. Bologna, Ferrara, Imola, Faenza, and Ancona were added to the dominion soon afterward; but Charlemagne (*q.v.*), whose Donation of 774 had promised far more, *c.* 781 limited the further acquisitions of the Holy See to the Sabina (Rieti and its vicinity, on the frontier of the Duchy of Spoleto), to some Campanian cities (soon lost), and to some parts of the formerly Lombard Tuscia, including Orvieto and Viterbo. (*See* also DONATION OF CONSTANTINE.)

With the breakup of the Carolingian Empire an era of vicissitudes began. The history of the Papal States is thereafter for centuries practically inextricable from that of Italy and of the papacy (*qq.v.*), or from that of Rome (*q.v.*) and of the other cities of the dominion. The extent over which papal authority was effective shrank or grew with the Holy See's prestige. The temporal power suffered from the growth of feudalism, from dis-

orders in Rome itself, and from the domination of the Saxon dynasty after the revival of the Holy Roman Empire for Otto I in the 10th century; but it reasserted itself in the second half of the 12th century thanks chiefly to the alliance with the Norman conquerors of southern Italy and to the genius of Pope Gregory VII (*q.v.*). The Duchy of Benevento was recognized as papal in 1052 and definitively acquired in 1077; and the countess Matilda (*q.v.*) of Tuscany bequeathed her great inheritance to the Holy See. Pope Innocent III (*q.v.*) took great advantage of the dispute between the Hohenstaufen and their rival Otto IV for the imperial crown to promote his claims, notably in the March of Ancona; and Otto in 1201 acknowledged the Church's right to the Duchy of Spoleto.

The rise of the communes (*see* COMMUNE [MEDIEVAL]) and the subsequent emergence of the *signorie* weakened papal authority, especially in the Romagna. The translation of the Papacy to Avignon (1309) left the dominion in Italy to chaos; and the brilliant work of reconquest and rehabilitation by Cardinal Albornoz (*q.v.*) in the 1350s and '60s was undone in the '70s by the War of the Eight Saints and by the beginning of the Great Schism.

At the end of the Great Schism in 1449 the Romagna, the Marches, and Umbria were still mostly in the lands of signorial houses exercising "vicariates" granted to them by the Holy See but in fact ruling as they saw fit. It was to subdue these places that Pope Alexander VI launched his son Cesare Borgia (*q.v.*) on his expeditions. Much of Borgia's conquests, however, fell away on Alexander's death (1503), and the restoration of the Papal State had to be undertaken again by Popes Julius II and Leo X (*qq.v.*) in the period 1510–21: they also won Modena and Parma and Piacenza for the Church. Modena, however, was recovered in 1527 by the house of Este; and Parma and Piacenza were granted in 1545 to the house of Farnese, to which moreover the ancient papal territory of Castro had been given as a duchy in 1537. Efforts to recover Ferrara from the Estensi were finally successful in 1598, and Urbino returned to direct papal rule in 1626. The attempt of the Barberini pope, Urban VIII, to take Castro back by force (1641–44) was frustrated, but the duchy was reannexed to the papal state in 1649.

In the 18th century, though they were traversed by foreign armies in the course of dynastic wars, the Papal States enjoyed a period of prosperity under paternalistic government. The French Revolutionary Wars and the Napoleonic Wars (*qq.v.*) changed everything: Bologna, Ferrara, and the Romagna were ceded by the Treaty of Tolentino (1797), under which the French also occupied the Marche and Umbria; Rome was a republic from February to November 1799; and after an interval in which the lands south of the Romagna returned to papal rule the Marches were annexed to the Napoleonic Kingdom of Italy in 1808 and the remnant of the Papal State to the French Empire in 1809.

The Congress of Vienna in 1815 restored the Papal States; but the liberalizing influence of Cardinal Consalvi (*q.v.*), which had culminated in the statute of 1816, was largely counteracted in Pope Leo XII's pontificate. Administratively, the state was divided between (1) Rome and its Comarca or district, under a special regime; (2) the Legations or *Legazioni*, under a cardinal legate or a vice-legate; and (3) the Delegations, under prelates.

The Italian Risorgimento gradually destroyed the temporal power. Austrian intervention against a revolt in the northern Legations (1831–32) was followed by the French occupation of Ancona till 1838. The conduct of Pope Pius IX (*q.v.*) in 1848 led to the proclamation of the short-lived Roman Republic in 1849. Thenceforward the temporal power depended on Austrian or French protection. Through the defeat of Austria in 1859 and the Battle of Castelfidardo in 1860 (*see* ITALIAN INDEPENDENCE, WARS OF) the Romagna and the Marche, with Perugia, Spoleto, Orvieto, and Rieti, were annexed to the Kingdom of Sardinia-Piedmont, which in 1861 became the Kingdom of Italy. Garibaldi's attack on the remnant of the Papal State in 1867 was defeated at Mentana; but in 1870 the final annexation to Italy was achieved. The Lateran Treaty of 1929 recreated a temporal power in the Vatican City State.

PAPAVERINE, one of the alkaloids present in opium, is sometimes used as a vasodilator and antispasmodic in medicine because of its ability to relax smooth muscle (*see* MUSCLE AND MUSCULAR SYSTEM: *Smooth Muscle*). It was first obtained by J. H. Merck in 1848 and was first synthesized by R. P. Pictet and A. Gams in 1909. Papaverine, whose formula is $C_{20}H_{21}NO_4$ and whose chemical name is 6,7-dimethoxy-1-veratrylisoquinoline, crystallizes in colourless prisms or needles, melts at 147° C, and is optically inactive. It is insoluble in water but dissolves readily in chloroform or hot alcohol. The hydrochloride crystallizes in plates and melts at 231° C. On gentle oxidation papaverine is converted into papaveraldine, which is the alkaloid xanthaline found in opium. The papaverine structure is equally important as a starting point for syntheses in the berberine series. *See* also CHEMISTRY: *Proof of Structure*.

PAPAYA, the succulent fruit of a large plant (*Carica papaya*), barely a tree since its palmlike trunk, though up to 25 ft. tall, is not so woody as a typical tree. The papaya is cultivated throughout the tropical world and into the warmest parts of the subtropics. It is the only economically important member of the family Caricaceae. Its origin is rather obscure; it may represent the fusion of two or more species of *Carica* native to Mexico and Central America.

AUTHENTICATED NEWS

GROVE OF PAPAYA TREES

The name papaw or pawpaw, often used in the West Indies, is likely to confuse this plant with *Asimina triloba*, the pawpaw (*q.v.*) of North America. Papaya is believed to be a corruption of the Carib word *ababai*. Several other common names are current in the Western Hemisphere: mamão in Brazil, *fruta bomba* in Cuba, *lechosa* in Puerto Rico, and *melon zapote* in Mexico.

Papayas are usually grown from seed. Their development is rapid, fruit being produced before the end of the first year. Under favourable conditions the life of a plant may be five years or more. The plant bears no lateral branches but is crowned by deeply lobed leaves, sometimes two feet across, borne on hollow petioles two feet long. Normally the species is dioecious, male (staminate) and female (pistillate) flowers being produced on separate plants; but hermaphroditic forms are known, and all sorts of irregularities in the distribution of the sexes are common. Staminate flowers are borne in clusters on stalks three feet long; the flowers are funnel-shaped, about an inch long, whitish, the corolla five-lobed, with ten stamens in the throat. The pistillate flowers are considerably larger, on very short stalks, and are often solitary in the leaf axils; they have five fleshy petals united toward the base and a large cylindrical or globose superior ovary crowned by five fan-shaped sessile stigmas.

The fruit is commonly spherical to cylindrical in form, 3 to 20 in. or even more in length, sometimes weighing as much as 20 or 25 lb. In general character it strongly resembles a muskmelon. The very juicy flesh is deep yellow or orange to salmon-coloured, about an inch thick. Along the walls of the large central cavity are attached the numerous round, wrinkled, black seeds the size of peas. The fruit is slightly sweet, with an agreeable musky tang, more pronounced in some varieties, and in some climates, than in others. The papaya is a popular breakfast fruit in many tropical and subtropical countries, and is also used in salads, pies, sherbets, juices and confections. The unripe fruit can be cooked like squash.

The plant is killed by heavy frosts but has long been grown successfully in Hawaii, southern Florida, and to a limited extent in protected locations throughout southern California, though the fruit does not usually attain full flavour in the last region.

The unripe fruit, as well as other parts of the plant, contains a milky juice, in which is present a protein-digesting enzyme known as papain, which greatly resembles the animal enzyme pepsin in its digestive action. It is usually obtained by scarifying green fruits while they are still on the plant. After the juice exudes and coagulates, it is scraped off and dried, to be used in the preparation of various remedies for indigestion and in the manufacture of meat tenderizers. Its value has long been recognized in the tropics, where it is a common practice to leave tough chickens or other meat wrapped in papaya leaves overnight before cooking, or even to rub them with the juice of the papaya to render them more tender.

BY COURTESY OF U.S. DEPARTMENT OF AGRICULTURE

VERTICAL SECTION (SHOWING ARRANGEMENT OF SEEDS) OF PAPAYA FRUIT

See W. Popenoe, *Manual of Tropical and Subtropical Fruits* (1920); W. H. Chandler, *Evergreen Orchards* (1958). (W. Po.; X.)

PAPEETE, capital and administrative centre of French Polynesia (the Society Islands, the Tuamotus, the Gambier Islands, the Marquesas, the Tubuai or Austral Islands, the Rapa Islands and Clipperton Island), lies on a beautiful bay at the northwest corner of Tahiti. Commune pop. (1962) 19,903. As the last good easterly harbour in the South Pacific, it became a trade centre in 1829, and has continued to be commercially important. After annexation it was made the seat of the French governor and administration, becoming a commune in 1890. Count Maximilian von Spee's German naval squadron shelled the town in 1914, but it was rapidly rebuilt and is a distinctively French town. It is one of the largest urban settlements in the South Pacific. *See* FRENCH POLYNESIA; TAHITI; PACIFIC ISLANDS. (F. J. WT.)

PAPEN, FRANZ VON (1879–), German statesman who played a major part in overthrowing the Weimar Republic and in helping Hitler to seize power, was born at Werl, in Westphalia, on Oct. 29, 1879, the son of a rich landowner. He first became a professional soldier, choosing a career in the general staff. During World War I he was military attaché at the German embassy in Washington till he was declared *persona non grata* in 1915. By 1918 he was lieutenant colonel and chief of staff with the 4th Turkish Army in Palestine. After the collapse of imperial Germany he resigned from the army and turned to politics. He was a member of the Prussian *Landtag* till 1932, belonging to the extreme right wing of the Centre (Catholic) Party. He became chairman of the board of the Catholic daily newspaper *Germania* and repeatedly advocated a policy of Franco-German understanding. Despite his charming ease of manner, however, Papen was not taken seriously in politics: he remained an amateur without a following and, at heart, a convinced monarchist.

To the surprise of the public, President Hindenburg appointed Papen chancellor on June 1, 1932; and next day Papen formed a cabinet including four barons and a count. Paradoxically, the purpose of the change was to induce the Nazi Party to support the government, which would thus control it; but though the government made a show of strength by deposing the Social Democratic administration of Prussia (July 20, 1932), Hitler remained in opposition, for he wanted to come to power himself. On Nov. 17, 1932, Gen. Kurt von Schleicher, the defense minister, refused any longer to participate in Papen's increasingly reactionary policy. Papen resigned, and Hindenburg asked Schleicher to form a new cabinet (Dec. 4).

Papen in resentment outwitted Schleicher. He came to terms with Hitler in a conversation at Cologne (Jan. 4, 1933), and forced Hindenburg to make Hitler chancellor (Jan. 30), whereupon Hitler took him into the cabinet as vice-chancellor. Papen believed that he and his friends would be able to restrain the Nazis from any excesses; but he soon learned that he had handed the state over to lawlessness. Yet he still put himself at Hitler's disposition after the bloodshed of June 30, 1934, when the victims included some of his own closest collaborators (*see* GERMANY: *History: The Third Reich, 1933–39*). Dismissed on July 3, he was sent as ambassador to Austria in August.

Papen worked for a peaceful *Anschluss* (union) of Austria with Germany; he was recalled on March 10, 1938, the day before *Anschluss* was achieved by force. A year later he was appointed ambassador to Turkey where he worked to prevent Turkey from joining Germany's enemies in World War II. Turkey broke off diplomatic relations with Germany in August 1944.

Papen was arrested by the U.S. 9th Army in the Ruhr in April 1945. On Oct. 1, 1946, he was found not guilty of conspiracy to prepare aggressive war by the International Military Tribunal at Nürnberg. A German denazification court in February 1947 sentenced him to eight years' imprisonment as a major Nazi, but on his appeal, in January 1949, he was reclassified as blameworthy only in a secondary degree, and released. In 1952 he published his memoirs, *Der Wahrheit eine Gasse;* there is an abridged English version. (T. V.)

PAPERBOARD, one of the two chief products of the paper industry; the other being paper. Paper, a broader term than paperboard, includes all kinds of matted or felted sheets of fibres (usually vegetable, but sometimes mineral, animal or man-made) formed on a fine wire screen from a water suspension. The distinction between paperboard and paper is not sharp but, generally speaking, paperboard is heavier, thicker and more rigid than paper. In general, all types of fibrous materials 12 points (0.012 in.) or more in thickness are classed as paperboard. There are, however, some exceptions: Certain grades as thin as 0.006 in., such as corrugating medium, lightweight chipboard, bristol board, tagboard, etc., are classed as paperboard because their manufacture and use are entirely those of paperboard. Similarly, other papers such as blotting papers, felts and drawing papers are classed as paper even though they are 0.012 in. or greater in thickness.

The many types of paperboard represent a wide range of properties and uses. Examples are those various types used for shipping containers, folding cartons, setup boxes, fibre drums, milk containers, bookbindings, advertising displays, electrical insulation, file dividers, bottle caps, panel board, shoe board, gypsum board, sheathing board, post cards, car signs, coasters, matchboards, food boards and butter cartons.

The early history of paperboard is not entirely clear because of the confusion between paper and paperboard; this is quite natural inasmuch as paperboard grew out of the paper industry. Although the Chinese are credited with inventing papermaking at about the start of the Christian era, paperboard as it is known in modern times did not make its appearance until the development of crude printing presses and the appearance of books. The development of books brought about bookbinding and eventually bookboards (cover boards). The latter represented probably the first appearance of paperboard. These early bookboards have been of particular value to historians because they were made by pasting together pieces of scrap paper, principally from discarded books. By separating the bookboards, historians have been able to gather information from predecessor books that no longer exist. The term pasteboard is derived from these pasted sheets.

The term cardboard is a vague and antiquated term applied to certain types of paperboard, notably boxboard, bristol board, bookboard, etc. Cardboard is too vague in meaning to be technical and in the paper industry has been replaced by the term board in combination with words indicating its character or use, *e.g.,* boxboard and container board. All paperboard is made on paper machines; however, boards for certain uses require thicknesses or fibrous combinations (or both) that are either not feasible or not economical to make on a conventional paper machine. In these cases the desired thickness or fibrous arrangement is achieved by pasting together layers of paperboard or paperboard and paper.

Pasteboard.—Much of what is popularly known as cardboard is pasteboard, made by combining several layers of paperboard or paper with adhesive. The pasting or laminating is usually done on

a pasting machine (sheet pasting is also practised) that accommodates several rolls of paperboard or paper. The plies are brought together by squeeze or press rolls almost immediately after the adhesive is applied. Aqueous adhesives are used most frequently, although emulsions and nonaqueous adhesive (asphalt, microcrystalline wax, resins, etc.) are used to impart special properties. In the case of the aqueous adhesives, the "combined" board may or may not be heated to speed up the development of the bond. One of the perennial problems with pasted or built-up board is its tendency to warp, caused by unequal stress build-up primarily as the result of nonuniform absorption of moisture on the two sides of the board.

The raw material for paperboard can be the same as for paper, the choice depending on the economics and end-use requirements. In the U.S. most paperboard is made from virgin wood pulp and/or waste paper. A relatively small percentage of paperboard is made from cereal straws, reeds, etc. Countries without a readily available source of wood fibre make more extensive use of cereal straws and reeds.

Paperboard Machines.—Paperboard is manufactured on various types of paper machines, most of which employ either a cylinder or the Fourdrinier process.

The cylinder machine uses wire-covered cylinders or molds on which a web is formed. The cylinders are partially immersed and rotate in a vat containing a diluted stock suspension (dispersion of fibres). The fibres are formed into a sheet on the cylinder as the water drains through and passes out the ends of the cylinders. The wet sheet is couched off (transferred from) the cylinder on a felt. A cylinder machine may consist of one or more cylinders, each supplied with the same or different kinds of fibres. In the case of a multicylinder paperboard machine, the wet web formed on each cylinder is successively couched one upon the other on an endless felt; thus, the sheet is formed by a series of individually formed sheets or plies of lesser substance. This makes possible wide variations in thickness or substance of the sheet as well as the kind of fibres used for each ply. The composite web or sheet is conveyed between endless felts to the press section, which squeezes out as much water as practical and at the same time helps bond the fibres together. The sheet then goes to the drier section where the remainder of the water is removed and the bonding of fibres completed.

The Fourdrinier paper machine differs from a cylinder machine in that the sheet is formed by flowing a dilute suspension of stock through a slice (narrow opening in the reservoir box) onto a moving endless belt of wire cloth supported in a horizontal plane by tubular rollers or a table. The water is removed downward through the wire and the fibres are retained on top of the wire belt. After sufficient water has been removed, the sheet is couched off onto a felt that carries it through the press and drier sections. The majority of the Fourdrinier machines used in the manufacture of paperboard are equipped with a secondary slice positioned part way down the wire. By this arrangement, most of the stock is applied at the primary slice and the rest at the secondary slice, providing greater product flexibility since stock applied at the secondary slice may be either a different type of fibre and/or more highly refined.

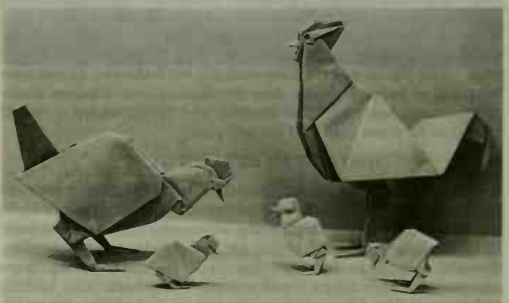
While a definite grain or fibre direction is apparent in all paperboards, the fibres in paperboard made by a conventional cylinder machine show a far greater directionality than a Fourdrinier-formed sheet. Various nonfibrous additives may be combined in the wet state or added to the surface of the board to impart special properties for specific use requirements.

In recent years two new designs of paperboard machines have been introduced, the dry-form cylinder and the Inverform machine. In the dry-form cylinder, the sheet is formed by flowing (approximately tangentially) a dilute suspension of stock onto the upturning surface of a revolving cylinder covered with a wire cloth or screen. The water is removed through the wire screen and the sheet is couched off as on a regular cylinder.

The Inverform machine consists essentially of a Fourdrinier wet end to which has been added one to five short-length endless top-wire sections. Each top-wire section is preceded by a flow box or slice; thus, the type and amount of stock added at each slice may be varied. The top wire is depressed into the fibre suspension, causing the water to flow upward as well as downward. The water flowing upward is removed by a special doctor (scraper) placed at an angle with the wire in such a way that the momentum of the moving liquid causes the water to run up the doctor and overflow into a trough. *See* PAPER MANUFACTURE. (R. C. McK.)

PAPER FOLDING, as practiced for several centuries in the orient, is the art of folding objects out of paper without cutting, pasting or decorating. Its early history is not known, though it seems to have developed from the older art of folding cloth.

In Japan, where it is called *origami*, paper folding has reached its greatest development, with hundreds of traditional folds and an extensive literature dealing with the art. Japanese folds divide roughly into two categories: figures used in ceremonial etiquette (such as *no shi*, folded decorations attached to gifts), and, in the second category, birds, animals, fish, insects, flowers, human figures, furniture and other objects. Some of the animals have amusing action features; best known are the bird that flaps its wings when its tail is pulled and the frog that hops when its back is tapped. Akira Yoshizawa of Tokyo is considered the



BY COURTESY OF THE COOPER UNION MUSEUM

"BARNYARD GROUP." EXERCISE IN ORIGAMI BY AKIRA YOSHIZAWA, TOKYO

greatest of modern paper folders. He wrote several books on *origami* and created a large number of new, often fantastically complex, figures possessing great realism and delicate beauty.

After the 1930s there was an upsurge of interest in paper folding in Spain and South America. Miguel de Unamuno, the great Spanish writer and philosopher, made a hobby of paper folding, inventing many new animal constructions and writing in his *Amor y pedagogía* (1902) a humorous essay on the art. In South America, Vicente Solórzano-Sagredo of Argentina was the leading expert on paper folding and author of the most comprehensive manuals in Spanish. George Rhoads of Evanston, Ill., and Giuseppe Baggi of New York were considered the most advanced of paper folders in the U.S.

Apart from the oriental tradition, the folding of coloured papers into ornamental designs was introduced by Friedrich Froebel into the kindergarten movement that he initiated in Germany in the 19th century. Later the Bauhaus, a famous German school of design, stressed the folding of paper as a method of training students for commercial design. Similarly independent of *origami* is the use of folded paper in mathematical recreations. Particularly intriguing are a variety of paper structures known as flexagons, discovered by Arthur H. Stone in 1939, that alter their faces in curious ways when properly flexed.

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(M. GA.)

PAPER MANUFACTURE. Paper is the general term for the substance commonly used for writing or printing upon or for wrapping. The word was derived from the French *papier*, through Latin from the Greek *papyros* (*see* PAPYRUS). Other names given to paper, in increasing gradations of thickness and stiffness, are bristol, cardboard, paperboard, and wallboard. All types of paper are made from pulps containing vegetable, mineral, or man-made fibres that form a matted or felted sheet on a screen when moisture is removed.

No fabricated product is used more extensively than paper. In the United States in the 1960s the paper industry ranked fifth in value of production (behind automobiles, meat packing, steel, and petroleum), and in Canada the pulp and paper industry ranked first. Paper and other products of wood pulp are so basic that a high value is placed on wood pulp by the national economy of many nations. For paper pulp, the annual increase in the rates of production varies from 3.2% in North America to 17% in Latin America, 25% in Africa, and 31% in the Near and Middle East. In the 1960s world output of paper was around 95,000,000 short tons annually, that of pulp around 78,000,000 short tons. Consumption of paper and paperboard among 130 nations and territories amounted to over 60 lb. per person per year. The less-industrialized countries in the mid-1960s, however, had only begun to consume paper; in more than half the countries of the world, consumption amounted to only 10 lb. or less per person per year. This figure was in sharp contrast with the per capita consumption of paper in North America, most of the Western European nations, Australia, New Zealand, and Japan, where it ranged from 100 to more than 400 lb. per year.

HISTORICAL DEVELOPMENT

Papermaking began about A.D. 105 when Ts'ai Lun, a Chinese court official, developed the idea of forming a sheet of paper from the macerated bark of trees, hemp waste, old rags, and fish nets. Prior to the invention of paper, ancient peoples employed many different substances for recording their thoughts, among them papyrus, parchment (*q.v.*) and vellum, cloth, bark, clay tablets, and stone. The Chinese, for many years before the invention of paper, used woven cloth as a writing material. The camel's hair brush, invented in 250 B.C. by a Chinese savant, Mêng T'ien, was a notable forward step in the writing of Chinese characters. It led to a need for less expensive and more abundant writing material. It is believed that the spread of writing (calligraphy) in China speeded the development of paper more than anything else. It is probable that the Chinese conceived the idea of matting and intertwining vegetable fibres into sheets of paper through their knowledge of feltmaking and weaving of cloth. The first paper was probably fabricated from disintegrated cloth, but before long the bark of trees and other vegetable materials were employed.

For over 500 years the art of papermaking remained in China. At the beginning of the 7th century knowledge of paper spread to Japan when manuscript books made of processed bark from the paper mulberry tree were introduced by Buddhist monks. Although paper was invented in China, the first block printing took place in Japan about A.D. 770 under the sponsorship of Empress Shōtoku, who sanctioned the printing of 1,000,000 prayer papers, a project that required six years to complete. The papermaking craft spread rapidly in Japan. Gampi (a plant of the Japanese mountain forests) was used for making thin, tough paper. Much later, rice straw and mitsumata bark were also used in paper manufacture.

Over six centuries elapsed before papermaking found its way westward, following the caravan routes from the Pacific Ocean to the Mediterranean. In A.D. 751 the Arabs occupying Samarkand were attacked by Chinese. The invasion was repelled by the Arab governor, who in the pursuit, it is related, captured certain prisoners skilled in papermaking and who imparted their knowledge to their new masters. Samarkand, with its crops of flax and hemp and an abundant supply of good water, was ideally located for papermaking. The extent to which paper was adopted for literary purposes is proved by the comparatively large number of 9th-century Arabic manuscripts that have been preserved. While the Arabs and their skilled Persian workmen apparently used flax as their principal papermaking material, later they also used rags supplemented with any vegetable fibre that would serve; cotton was used very sparingly, however, if at all.

Following the caravan routes to Baghdad and Damascus, the art of making paper reached Egypt in the 10th century. Spreading along the Mediterranean Sea to Morocco, where paper was made early in the 12th century, the craft did not reach Europe until the middle of the 12th century, when the Moors established the manufacture of paper in Spain, with headquarters in Játiva, an ancient town of Valencia.

In Italy also the art of papermaking was no doubt established through the Arab occupation of Sicily. But the paper made both there and in Spain was of Oriental quality. Thus approximately 400 years elapsed between the Battle of Samarkand and the manufacture of paper in Europe; there was a spread of about 1,000 years between the invention of paper in 105 and its use on the European continent in Sicily about 1102.

Paper mills appeared in Fabriano, Italy, in 1276 and in Troyes, France, in 1348. Watermarks (*q.v.*) were first used in Europe (Italy) in 1282, in the form of crosses and circles. A few years later the fleur-de-lis appeared as a watermark, and soon thereafter the initials or names of papermakers were found in paper. The origin of watermarks is not clear. They may have been used as marks of identification for sizes of molds and the paper formed on them, or as trademarks of the paper makers who fabricated the molds or the paper or both. It is also possible that watermarks were religious symbols, since paper manufacture was one of the most developed trades of the religious groups so common in Europe at that time. Watermarks may have been nothing more than a fancy with the papermakers, developing designs or emblems as a means of aesthetic expression. At the present time, watermarks are trademarks which identify the grade of paper and the mill where it is made.

The earliest use of animal sizing (gelatin) for paper in Europe was about 1337, although the Chinese used starch as a size for paper as early as 768. The size was necessary to keep the paper from absorbing ink.

In the second half of the 14th century the use of paper for literary purposes had become well established in all of Western Europe. In the 15th century it gradually superseded vellum (usually made of the whole skin of a calf, goat, or lamb). In manuscripts of the latter period it is not unusual to find a mixture of vellum and paper.

Paper was used in England at the beginning of the 14th century, but not until late in the 15th century did John Tate, the first English paper manufacturer, set up a mill in Hertford. Nearly 100 years later, in 1588, Sir John Spilman, a goldsmith to Queen Elizabeth I, erected a paper mill at Dartford. In 1589 he was granted a patent that gave him a monopoly in the collecting of rags and the making of paper in the kingdom.

Paper used by the early printers of colonial America was imported from Europe. From the combination of the requirements of a Philadelphia printer, William Bradford, and the arrival of an ambitious German papermaker, William Rittenhouse, the first paper mill in North America was built in 1690 at Roxboro (Pa.), now a part of Germantown. During the Revolutionary War an acute paper shortage developed, and additional mills were constructed. Until the early 1800s paper was made from rags and cloth. Each sheet was individually fabricated, and a good worker could produce 750 sheets a day.

Groundwood paper, made from mechanical and chemical wood pulps, is claimed to have been produced in the mill of I. Augustus Stanwood and William Tower in Maine in 1863. Four years later a groundwood mill was established in Curtisville, Mass., and the age of economical, mass-produced paper was launched.

RAW MATERIALS AND PULP PRODUCTION

Rags and other fibres, such as straw, grasses, and the inner bark of the mitsumata (paper mulberry), have been used for making paper. Except for certain special papers (*e.g.*, asbestos paper),

nearly all papers are made of cellulosic (vegetable) fibres.

Nature's most prolific source of cellulose is the forest, though trees differ in the value of their fibre for making paper. The fibre of flax (linen), cotton, jute, sisal, manila hemp, etc., usually comes to the paper industry as a secondary product, after serving as cloth, clothing, sacking, rope, etc. Agricultural wastes—straw, corn stalks, bagasse (sugar-cane waste), bamboo, and some other grasses—are used for making certain grades; some of these are utilized in great amounts. Finally, one of the most important sources of papermaking material is the fibre recovered from old papers, bags, and boxes.

A discussion of papermaking materials involves not only their sources and characteristics but also the methods by which the fibre is recovered and made available. The logical as well as the historical approach is to consider first the treatment of rags.

Non-Wood Fibre Sources

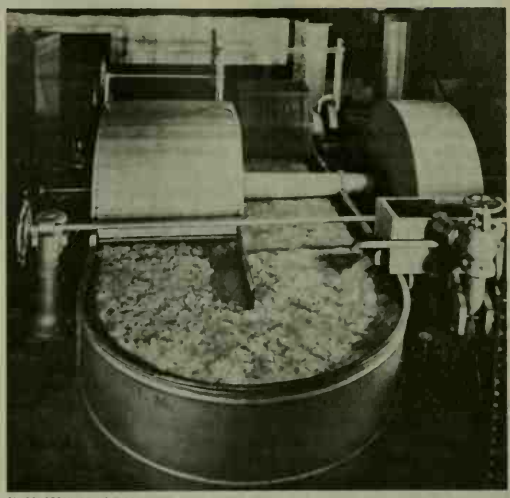
Rags.—Practically all paper up to the middle of the 19th century had cotton and linen rags as its raw material and was handmade. New and old rags are still used for making writing papers, especially in grades where permanence and durability are primary requirements. In processing rags to pulp, they are first cleaned of loose dirt and dust in a boxlike thrasher in which a drum with pins on its surface whips them against a beam. Next they are sorted into kinds and colours. Pockets are emptied, buttons removed, and heavy seams ripped. The rags are chopped into small pieces and then given a second dusting before they are fed to the rag boiler. Bits of iron are removed by a magnetic roll on the sorting conveyor.

Rags usually contain substances that interfere with further processing, such as starch, mineral loading, dirt and grease, some natural waxes and resinous materials, and colours difficult to bleach. To soften the rags, remove foreign matter, and render the colour bleachable, they are treated with an alkaline cooking liquor in a kier or a rotary boiler for 6 to 15 hours at a pressure of 20 to 40 pounds per square inch (psi). A detergent or wetting agent may be used to assist this process. The cooking liquor may be a solution of caustic soda, caustic lime, or a mixture of soda ash (sodium carbonate) and lime. New rags of course require less drastic treatment than old, dirty rags. There are several variations of the cooking operation.

Rag boilers used in North American mills usually comprise a cylinder or globe rotating about a horizontal axis. Rags are charged through manholes in the boiler and spread out. Steam is introduced through one of the bearing trunnions. When the cooking operation is complete, the free liquor is drawn off and the boiler is rotated slowly with the manholes open to dump the rags. The rags are removed with hooks.

The kier is a stationary cooker with a perforated bottom. The cooking liquor is sprayed in at the top, percolates through the rags, passes through the perforated bottom to a reheater, and is again introduced at the top of the kier. This equipment, common in the textile industry, is used to some extent in paper mills, particularly in England and continental Europe.

To rid the rags of chemicals and dissolved substances or attached materials, they are washed in a machine that also ravels the fabric into threads. This washer is a tub with round ends and straight sides, with a centre partition as high as the sides (fig. 1). It is usually about 24 ft. long by 12 ft. wide and 3½ to 4 ft. deep. A large roll having thin bars set in the periphery is located in one channel. These just clear a group of similar bars in the bottom of the channel under the roll, which is rotated on its shaft. In the other channel is a rotating, screen-covered dipper that extracts dirty water from the rags at the same rate as fresh water is added. By lowering the roll so that the two sets of bars nearly touch, the rags are raveled. When the washing is complete, the fresh water is shut off and the dipper run for a time to thicken the stock, now called half stuff. Then a bleaching solution (calcium hypochlorite) or chlorine gas is introduced and thoroughly mixed with the stock, after which the contents of the washer are stored for ten days or so in drainers before being converted to paper stock by beating, refining, and sizing operations.



BY COURTESY OF HOWARD SMITH PAPER MILLS LIMITED

FIG. 1.—WASHING RAG HALF STUFF. THE BEATER ROLL IS IN THE LEFT CHANNEL, THE SCREEN-COVERED DIPPER IN THE RIGHT

In general, rag-pulp fibres are long and strong and contain a large percentage of stable cellulose. Rag pulp is used in the manufacture of so-called rag-content papers, which contain a minimum of 25% rag fibre. These papers are used for bonds, currency, blueprints, and other industrial specialties.

Straw.—Straw is cooked with lime, lime and soda ash, or caustic soda in spherical rotary digesters. The contents are dumped on a draining floor and conveyed to the paper-mill beaters where the necessary washing is done.

Esparto Grass.—Esparto (*q.v.*) is an important papermaking material in England and continental Europe. It is usually cooked in stationary digesters and is bleached when used in the manufacture of high-grade writing and printing papers.

Wastepaper.—One of the most important sources of materials for paper is reclaimed or wastepaper. This is mechanically disintegrated in water to form a pulp suspension, which may be treated chemically with an alkaline solution to aid in removing ink and other extraneous material. After washing, the pulp is bleached to give a product suitable for the manufacture of book paper.

Man-Made Fibres.—The need for papers with specific end uses has led to research in the utilization of glass fibres, rayon, nylon, Orlon, Dacron, and other man-made fibres. Asbestos and wool fibres have been used for many years in paper specialties, but more than 90% of papermaking fibres have their source in wood pulp.

Wood

Wood is made up of a number of chemical components, such as cellulose, the hemicelluloses, lignin, resins and other extractives, and a small amount of mineral matter. Softwoods contain 25 to 32% lignin, hardwoods 17 to 26%. An approximate analysis of a coniferous wood, white spruce, is as follows: cellulose, 60%; hemicelluloses, 11%; lignin, 28%; extractives and ash, 1.5 to 2%. Cellulose is the basic material for paper. (*See* also Wood: *Wood Chemistry;* Cellulose.)

The dimensions of fibres comprising wood pulp or other cellulose raw material differ according to their source. Softwood fibres average 0.1 to 0.2 in. in length and 0.001 to 0.0015 in. in width, hardwood fibres 0.024 to 0.08 in. and 0.0007 to 0.001 in., respectively.

Wood pulps may be classified into two general groups—mechanical and chemical. Mechanical pulp, generally called ground-

wood, is not further divided except as fine, coarse, or bleached. Chemical pulps are classed as unbleached sulfite (strong and news grade), bleached sulfite (dissolving and paper grade), bleached and unbleached sulfate (kraft), and soda. "Semichemical" is a term applied to a process of cooking followed by mechanical treatment.

Spruce, balsam fir, and hemlock are considered the best woods for sulfite and mechanical pulping; several varieties of pine are utilized for sulfate (kraft) pulping; hardwoods are pulped by all of the pulping processes. The chief European pulpwoods are Norway spruce, Scotch fir, and hardwoods. A cord of pulpwood (128 cu. ft.) yields about one ton of mechanical pulp or half a ton of unbleached chemical pulp.

Because all wood is composed of the same essential components, the processes for making wood pulp are similar in principle. Prior to the pulping process, the bark is removed from wood either by hand, by means of barking drums, or hydraulically by means of high pressure jets. The bark is used for fuel and for making other products.

Mechanical (Groundwood) Pulp.—Mechanical pulp is produced by pressing the barked and cleaned logs sideways against a revolving natural or synthetic pulpstone in the presence of water. When a stick is pressed lengthwise against a roughened (dressed) grindstone revolving at a peripheral speed of about 3,500 ft. per minute for natural sandstone or about 5,000 ft. per minute for artificial stones, the fibres are torn from the wood and rubbed to a certain degree of fineness. The character of the pulp depends on the quality of the wood, the pressure against the stone, the temperature of grinding, and the pattern on the stone. The stones also may be of different sizes and degrees of hardness and sharpness of grit.

Natural pulpstones are 27 to 36 in. wide by 54 in. or more in diameter. Artificial stones are 27 to 54 in. wide and 54 to 72 in. in diameter. Standard lengths of wood ground are 24, 32, 48, and 50 in. Small grinders are fed by hand. In the continuous grinder there is a tall chamber above the stone, and the wood is drawn down against it by the movement of spikes on conveyor chains. Another (ring type) grinder has a huge ring with teeth on the inner side and is set off-centre so that the stone nearly touches it. Into the narrow angle so formed, the wood is pinched by the movement of ring (slowly) and stone (faster) in the same direction, and the stone grinds off the fibre.

Under the stone is the pit into which the pulp falls, being washed from the stone by a shower. From there the thin pulp flows over a coarse screen that removes slivers and other insufficiently ground bits of wood. The screened stock then passes through finer screens to obtain pulp suitable for making paper. To save storage-tank space and pumping equipment, the pulp is thickened. This is done by submerging a rotating cylinder covered with wire screening in a vat, continuously fed by the thin pulp. Water flows through the screen and out the ends of the cylinder, leaving a mat of groundwood on the surface. The pulp is squirted or scraped off, and it may flow to a storage tank or be removed from the wire by contact with an endless felt and wound on a roll in a thick layer. When thick enough, the layer is cut loose and folded into a bundle, or lap, containing about 30% by weight of dry fibre. In this form groundwood pulp is conveniently stored and shipped.

The lignin in the wood is not removed by this pulping process; consequently paper made from mechanical pulp does not retain its brightness and strength as long as do papers made from chemical pulp. Groundwood paper does possess certain qualities desired for printing and other purposes. Newsprint is largely mechanical wood pulp, with some chemical pulp added for strength. The colour of groundwood pulp can be improved by bleaching with hydrogen peroxide, a hydrosulfite, or a hypochlorite.

Mechanical pulp is much cheaper than any other form of paper pulp. In the pulping process, only about 7% of the wood is lost, compared with about 50% or more lost in the chemical processes. Although no chemicals are required for the production of groundwood pulp, a product known as chemigroundwood pulp is produced by grinding, following a mild chemical treatment of the wood. Chemigroundwood pulp has been arbitrarily classified between groundwood pulp and sulfite pulp, with strength properties closer to sulfite. The equipment required for the manufacture of groundwood pulp is less expensive initially and requires less maintenance than that for chemical pulp.

Chemical Pulps.—The most common chemical processes are sulfite (using an acid bisulfite solution), soda (caustic soda solution), or sulfate (caustic soda and sodium sulfide).

BY COURTESY OF S. D. WARREN CO.

FIG. 2.—DIGESTER USED TO COOK CHIPS FROM WASHED AND DEBARKED LOGS TO REMOVE NONCELLULOSE IMPURITIES

In each of the chemical processes for pulping, wood must be chipped before it is cooked. Rotating knives cut across the logs, producing chips $\frac{3}{8}$ to $1\frac{1}{8}$ in. long and about $\frac{1}{8}$ in. thick. These are conveyed to storage bins and then to chemical cooking vessels, called digesters (fig. 2), where a chemical solution, or cooking liquor, is added to the chips. The mixture is cooked with steam; as a result the ligneous and other materials are solubilized, thus separating the fibres.

The digester has a conical bottom section, cylindrical centre section, and domed top. Chips are fed in through a throat at the top that can be tightly closed with a cover plate. At the bottom a fitting provides inlets for the cooking liquor and steam, and an outlet discharges the cooked chips. Some digesters are kept at the proper cooking temperature by continuous introduction of steam. In others, the cooking liquor is drawn off through strainers that hold back the chips, passed through a reheating chamber, and fed back into the top of the digester. This system gives faster and more uniform cooking.

Sulfite Process.—Sulfite pulp is made by cooking chips, usually from low-resin coniferous woods such as spruce or fir, in a solution containing calcium, magnesium, or ammonium bisulfite and an excess of sulfur dioxide, under pressure and at an elevated temperature. The resulting pulp is bleachable to a high brightness and is practically pure cellulosic material. The yield is 45 to 50% of the original wood.

The chemical reactions occurring in the digester are complex and are the subject of constant research. Fundamentally, however, the action of the bisulfite and free sulfur dioxide renders soluble the encrusting matter, mainly by forming soluble lignin-sulfonates and by hydrolyzing gums, etc. When the digester is blown (emptied), the softened chips emerge at high velocity and break up against a firm target. Most of the waste liquor drains through the perforated bottom of the blow pit, and more is removed from the pulp by high-pressure hosing.

The cost of manufacturing sulfite pulp, representing 50% or less of the wood, is considerably higher than that of mechanical pulp. Furthermore, more labour and power are spent on preparing the wood before the chips reach the digester. A large chemical plant must be maintained for making the cooking acid, and the equipment is costly to install and maintain. The sulfite process requires about 1,300 to 1,500 lb. of coal, 275 lb. of sulfur, and 350 lb. of limestone per ton of pulp. In recent decades basic changes in the process chemicals and processing methods have taken place. Most new sulfite-pulp mills have magnesia base systems instead of calcium, with heat and process-chemical recovery.

Soda and Sulfate (Kraft) Processes.—These processes differ essentially from the sulfite process in that the cooking liquor is alkaline and thus has less corrosive action on iron and steel, and the digesters are not lined. The active substance in the alkaline cooking liquors is sodium hydroxide, formed by causticizing a solution of soda ash or sodium carbonate with lime. Recovery of the sodium is an important factor in the economy of alkaline processes.

Pines and hardwoods are readily cooked by alkaline liquors.

The resins of pines, which cause trouble in the sulfite process, are converted to soluble soaps in the soda and sulfate processes and are washed out. The liquor may be added to the digester with the chips or after the digester is partly filled with chips. Direct steaming is used in some digesters, but the majority have liquor circulation systems with indirect heating. Operation of soda and sulfate digesters is much the same. The pulp is blown from the digester into a steel tank with a conical bottom and an agitator. This brown stock is brought to a uniform consistency and screened in a knotter as it passes to the washers, which are similar to those used on sulfite pulp.

The rosin soap formed (particularly when cooking pinewood) produces foam on the black liquor that is washed out of the pulp; a foam tank removes the foam before the liquor goes to the evaporators. There the liquor is thickened to a point where it contains about 50% solids; these represent the lignin and other substances that made up about 50% of the original wood. This black sticky mixture can be pumped while hot. It is fortified with chemicals to replace losses and is sprayed into a furnace where it burns and generates steam. The ash formed contains most of the sodium in the original cooking liquor. In the soda process sodium carbonate remains; in the sulfate process, sodium sulfate, the makeup chemical, is reduced to sodium sulfide in the furnace. The presence of this sulfide in the cooking liquor modifies the effect of cooking and produces the stronger kraft pulp of the sulfate process.

In the recovery process (reuse of liquor) the smelt, or molten black ash, from the furnace is run into a dissolving tank where it is dissolved in water to form green liquor. The green liquor is then causticized with lime to change the sodium carbonate to sodium hydroxide, producing white liquor containing the hydroxide and sulfide. After settling, the white liquor is available for a succeeding cooking operation. The calcium carbonate that has settled out of the white liquor is fed to a lime kiln (about 8 ft. in diameter and 300 ft. long) where it is burned to drive off carbon dioxide, leaving lime for another turn in the causticizing operation.

In the soda process, caustic soda (sodium hydroxide) at elevated temperatures dissolves most of the lignin in the wood, with slight effect on the cellulose fibres. Most soda-pulp mills now add 8% to 12% of sodium sulfide to the pulping solution to aid in the removal of lignin.

Soda pulp is composed of relatively short fibres, because short-fibred hardwoods are processed by this method, and thus lacks the strength of other pulps. After bleaching, soda pulp is used in the manufacture of book, magazine, and envelope papers, especially where soft texture and bulk are required.

Cold-soda-chemimechanical pulp results from treating hardwood chips with sodium hydroxide solution at room temperature and preparing fibres from the softened chips in a mechanical refiner, such as a disk attrition mill. Yields vary from about 87% for corrugating pulps to 85 to 92% for printing papers. The unbleached pulp, low in brightness, is bleachable, especially with a combination of peroxide and hypochlorite bleaching agents.

In the sulfate-pulping process, the name "sulfate" arises from the fact that chemical losses are replaced with sodium sulfate, "salt cake." In making pulp by the soda process already described, the cooking solution, or liquor, consists mainly of caustic soda. Sulfate pulping differs from the soda process because sodium sulfide is used in the cooking liquor along with the caustic soda. Sodium sulfide is made by reducing sodium sulfate, which is added to the recovery furnace. Compared to the soda-pulping process, sulfide accounts for a stronger pulp and reduces the cooking time. Many soda-pulp mills have converted to the sulfate process, and soda mills have found it advantageous to add a small amount of sulfide to the cooking liquor; there is thus basically no difference between the soda and sulfate processes.

The pulp industry developed rapidly in Sweden, where the pulp became known as "kraft," meaning "strong." This is the outstanding characteristic of papers made of sulfate (kraft) pulp. The sulfate process is practically a universal pulping method because it can be employed successfully for pulping almost any suitable wood, both resinous and nonresinous. This fact has given great impetus to the sulfate process in many parts of the world, especially in the southern and western United States. Sulfate pulp is bleachable to a high brightness and can be used in almost any grade of paper. The yield varies from 40 to 50%. So-called high-yield sulfate pulp may yield as much as 65% of the raw material.

Semichemical Process.—Another way of making wood pulp, combining mechanical and chemical methods and called the semichemical process, was developed primarily for hardwoods. This process is increasing in use because of (1) the high yield obtained (up to 75% or better); (2) the suitability of a variety of pulpwoods, especially the hardwoods; (3) the reduced cost of manufacture; (4) the suitability of semichemical pulps for a variety of papers when mixed with other fibres; and (5) the expansion of the paperboard industry, including corrugating board for packaging.

In the semichemical process, chips are cooked in a mild chemical solution, and the fibres are separated mechanically by means of a refiner. The first semichemical pulp mill, established in 1925 in the United States, utilized by-product chestnut chips from tannin extraction. From the modest beginning of ten tons of pulp per day, the semichemical pulp industry in the United States came to be rated fourth among the major pulping processes.

A distinction is made between semichemical pulping and chemimechanical pulping. In the latter process there is no major change in the lignin material bonding the fibres, whereas in the semichemical process lignin is partially removed. This has led to the following classification of these pulping methods: (1) neutral sulfite semichemical; (2) kraft semichemical; (3) acid-sulfite and bisulfite semichemical; (4) cold-soda chemimechanical; and (5) sulfite chemimechanical.

Washing and Bleaching

Following the pulping operation, the unbleached pulp must be washed free of soluble impurities and screened to remove knots, dirt, and uncooked fibre bundles before it can be used for the manufacture of paper or other products. Much unbleached pulp is further purified and whitened by bleaching, a continuation of the cooking process. All natural fibrous materials and unbleached pulp contain impurities that impart colour and make them unsuitable for the manufacture of white papers. In bleaching these fibres, the two basic objectives are (1) removal of the colouring materials by converting them to soluble compounds; and (2) changing the residual coloured matter to a colourless form that possesses stability to light and heat. The principal bleaching and purifying agents are chlorine, hypochlorite, and chlorine dioxide. Other chemical compounds used are peroxide for mechanical or other high-yield pulp, hydrosulfite for mechanical pulp, and borohydride.

During the development of methods for bleaching plant fibres, advantages were found in adding only a part of the bleaching chemical at the beginning of the operation and the remainder later in one or more portions. Out of this came the modern multistage bleaching process, which yields a product of improved whiteness or brightness, with more economical consumption of bleach, and pulp fibres with a minimum of degradation. A typical multistage bleaching operation for a high-brightness sulfate pulp comprises the following: (1) chlorination; (2) caustic soda extraction; (3) addition of chlorine dioxide; (4) caustic soda extraction; and (5) another treatment with chlorine dioxide, with interstage washing of fibres with water to remove soluble products formed during the bleaching and extraction stages.

Hydrogen peroxide and sodium peroxide increase brightness of mechanical pulp (groundwood) fibres from 5 to 15%. Zinc or sodium hydrosulfite, although reducing agents, whiten groundwood 5 to 8 units. Sulfite, soda, and sulfate unbleached pulps yield bleached products of different brightness depending on (1) the amount of bleaching chemicals added; (2) the sequence of stages; and (3) the number of stages. Time and temperature are important variables.

The visual whiteness of a bleached pulp is usually defined in

terms of "brightness," which is determined as the numerical value of the reflectance of pulps to light in the blue and violet portion of the spectrum (457 mμ); it is measured by an instrument in calibration with a master instrument of specified type and design.

MANUFACTURING OPERATIONS AND EQUIPMENT

The manner in which the Chinese court official Ts'ai Lun formed the first paper in the 2nd century and the technique employed by the modern paper machine differ little in principle. It is probable that the original Chinese papermaker poured a suspension of fibres on a cloth-covered frame or mold. The water drained away and the fibres dried in the form of a sheet on the mold. The technique of papermaking was soon improved by dipping the mold directly into the water suspension of macerated fibres and allowing the water to drain away. The wet sheet was then couched off by means of a woolen fabric or felt and was dried. By this change, better sheets in larger quantities were produced.

Papermaking in the 20th century has changed from an individual art to an industrial art. At the same time paper itself has changed from a primarily cultural product used for newspapers, books, and writing paper to a basic product, like steel, adaptable to many purposes.

Preparation of Stock.—Integrated paper mills receive pulp chiefly from their own mills. Other paper mills purchase pulp from market suppliers. Pulp, by itself and without further treatment, is unsuited to the manufacture of most papers. Mechanical treatment, termed beating and refining, is given to the fibres to shorten them, to improve their felting qualities by fraying their outside walls, and to improve the strength of the paper. These processes of mechanical treatment and chemical addition constitute stock preparation. In this operation, sizing agents, pigments, colours, and other materials may be added, depending on the end use of the paper.

FROM R. N. SHREVE, "THE CHEMICAL PROCESS INDUSTRIES," 1956, BY PERMISSION OF MCGRAW-HILL BOOK CO., INC.

FIG. 3.—OPERATION OF A BEATER

Beating.—Paper manufacture may be considered as beginning in the beater room. The beater (fig. 3) is a machine fundamentally the same as the washer, but more carefully designed and built. It consists of a tank containing a heavy roll that revolves against a bedplate. The roll is capable of being set very accurately with respect to the bedplate, since the progressive adjustment of the roll position is the key to good beating. A beater may hold from 300 to 3,000 lb. of stock, a common size being about 24 ft. long, 12 ft. wide, with ends of semicircular shape, and about 3½ ft. deep. A centre partition provides a continuous channel.

Pulp is put into the beater and water is added to facilitate circulation of the mass between the roll and bedplate. As the beating proceeds, the revolving roll is gradually lowered until it is riding full weight on the fibres between it and the bed-plate. This action splits and mashes the fibres, creating hairlike fibrils and causing them to absorb water and become slimy. The beaten fibres will then drain more slowly on the paper-machine wire and bond together more readily as more water is removed and the wet web is pressed. Much of the beating action results from the rubbing of fibre on fibre. Long fibres will be cut to some extent.

Other types of beaters have been developed, but all follow the same principle and have the same function. Although beaters are widely employed, they are being replaced by continuous refiners in stock preparation.

Refining.—The purpose of refining is to brush out knots or clusters of fibres and to cut the fibres to more uniform lengths. Further conditioning may occur to increase the area of fibre surface, which is a factor in making fibres adhere to each other. Refining equipment is characterized by the principle of close-clearance action on the fibres and treatment by continuous flow.

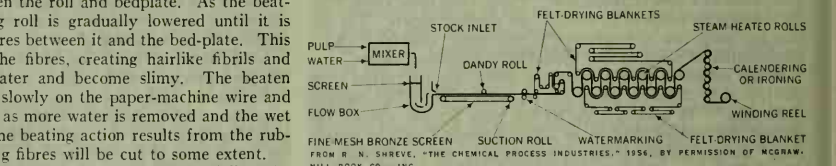
The material entering the refiner is automatically regulated to a uniform consistency by an instrument that controls the amount of water added as the stock is pumped from the beater chest. Refiners operate on the principle of one set of bars or knives passing another set at a controlled distance and at high speeds. The two distinct types are: (1) a conical plug with bars on the surface revolving in a shell, with corresponding bars on the inner surface; and (2) two disks, of which one or both rotate and which are grooved with sharp-edged ridges. In the first type the plug is accurately centred in the shell, and the machine is given a preliminary run with a slurry of sand to grind the bars to a perfect fit. In operation the plug is pushed in or drawn out by special gearing (which may be automatically controlled) to regulate the degree of rubbing and cutting of the fibre. The stock is fed in at the small end at a constant rate and emerges at the large end of the machine. It flows from there to the machine chest, of which there are two if the paper machine makes a variety of grades or colours, since it takes time to prepare for the switch-over when the first run is finished.

Chemical Addition.—Paper can be made from cellulose fibres alone, but many properties are lacking in such a paper, and it would be entirely unsuitable for a large range of uses for which paper is needed. Many of these properties are supplied by chemical addition, largely in the stock-preparation process. While the selection of the proper fibres for a given paper is important, nonfibrous materials added to the stock supply the required properties not inherent in paper made from fibres alone, such as (1) size and aluminum sulfate to give resistance to water penetration; (2) certain resins to give wet strength properties; (3) fillers to enhance the opacity and brightness of paper; (4) pigments and dyes to give colour; (5) deflocculants to reduce the tendency of fibres to agglomerate; and (6) other additives to increase the tensile strength, absorbency, softness, and filler-retention properties.

Chemical additives may be added to the paper stock in the beater, or in the chests, or added continuously at almost any point in the processing operation, including the headbox on the paper machine or after the paper is formed in the press section, size tub, or calender water box.

Paper Machines.—Paper is made from the processed stock on the paper machine, one type being the Fourdrinier machine, invented in France by Louis Robert in 1799 and commercialized five years later in England. Various modifications of the Fourdrinier machine have been developed over the years. The cylinder machine, another type, was invented by John Dickinson of Germantown, Pa., in 1809.

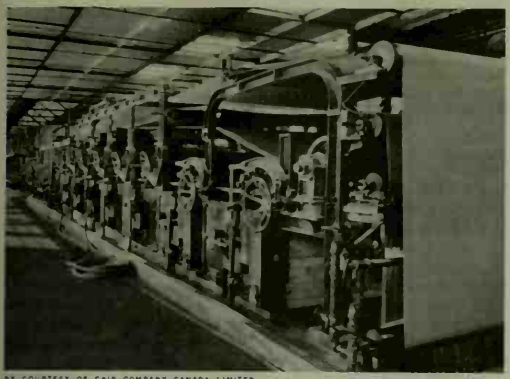
Fourdrinier Machine.—Papers varying in weight from lightweight tissue to 16-point test liner (one point is $\frac{1}{1,000}$ inch and is used to express thickness) are made on the Fourdrinier machine (fig. 4). For descriptive purposes, the machine may be divided into four sections: (1) the wet end; (2) the press section; (3) the drier section; and (4) the calender section. In the wet end the stock flows from a headbox through a sluice to the top of a moving endless belt of wire cloth (the Fourdrinier wire). There



FROM R. N. SHREVE, "THE CHEMICAL PROCESS INDUSTRIES," 1956, BY PERMISSION OF MCGRAW-HILL BOOK CO., INC.

FIG. 4.—ESSENTIAL OPERATIONS OF A FOURDRINIER PAPERMAKING MACHINE

a web of paper is formed as the water is removed from the fibre-water mixture by drainage and by suction boxes. The press section usually comprises two or more press rolls to further remove water in the formed web and to impart surface characteristics to both sides of the paper. The wet web is carried through the presses by felts. The drier section includes two or more tiers of steam-heated cylinders, and the paper is held close to the heated surfaces by means of canvas drier felts. In the fourth section usually there are from one to three calender stacks, with a reel device for winding the paper into a roll as it leaves the machine. The calenders



BY COURTESY OF GAIR COMPANY CANADA LIMITED

FIG. 5.—WET END OF CYLINDER-TYPE BOARD MACHINE SHOWING VATS, FELTS, AND PRESSES SQUEEZING WATER OUT OF PAPER

smooth the paper and impart the desired finish or gloss to the surface. The paper may be further finished in a separate operation using a supercalender. The Harper and the Yankee (machine-glazed) paper machines are modifications of the Fourdrinier.

Cylinder Machine.—The cylinder machine (fig. 5) differs from the Fourdrinier mainly in the method of forming the continuous paper web. This is accomplished by the use of wire-covered cylinders or molds that rotate in a vat containing a dilute stock suspension. As the water drains through and passes out at the ends of the cylinders, the fibres are formed on the wire. The wet web is couched off the cylinder onto a felt that is pressed against the cylinder by a couch roll. A cylinder machine may possess one or several cylinders, each of which can be supplied with the same or different kinds of stock. A cylinder machine offers a wide variation in thickness or weight of the finished paper, as well as variation in the composition of the stock used in the different layers of the sheet.

Paper machines, sometimes more than three stories high, can fabricate paper over 30 ft. wide at speeds up to 2,500 ft. per minute or more. Some Fourdrinier machines are designed to run more than 3,000 ft. per minute. Cylinder machines operate at a much slower speed, 10 to 15 ft. per minute when heavy paperboard is made.

Special Paper Machines.—Special machines are required for many pulp and paper products, from light tissue to heavy building boards. These machines are adaptations of the basic Fourdrinier and cylinder designs. A high-speed machine (2,500 to 3,000 ft. per minute) has a short Fourdrinier wire and a so-called Yankee drier, 12 to 14 ft. in diameter. A transfer attachment picks the paper from the wire and presses it against the polished surface of the drier until dry; then it peels off, like a handkerchief dried on glass. The Yankee drier is also used in making other tissues, light wrappings, and crepe papers. Creping is done by a "doctor" that scrapes the paper off before it is quite dry and wrinkles it in doing so.

For building and insulating boards up to an inch or more in thickness, both Fourdrinier and cylinder-type machines are used. One of the latter has two vacuum-equipped cylinders; the Fourdrinier type has high deckle boards and special suction units. In these machines the sheet is gradually pressed between two felts or two wires to the desired thickness and cut into slabs. The cutter moves across diagonally to compensate for the forward movement of the board and to produce square ends. The boards are then fed successively by a "tipple" to different decks of an eight-deck drier and carried through it on chain-driven rollers. A typical board drier is more than 500 ft. long, with five zones at increasing temperatures. The board must be heated gradually to the point where moisture left in the centre will migrate to the over-dried surface layers and give a uniformly dry product. Hardboard, such as Masonite, is pressed and dried at the same time between the plates of a hydraulic press. Board sheets are then trimmed to standard sizes and wrapped.

Finishing Operations.—Newsprint, much book and magazine paper, and many wrapping papers and boards need only to be wrapped, if ordered in rolls, when they come off the paper machine. Other papers require further finishing or special treatment, some of which is done by the converter. For example, a very smooth surface on printing papers is obtained by passing the web through a supercalender. This machine is similar to the paper-

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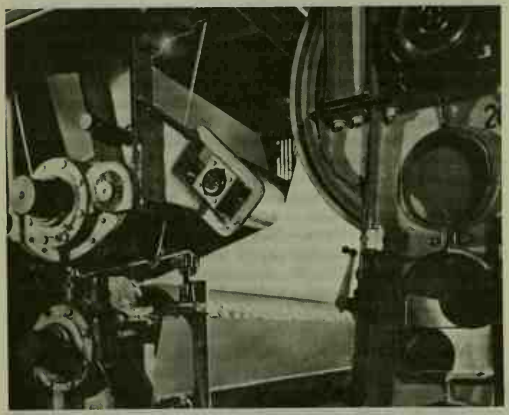
FIG. 6.—ONE OF THE WORLD'S LARGEST PAPER MACHINES, LOCATED AT FORT WILLIAM, CANADA, USED IN MAKING NEWSPRINT PAPER

machine calender, but alternate rolls are made of circles of paper compressed to a dense hard mass and ground to a true cylinder. The special surface on writing papers is produced by building a stack of alternate sheets of paper and sheets of linen, crash, rippled cardboard, etc., with sheets of zinc at intervals and passing the "form" back and forth several times between rolls that exert a pressure of 60 to 80 tons.

Another type of finish is the impression made by the embossing machine, which has two rolls; one has the pattern embossed on it, and the other may have a matching pattern engraved on its surface, or it may be a roll of softer material that will take the indentation. To get sheets thicker than can be produced on the paper machine, or sheets of varying qualities or colours, pasting or laminating is employed. Web pasters will laminate up to six sheets for wallboards, asphalted products, moisture-proof kraft lining paper, etc.

Most important of the special processes is the coating of paper for fine printing (fig. 7). The purpose is to fill the small depressions caused by irregularities in size of fibres or formation of the sheet and to give a surface of homogeneous material and structure that can be finished to almost perfect smoothness by the supercalenders. A mixture of clay or other white mineral matter,



BY COURTESY OF HOWARD SMITH PAPER MILLS LIMITED; PHOTOGRAPH, ARNOTT & ROGERS

FIG. 7.—COATING UNIT BETWEEN DRYERS, MAKING MACHINE-COATED MAGAZINE PAPER

casein or other adhesive, and dyes is spread smoothly on one or both sides of the paper.

One-side coating is applied by an applicator roll and is then smoothed by brushes of finest badger hair. Two-side coating is obtained by passing the web through a bath or between a pair of applicator rolls and then between four to ten pairs of brushes. Single-coated paper is dried in loops or festoons on a conveyor or over rollers, in either case passing through a drying chamber. Double-coated paper must be floated on hot air to set the coating before it contacts other support. Certain grades and weights of paper can be coated in the paper-machine drier, by locating an applicator unit about two-thirds of the way down the length of the drier, where the paper is sufficiently moist to permit penetration of the clay through the sheet. This is necessary in order to get equal smoothness on both surfaces.

Somewhat akin to machine coating is the sizing of paper with glue. Glue, or surface, sizing is obtained by passing the paper through a size tub, where press rolls squeeze out the excess. The paper is made stronger; it is resistant to spreading of ink; and fibres are not picked up by a writing pen. Paper is waxed in a somewhat similar way by passing the web through a bath of molten wax, then over a chilling roll to harden the wax.

See also PAPER PRODUCTS.

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PAPER MONEY: *see* ASSIGNATS; BANKING; CURRENCY; MONEY; QUANTITY THEORY OF MONEY.

PAPER PRODUCTS. Until the mid-1800s, products made of paper were relatively few; paper was used basically as a means of recording communications. Even the common envelope was unknown prior to 1841. During the Industrial Revolution of the 19th century, paper became much more abundant because of the discovery of methods by which the fibres of wood could be isolated and purified by chemical means. Since then, paper has been converted into articles for almost innumerable purposes.

In 1850 paper bags were made for the first time, entirely by hand; the earliest automatic bag-making machine was built in 1876. By 1894 automatic machines for making paper boxes were in general use, marking the beginning of the paper-packaging industry. Corrugated fibre containers came into use in 1903, gradually replacing wooden boxes, and three years later the first paper milk cartons were made. By 1910 the wrapping of bread in printed paper was widespread in the United States, and fruit was being wrapped in paper for shipment.

Developments in the packaging field since the 1930s have been the chief reason for the elevation of the paper industry to fifth place among the industries of the United States. New or modified paper containers were developed, and new packaging materials were made available.

Paper is exceedingly versatile and economical to use. It can be designed to provide such qualities as high wet strength and resistance to impact or tear, water vapour, certain gases, oil, grease, molds, tarnish, flame, insects, rodents, and corrosion. Paper is suited for packaging food products because it is naturally nontoxic, odourless, and tasteless.

Coating for Paper Products.—Paraffin is used in the treatment of paper cups, dishes, cartons, wrappings, and many other products. Wax produces films that are hard and glossy, nontacky, and water resistant. Paper treated with blends of microcrystalline wax and paraffin wax has increased oil and water-vapour resistance and heat-sealing property. It is suitable for packaging butter, lard, cookies, and other fat-containing foods, including frozen foods. (*See* PETROLEUM WAXES.)

Solvent coating of paper involves the use of film-forming resins, such as nitrocellulose, ethylcellulose, the polyvinyls, polyethylene, and rubber compounds. These coated papers find use as decorative wrappers, food wrappers, and bottle-cap linings. Depending on the coating material, they may be water resistant, water-vapour resistant, grease resistant, alkali resistant, and heat sealing.

Extruded coatings have made possible the use of thin films of plastic resins, especially polyethylene, on the surface of paper. Polyethylene-coated papers have chemical, tear, and puncture resistance; heat sealability; and gas, moisture, and grease resistance, as well as durability on folding. They are odourless and tasteless. The paper or paperboard backing gives structural stability and strength, as well as an excellent surface for printing. The thickness of the coating depends on the barrier properties required; for instance, in the case of the small sugar envelope, the polyethylene coating is only 0.25 mil. or 4 lb. per 3,000 sq.ft. Plastic exterior coatings also provide better printing surfaces and product protection for folding cartons. In addition, glueable polyethylene coatings permit gluing a plastic-coated surface to an uncoated surface on commercial gluing equipment.

In the latex form, polyvinylidene chloride is used as a coating for paper and its products where outstanding resistance to water vapour, grease, and gas is important.

Paper Packaging.—The basic packaging papers are kraft, glassine, vegetable parchment, waxed paper, and tissue. Com-

binations of treatments and the use of coatings and support materials provide a widely diversified group of papers. Kraft paper, in one form or another, is used in connection with nearly every important product.

A product of increasing importance in the paper industry is the composite or foil can, in which the major portion is composed of kraft paper. In the motor-oil market alone, the use of foil instead of metal containers offers great savings in shipping costs because of the reduction in weight.

The set-up paper box industry has increased in volume, largely due to prepackaging by department stores and specialty stores. Merchandising techniques of the self-service supermarket have resulted in a growing usage of paper materials for packaging dairy products, fruit juices, frozen foods, etc. Some containers are designed to withstand oven heat, so that the contents may be warmed before serving.

Paper bags, which have the advantage of flexibility, can be made in various dimensions and of almost any grade of paper that can be treated for protective purposes. The multiwall bag and the fibre drum are standard paper containers for dry, free-flowing industrial products. Made in large sizes, paper bags and cartons are used to enclose mattresses, furniture, and even automobiles. Flexible paper wrapping has been developed for the outside storage of lumber. Shipping bananas in cartons reduces losses due to rot and damage. Citrus fruits and lettuce can be shipped with little damage and considerable economy in paperboard containers.

Corrugated boxes are used instead of wooden containers for shipment of such household furnishings as rugs and refrigerators. This type of container is also employed in place of wooden kegs for nails, nuts, and bolts. A coating on kraft paper has led to vapour-phase-inhibitor packaging for prevention of corrosion of iron materials, without the application of grease. (*See* also PACKAGING.)

Other Paper Products.—Much of the growth experienced by the paper industry has been achieved for the following reasons: (1) Paper is an inexpensive and convenient substitute for textiles in such products as cement and fertilizer bags, potato bags, flour and feed sacks, rug backings, waste collection bags, mail sacks, underwear, disposable raincoats, and swimming suits. (2) Paper can be substituted for wood, glass, and other materials to reduce weight, danger of breakage, etc. (3) Cleanliness and comfort are increased by use of disposable paper products such as tissues, napkins, towels, diapers, hospital pads, bed sheets, and eating utensils. (4) Paper products are useful adjuncts in industrial products such as industrial filters, base material for plastic sheets, insulation in electrical equipment, and for concrete forms, tarpaulin coverings, etc.

Paper made from wood pulp is used for paper-bound books, newspapers and magazines, stationery, posters, wrapping paper, wallpaper, labels, stencils, envelopes, and for the paper and tape used for teletype machines. Rag pulps are used in producing fine writing papers such as bond paper, and for bank notes, currency, drawing paper, blotting paper, and computing machine paper. Flax pulp provides fine grades of paper for cigarettes and carbon paper. When coated on one side with abrasive material, papers become sandpaper or tanning paper. Gummed papers are used for stickers, labels, postage stamps, and various types of adhesive tapes. Paper cloths are used for draperies, lamp shades, dusting cloths, table coverings, book bindings, and wallets. Technical papers are made from many different types of fibres, depending on the end use. Oil and air filters for engines are made of specially formulated paper. Rubber-content papers protect rockets. Special papers insulate power transmission lines and transformers. Even hats and shoes contain treated paper.

See also PAPER MANUFACTURE.

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PAPHLAGONIA, an ancient district of Asia Minor, situated on the Black Sea between Bithynia, Pontus, and Galatia, roughly bounded by the Halys (Kizil Irmak) River on the east and the Billaeus (Filyos Cayi) on the west. Although the Paphlagonians played scarcely any part in history, they were one of the most ancient nations of Asia Minor; the Paphlagonian chieftain Pylaemenes figures in the *Iliad*. They were among the peoples conquered by Croesus, and they sent a contingent to the army of Xerxes in 480 B.C. Paphlagonia formally submitted in 333 to Alexander the Great, and after his death was assigned to Eumenes. It continued, however, to be governed by native princes until it was absorbed by the encroaching power of the kings of Pontus. They became masters of the greater part of Paphlagonia as early as the reign of Mithradates II (302–266 B.C.), but it was not until that of Pharnaces I that Sinope (modern Sinop) fell into their hands (183 B.C.). From that time the whole province was incorporated with the kingdom of Pontus until the defeat of Mithradates VI (*q.v.*) in 65 B.C. Pompey united the coast districts of Paphlagonia with the province of Bithynia, but left the interior of the country under the native princes until the dynasty became extinct, when the remainder of Paphlagonia was incorporated in the province of Galatia (*c.* 6 B.C.). Several of these rulers appear to have borne the name of Pylaemenes, as a token that they claimed descent from the Homeric Pylaemenes. Under the later Roman Empire Paphlagonia became a separate province in the 4th century A.D.

Paphlagonia was a rugged mountainous country, but it included fertile plains by the coast of the Black Sea, where the olive could be grown. It was celebrated for its horses, and sheep were also bred in the district. The mountains were clothed with dense forests, conspicuous for the quantity of boxwood they furnished. The coasts were from an early period occupied by Greek colonies, among which the flourishing city of Sinope, founded from Miletus in the 7th century B.C., was preeminent. The most considerable towns of the interior were Gangra (modern Cankiri), in ancient times the capital of the Paphlagonian kings, afterward called Germanicopolis, situated near the frontier of Galatia; and Pompeiopolis (Taskopru), in the valley of the Amnias (Gok Irmak, a tributary of the Halys), near which were extensive mines of the mineral called by Strabo *sandarake* (realgar), which was largely exported from Sinope.

PAPHOS, the name of a modern town and administrative district (pop. [1960]: town 9,083; district 58,159) and of two ancient cities on the west coast of Cyprus. The older ancient city (Greek Palaipaphos) was at modern Kouklia, about 26 mi. (42 km.) W of Limassol and a mile inland, near the left bank of the Dhiarrizos River. New Paphos, which had already superseded Old Paphos in Roman times, was 10 mi. (15 km.) farther west, at the other end of a fertile coast plain, and 1 mi. (2 km.) S of modern Ktima; New Paphos and Ktima together form modern Paphos.

Paphos was traditionally founded either by the Arcadian Agapenor, returning from the Trojan War, or by his reputed contemporary Cinyras; the historical Cinyradae were kings of Paphos until its final conquest by Ptolemy I of Egypt (294) and continued to act as high priests afterward. The town certainly dates back to the Mycenaean settlement in Cyprus (14th century B.C.) and had a king Eteander among the subjects of Esarhaddon of Assyria in 672. In Hellenic times the kingdom of Paphos was second only to Salamis in extent and influence. It took part in the Ionian revolt (498–493), during which the Persians besieged and captured it; the siege works have been discovered by excavation.

Paphos owed its ancient fame to the cult of the "Paphian god-

dess," a fertility goddess associated with sacred doves and probably temple prostitution. The Greeks identified her with Aphrodite and localized at Paphos the legend of her birth from the sea foam (Greek *aphros*). She was worshiped in a temple in the central aisle of which stood a conical stone; a stone at present in the Cyprus Museum, Nicosia, may be the original. The site was excavated by British expeditions in 1888 and again from 1950 onward. After the foundation of New Paphos and the Roman occupation of Cyprus (58 B.C.), the importance of the old town declined rapidly. Though restored by Augustus and renamed Sebaste after the great earthquake of 15 B.C., and visited in state by Titus in A.D. 69, it was ruinous and deserted by the 4th century A.D.

New Paphos became the administrative capital of the whole island in Ptolemaic and Roman days, as well as the head of one of the four Roman districts. It was at Paphos that St. Paul converted the Roman proconsul Sergius Paulus. In A.D. 960 it was attacked and destroyed by the Saracens. The site shows a Roman theatre, amphitheatre, rock tombs, part of the city wall, the moles of the Roman harbour, an early Byzantine castle, and a ruined Latin cathedral. *See* also CYPRUS.

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PAPIAS OF HIERAPOLIS (fl. late 1st century or early 2nd century A.D.), one of the Apostolic Fathers (*q.v.*), was probably a bishop among the Christians of Hierapolis (a crossroads town in western Asia Minor).

His significance lies in the surviving fragments of what he wrote. He is also important because of the kind of Christianity he represents, rather different from that of the major writers of his time (Clement, Ignatius) and closer to the *Shepherd* of Hermas.

The fragments of his five books of *Exegeses of the Dominical Oracles* provide valuable testimony not only to Christian tradition in his time and earlier but also to the Jewish Christianity of which he was a prominent representative. The precise meaning of "dominical oracles" is uncertain, but they were probably Old Testament prophecies which, like much of the rest of the Old Testament, Papias interpreted in relation to Jesus Christ. According to Anastasius of Sinai (7th century), Papias referred the creation story to Christ and the church and interpreted paradise as equivalent to the church. It would appear that in his view Christ came to restore the order which was lost when the angels disobeyed God and fell (in the Septuagint, Gen. 6:1). Such speculations, according to J. Daniélou, are Jewish-Christian.

Eusebius of Caesarea (4th century), who had read Papias' work, says that from oral tradition Papias related "certain strange parables of the Saviour and teachings of his, and some other matters of a rather mythical character." What Eusebius found most objectionable was Papias' idea about the Kingdom of God on earth, but he was not especially enthusiastic about Papias' story that Justus Barsabbas (Acts 1:23) drank poison without ill effects or about his account of a woman "accused of many sins before the Lord" (perhaps John 7:53–8:11?). Eusebius did not mention, but would not have liked, the macabre details about the death of Judas (*cf.* Acts 1:18) quoted from Papias by Apollinarius of Laodicea (late 4th century). Presumably Papias' purpose in making these statements was to show that Gospel prophecies were literally fulfilled (*cf.* Mark 16:18, a text known to 2nd-century Christians); for this reason, according to Georgius Hamartolus (George the Monk, or the Sinner; 9th century), he said that "John was slain by the Jews," in fulfillment of Mark 10:39 (Matt. 20:23).

The most unintelligent (in Eusebius' view) of Papias' statements were concerned with millenarian doctrines. Irenaeus (late 2nd century) explicitly quotes what Papias said about the miraculous productivity of the earth and the harmony of animals with one another and with men in the age to come; only Judas expressed doubts about this prediction made by the Lord. Even in the 7th century men remembered Papias as teaching that "there will be enjoyment of foods in the resurrection" (Maximus Confessor). Papias' views are practically identical with those found in Jewish apocalyptic writings, notably II Baruch (29:4–6; 2nd century).

Papias was not, however, a representative of a purely Jewish-Christian tradition; the culture in which he lived was one in which Jewish and Greek ideas had flowed together, as may be seen from the fragments concerning oral tradition and the origins of the Gospels of Matthew and Mark. (These are preserved, as might be expected, by Eusebius.) "Unlike the many, I took pleasure not in those who spoke the most, but in those who taught the truth; not those who recalled the commands of others, but those who delivered the commands given by the Lord to faith, coming from the Truth himself." He describes his investigations in regard to sayings of the Lord's disciples—in a way that does not make quite clear how he learned about them but does show that he was close to "the elder John." From this (or another) elder he learned that Mark's treatise (presumably the Gospel) was based on the teaching of Peter about Christ, though it was not written "in order" (chronological or literary). This statement seems to defend Mark against criticism based either on Luke or, more probably, on John (whose order is rather different from Mark's). Of Matthew, Papias said that he "compiled the oracles in the Hebrew language [or, a Hebrew dialect]; but everyone translated them as he was able." Here he seems to be criticizing a Greek version of Matthew's oracles. Unfortunately it is not certain that by the collection of oracles he means the Gospel.

Papias' statements about the Gospels are thus rather enigmatic, and they have led to a great deal of controversy. According to Eusebius he used both I John and I Peter, but it is not known how Eusebius knew this. Papias' relation to the Gospel of John is described in the Anti-Marcionite Prologue but without a high degree of credibility. His work was obviously a treasure of early Christian literature—now buried.

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PAPIER-MÂCHÉ is repulped paper that has been mixed with glue or paste and is capable of being molded.

The art of making articles of papier-mâché, beautifully decorated in Oriental motifs and handsomely lacquered, was known in the East centuries before its introduction in Europe. Molded paper products were first made in France in the early part of the 18th century, probably to utilize used paper and avoid complete waste of a costly material. Interest in papier-mâché spread to other countries and before the close of the century German and English manufacture rivaled French production in quantity and quality. Frederick the Great established a papier-mâché factory in Berlin in 1765.

Various paper materials came to be known as papier-mâché. By a process originating with Henry Clay of Birmingham, Eng., in 1772, sheets of a specially prepared paper were covered with glue and then pasted together until a desired thickness of paper was reached. This material could be pressure-molded into a number of useful articles, notably trays and panels for furniture and coaches. It later provided the stock from which papier-mâché button blanks were stamped. Another type was ceramic papier-mâché, consisting of pulped paper mixed with glue, rosin, a drying oil, and lead acetate; from it could be made such products as toys, picture frames, figurines, and ornamental moldings. Still another type that served as a fine molding material was made by reducing dried paper pulp to powder and mixing it with paste and a small amount of potash.

Although the papier-mâché industry declined during and after the second half of the 19th century, the substance continued to have many uses. An application that remained important was the use of papier-mâché in matrices from which stereotype printing plates are cast. The paper mold, when curved in a casting device, produced curved plates that made printing from rotary presses practicable. Papier-mâché also continued to be used in the manufacture of toys, masks, model scenic materials, and similar items.

(E. L. Y.)

PAPIN, DENIS (1647–*c.* 1712), French physicist, and inventor of a device that was the forerunner of the autoclave (*q.v.*), was born at Blois on Aug. 22, 1647. Papin acted as assistant to Christiaan Huygens in his experiments with the air pump. Later he went to London and assisted Robert Boyle. He introduced a number of improvements in the air pump and invented the condensing pump. In 1679 he invented his steam digester, a closed vessel with a tightly fitting lid in which water was heated. Because the steam was prevented from escaping, a high pressure was generated, causing the boiling point of the water to rise considerably. A safety valve of his invention guarded against excessive rise of pressure.

In 1684 Papin received from the Royal Society an appointment as temporary curator of experiments, with a small salary. In this capacity he carried on numerous and varied investigations in hydraulics (*Phil. Trans.*, 1685, etc.). In Nov. 1687 he was appointed to the chair of mathematics in the University of Marburg, and there he remained until 1696, when he removed to Kassel. In 1705 G. W. Leibniz sent him a sketch of T. Savery's steam engine for raising water, and this stimulated him to further work, which resulted in his *Ars nova ad aquam ignis adminiculo efficacissime elevandam* (1707). In 1707 Papin returned to London where he died in obscurity, probably early in 1712.

Many of Papin's writings were collected by himself into a *Fasciculus dissertationum* (1695), of which he published also a translation into French, *Recueil de diverses pièces touchant quelques nouvelles machines* (1695). His correspondence with Leibniz and Huygens, along with a biography by Ernst Gerland, was published as *Leibnizens und Huygens Briefwechsel mit Papin, nebst der Biographie Papins* (1881).

See A. L. Todd, "Original High Pressure Cook," *American Mercury*, vol. 87 (Aug. 1958).

PAPINEAU, LOUIS JOSEPH (1786–1871), Canadian politician, the eloquent and fiery exponent of the rights of French Canadians in the period preceding the Rebellion of 1837, was born at Montreal on Oct. 7, 1786. The son of Joseph Papineau, a notary and member of the Legislative Assembly of Lower Canada (Quebec), he was elected to the assembly in 1808 and in 1815 became its speaker, a position which he occupied almost continuously until 1837. He came to be regarded as the leader of the French-Canadian people in their long struggle against the governors of Lower Canada and the English-dominated executive and legislative councils. Papineau inspired the Ninety-Two Resolutions, a resounding statement of French-Canadian grievances, passed by the assembly in 1834. In March 1837 the governor, Lord Gosford, was authorized to reject the demands of the assembly and to appropriate provincial revenues without the assembly's consent. In the movement of protest that followed, Papineau made inflammatory speeches, although it is doubtful whether he actually desired armed rebellion. At the commencement of hostilities at St. Denis on the night of Nov. 22–23, 1837, Papineau abandoned the *patriote* force led by Wolfred Nelson and escaped to the United States. He lived in Paris from 1839 until amnesty was granted, and he returned to Canada in 1845.

He sat in the Legislative Assembly of the Province of Canada (Upper and Lower Canada had been united in 1841, with a single legislature representing Canada West and Canada East) from 1848 to 1854 but never regained his former dominance, having been displaced by L. H. LaFontaine as leader of the French-Canadian majority. He inspired the group of young French Canadians who formed the Rouge Party, a forerunner of the Liberal Party in Quebec. He died at Montebello, Que., on Sept. 24, 1871.

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PAPINI, GIOVANNI (pseudonym GIANFALCO) (1881–1956), Italian writer and critic who helped to open Italian literature to foreign influences, was born in Florence, Jan. 9, 1881. He founded the reviews *Leonardo*, with G. Prezzolini (1903), and *Lacerba*, with A. Soffici (1913), and contributed to *La Voce*. Professedly an iconoclast, he demolished many established reputations in his books, *Crepuscolo dei filosofi* (1906) and *Stroncature* (1916). His autobiographical *Un uomo finito* (1912; Eng. trans., *A Man—Finished*, 1924), and his stories, *Il Tragico quotidiano* (1906) and *Parole e sangue* (1912), seem now uninteresting, and his poems, *Cento pagine di poesia* (1920) and *Pane e vino* (1926), mediocre, but his criticism has had lasting influence. An atheist, he was converted in 1919 and became a Roman Catholic, and his *Storia di Cristo* (1921, Eng. trans., *The Story of Christ*, 1923) achieved immense success. He died at Florence, July 7, 1956.

See G. Prezzolini, *Discorso su Giovanni Papini* (1915); A. Viviani, *Gian Falco* (1934). (F. Di.)

PAPINIAN (AEMILIUS PAPINIANUS) (*c.* A.D. 140–212), one of the last of the great Roman jurists, probably came from Emessa, Syr., and may have been a pupil of Q. Cervidius Scaevola. Having served under Marcus Aurelius, he became (203–205) *praefectus praetorio* under Lucius Septimius Severus. He was killed on the orders of Caracalla (*q.v.*) in the slaughter of supporters of Geta—according to legend, for his refusal to justify Caracalla's fratricide.

The greatest of the Severine jurists, Papinian shows appreciation of the practical needs of life and leans to the equitable solution of problems. It is indeed the lofty moral tone of his views which explains Papinian's prestige in the Christian Empire, for in creative power he does not really compare with the great earlier figures Labeo and Julian.

His principal works were collections of cases—*Quaestiones* (37 books) and *Responsa* (19 books); but he also wrote *Definitiones* and monographs *de Adulteriis* and on aspects of municipal law. His style is precise and elegant. In the postclassical law schools, Papinian's authority was definitive: third-year students were styled *Papinianistae*, his *Responsa* being the basis of their studies. The Law of Citations (A.D. 426), regulating the forensic use of juristic literature, gave special prominence to Papinian's views.

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PAPIRIUS, LUCIUS (called CURSOR, "runner"; apparently a family name, although Roman tradition made him a great runner; 4th century B.C.), Roman general, five times consul and twice dictator. In 325 B.C. he was appointed dictator to carry on the Second Samnite War. After the disaster of the Caudine Forks (*q.v.*; 321), Cursor captured Luceria, where a colony was founded. In 309, when the Samnites rose once more, Cursor was appointed dictator for the second time, and is credited by Livy with a decisive victory at Longula. His son of the same name, also a distinguished general, fought in the Third Samnite War (293) and captured Tarentum (272).

PAPPATACI FEVER (PHLEBOTOMUS FEVER, THREE-DAY FEVER, SAND-FLY FEVER) is an acute, infectious, febrile disease caused by a virus and producing temporary incapacitation. It is transmitted by the bloodsucking female sand fly, *Phlebotomus papatasii*, and is prevalent in the moist subtropical countries of the eastern hemisphere lying between latitude 20° and 45° N, particularly around the Mediterranean Sea, in the Middle East, and in parts of India. It breaks out in epidemic form during the summer season following the breeding of this species of fly, but the reservoir for the virus between epidemics is unknown. The sand fly becomes infected as a result of biting an infected person when the virus is circulating in the patient's blood; *i.e.*, from 48 hours before until 24 hours after the onset of fever. The virus then requires seven to ten days to incubate, after which the sand fly remains infected for life.

Pathogenesis and Symptomatology.—Man becomes infected from the bites of infected female sand flies. Using human adults of both sexes and different racial groups as volunteers, A. B. Sabin, C. B. Philip, and J. R. Paul (1944) obtained 95% infection following skin exposure to infected *Phlebotomus papatasii*. The virus multiplies and becomes widely disseminated throughout the body, and within two and one-half to five days after exposure there is suddenly a feeling of lassitude, abdominal distress, and dizziness,

followed within one day by a chilly sensation and a rapid rise in temperature during the next 24 to 48 hours to 102°–104.5° F (38.8°–40.3° C). As in dengue, there are severe frontal headache and postorbital pain, intense muscular and joint pains, and a flushed appearance of the face but no true rash or subsequent desquamation. During the first day of fever there is an accelerated pulse. Usually after two days the temperature slowly returns to normal; only rarely is there a second episode of fever. Following the febrile period there is great fatigue and weakness, accompanied by slow pulse and frequently subnormal blood pressure. Convalescence may require a few days or several weeks.

Prognosis is always favourable. The average case is considerably less severe than in dengue. Diagnosis is based on the clinical manifestations, the geographical area in which the disease occurs, the prevalence of *Phlebotomus papatasii*, and the epidemic development of the disease. More specifically, although there is no change in the total number of white blood corpuscles, there is an increase in the proportion of immature neutrophilic forms. Treatment is entirely symptomatic.

Prevention.—Sand flies breed in vegetation within a few hundred feet of human habitations. These breeding places are difficult to discover, hence larvicidal control is impractical. The blood-sucking females feed only from sunset to sunrise and only at ground level, so that sleeping above the ground floor provides moderately good protection. Ordinary mosquito netting and screening are useless, since unfed female flies can pass through 18-mesh squares. Insect repellents, such as dimethyl phthalate, when applied to exposed skin, will keep sand flies away for a few hours, but the use of DDT sprays on verandas, on screens, around doors and windows, and within habitations will readily kill all adult sand flies that alight on the sprayed surfaces. With this procedure an epidemic can be rapidly terminated. *See* also SAND FLY. (E. C. F.)

PAPPENHEIM, GOTTFRIED HEINRICH, GRAF ZU (1594–1632), German cavalry commander conspicuous in the first half of the Thirty Years' War (*q.v.*), was born on May 29, 1594, at Treuchtlingen, the seat of a junior branch of a family that had the hereditary right to perform the ceremonial functions of archmarshal of the Holy Roman Empire. Originally a Lutheran and destined for a diplomatic career, he studied law at the universities of Altdorf and Tübingen, but changed his profession and his religion and became a soldier. Serving with the Catholic League headed by the elector Maximilian I of Bavaria, he showed himself to be a tempestuous cavalry officer, always charging ahead of his men and frequently wounded, a refractory subordinate, ruthless and brutal even by contemporary standards, but idolized by his regiment of cuirassiers, known as the Pappenheimers, whose colonel he became in 1623. He fought in the Bohemian War of 1620 and against Ernst von Mansfeld in 1621–22. After service with the Spaniards in Lombardy and the Grisons (1623–26), he was recalled by Maximilian to quell the rising of the Upper Austrian peasants against their Catholic oppressors. This he achieved with inhuman ferocity (November 1626). In the Danish War he conquered Wolfenbüttel (1627) and expected to be enfeoffed with the duchy of Brunswick-Wolfenbüttel, but received only elevation to the rank of imperial count (1628). The storming of Magdeburg (May 20, 1631) was chiefly due to Pappenheim's undaunted courage, which he also displayed, though without success, in the first of the Battles of Breitenfeld (*q.v.*). He showed great skill in covering Tilly's retreat and in executing independent operations against the Swedes in northwestern Germany. Early in November 1632 Wallenstein sent Pappenheim, by this time an imperial field marshal, toward Westphalia and the lower Rhine, but recalled him to Saxony on the eve of the Battle of Lützen (*q.v.*). Mortally wounded almost immediately after his arrival, Pappenheim died a day later, on Nov. 17, 1632, in Leipzig. (S. H. S.)

PAPPUS OF ALEXANDRIA, Greek geometer, flourished about A.D. 320, as inferred from references to a solar eclipse in his commentary to Ptolemy's *Almagest*.

The great work of Pappus, written about A.D. 340 in eight books and entitled *Collection*, survives only in an incomplete form, the first book being lost, and the rest having suffered considerably. He also wrote commentaries on the *Analemma* of Diodorus, on Ptolemy's *Almagest*, on his *Planisphaerium* and *Harmonica*, and on Euclid's *Elements*. Citations from the commentary on the *Elements* are made by Proclus and others, while fragments of the portion relating to book x survive in the Arabic. Suidas also mentions geographical works.

The characteristics of Pappus' *Collection* are that it contains an account, systematically arranged, of the most important results obtained by his predecessors; and, secondly, notes explanatory of, or extending, previous discoveries. These discoveries form, in fact, a text upon which Pappus enlarged discursively. Very valuable are the systematic introductions to the various books, which set forth clearly in outline the contents and the general scope of the subjects to be treated. From these introductions it is clear that the style of Pappus' writing is excellent and even elegant when free from the shackles of mathematical terminology.

It can only be guessed that the lost book i was concerned with arithmetic. The whole of book ii (the existing fragment begins in the middle of the 14th proposition) related to a system of continued multiplication coupled with the expression of large numbers in terms of so-called tetrads (powers of 10,000) due to Apollonius of Perga.

Book iii, clearly introduced as beginning a new subject, contains problems in plane and solid geometry. It includes sections: (1) On the famous problem of finding two mean proportionals between two given lines, to which Hippocrates of Chios had reduced the problem of duplicating the cube. Pappus gave several solutions of this problem, including his own, and also a method of approximating continually to a solution, the significance of which he apparently failed to appreciate. (2) On the arithmetic, geometric, and harmonic means between two straight lines, and the problem of representing all three in one and the same geometrical figure. This serves as an introduction to a general theory of means, of which Pappus distinguished ten kinds with examples. (3) On a curious problem suggested by Euclid, i, 21. (4) On the inscribing of each of the five regular polyhedra in a sphere.

Of book iv the title and preface have been lost, so that its purpose has to be gathered from the book itself. At the beginning is the well-known generalization of Euclid, i, 47; then follow various theorems on the circle, leading up to the problem of the construction of a circle that circumscribes three given circles touching each other two and two. This and several other propositions on contact (*e.g.*, cases of circles touching one another and inscribed in the figure made of three semicircles; known as shoemaker's knife) form the first division of the book. Pappus turned then to a consideration of certain properties of Archimedes' spiral, the conchoid of Nicomedes, and the curve discovered by Hippias of Elis about 430 B.C., and known by the name quadratrix. Proposition 30 describes the construction of a curve of double curvature called by Pappus the helix on a sphere, a construction analogous to that of Archimedes' spiral in a plane. The area of the surface included between this curve and its base is found by the classical method of exhaustion equivalent to integration. The rest of the book treats of the trisection of any angle, and the solution of more general problems of the same kind by means of the quadratrix and spiral. In one solution of the former problem is the first recorded use of the property of a conic (a hyperbola) with reference to the focus and directrix (*see* CURVES, SPECIAL).

In book v (after an interesting preface concerning regular polygons, and containing remarks upon the hexagonal form of the cells of honeycombs) Pappus addressed himself to the comparison of the areas of different plane figures which all have the same perimeter (following Zenodorus' treatise on this subject), and of the volumes of different solid figures which all have the same superficial area; and, lastly, to a comparison of the five regular solids. Incidentally Pappus described the 13 other polyhedra bounded by equilateral and equiangular but not similar polygons, discovered by Archimedes, and found, by a method recalling that of Archimedes, the surface and volume of a sphere.

According to the preface, book vi is intended to resolve difficulties occurring in Theodosius' "Little Astronomy." It accordingly comments on the *Sphaerica* of Theodosius, the *Moving*

Sphere of Autolycus, Theodosius' book *On Days and Nights*, the treatise of Aristarchus *On the Sizes and Distances of the Sun and Moon*, and Euclid's *Optics and Phaenomena*.

The preface of book vii explains the terms analysis and synthesis, and the distinction between theorem and problem. Pappus then enumerated works of Euclid, Apollonius, Aristaeus and Eratosthenes (33 books in all) with the lemmas necessary for their elucidation. With the mention of the *Porisms* of Euclid is an account of the relation of porism to theorem and problem. In the same preface are included the famous problem of Pappus, which formed the basis for René Descartes's *Géométrie;* and the theorems which were rediscovered by and named after Paul Guldin (1577–1643), but appear to have been discovered by Pappus himself. Book vii contains also (1), under the head of the *de determinata sectione* of Apollonius, lemmas which, closely examined, are seen to be cases of the involution of six points; (2) important lemmas on the *Porisms* of Euclid (*see* PORISMS); (3) a lemma upon the *Surface-Loci* of Euclid which gives a complete proof of the focus-directrix property of the three conic sections.

Lastly, book viii treats principally of mechanics, the properties of the centre of gravity, and some mechanical powers. Interspersed are some questions of pure geometry. Proposition 14 shows how to draw an ellipse through five given points.

Through an Arabic translation, made about A.D. 915 in Baghdad, a commentary of Pappus on the theory of irrational quantities, as presented in book x of Euclid's *Elements*, has survived. The main interest of the commentary consists in the great number of remarks about the historical development of the theory of irrationals from Theaetetus to Apollonius. From a purely mathematical viewpoint it must be said that Pappus nowhere went beyond an elaborate formal classification of irrational quantities.

As is known from book vi of the *Collection* Pappus was also interested in astronomy, which indeed was considered as part of mathematics in antiquity. It is certain that Pappus wrote a large commentary on at least the first six, perhaps on all 13 books of the *Almagest*. Preserved are only the commentaries to the lunar theory in books v and vi, the first of which was published in Basel (1538), both in a modern edition by A. Rome (1931). Again, the main importance of this work lies in its occasional historical references; the main text is an extremely pedantic exposition of Ptolemy's discussion, only rarely going beyond the obvious.

Of the *Collection* of Pappus the best edition is that of F. Hultsch, *Pappi Alexandrini collectiones quae supersunt . . .* (1876–78). A French translation by P. Ver Eecke was published in 2 vol. (1933). Previously the entire *Collection* had been published only in the Latin translation (with commentary) by Commandinus (1588 *et seq.*). The commentary to Euclid x was published by G. Junge and W. Thomson, Arabic text with English translation and commentary (1930); the Greek text of the commentary to the *Almagest*, books v and vi, is given in vol. i of Rome, "Commentaires de Pappus et de Théon d'Alexandrie sur l'Almagest," *Studi e Testi*, vol. 54 (1931). The extensive introduction to the latter work also contains the determination of the date of Pappus.

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(T. L. H.; O. E. N.)

PAPUA, a name for the whole island of New Guinea, also used for British New Guinea, and known as Territory of Papua. *See* NEW GUINEA.

PAPUAN, a term used to describe: (1) persons of European descent, as distinct from native, born in the Australian territory of Papua (formerly British New Guinea, 1888–1906); (2) an ethnic grouping (according to the original use of Papuan, *see* below); (3) the languages of the island of New Guinea, except those spoken by many coastal peoples around the eastern tip from Cape Possession in the south to Collingwood bay in the north, and by some isolated coastal groups farther west along the northern coast, particularly in West (previously Netherlands) New Guinea.

The languages of these latter groups belong to the Melanesian branch of the Austronesian or Malayo-Polynesian family of languages. The several hundred Papuan languages of New Guinea, now called non-Melanesian, were thought to be unrelated to one another, though having some structural features in common. Research, however, shows that these include several quite large groups of related languages (*see* PAPUAN LANGUAGES).

Papuan (Malay *papuwah*, "frizzly" or "woolly-haired") was first applied by early navigators to the natives of New Guinea and adjacent islands. It is in this sense that the word Papuan will be used for the remainder of this discussion. A. R. Wallace (*The Malay Archipelago*, 1869) described the Papuan as having a face at once compressed and projecting, with protuberant and overhanging brows, large and prominent mouth, and a large nose, the apex of which is elongated downward, the ridge thick and the nostrils large. He saw the skin colour as varying from a dusky brown to a deep, sooty brown, but not as darkly pigmented as that of some Negroes. The legs seemed long and thin, but the striking feature was the harsh, dry, frizzly hair growing in little tufts or curls to a considerable length and forming a compact frizzled mop.

The Papuans are of medium height on the coasts, but tend to be short in the high inland regions and they are mostly longheaded; they are regarded as the basic population of New Guinea, of the islands west of it as far as Flores and Halmahera (Djailolo) and of the Melanesian chain in the north and east. The actual population picture, however, is complex. There are Australoid indications, pygmy groups and variations of average height in different regions. Further, the isolating and strikingly varied nature of the environment (*e.g.*, islands, mountain ranges, torrential rivers, lowlands, highlands) have provided conditions for the preservation of variations and mutations. Differences in average heights and in skin colour could have arisen in this way. Skin colour varies in different regions and also in any one region (from dark brown to reddish white). Blood-group analysis points to two immigrant races (but no hint of any Asian source) and also to distinct enclaves in isolated parts, *e.g.*, the existence of the Kukukuku people in the mountain region north of Kerema and westsouthwest of Lae, illustrates the complexity. Their blood pattern is unlike any other so far found in New Guinea and their language is unrelated to the highland and other languages. (*See* also AUSTRALIA, COMMONWEALTH OF: *The People;* NEW GUINEA.)

Melanesia ("black islands") was so called because early observers considered the islanders black. Differences among the Papuans have arisen through natural genetic changes and interbreeding with later groups, mainly proto-Polynesian. Some Melanesian groups occupied the coastal fringe of the eastern tip of New Guinea and mixed with the Papuans, forming the so-called shorter Papuo-Melanesian type. The latter's head is less high and not so consistently dolichocephalic as the Papuan's, the brow ridges less prominent, the forehead commonly rounded and not retreating, the nose smaller, skin colour lightish yellow to dark bronze, and hair sometimes curly to wavy.

Except in a generalized and geographical sense, the terms Papuan and Melanesian must be used very cautiously when indicating racial differences. Distinguishing roughly between these two groups, the population figures in 1962 for Papuans were 700,000 in West New Guinea and about 1,673,000 in the Australian territory. In addition, there were about 90,000 Papuo-Melanesians and Papuans from the eastern tip and adjacent islands, while the 230,000 natives of the Australian section of the Melanesian chain include many who speak non-Melanesian languages and are thought of as Papuan.

Culture and Social Organization.—The culture of the indigenous Papuans is varied and the literature on it has increased very greatly since the inauguration of planned research in the 1920s. Only very few groups are nomadic; almost all are gardeners, practising subsistence cultivation, the staple food varying according to regions: taro, sweet potato, yam, banana, or sago. Coastal peoples also rely on fishing (with nets, traps, hooks, spears, and bows and arrows). Hunting for marsupials and birds is important in many regions. Pig-breeding for food and especially for ceremonial feasts and for trade is the most significant occupation in many parts; Papuans were sometimes called "the people of the pig."

Garden land, or in some cases its usufruct only, is the property

of individual families and is inherited in the male or female line according to the region. Some trees, such as casuarina in the highlands and coconut on the coast, may be the property of individuals who do not own the land on which the trees grow. Gardening techniques vary from roughly clearing and burning a patch of forest and planting yams or other plants in holes, to the advanced system of the central highlands. There, mounds up to two feet high and from six to nine feet square or circular are dug all over and planted mainly with sweet potatoes. The paths in between serve as runways for the heavy rainwaters and thus prevent erosion, especially on the steep sides of mountains. Draining ditches are also dug and from the air the gardens look like a checkerboard. Crops are harvested twice, after which cane grass is allowed to grow. Casuarinas are then planted around the garden fence (necessary to keep out pigs) and on reaching a height of 20 ft. provide timber for fence and housebuilding. The grass is then burned and dug in, and the soil is again ready for use. In the meantime, other garden land is used.

On the coast and the rising hinterland Papuans live in hamlets and villages, often on the crests of ridges and on hilltops (a defense precaution). The village system also characterizes the eastern valleys of the central highlands, but from the Chimbu to Wabag (west of Mt. Hagen), and in the central highlands of West New Guinea all the tribes live in homestead formation. Each man has a house in his garden for his wife or wives, daughters, and small sons. He may also have a separate house for himself and his older sons in his garden or somewhere on his clan's land, or he may share a man's house with relations and friends. A rectangular-shaped park provides a meeting place where dancing and feasts are held.

Houses along the coast and on the rising hinterlands are usually built on piles whether over the water or not. Some are communal houses, up to 160 yd. long, where a whole clan, several clans, or even a whole village may live, each family having its own fireplace. There is usually a separate men's longhouse in the village (or for a group of villages), which is also a club and ritual centre. The manhandling of the immense logs used in these buildings and also in the similarly large ceremonial houses in the Sepik district, involves large-scale co-operation and organization. In the central highlands houses are not raised. The airtight low, thick walls, thatched roofs, small doors that are closed at night, and a fire in the midst provide the warmth necessary at altitudes of from 5,000 to 10,000 ft. Casuarina is the usual building material.

Social organization includes the lineage and clan systems everywhere, moiety division in some parts, and classificatory kinship as the basis of behaviour. Phratries and subclans are also present, particularly in the densely populated highlands. There is no chieftainship, but leaders are men of "big name," of personal influence and, in some tribes, of wealth.

Totemism (*q.v.*) is reported from the south coast of Papua, but not from the Australian central highlands or the rising hinterlands, and its existence in West New Guinea is doubtful. Gardening magic is fairly general, as also is sorcery. Almost everywhere boys are initiated into the men's secret cult, with the right to enter the houses in which secret symbols of spirits and ancestors are kept, and to take part in secret rites. Papuan mythology and ritual do not reveal any over-all cosmological and religious system, and differ thus from the Australian aboriginal situation.

Papuans have a well-developed aptitude for trade. In the western central highlands of Australian New Guinea an involved system of delayed exchange ends each cycle with a businesslike handing-over of goods, especially pigs, but also polished stone axes, pearl shells (traded in from the coast), and other articles. Compensation for deaths in war is made at the same time; but many articles are traded without ritual. Much ingenuity has been applied in obtaining salt (from inland saline soakages) that is traded over long distances; pottery from the region of Port Moresby is extensively traded for sago from the region of the Gulf of Papua.

Group dancing is common, but its swaying and quiet stepping lacks the vigorous ballet work of Australian aboriginal corroborees. Singing follows much the same soothing pattern, though some of the head-hunting songs are startling. Music is provided by artistic hand drums, bamboo flutes, panpipes, and jew's-harps.

Administrative and Economic Development.—Fighting and head-hunting (*q.v.*), where previously practised, were almost put down in the 1960s; disputes are settled in courts. Administration posts, mission stations, schools, hospitals and trade stores are established in almost every tribal and subtribal region. Medical, educational and agricultural officers include trained native personnel, and leading natives are appointed as administration representatives in every suitable geographical unit. Many local councils, along the lines of municipal councils, and co-operative and rural progress societies function successfully in the Australian territories. Many natives are independent cash-crop producers; *e.g.*, of coffee, passion fruit and copra. Native representatives are appointed to the legislative councils of the territories. A native Papuan was consecrated a bishop of the Church of England in 1960. From May 1963 the administration of West New Guinea (West Irian) was transferred to Indonesia. *See* also MELANESIA.

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PAPUAN LANGUAGES are the languages spoken in New Guinea and in some islands mostly in its vicinity. They show a structure markedly different from that of the Malayo-Polynesian (*i.e.,* Indonesian, Micronesian, Melanesian and Polynesian) languages and of the Australian languages spoken by the indigenous population of Australia. The term "Papuan languages" is apt to mislead, because it gives the impression of the existence of a genetically related group of languages. In reality no facts are established which point to such a relationship. The languages designated by the term "Papuan" are all widely divergent in sound system, grammatical structure, and vocabulary. Some of them have a highly developed verb system with elaborate distinctions for person and gender, others show in their noun system distinctions between singular, dual, trial, and plural, structural traits which are absent in the Austronesian languages. In many Papuan languages the object precedes the verb. But such traits are present in some languages and absent from others and therefore cannot be used for a general characterization.

In certain regions of New Guinea the diversity of language is bewildering. Neighbouring tribes seem to speak quite unrelated languages. Nevertheless, hasty conclusions must be avoided. It must be taken into account that—as is known in other parts of the world—this impression of diversity often diminishes or even disappears when language research progresses.

This does not mean, however, that no genetic relations at all between the Papuan languages have been established. In some regions in New Guinea the Papuan languages are found to be very similar in structure (*e.g.*, in the so-called western and eastern highlands); on north Halmahera it seems preferable, according to H. Van der Veen, to distinguish between different dialects rather than between different languages. H. K. J. Cowan (1957) attempted to connect the north Halmahera dialects with some of the Papuan languages of the Vogelkop peninsula to the southeast.

Scientific knowledge of the Papuan languages is generally very

slight. It has not even been possible to determine their exact number and their location, but it may be safely assumed that they number about 300. This lack of knowledge is caused in the first place by the inaccessibility of the interior of New Guinea. First contacts were not made with several tribes until after World War II. Extensive parts of the interior are completely unknown. The number of linguists who have done fieldwork in New Guinea is exceedingly small. Most of the linguistic data are collected by missionaries, and for many languages translations of parts of the Bible or other religious literature form the only sources of information. Often these are not printed, but are only available in manuscript form. Only after World War II was linguistic research somewhat intensified.

GEOGRAPHICAL DISTRIBUTION

Papuan languages are spoken: (1) in the interior of Portuguese Timor and on a few islands in its vicinity (Kisar, Alor); (2) in the northern part of Halmahera (in south Halmahera, Austronesian languages are spoken); (3) in the whole interior of New Guinea from west to east, as far as Goodenough bay and Orangerie bay, and also in many places on the coast; (4) in New Britain and New Ireland (Melanesian languages are also spoken there); (5) on some of the Solomon Islands (Bougainville and the western Solomons).

1. Timor.—On Timor and adjacent islands the following Papuan languages may be distinguished: in the interior of Timor: Makasai, Bunak, Waimaha and Kairui; on Kisar: Oirata; on Alor: no generally accepted name.

2. North Halmahera.—According to Van der Veen (1915), ten clearly related dialects are spoken on north Halmahera: Galela, Tobelo, Tobelo-Boëng, Tobelo-Dodinga, Modole, Tabaru, Sahu, Loda, Ternate, Tidore.

3. New Guinea.—In the present state of knowledge it is impossible to give a complete and reliable list of the languages spoken in New Guinea. Many languages are completely unknown. The existing surveys do not mention the same languages, and moreover the same language is often called by different names.

West (formerly Netherlands) New Guinea.—Of the 48 languages mentioned by A. Capell (1954), only the following are more or less known by short grammars and word lists or both: Ayamaru, near Lake Ayamaru in the interior of the Vogelkop peninsula; Mansibaber, on the east side of the Vogelkop peninsula; Sentani, in the north near Lake Sentani, which is near Hollandia; Marind, on the southeast coast near Merauke; Riantana; Ndom; Kimaghama (these last three being spoken on Frederik Hendrik Island); Awju, southwest of Tanahmerah and on the upper Mapi river; Kamoro, on the Mimika river; Ekari, near Lake Paniai and Lake Tigi; Moni, east of Lake Paniai.

Trust Territory of New Guinea.—In the trust territory, of the 93 languages listed by Capell (1954), only the following have become more or less known: Arapesh on the north coast west of the Sepik river; Monumba and Ngaimbon on the north coast east of the Sepik river; Garus and Nobonob, also on the north coast north of Madang; Bongu on the north coast south of Madang; Kate, near Finschhafen; Ono, in the Kalasa district.

In Papua, of the 100 languages mentioned by Capell (1954), only the following have been studied: Kiwai, spoken on Daru Island, on the coast opposite this island and on the Fly river delta; Gogodala, on the Fly river opposite Madiri; Kerewa, in the southern part of the Kikori delta; Namau or Koriki, around Maipua, Purari river delta; Orokolo, on the south coast east of Maipua; Toaripi, on the south coast near the mouth of the Lakekamu river; Fuyuge or Mafulu, near Mafulu, Wharton range, central division; Binandere in the region of the Gira and the Mambare rivers.

4. New Britain and New Ireland.—Of the six to eight Papuan languages spoken on New Britain (according to Capell: Baining, Taulil, Gaktai, Sulka, Tumuip, Idue and perhaps Bau and Maseki) only Baining is fairly well known. On New Ireland the only Papuan language is Panaras.

5. Solomons.—Of the 13 Papuan languages, 9 are spoken on Bougainville. The remaining four are spoken on Vella Lavella Island southeast of Bougainville, on Renonga, an island south of New Georgia and on a few islands northwest of Guadalcanal (Russell Islands and Savo). Of these languages Rugara and Nasioi on Bougainville and Bilua on Vella Lavella Island are fairly well known.

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(E. M. U.)

PAPYROLOGY. The care, reading and interpretation of the papyri from Egypt is the science of papyrology. Included in this study also are writings upon other materials, such as potsherds, parchments, wooden and waxed tablets and stone, whether in the classical languages or in Egyptian demotic. The paleographical and technical skills of scholars trained in this area have also been directed toward similar documents found elsewhere in the Greco-Roman world.

It was a revelation to classical scholars when, in the 19th century, Greek and occasionally Latin texts of every sort began to emerge in vast quantities from the dry sands along the Nile. Whether as individual papyrus sheets, as rolls or as booklike codices, they afforded a wealth of new information about the literature and the civilization of Greece and Rome and especially about the Egypt of Hellenistic and Roman times.

Discovery of Papyri.—*Egypt.*—The first papyrus roll to be brought to Europe was the so-called Charta Borgiana now in Naples. This account of compulsory labour upon an irrigation project in A.D. 192 was bought by a merchant in 1778; it is said that the villagers burned others when he would not buy them. In the 19th century, indifference gave way to a keen interest, as scholars realized the importance of the material. Papyri in varying states of disrepair were found by peasants in mounds at the desert's edge, sites of ancient settlements. The papyri were found in rubbish heaps, tombs and houses in those parts of Egypt where there is little or no rain and occasionally in charred condition in lower Egypt also; they were bought eagerly by dealers. Important groups of documents came from Memphis and Saqqarah, a large fragment of Homer from Aswan, and a substantial manuscript of the little-known Attic orator Hyperides from Thebes. The ancient Arsinoë (Al Fayyum, southwest of Cairo) yielded an enormous mass of papyri, partly in Arabic, which were bought by the Austrian archduke Rainer and taken to Vienna.

After the Egyptologist Sir Flinders Petrie began to find Greek papyri in his excavations at Gurob (1889–90), the systematic search for them was undertaken by the Egypt Exploration fund, and the English papyrologists B. P. Grenfell and A. S. Hunt excavated many sites. At Tebtunis (southern Al Fayyum) a cemetery of sacred crocodiles yielded wrappings made from used papyrus documents of the Hellenistic period; 13 seasons of digging at Oxyrhynchus in middle Egypt (1896–1909) brought to light thou-

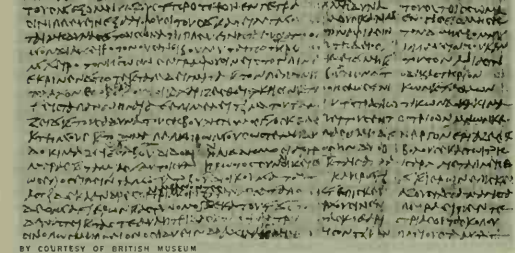
sands of texts including large numbers of previously unknown literary works. This example was followed by scholars of other nationalities, French, German, Italian and American. Excavations have been undertaken by the University of Michigan in the northern Al Fayyum and by Achile Vogliano at Tebtunis and the near-by Medinet Madi. After 1920, a Société Egyptienne was established for the purchase of papyri, and the government has taken active steps to prevent loss or damage of papyri found accidentally or in clandestine excavations.

Near East.—Finds in the near east also have been significant. A jar found by a peasant at Avroman (Kurdistan) about 1909 contained parchments of the Parthian period, three of which were preserved. All are contracts, two in Greek, one in Middle Persian (Pahlavi). At Doura-Europus on the middle Euphrates, systematic excavations between 1921 and 1936 of the French Academy and Yale university revealed 155 documents, a few literary, the rest either legal papers or records of a Roman military unit. At Hafir al-Auja (Nessana) in southern Palestine, in a desert region, the ruins of two churches excavated in 1937 by the H. D. Colt expedition recovered nearly 200 literary and nonliterary papyri of the Byzantine period. After World War II, sensational discoveries of parchments and papyri were made first by Bedouins and then by archaeologists in caves west of the Dead sea, in the Wadi Qumran and the Wadi Murabbaat. (*See* DEAD SEA SCROLLS.)

Mediterranean.—A certain number of papyri have survived from antiquity in libraries. Some of these are literary; others, like the "Ravenna papyri," are high documents of church or state. Herculaneum (Campania) has yielded charred rolls of literary papyri. A find of 45 wooden tablets, sealed in a jar, containing business documents was made by peasants in 1928 at an unknown location on the frontier between Tunisia and Algeria.

Study.—*Collections.*—The largest collection of papyri is that of the archduke Rainer in Vienna, amounting to well over 100,000 pieces, half of them in Arabic. Probably second in size is that of the Egyptian museum in Cairo, with those of the Berlin museum, the British museum and the Universities of Oxford and Michigan following in that order. Notable collections exist also in Florence and Milan in Italy, Heidelberg in Germany, Strasbourg and Paris in France, Manchester in England and at Yale, Columbia and Princeton universities in the United States. In addition, there are many smaller groups of texts in private and public collections throughout the western world.

Handling.—Papyri present special problems of cleaning and decipherment. They are normally found dirty, crumpled, stuck together, ragged and full of holes. Charred papyri present particular difficulties. Hugo Ibscher of Berlin became an expert in opening, arranging and cleaning them, and his methods are followed by scholars and museum personnel. The papyri must be humidified, separated, sorted and washed with great care, and then stored between sheets of blotting paper, glass or cellophane. Reading is done with magnifying glass and a mirror to concentrate light upon the text, and is often aided by infrared photography.

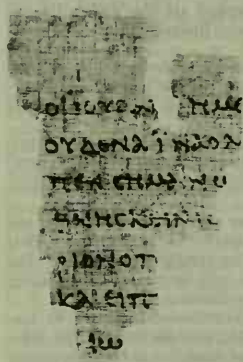


BY COURTESY OF BRITISH MUSEUM

SECTION OF PAPYRUS MANUSCRIPT OF THE "CONSTITUTION OF ATHENS," FOUND AT ASYUT, IN EGYPT; 2ND CENTURY A.D.

Publication.—There is a generally uniform method of publication of papyri which greatly facilitates research. The pattern, as first established by Grenfell and Hunt, consists of: (1) description of a papyrus, its date and hand and general interest and importance; (2) text and translation; (3) commentary. Publications of papyri are designated by the name of the collection (place of finding, the editor or other distinguishing feature) and accepted abbreviations are standard. Well in excess of 30,000 documents of all sorts have been published, less than 20% of those known to exist.

Literary Texts.—More than 2,500 manuscripts of Greek and Roman literary works, principally papyri, are on record. These vary from tiny scraps to large rolls or codices and range in date from the 4th century B.C. to the 8th century A.D. Somewhat more than half belong to texts known previously through medieval manuscripts; their importance consists in the light they throw upon the history of these texts and upon the literacy of Greco-Roman Egypt. Homer's *Iliad* is much the commonest, with the *Odyssey* second. Demosthenes, Euripides, Hesiod, Isocrates, Plato, Thucydides, Aeschylus and Xenophon follow in that order, with many known Greek authors represented by at least one papyrus. In general, Egypt read the authors whose survival through the middle ages was due, in the main, to their ancient popularity. The papyrus texts of these works, however, have proved discouraging to modern criticism, since they show that medieval manuscripts do not represent a single ancient tradition.



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FRAGMENT OF PAPYRUS MANUSCRIPT OF THE GOSPEL OF JOHN, THE EARLIEST OF ALL NEW TESTAMENT FRAGMENTS; ABOUT A.D. 125

About 45% of the literary papyri remain unidentified and are classed only as epic, comedy, history or the like. Others belong to authors or to works which did not survive the middle ages, and their discovery has been sensational. Perhaps the most important single find was that of the *Constitution of Athens* by Aristotle, acquired in 1890 by the British museum through the agency of John Alexander, an American missionary teacher in Asyut, a discovery of first importance to Athenian constitutional history. Of less but still great importance was the discovery about the same time of extensive remains of four orations of Hyperides. In history, the most important find was that of the *Hellenica* (at Oxyrhynchus) by an unknown historian of the 4th century B.C., describing events of the beginning of that century; the most tantalizing is the fragment of a history of his own reign by King Ptolemy III Euergetes. In philosophy, there are a treatise of Epicurus *On Exile* and a number of tracts by the Epicurean writer Philodemus (from Herculaneum). Drama is represented by many extensive fragments of previously unknown plays by the great masters, including a satyr play, *Ichneutai,* by Sophocles; there are several incomplete plays of Menander and one practically complete, *Dyscolus;* numerous finds of poetic texts, Archilochus, Alcman, Sappho, Alcaeus, Hipponax, Bacchylides, Pindar, Corinna, Timotheus, Herodas and Callimachus are only the most notable of those poets who have become known, or better known, through papyri.

Latin papyri are in general much rarer than Greek, so Latin literature has benefited less in this way. Among a number of manuscripts of known authors special interest attaches to a text of Virgil from Nessana with a word-by-word translation into Greek; this is of the 6th century A.D.

Popular Literature, Science and Magic.—There is also a large number of semiliterary texts, ranging from the collection of

his own poems by the 6th-century amateur Dioscorus to crudely written religious talismans and magical spells. Also noteworthy are works of literary criticisms, grammars and commentaries on classical writers, and the *Acts of the Pagan Martyrs*, accounts of trials of notables of Alexandria before various Roman emperors, as well as a complete school book (3rd century B.C.). In science, medicine is best represented, but manuscripts dealing with chemistry, mathematics, astronomy, botany, zoology and even cooking are not uncommon.

Biblical Manuscripts.—Papyrology has contributed remarkably to knowledge of the Bible. Finds both in Egypt and at the Wadi Qumran provide evidence for the Hebrew Old Testament and of its translation into Greek, back to the 2nd century B.C., before the establishment of the Masoretic text; and they support in some degree the theory that the standard Greek translation, the Septuagint, was only one of several such translations in existence at that time. A fragment of the Gospel of John belongs to about A.D. 125 and shows that that work was composed at least as early as the end of the 1st century A.D. Seven biblical papyri belong certainly to the next century, and nearly 20 more to the 3rd. There are 66 such manuscripts known from Egypt, and the Dead sea documents have added many more.

Judaism and Christianity.—The caves of the Wadi Qumran have supplied numerous sacred writings of an Essene community of Jews of about A.D. 70, and the caves of the Wadi Murabbaat have yielded texts of a more orthodox sort from the time of the Bar-Cochba rebellion 65 years later. These manuscripts are preserved and studied in Jerusalem in the Palestine museum and the Hebrew university. Egyptian papyri have brought to light many Greek texts of the early Church together with Coptic manuscripts of Gnosticism and Manichaeism. Notable are two fragments of the *Sayings of Jesus* from Oxyrhynchus in a papyrus of the 2nd or 3rd century, which may go back to a tradition prior to the four canonical Gospels. Several apocryphal gospels have appeared, including one of unknown name dating about A.D. 150 which is an abbreviated synopsis of the four. A Greek fragment of Tatian's *Diatessaron* was found at Doura. In the patristic field, two major works of Origen, part of the *Against Celsus* and a new text, *Conversations with Heracleides*, were found in 1941 in the Tura caves near Cairo. Information about the great persecution under the emperor Decius, about A.D. 250, is given by the nearly 50 certificates of pagan sacrifice found in Al Fayyum and at Oxyrhynchus; apparently inhabitants of Egypt, in one case even a priestess of the crocodile god Petesuchos, were required to sacrifice so as to prove that they were not Christians.

Nonliterary Texts.—These texts include a great variety of documents. From Egypt there are papyri and ostraca (shards); from Nessana, papyri; from Avroman and Doura, parchments and papyri; from Pompeii and Tunisia, waxed and wooden tablets. The contents are short texts, tax receipts, accounts, letters and contracts. Parchments and papyri, whether as single sheets or as rolls, were adapted to every sort of writing, public or private. Laws, decrees, official correspondence, records and returns, contracts, accounts, memoranda and private letters including such specialized types as questions to an oracle or invitations to dinner are all represented. They provide the historian with an inexhaustible source of material, the most valuable of which comes in the form of great archives reflecting the activity of an individual: Zenon of Caunus at Philadelphia in Al Fayyum in the 3rd century B.C.; the Macedonian Ptolemaeus, a recluse in the Serapeum at Memphis in the 2nd century, B.C.; and Aurelius Isidorus at Karanis in Al Fayyum in the time of Diocletian and Constantine. Smaller archives exist, often scattered widely, and many isolated papyri.

History.—These texts tend to reflect history rather than to record it, but they supplement and amplify knowledge in many ways. Little would be known of the internal history of Egypt under the Macedonians and Romans, of Doura under the Parthians and Romans, and of Nessana under the Byzantines and Arabs without them, and it is certain that the history of the Bar-Cochba rebellion must be rewritten in the light of the texts from the Wadi Murabbaat. The most specific contribution of the texts is in the field of chronology. A Doura parchment, for example, shows that the Parthians did not occupy that city until after 116 B.C., and the Karanis papyri show that the usurper Domitius Domitianus was recognized as emperor in Egypt between Aug. and Nov., A.D. 296. Two papyri of the Zeno archive from the winter and spring of 253–252 B.C. report the journey of the princess Berenice to Syria to marry King Antiochus II, ending the Second Syrian War. More importantly, the texts throw light on the careers and personalities of such prominent persons as Tiberius Julius Alexander, Philo's nephew, governor of Egypt and a supporter of the future emperor Vespasian. Two edicts of Germanicus and a letter of Claudius to Alexandria are important additions to historical knowledge. Late papyri give welcome information on the policies of Egypt's rulers after the Arab conquest.

Political Institutions.—The papyri have given a vivid and detailed picture of the administration of Egypt under the Macedonians, Romans and early Arab caliphs; the emphasis at all periods remains the same: finance. Already under the pharaohs, Egypt was famed as the land of a highly organized central bureaucracy managing a society divided into strict castes; and Ptolemaic kings, Roman emperors and Muslim conquerors continued the system with few changes. The economy was based on registry and control of labour and a detailed land survey. Each year the sowing was performed after the inundation according to a vast plan originated in the villages, consolidated in the provinces and approved in the capital, Alexandria. The operation was closely supervised by special officials, who, as their instructions went, were to see that the plan was meticulously followed, but at the same time abuses were to be checked and everyone kept in good humour. A decree of Ptolemy II protected the native population of Palestine from private exploitation and required the registration of cattle. The great revenue laws papyrus of the same king lays down in minute

BY COURTESY OF THE BROOKLYN MUSEUM

FIFTH-CENTURY-B.C. ARAMAIC PAPYRUS FROM THE JEWISH COLONY AT ELEPHANTINE, IN EGYPT, BEING OPENED AT THE BROOKLYN MUSEUM

detail the operation of industry under a government monopoly and another law protected the Nile transport system from piracy and malfeasance. Dikes and canals were maintained by compulsory labour. Periodic royal indulgences promised better conditions for the taxpayers. Nevertheless, taxes were piled upon taxes, especially under the Romans, who added a census, a poll tax and a central land registry. Service in the army and police was a hereditary obligation, and only the few cities enjoyed some administrative autonomy. In the later empire, new cities were created and required to assume responsibility for imperial taxation, a crushing burden on the propertied classes.

Law.—Administrative law in Ptolemaic Egypt is well known from the type of documents mentioned in the preceding section, but the civil and criminal codes in the Hellenistic world can be recovered only from the practice appearing in the documents. Royal courts existed in Egypt and at Doura, deciding private suits and complaints according to instructions issued by the king. In Egypt, at least, access to these courts was through a petition addressed to the king, but handled at the level of the provincial governor. The law of contracts, on the other hand, was based on customary usage depending in part on the status of the contracting parties. Greeks and Egyptians remained separate, at least in theory, and the practices of the former were affected by the city to which they belonged, in Egypt or perhaps elsewhere. Status, that is, was personal. Procedures were adopted, nevertheless, to make possible desired commercial relationships, and something like general legal practice was worked out so that contracts would be valid everywhere. These contracts testify to a wide variety of transactions: sale and mortgage, rent and lease, loan and deposit, service and apprenticeship, as well as the personal relationships, marriage, divorce, testamentary disposition and adoption. Considerable interaction occurred between Greek and oriental practices. With the Roman conquest, this Hellenistic *jus gentium* encountered an already highly developed Roman *jus civile*, and under the Roman administration there were legal documents of the first importance, a gnomon or manual of the administrator of the privy purse, extracts from the civil law of Alexandria, decisions of the emperor Lucius Septimius Severus and a fragmentary text of the decree of Caracalla extending citizenship to all the inhabitants of the empire (A.D. 212). Fragments of Gaius and Ulpian show that the Roman jurists were studied in Egypt. Jurisdiction was under the provincial governor who presumably issued a provincial edict for the guidance of all concerned. Local issues were settled by delegation to civil and military officials.

Culture.—In Egypt and, in a small way, at Doura, the documents throw light on Hellenistic demographic and cultural phenomena, the spread of culture into the near east, following the conquests of Alexander the Great. They reveal who were the Greeks migrating into the new areas, where they settled and their way of life, their relations with the natives; and in reverse, how life in the orient was affected by the newcomers. There is no doubt that, following Alexander's lead, many Iranians, Babylonians, Aramaeans and Egyptians continued to play a large part in government, business and society, while learning Greek and Greek ways. A letter of the Zeno archive preserves the complaint of a Semite who charges discrimination "because I cannot pass as a Greek." On the other hand, many Greeks married native women and generations of mixed blood followed the pioneers. This process can be traced through personal names. The immigrants worshiped native deities, sometimes calling them by Greek names, but were not readily admitted into the local priesthood. All worshiped the official gods as well as the kings of the ruling dynasties, a practice continued in the deification of the Roman emperors. The blend of Greek rationalism and oriental mysticism produced the great world religions of the empire: Mithraism, the worship of Isis and Osiris and Christianity. A similar blend appears in economic life also, although the social pattern, including such things as the family, entertainment, clubs, education, dress and food, remains largely Greek. Trade and commerce, banking and finance, may be followed in detail. Prices are preserved frequently enough to make possible some economic statistics.

Language.—The documents provide an immense fund of material for tracing the development of popular Greek over 1,000 years. The same is true to a lesser extent of Latin and the Oriental languages. In general, wide literacy, based upon a system of public and private schools, is attested by the numerous finds of literary papyri, especially at Oxyrhynchus, and this served as a brake upon the tendency of the spoken language to change too rapidly, especially in a multilingual society. The process which transformed ancient Greek into modern Greek was well under way in this period. Some personal letters of the later Roman period, for example, are hardly intelligible in terms of classical Greek. This Hellenistic Greek has been profitably used in the interpretation of the New Testament.

In the field of paleography (*q.v.*), the papyri illustrate the development and history of both cursive writing and book hand, as well as a system of punctuation. Accents appeared in manuscripts of Greek authors, occasionally as early as the 2nd century A.D. The codex or book appeared as a successor to the roll at about the same time, and was used at first only for Christian texts. Parchment was used for books (originally made up of papyrus quires) in late antiquity and became the normal material for such purposes in the middle ages.

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PAPYRUS, the paper reed, *Cyperus papyrus*, in ancient times cultivated in the delta of the Nile in Egypt, where it was used for various purposes, and especially as a writing material. *Cyperus* is a member of the sedge family (Cyperaceae), to which the bulrushes also belong. (For botany of the plant, *see* CYPERACEAE.) *Cyperus papyrus* is now extinct in Lower Egypt but is found in the upper Nile regions and in Ethiopia, as well as in Syria and in scattered places in southern Europe.

The first accurate description of the plant is given by the Greek philosopher-naturalist Theophrastus, who stated that it grew in shallows of two cubits (about three feet) or less, its main root being of the thickness of a man's wrist and ten cubits in length. From this root, which lies horizontally, smaller roots push down into the mud, and the stem of the plant springs up to the height of four cubits, being triangular and tapering in form.

Theophrastus also enumerated the various uses to which the papyrus plant was applied. Of the flower head nothing could be made but garlands for the shrines of the gods, but the wood of the root was employed in the manufacture of different utensils as well as for fuel. Of the stem of the plant were made boats, sails, mats, cloth, cords, and, above all, paper. Its pith was a common article of food, being eaten both cooked and in its natural state. Herodotus, too, noticed its consumption as food, and incidentally mentioned that it provided the material of which the priests' sandals were made. He likewise referred to its use as tow for calking the seams of ships. That the plant was itself used also as the principal material in the construction of light skiffs is shown by sculptures of the 4th dynasty, which shows men building a boat with stems cut from a nearby papyrus plantation. Isa. 18: 2 refers to "vessels of papyrus upon the waters."

JOHN H. GERARD

PAPYRUS, OR PAPER REED (CYPERUS PAPYRUS)

The widespread use throughout the ancient world of the writing material manufactured from the papyrus plant is attested by early writers and by documents and sculptures. Papyrus rolls are represented in ancient Egyptian wall paintings, and many examples of the rolls themselves are extant. Papyri have often been found in tombs in Egypt, in the hands or swathed with the bodies of mummies. The ritual of the dead is most frequently the subject. Besides the ritual and religious rolls, there are also ancient civil and literary documents, as well as papyri relating to sales of property, etc. Coptic papyri mainly contain biblical or religious texts or monastic deeds. Papyrus was also known to the Assyrians, who called it "the reed of Egypt." That the Greeks also used papyrus early in their history is proved by the reference of Herodotus to its introduction among the Ionian Greeks, who called it "skins," the material to which they had already been accustomed. In Athens it was doubtless in use for literary as well as for other purposes as early as the 5th century B.C.

Papyrus also made its way into Italy, but at how early a period is not known. It may be presumed, however, that from the very first it was employed as the vehicle for Roman literature. During the period of the empire, the use of papyrus must have been extensive, for it was not only required for the production of books but also was universally employed for domestic purposes, correspondence, and legal documents. So indispensable did it become that Pliny the Elder reports that in the reign of Tiberius, because of the scarcity and dearness of the material caused by a failure of the papyrus crop, there was a danger of the ordinary business of life being disrupted.

Manufacturing Methods.—The account given by Pliny (*Natural History*, xiii, 11–13) of the manufacture of paper from the papyrus plant should be taken strictly to refer to the process followed in his own time; but, with some differences in details, the same general method of treatment had doubtlessly been practised from time immemorial. His text, however, is so confused, both from obscurity of style and from corruptions in the manuscripts, that there is much difference of opinion as to the meaning of many words and phrases employed in his narrative, and to their application in particular points of detail.

In one important particular, however, affecting the primary construction of the material, there can be no doubt. The stem was cut into longitudinal strips, those from the centre of the plant being the broadest and most valuable. The strips were laid side by side to the required width, thus forming a layer across which another layer of shorter strips was laid at right angles. The two layers thus "woven" formed a sheet, which was then soaked in water of the Nile. The mention of a particular water has caused trouble to the commentators. Some have supposed that certain chemical properties of Nile water acted as a glue or cement to cause the two layers to adhere; others, with more reason, that glutinous matter contained in the material itself was dissolved by the action of water, whether from the Nile or any other source; and still others read in Pliny's words an implication that a paste was actually used.

The sheet was finally hammered and dried in the sun. Any roughness was leveled by polishing with ivory or a smooth shell. But the material was also subject to other defects, such as moisture lurking between the layers, which might be detected by strokes of the mallet; spots or stains; and spongy strips, in which the ink would run and spoil the sheet. When such faults occurred, the papyrus had to be remade.

To form a roll the several sheets were joined together with paste (glue being too hard), not more than 20 sheets to a roll. (There are, however, still extant rolls consisting of more than the prescribed number of sheets; perhaps the number was not constant in all times.) The roll (*scapus*) seems to have been a standard length of papyrus, as sold by the stationers. The best sheet formed the first or outside sheet of the roll, and the others were joined on in order of quality, so that the worst sheets were in the centre of the roll. This arrangement was adopted, not for the purpose of fraudulently selling bad material under cover of the better exterior, but in order that the outside of the roll should be composed of that which would best stand wear and tear. Besides, in case of the entire roll not being filled with the text, the unused and inferior sheets at the end could be better spared, and so might be cut off.

Writing Material.—Eight different kinds of papyrus writing

material and their dimensions are also described by Pliny. The best quality, formed from the middle, and broadest, strips of the plant, was originally named *charta hieratica*, but afterward, in flattery of the emperor Augustus, it was called, after him, *charta Augusta*. The grades descended in quality and size to the *charta emporetica*, the common packing paper. A ninth grade was added in the reign of Claudius.

The first sheet of a roll was named *protokollon*, the last *eschatokollion*. Under the Romans, the former bore the name of the maker with the date and place of manufacture. It was the practice to cut away the portion thus marked, but in case of legal documents this mutilation was forbidden by the laws of Justinian. On the Arab conquest of Egypt in the 7th century, the manufacture was continued, and the protocols were marked at first, as it appears, with inscriptions in both Greek and Arabic, later in Arabic only. (The study and interpretation of documents of papyri are treated in PAPYROLOGY.)

Later Cultivation and Use.—Papyrus was cultivated and manufactured for writing material by the Arabs in Egypt down to the time when the growing manufacture of paper from plant fibres in the 8th and 9th centuries rendered papyrus unnecessary. (*See* PAPER MANUFACTURE.) It is not probable that papyrus was ever manufactured from the native plant anywhere but in Egypt. At Rome there was certainly some kind of industry in papyrus, but it seems probable that this was confined to the remaking of material imported into Italy. This second manufacture is thought to have been detrimental to the papyrus, as it would then have been in a dried condition requiring artificial aids, such as a more liberal use of gum or paste, in the process.

As to cultivation of the plant in Europe, according to the Greek historian Strabo, the Romans obtained the papyrus plant from Lake Trasimeno and other lakes of Etruria, but this statement is unsupported by any other ancient authority. At a later period, however, a type of papyrus was cultivated in Sicily, which has been identified with the Syrian variety (*Cyperus syriacus*), far exceeding in height the Egyptian plant and having a more drooping head. It grew in the east and south of the island, where it was introduced during the Arab occupation. It was seen in the 10th century by the Arab traveler Ibn Haukal in the neighbourhood of Palermo, where it throve luxuriantly in the pools of the Papireto, a stream to which it lent its name. From it, writing material was made for the sultan's use. But in the 13th century the local sources of papyrus began to fail, and in 1591 the drying up of the Papireto caused the extinction of the plant in that district. The plant is still to be seen at Syracuse, but it was probably introduced there at a later time and raised only as a curiosity, as there is no notice of it to be found previous to 1674.

Even after the introduction of vellum (*see* PARCHMENT) as the ordinary vehicle for literature, papyrus still continued to some extent in use outside Egypt, and was not entirely superseded until a late date. It ceased, however, to be used for books sooner than for documents. In the 5th century, St. Augustine apologized for sending a letter written on vellum instead of the more usual substance, papyrus. Of medieval literary Greek papyri, very few relics have survived, but documents of the 8th and 9th centuries have been discovered in Egypt. Medieval Latin manuscripts on papyrus in book form are still extant. The employment of the material in Italy for legal purposes is illustrated by the large number of documents in Latin, preserved at Ravenna, that date from the 5th to the 10th century. In the papal chancery it was used at an early date, and as late as the 10th century papyrus was still preferred, to the exclusion of other materials, for papal deeds. Of the Merovingian period, there are still extant several 7th-century papyrus deeds; under Charlemagne and his successors it was not used, and by the 12th century the manufacture of papyrus had ceased entirely.

See also references under "Papyrus" in the Index.

(E. M. T.; X.)

PARÁ, a northern state of Brazil, bounded on the north by British Guiana, Surinam, and the territory of Amapá, on the east by the Atlantic Ocean and the states of Maranhão and Goiás, on the south by Mato Grosso, and on the west by Amazonas. Area, 474,896 sq.mi. (12,480,422 sq.km.); pop. (1960) 1,550,935. The chief city and capital is Belém, pop. (1960) 359,988; other important towns include Santarém, Óbidos and Bragança.

The state of Pará lies along the Equator and is crossed by the main channel of the Amazon River. The climate is equatorial: contrary to popular impression, the temperatures are never so high as in central United States—a temperature of 100° has never been recorded. The average is about 78°, with a range between coldest and warmest months of about 4°. Rainfall and humidity are high. The year is divided into a very rainy season from January to June and a season of less rain for the rest of the year. Wherever there is exposure to the easterly winds the humidity is compensated for and the climate is quite comfortable. Except for a few patches of savanna, most of the state is covered with a tropical rain forest, or selva.

An enormous amount of water pours into the ocean through the state of Pará. The Amazon itself winds about on its floodplain, leaving a maze of abandoned channels in the form of oxbow lakes and an intricate crescentic pattern of levees and swamps, much like the lower Mississippi. At Óbidos the floodplain is scarcely a mile in width, but it opens out again downstream. The margins of the floodplain are marked by valley bluffs—steep slopes which rise abruptly about 150 to 200 ft. (30 to 61 m.) above the river. The floodplain—which is somewhat less than 10% of the total area of Pará—is inundated each year during high-water stages but the country above the valley bluffs is never flooded. The chief towns are located on the bluffs at places where the main channel of the river swings against the margin of the floodplain. The Amazon receives the water of several great tributaries. From west to east on the southern side are the Tapajóz, the Xingú, and the Tocantins. No large tributaries reach the Amazon on the northern side within Pará. At the mouth of the Amazon is Marajó Island (*q.v.*). It is 183 mi. (295 km.) long by 124 mi. (200 km.) wide, with an area of 15,444 sq.mi. (40,000 sq.km.). The northwestern part of the island is a part of the floodplain; but in the east and south the island is made up of higher ground. The Tocantins provides most of the water in the Pará River, on the southern side of Marajó Island, while the main stream of the Amazon passes to the north. The Pará River and the Amazon are connected by a network of side channels. Lying across the mouth of the main stream, north of Marajó Island, are two smaller islands which, like eastern Marajó, stand above the floods. They extend in a southeast to northwest direction: Caviana is 48 mi. (77 km.) long and Mexiana is 34 mi. (55 km.) long.

The soils of much of Pará are not fertile. The alluvial material on the floodplain could yield abundant crops, especially rice, but the settlers along the Amazon have never made much use of it. Beyond the valley bluffs where the land is never flooded and where mud and silt are never deposited, the soil has for a long time been exposed to the action of percolating rain water. Water sinking into the soil carries the finer soil particles down far beyond the reach of shallow-rooted crops; it also dissolves and carries away the more easily soluble of the minerals. The result is a sandy soil made up largely of iron and aluminum compounds in which crops do poorly. Trees, with deeper roots, can grow luxuriantly in the moist climate; but agriculture without modern fertilizing techniques has never been successful. The native Indians used a small clearing only for a year or so before shifting to a new clearing; much of their food supply came from the river itself—from fish, turtles, and turtle eggs.

The Amazon region was never very attractive to the Portuguese settlers. Belém was founded in 1615, chiefly to keep other European nations from settling there. Jesuit missions were the first settlements upstream, as at Santarém in 1661. In the 1870s a colony of people from the southern United States, together with slaves they brought with them, settled near Santarém and tried to plant cotton and sugarcane. The colony was never successful. Between 1850 and 1910 there was a period of feverish activity as workers went out into the forests to tap the rubber trees. Rubber in large quantities was shipped out through Belém and the city grew rapidly in size and importance. Production dropped rapidly after 1910. Even the Ford plantations on the Tapajóz, although

technically successful, failed to produce enough rubber for the needs of the Ford industries.

The chief exports of Pará are gathered from the forest. They include Brazil nuts, medicinal plants, insecticides, and some rubber. Between Belém and Bragança there is a small farming area, producing cotton, cacao, manioc, sugarcane, rice, tobacco, and maize. New Japanese colonists along the Amazon are growing jute in increasing quantities. The savannas of Marajó Island are used for the pasture of cattle. (P. E. J.)

PARÁ CITY: *see* BELÉM.

PARABLE, a form of illustration (Greek *para-bole*, a juxtaposition for comparison) in all folk literature, especially Semitic. The Old Testament and the Talmud abound in parables, but the Christian west well-nigh restricts the term to those of Jesus. A parable pure in form offers a single point of comparison between an abstract declaration or demand and a vivid story or situation. Thus (the value of) the Kingdom of God is like (the value of) the one precious pearl for which a merchant sacrificed all he had (Matt. 13:45–46).

A true parable is self-explanatory. But the author of the Gospel of Mark, reflecting one facet of early Christian opinion, regarded (some, not all?) parables as mysteries requiring detailed explanation (Mark 4:10–12; the *mashal* of the Old Testament was sometimes a riddle). Consequently he allegorized the Parable of the Sower, which originally taught: be no more perturbed at the varying receptivity of men than the sower is at that of soil. Considering it an allegory, he made it yield a whole series of parallels to details in the story. This tendency recurs in Matt. 13:36–43 as compared with 13:24–30, though here "the enemy" is perhaps an allegorical element in the story itself. (KE. G.)

PARABOLA, in geometry, is a conic section (*q.v.*). This curve may be obtained as the intersection of a circular cone, right or oblique, with a plane which is parallel to one element of that cone (*see* fig. 1).

This curve, however, may be defined directly as a plane curve, without the help of space considerations, as follows: a parabola is the path of a point which moves in the plane so as to remain equidistant from a fixed point F (the focus) and a fixed line *d* (directrix) (*see* fig. 2).

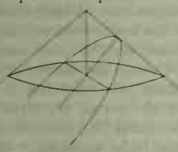

FIG. 1.—CIRCULAR CONE PARABOLA

Let D denote the foot of the perpendicular from the focus F upon the directrix *d*. The midpoint O of the segment FD = *p* lies on the parabola, for O satisfies the above definition; the point is called the vertex of the parabola. The perpendicular to DF at the vertex O is the tangent at O to the parabola.

If on the indefinite line DF a point E is taken on the same side of O as the focus F, the perpendicular to DF at E contains two points of the parabola which may be located as the points of intersection M, M′ of that line with the circle having F for centre and ED for radius.

The two points M, M′ are symmetrical with respect to line DF, and therefore this line is said to be the axis of symmetry, or, briefly, the axis of the parabola.

The perpendicular to the axis DOF of parabola at the focus F meets the parabola in two points P, P′ such that FP = FP′ = FD. The segment PP′ is said to be the *latus rectum* of the parabola.

As the point E moves farther and farther away on the axis in the direction DOF, the segment MM′ increases in length indefinitely. Hence the parabola is an open curve of infinite extent. No point of the parabola lies on that side of the tangent to the parabola at O which contains the directrix.

If vertex O is taken as the origin of a rectangular system of coordinates, and DF as the *x*-axis, the tangent to the curve at vertex O will be the *y*-axis; the equation of the curve will be $y^2 = 2px$, where $2p$ = DF is said to be the parameter of the curve.

Indeed, co-ordinates of points F, D are respectively $(p/2, 0)$, $(-p/2, 0)$, and if co-ordinates of point M are (x, y), then QM = DE = $p/2 + x$, $FM^2 = ME^2 + FE^2 = y^2 + (x - p/2)^2$. Now QM = FM, by definition, hence $(p/2 + x)^2 = y^2 + (x - p/2)^2$, which, after simplification, gives the stated result.

The properties of the parabola obtained by construction may readily be verified using this equation.

Books dealing with conic sections contain many properties of the parabola. Some examples are:

1. The two tangents drawn to a parabola from a point on its directrix are perpendicular to each other; the line joining their points of contact passes through the focus.

2. The normal *n* at a point M of the parabola bisects the angle formed by the focal radius FM of M and the parallel through M to the axis of the curve (*see* fig. 2).

The latter proposition has an interesting and important optical interpretation, as follows: if a ray of light FM emanates from a source placed at the focus F of a parabola, its reflection in the curve at the point M travels in the direction parallel to the axis of the parabola.

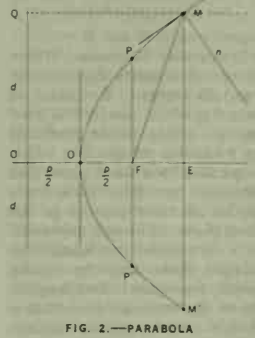

FIG. 2.—PARABOLA

This property is one of the many practical applications of the parabola (*see* PARABOLOID). The cables of suspension bridges take on a parabolic shape. A cannon ball or a ball thrown by hand would have for its trajectory an arc of a parabola except for air resistance. The graph of a quadratic polynomial, $y = ax^2 + bx + c$, is a parabola.

The path of a point moving in the plane so that the ratio of its distance to a fixed point F (focus) and a fixed line *d* (directrix) has a fixed value *e* is either an ellipse (*q.v.*) or a hyperbola (*q.v.*) according as the value of *e* is smaller than unity or exceeds unity. In the case of the parabola the two distances involved are equal to each other, hence their ratio *e* is exactly equal to unity. Thus is focus F and directrix *d* are kept fixed and *e* is given a number of different values, it yields a series of ellipses as long as those values of *e* are smaller than unity and a series of hyperbolas for the values of *e* greater than unity. The parabola thus becomes the curve of transition, or the connecting link between the two sets, with *e* = 1.

The focus-directrix definition for all three varieties of conics was known to the ancients. It is to be found in the mathematical *Collection* of Pappus (*c.* A.D. 340) and is quite likely due to Euclid (*c.* 300 B.C.).

In the light of this definition the parabola may be said to be an elongated ellipse whose second focus, second vertex and centre all coincide with the point at infinity of the axis of the parabola. Many properties of the parabola may then be derived from those of the ellipse.

Thus the reflective property of the parabola mentioned before is a modification of a property of the ellipse, namely, a ray of light emanating from a source placed at a focus of an ellipse is reflected by the curve in such a manner that the reflected ray passes through the second focus. On the other hand the parabola may be said to touch the line at infinity at the infinite point of its axis. The parabola is thus a special case of the hyperbola whose two points of intersection with the line at infinity are distinct. *See* also CURVES, SPECIAL; and references under "Parabola" in the Index. (N. A. CT.)

PARABOLOID, in geometry, is a quadric surface having no centre of symmetry (*see* SURFACE).

Consider two perpendicular planes in which are located two parabolas A,B having a common vertex and a common axis *d*.

1. The two parabolas A,B open in the same direction (*see* fig. 1). If a variable ellipse E whose plane is perpendicular to the axis *d* moves so that the ends of its major and minor axes lie on A and B, respectively, the surface generated by E is an elliptic paraboloid. The planes of A and B are planes of symmetry; the

common vertex and common axis d are the vertex and the axis of the elliptic paraboloid.

If A and B are congruent, ellipse E becomes a circle and the paraboloid is a paraboloid of revolution; *i.e.*, one that may be generated by revolving either of the parabolas A,B about its axis. The focus of the revolving parabola is the focus of the paraboloid, which serves to make parabolic mirrors, used in headlights. Because of the reflective property of the parabola (*q.v.*), such a mirror reflects the rays of light emanating from a source placed at its focus into rays parallel to the axis of the mirror.

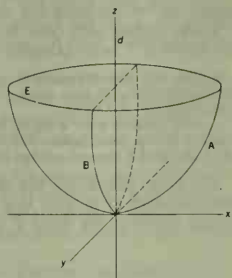

FIG. 1.—ELLIPTIC PARABOLOID

The canonical equation of the elliptic paraboloid is $x^2/a + y^2/b = z$; for the paraboloid of revolution it is $a = b$.

2. The two parabolas A,B open in opposite directions. If one of the parabolas, say A, remains fixed and B moves rigidly while its plane remains parallel to itself and the vertex of B remains on A, the surface generated by B is a hyperbolic paraboloid (*see* fig. 2). It may also be generated by a variable straight line which is parallel to a fixed plane and intersects two fixed skew lines, neither of them parallel to the fixed plane. Through any point of a hyperbolic paraboloid two straight lines may be drawn which, throughout their lengths, lie on the surface. It is thus a doubly ruled quadric surface with the equation $x^2/a - y^2/b = z$, with $ab > 0$. If $a = b$ the hyperbolic paraboloid is said to be equilateral, with an equation that may also be put in the form: $2xy = a^2z$. (N. A. Ct.)

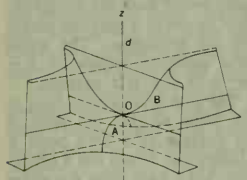

FIG. 2.—HYPERBOLIC PARABOLOID

PARACELSUS (Theophrastus Bombastus von Hohenheim) (*c.* 1490–1541), physician and alchemist, who established the role of chemistry in medicine, was born near Einsiedeln in the canton Schwyz in Switzerland. The epithet Paracelsus was probably his own invention and was meant to denote his superiority to Celsus. Paracelsus studied at the University of Basel and then with J. Trithemius, abbot of Sponheim, but he soon departed to the mines in Tirol where he became absorbed in the mechanical difficulties of mining, in the nature of minerals, and in the diseases of miners.

On his return to Basel in 1526, Paracelsus lectured on medicine at the university. The lectures, in German rather than Latin, were preceded by a solemn burning of the works of Galen and Avicenna; they discredited past and contemporary medicine and set forth the lecturer's own theories and methods of treating disease. His opponents pointed out that he possessed no degree and that there were serious defects in his system. The controversy came to a crisis through a dispute about fees and in 1529 Paracelsus resumed his wanderings. In 1541 Archbishop Ernst invited him to settle at Salzburg under his protection, and there he died on Sept. 24. The cause of his death is uncertain; his enemies asserted that he died in consequence of a drunken debauch, but others maintain that he was thrown down a steep incline by emissaries of jealous physicians and apothecaries. He was buried in the churchyard of St. Sebastian, and in 1752 a monument was erected to his memory.

In his works Paracelsus shows a genuine desire to promote the progress of medicine, but it is questionable whether he introduced a single new truth. Fundamentally, his system is based on a visionary Neoplatonic philosophy in which the life of man is regarded as inseparable from that of the universe. For him, the scriptural *limus terrae* from which the body of man is created is in reality an extract of all beings previously created. It is primarily a compound of "salt," "sulfur," and "mercury," the separation of these mystic elements in man being the cause of sickness. The separation is due to the failure of the archaeus, an occult vital force which is situated in the stomach, to perform its function of separating the useful from the poisonous. For the treatment of disease, Paracelsus introduced mineral baths, made opium, mercury, lead, sulfur, iron, arsenic and copper sulfate a part of the pharmacopoeia, and popularized tinctures and alcoholic extracts. Since man contains all elements and requires them for the curing of his diseases, the physician must know the physical sciences and alchemy; he must also know astronomy, for not only do the stars influence disease but man, like all terrestrial beings, is penetrated by the astral spirit; third, the physician must know theology, since, in addition to body and spirit, man has a third factor, the soul, which was created by God, and to which the spirit serves as a kind of body. With Paracelsus' lofty views of the true scope of medicine it is impossible to reconcile his ignorance, his superstition, and his erroneous observations.

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PARACHOR, a characteristic of any substance; the value of this property is given by the value of the function $M\gamma^{\frac{1}{4}}/(D - d)$ where M is the molecular weight of the substance, γ is the surface tension of the liquid in contact with its saturated vapour, and D and d are the densities of the liquid and saturated vapour, respectively. The values of γ, D and d are all to be measured at the same temperature. The term parachor was introduced by S. Sugden (*J. Chem. Soc.*, 1924).

If the parachor of two liquids is independent of temperature, the ratio of the parachors is the ratio of the molar volumes, M/D, of those liquids when both are determined for the same surface tension, not at the same temperature. Though the dimensions of the parachor are not those of the volume, the parachor is regarded as a molal volume corrected for the forces of attraction between molecules; hence the name (Gr. *para*, "by the side of"; *chora*, "space"). The parachor was found to be an additive function of atomic and structural constants called by Sugden "atomic and structural parachors." He and his collaborators made many interesting applications of the function to determinations of chemical constitution. The method is not always reliable.

See S. Sugden, *The Parachor and Valency*, p. 30 *et seq.* (1930); G. W. Thomson in A. Weissberger, *Physical Methods of Organic Chemistry*, 2nd ed., vol. i. pp. 413–425 (1949). (G. W. Wd.; T. F. Y.)

PARACHUTE, an umbrellalike device that offers resistance to the air and thus retards the rate of descent of a falling body or the speed of an airplane or missile. Parachutes are used chiefly to enable persons to descend safely to the ground from a plane in flight. They can also be used to drop supplies, equipment, bombs or other munitions. Parachutes are sometimes used to reduce the speed of a plane or missile as it comes in for a landing or approaches its target; in this case the chute is securely fastened to the plane or missile and acts as a brake.

Early Uses of Parachutes.—Louis Sébastien Lenormand of France is generally credited with being the first to demonstrate the parachute principle in 1783, when he made a jump from a high tower. The idea had been anticipated by Leonardo da Vinci (1514), Fausto Veranzio (1595) and the Montgolfier brothers (1779). Jean Pierre François Blanchard, a pioneer French balloonist in 1785 placed a dog in a basket to which a parachute was attached and dropped it from a balloon high in the air. Blanchard claimed that he himself descended from a balloon in a parachute in 1793.

Another French aeronaut André Jacques Garnerin (1769–1823)

is credited with being the first to use a parachute regularly and successfully. His first public exhibition of parachuting was made in Paris, France, Oct. 22, 1797, when he successfully jumped from a height of more than 2,000 ft. He gave a similar exhibition in England on Sept. 21, 1802, when he jumped from a height of about 8,000 ft. His parachute was umbrella-shaped, made of white canvas and approximately 23 ft. in diameter. Jordaki Kuparento, a Polish aeronaut, made a successful emergency descent by parachute in 1808 when his balloon caught fire at a considerable height.

Transition to Modern Use.—The first successful use of a parachute in a descent from a moving airplane was made in 1912 by Capt. Albert Berry at St. Louis, Mo. During 1913–14 there was much discussion concerning the practicability of using parachutes for escapes from airplanes, but by the time World War I started (1914), the question had not been satisfactorily decided. The primary reason for the indecision was the size of the parachutes then in common use; it was thought to be practically impossible for a pilot to clear the plane without fouling of the parachute or the suspension lines. At the beginning of World War I, therefore, parachutes were used only by observers in captive balloons, some of whom made seven or eight parachute descents daily. Parachutes were improved in Germany to the extent that German aviators used them extensively as life-saving devices in the last months of that war. The American first pursuit group from Sept. 26 to Nov. 11, 1918, brought down 11 enemy aircraft from which the pilots escaped by means of parachutes.

The allies were debating the advisability of using parachutes when the Armistice was signed and in 1919 the seat pack type of parachute was adopted as regular airplane equipment by the U.S. army. Although pilots were reluctant to use parachutes, they were eventually convinced of their value, and the first U.S. army order making it compulsory to wear them was issued by the adjutant general in 1922. Soon the British Royal Air Force adopted the U.S. type of parachute with its cushionlike pack.

During the years following World War I, efforts in the technical development of parachutes were also made in Italy, Germany and the U.S.S.R., but the transition from chutes used in balloons to those suitable for fast heavier-than-air craft was slow. There were many problems involved in developing a parachute suitable for use from fast-moving planes, but they were gradually solved.

At the beginning of World War II the armies of all major countries were well equipped with parachutes for various purposes. The principal uses of parachutes were to enable men to escape from disabled aircraft; to drop men and material for combat actions or to drop supplies into inaccessible positions; to place agents in enemy territory; to stabilize and retard aerial bombs, mines and torpedoes; and to slow aircraft during approach and landing. During World War II the possibilities of the use of parachutes for aerial warfare as well as for civilian use were strongly indicated and successfully applied. The following is a brief review of the most remarkable incidents of parachute use during the war years.

Wartime Use of Parachutes.—Gen. William Mitchell (*q.v.*), U.S. army air service, is credited with having been the first military leader to declare publicly after World War I that air infantry and parachute troops would play an important part in the next war. Some experimental work was done under his direction with parachute troops (paratroops) and air-borne infantry, in the early 1920s, but this work was temporarily abandoned in the U.S. The U.S.S.R. and Germany, however, did not neglect the training of paratroops. The U.S.S.R., in practice war games, landed whole divisions of troops by parachute. Germany experimented in this field too, but, because of the restrictions of the treaty of Versailles, no publicity was given to the trials.

During the winter of 1939–40, at the height of its campaign against Finland, the U.S.S.R. used many paratroops as air infantry, transporting these troops behind the Finnish lines and dropping them, together with machine guns, ammunition and other material, by parachute. In April 1940 the Germans, at war with Great Britain and France, entered Norway by air, sea and land. Paratroops were used in this campaign with great success, the first time that they had been so used by Germany. The Germans landed men, machine guns, light artillery, food and ammunition successfully by parachute. In May 1940, German troops invaded the Netherlands, Belgium and Luxembourg, again using parachutes to good advantage. Glider troops, the so-called air infantry, participated in the air-borne invasions of the Netherlands and they, together with the paratroops, contributed to the speedy success of the Germans. Before the end of World War II parachutes were used by both sides for mass landings of men and matériel.

Diversified use of parachutes requires a large number of specially designed and developed types of parachutes. This tendency to use specialized types continued and was intensified after the war. A separate branch of aeronautical sciences developed to deal with all problems involved in the reduction of speed of moving objects through air by means of parachutelike devices.

Man-Carrying Parachute.—As noted above, this type of parachute consists of a canopy, suspension lines, chute pack, pilot parachute and harness. The harness is a system of webbings laid upon the body of the wearer in such a way that the forces of the parachute can be transmitted to the man without causing discomfort or injury at the instant of the parachute inflation.

Attached to the harness is the parachute pack, which includes the parachute canopy, suspension lines and pilot parachute. The pack can be so arranged that the man sits on it, or it can be fastened to his back, or it can be fastened by means of snap hooks to the chest portion of the harness.

The pack can be opened by means of a ripcord, which must be pulled by the man or by an automatic timing device, or by means of a static line fastened to the aircraft. The manual operation of pulling the ripcord is used for pilot escape; the static line system is used by paratroopers. After the pack is opened the pilot parachute is ejected into the air stream where it quickly inflates and pulls the main parachute out of the pack. Modern man-carrying chutes are made of nylon with a specific weight of 1.1 oz. per square yard and a tensile strength of 40 lb. per inch of width. The suspension lines are also made of nylon.

The pilot-escape parachute has a diameter of 28 ft. and provides sufficient drag to slow the rate of descent of a 200-lb. man to approximately 20 ft. per second (f.p.s.). Parachutes for air-borne troops are usually somewhat larger; the U.S. army parachute for air-borne troops is 35 ft. in diameter and provides for the very heavily laden paratrooper about the same rate of descent. Chest type parachutes are usually about 24 ft. in diameter with an approximate rate of descent of 25 f.p.s. for a 200-lb. load. The rate of descent of 20 f.p.s. is considered a safe sinking speed for untrained parachutists while 25 f.p.s. is acceptable for untrained men only under emergency conditions. For dropping cargo, parachutes up to 100 ft. in diameter are used, and for very heavy equipment several parachutes are combined.

How Parachutes Are Made.—The canopy of a flat parachute as described above is made of 24 or 28 triangular-shaped panels, each made of several small pieces of a fabric stitched together so that a tear would never become larger than the piece in which it originates. The individual pieces are sewn together to triangular gores in such a manner that the direction of the yarn of warp and filling intersect the centre line of the gore under an angle of 45°. This measure increases the strength of the parachute. The gores are then sewn together to form a circular canopy with a small vent in the middle. The shroud lines are run through the seams that bind the panels together. Each shroud line runs from the D-ring by which it is attached to the harness, over the top of the canopy and down to another D-ring, which is also attached to the harness. In general, a 24-ft. canopy has 24 panels and 24 shroud lines; the latter are brought down in four groups of six each. A 28-ft. canopy has 28 panels and 28 shroud lines, and the lines are brought down in four groups of seven each. The length of the lines below the periphery is usually equal to the diameter of the flat parachute canopy.

The containers or pack covers are made of strong nylon. They are of different sizes and shapes, and are most ingeniously made to assure that the pilot chute is released first; that the canopy is smoothly pulled out by the pilot chute; and that the shroud lines do not become entangled.

BY COURTESY OF U.S. AIR FORCE

FIG. 1.—PERSONNEL PARACHUTE

Descending chutist and underside of conventional 28-ft. circular flat chute used by U.S. air force, showing triangular-shaped panels

The harness is a cleverly designed contrivance that attaches the parachute firmly and safely to the wearer. It may be released from the parachutist's body instantly in the event of a landing in high wind or in water. This quick-release feature is important because the parachutist may be severely injured or drowned if he is unable to free himself quickly from the parachute and is dragged over the ground or through the water.

How Parachute Descents Are Made.—In the drag-off method, formerly widely used, the jumper crawled out of the cockpit onto the wing or fuselage, far enough so that his parachute would not be fouled by the tail assembly, and pulled the ripcord, allowing the drag of the filling canopy to draw him away from the plane. This procedure cannot be used in modern aircraft. In the free-fall method, which generally succeeded the drag-off method, the parachutist steps, falls, jumps or is ejected from the aircraft and the ripcord is pulled when he is clearly separated from the plane. When jumping from a high-speed aircraft, a definite time delay may be necessary in order to avoid exposure of the parachute to an airstream with too high a velocity.

When mass jumps are made, as in the dropping of parachute troops, the parachute is usually pulled out of the pack automatically by a static line attached to the airplane. This line is sufficiently long to make sure that the parachutist is clear of the aircraft before his parachute opens. Between static lines and the parachute is one weak link which finally breaks and thereby disconnects the parachutist from the airplane.

Opening Shock and Maneuverability.—The stretching of the suspension lines and of the canopy to the full length and the filling of the canopy occur more or less simultaneously. However, the main portion of the inflation follows the stretching of the lines. During the filling a strong force, called the opening shock, is exerted upon the suspended man or the load. Opening shocks between 4,000 and 5,000 lb. have to be expected at speeds of 400 m.p.h. and at low altitudes. At speeds higher than 400 m.p.h. the opening shock may be so great that a man may be fatally injured or his parachute destroyed. It has also been found that up to 40,000-ft. altitude the opening shock of parachutes increases with altitude, and may be assumed that this also is true up to higher altitudes. The violence of the opening shock depends also on the type of parachute. The desire to reduce the violence of the opening shock has been a strong incentive for the design of improved types of parachutes.

A certain degree of maneuverability can be achieved with every parachute; *e.g.*, in order to glide to the left an experienced parachutist will pull down on the suspension lines on the left-hand side. The possibility of directing to a selected point is so small that in general, the armed services of the larger countries do not attempt to train their men in the art of chute maneuvers. Sport jumpers, however, acquire great skill in this matter and yearly meets are held in which many nationally selected crews compete in target jumping.

Parachute Evolution.—Up to the beginning of World War II, practically all parachutes in use were of the solid, flat type, consisting of a more or less flat circular canopy made of solid cloth. This type of parachute had certain undesirable features such as high opening shock and an inherent tendency to oscillate or glide. In order to achieve a high degree of air resistance without excessive opening shock and uncomfortable or dangerous oscillations, extensive studies were conducted in wind tunnels and other aerodynamic research facilities. The results of these efforts were radically new types of parachutes, the ribbon parachute (1938) and the guide surface parachute (1943), both of German origin. Between these two extremes a number of in-between designs can be found.

Solid, flat parachutes with medium porosity are all unstable; they either oscillate, glide or perform a combined motion. Ringslot parachutes, which consist of concentrically arranged rings of cloth and open spaces are more stable than any flat parachute made out of solid cloth. The ribbon parachutes belong to the same family, and their geometric porosity is of the same order as that of ringslot parachutes; however, the individual units of material and open space are smaller, and the stability of ribbon parachutes is in general better than that of the ringslot parachutes. Formed gore parachutes attempt to control parachute behaviour by shaping the canopy. They are characterized by the drawn-in skirt and are generally more stable than the comparable flat parachutes with the same porosity.

In the design of the guide surface chutes, the concept of parachute shaping has been carried considerably farther. They are made of low-porosity cloth and have a conical surface at the lower portion of the canopy. Guide surface chutes are most stable in their class. They are specialized for stabilization of bombs, mines and torpedoes (stabilization type); for the recovery of guided missiles and escape capsules (universal type); and for rescue of men from high-speed aircraft (personnel type).

Ejection Seats and Escape Capsules.—In high-speed aircraft it is very difficult, sometimes impossible, for the pilot to leave the disabled aircraft. The airplane may tumble or spin and the accelerations during such uncontrolled flight may make it impossible for the pilot to bail out. The high velocity air stream may press the pilot with so much force against a part of the aircraft that he is unable to free himself. Furthermore, if the pilot should be able to leave the aircraft the air stream would probably blow him against the tail structure with great force. To meet this problem, high-speed military and research aircraft are equipped with cartridge-actuated ejection seats.

Under normal flight conditions an ejection seat is used like any regular pilot's seat. In an emergency the seat is ejected from the aircraft structure by means of a cylinder and piston arrangement actuated by the explosion of a small charge of propellant. The pilot is literally blown out of the airplane. During the period of ejection the pilot has an upward velocity of approximately 60 ft. per second, which is usually sufficient to clear safely the tail structure of the aircraft. The ejection seats also have a number of safety arrangements that prevent arms and legs from being violently moved by the air stream. In seats without these precautions dislocation of joints or bone fractures have occurred. (*See* fig. 2.)

During the ejection the pilot is held in the seat by a lap belt, and his parachute is connected to his harness. The parachute remains inactive until the pilot is separated from the ejection seat by the opening of the lap belt. When the seat and the pilot have drifted far enough apart, the parachute is automatically opened and the pilot descends in normal fashion. The instant of the open-

ing of the lap belt and the opening of the parachute is carefully timed in order to avoid excessive opening shocks and also to allow the bail-out altitude to be as low as possible.

The use of ejection seats is limited to high subsonic, transonic and low supersonic speeds since the high velocity air stream imposes unacceptable deceleration of the pilot in the ejection seat. In addition, the air blast may tear away protective helmets, oxygen masks and garments and thereby jeopardize the pilot's life. For the protection of a single pilot or a crew of two, pilot escape capsules have been proposed. These capsules are a part of the aircraft structure, usually the cabin or cockpit, and in case of emergency they are separated from the air frame.

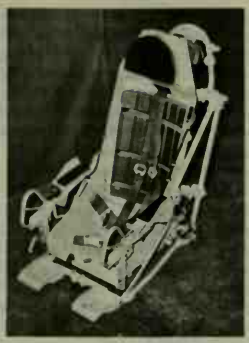

FIG. 2.—PILOT EJECTION SEAT FOR JET FIGHTER PLANE

Properly designed pilot capsules appear to be suitable for escapes from supersonic and hypersonic aircraft as well as for space vehicles. During the descent, two or three parachutes are used to stabilize and to decelerate the capsule.

Landing-Brake Parachutes.—Parachutes of this type serve to reduce the speed of an aircraft during its landing approach and to shorten its landing run. This method was a standard procedure in the landing of German troops transported in glider airplanes during World War II and after the war it was widely used for military aircraft. Ringslot or ribbon parachutes are used for this purpose.

Because of a favourable flow pattern surrounding the parachute, landing-brake parachutes are deflected upwardly and do not touch the ground until the aircraft speed is almost zero at which time the parachute partially collapses and glides over the ground. (*See* fig. 3.)

In some cases a small parachute is used during the landing approach and a larger one to reduce the landing run. In general, the parachute used during the approach must be small enough to allow the aircraft to remain air-borne and able to climb again. This requirement is necessary because the pilot may wish to discontinue the landing maneuver and fly another approach.

Pilotless Aircraft and Missile Recovery Parachutes.—A number of small, pilotless airplanes used for target practice can be recovered after their fuel is expended or after they are hit by a projectile. As some of these targets fly at high subsonic speed, it has been necessary to develop intricate parachute systems for initial deceleration and final landing. These parachute systems have not been developed for the recovery of manned aircraft in spite of numerous patent applications and other proposals.

In the development of missiles it is sometimes highly desirable to recover entire missiles, because the recovery of a missile which did not function satisfactorily is very essential since it allows the investigation of the cause of malfunction. The first example of a missile recovery came in 1943 when the German V-2 missile, during its flight test program, was recovered by a ribbon parachute. The recovery of missiles is now a well-established practice. The recovery of capsules which are ejected from satellites or space vehicles and which may contain instruments or living beings is a further extension of the technique of missile recovery methods.

BY COURTESY OF BOEING AIRPLANE COMPANY

FIG. 3.—A 32-FT. LANDING-BRAKE RIBBON CHUTE SLOWING DOWN A 600-M.P.H. BOEING STRATOJET ON RUNWAY

Care of Parachutes.—The life of a man depends upon the quality, freshness and packing of each parachute manufactured or repacked. Parachutes not regularly used should be unpacked, inspected, dried out and repacked once in every 30 to 60 days. Air-conditioned and practically dustproof sheds have been designed for this purpose.

Each man-carrying parachute carries information as to the date on which it was last inspected, dried and packed, together with the name of the inspector. Parachutes made out of nylon or other synthetic material are taken out of personal use after they reach a certain age, because the physical properties of these materials deteriorate with time regardless of use. In the United States the age limit for nylon is seven years. (H. G. He.)

Sport Parachuting.—The two criteria of sport parachuting are style during free fall—the period after exit from the aircraft and before the opening of the parachute—and accuracy in landing. By spreading and arching his body a parachutist can hold a stable position during descent in free fall, or he can make turns, loops, and barrel rolls, and increase or decrease his rate of descent. By combining these techniques a parachutist may catch up to another parachutist during free fall and actually pass a baton for a free fall relay event.

Sport parachutes that give the parachutist control of his direction and a horizontal speed of close to 10 m.p.h. have permitted improved standards of accuracy in landing. Distance is measured from the exact centre of the crosslike target to the point of impact of the parachutist.

Sport parachutes have large holes that permit the air to escape and drive the parachute in the direction opposite the hole, much like a low-power jet engine. The parachutes may be rotated by a light pull on a control knob that regulates the direction of the escaping air. The curved surface of the parachute moving through the air gives lift like an airplane wing. This lift effect greatly reduces the landing shock.

A device called the sleeve that controls the deployment of the parachute canopy is perhaps the main technological development behind the growth of sport parachuting. The sleeve is a three-way safety factor. It draws the parachutist upright during deployment and thereby virtually eliminates the opening shock. It controls the canopy during deployment and makes it impossible for a man to wrap up in the parachute while it opens. The sleeve also lessens the possibility that the canopy will remain closed by removing the pilot chute pressure from the apex of the canopy during the opening.

An outgrowth of informal competition for accuracy, sport parachuting came into its own at the first world championship meet in Yugoslavia in 1951 with five countries participating under the sponsorship of the Federation Aeronautique Internationale. World championship meets are held every two years. The U.S. was represented for the first time in 1954 when Fred Mason took 21st place in the second world championship meet at St. Yan, in France.

The first U.S. sport parachuting team competed in 1956 in the third world championship meet in Moscow, U.S.S.R. The first two sport parachuting centres in the United States were created in 1959 at Orange, Mass., and Hemet, Calif.

Improved equipment and techniques created an amazing safety record for the sport. The Telsan technique of parachuting instruction permits persons who have never before seen a parachute to make a static line jump, during which the parachute opens automatically, after only four hours of instruction. In France, 100,000 student jumps were made without a fatality. Strict international regulations condemn unsafe practices. Sport parachutists are required to open their parachutes at a safe altitude of 2,200 ft.

The sport of parachute jumping is governed in each country by the parachute branch of the national aero club. In the United States the official body is the Parachute Club of America, a branch of the National Aeronautic association. (J. A. I.)

PARADISE (from Old Persian *pairidaeze* [*pairi*, "around," *dix*, "mold"], signifying an enclosed area, particularly a royal park or hunting ground) was first used in its Hebrew form in the Old Testament (S. of Sol. 4:13; Eccles. 2:5; Neh. 2:8) to mean the sort of enclosure suggested by the Persian word. In the Greek translation of the Hebrew Scripture, however, "paradise" (Gr. *paradeisos*) was employed to designate also the Garden of Eden (Gen. 2:8), the original, blissful abode of man on earth (*see* EDEN). In later Jewish writings it further became the name for a heavenly realm, understood as the archetype of the earthly Eden. This heavenly paradise was pictured as a place of rest and refreshment in which the righteous dead enjoy the glorious presence of God. It was in this sense of a heavenly realm that the word was used in the New Testament (Luke 23:43; II Cor. 12:3; Rev. 2:7).

Some belief in a paradise either as an original or a final state of bliss and abundance is probably to be found universally in man's religions. Among many primitive peoples there is the idea of a fuller life beyond the grave, a land in which there will be an absence of pain and suffering and a complete satisfaction of bodily desires. A final state of bliss is variously conceived of in the higher religions as, for example, a heavenly afterlife (Islam, Christianity) or union with the divine (Hinduism) or an eternal condition of peace and changelessness (Buddhism). Accounts of a primordial earthly paradise in the higher religions range from that (as in Judaism, Christianity, and Islam) of a garden of life to that (as in Buddhism and Hinduism) of a golden age of human society at the beginning of each great cosmic cycle of existence. Among primitive peoples the belief in an original, earthly paradise is often that of a time when heaven and earth were very close together or actually touching, and men and the gods had free and happy association. In both primitive and higher religions the primordial paradise is frequently pictured as being at the centre of the earth, the point from which the universe originally spread out in the process of creation, and as being a place in which man neither toiled, suffered, nor died, and in which he had abundant life. Indeed, all accounts of that first paradise speak of an ideal humanity enjoying spiritual and physical plenitude in a far distant, but not forgotten, time—"in the beginning."

See also HEAVEN.

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PARADISI (PARADIES), **PIETRO DOMENICO** (*c.* 1710–1791), Italian composer, harpsichordist, and singing teacher, was born at Naples about 1710. (The form of his name, Paradies, by which he is generally known, may be French or perhaps German.) Nothing is known of his early life. In 1738 his opera *Alessandro in Persia* was produced at Lucca, and the serenata *Il decreto del fato* was produced at Venice in 1740. By 1747 he was in London, where he produced his opera *Fetonte* and gave singing and harpsichord lessons. In 1754 he issued a set of 12 *Sonate di gravicembalo*, some of which are among the classics of Italian harpsichord music. He also composed several operatic works, symphonies, and organ concertos. Little is known of his later life; he left England sometime after 1750 and is said to have died in Venice on Aug. 25, 1791. (Cs. CH.)

PARAFFIN HYDROCARBONS (ALKANES). Paraffin (alkane) is the generic name given to the saturated hydrocarbons having the general formula C_nH_{2n+2}. The paraffins are major constituents of natural gas and petroleum. Paraffins containing fewer than 5 carbon atoms per molecule are gaseous at room temperature, those having 5 to 15 carbon atoms are usually liquids, and the straight-chain paraffins having more than 15 carbon atoms per molecule are solids. Branched-chain paraffins with five to eight carbon atoms per molecule have a much higher octane number than straight-chain paraffins and, therefore, they are the more desirable constituents of gasoline (petrol).

The hydrocarbons are not miscible with water; they are soluble in absolute alcohol, ether, and acetone. All paraffins are colourless.

Synthesis.—Paraffins can be prepared as follows: (1) Hydrogenation of olefins in the presence of catalysts such as nickel or platinum. (2) Transformation of alkyl halides into alkyl magnesium halides (Grignard reagents), which are then decomposed with water or dilute mineral acids. (3) Reduction of ketones by means of amalgamated zinc and hydrochloric acid (Clemmensen reduction) or with hydrazine and sodium ethoxide (Wolff-Kishner reduction). (4) Reduction of an alkyl halide by means of such reagents as lithium aluminum hydride ($LiAlH_4$), sodium and alcohol, hydrogen and platinum, etc. (5) Dehydroxymethylation of primary alcohols by reaction under pressure with hydrogen in the presence of a nickel catalyst at 150°–225° C (302°–437° F); methane and water are formed as by-products. (6) Reaction of alkyl halides with metallic sodium (Wurtz synthesis); the yields of the desired paraffins are sometimes, however, very low. (7) Reduction of carbon monoxide with hydrogen at 200°–250° C and at atmospheric pressure in the presence of a catalyst consisting of cobalt, thoria, and kieselguhr (Fischer-Tropsch Synthesis). This process, which yields a mixture of straight-chain paraffins, was used in Germany during World War II for the production of gasoline and lubricating oils.

Reactions.—The paraffins are resistant to the action of aqueous solutions of acids, alkalies, and oxidizing agents at room temperature. This inertness gave rise to the name "paraffin" (Lat. *parum*, little; *affinis*, akin).

Thermal and Catalytic Cracking.—At a sufficiently high temperature paraffins decompose to lower paraffins, olefins, and hydrogen. Propane at 600° C decomposes as follows:

$$CH_3CH_2CH_3 \rightarrow \underset{\text{ethylene}}{CH_2=CH_2} + \underset{\text{methane}}{CH_4}$$

$$CH_3CH_2CH_3 \rightarrow \underset{\text{propylene}}{CH_3CH=CH_2} + H_2$$

Ethylene and methane are the principal products. Paraffins of higher molecular weight, on cracking, form hydrogen and a complex mixture of olefins and lower-boiling paraffins.

In the presence of a silica-alumina catalyst at 500°–550° C, paraffins decompose to form a complex mixture composed mainly of branched-chain paraffins and olefins. This method is used commercially for making high-octane gasoline.

Isomerization.—In the presence of catalysts such as aluminum chloride-hydrogen chloride, *n*-butane is reversibly isomerized to isobutane. The isomerization occurs at about 80°–125° C and at a pressure of 3 to 10 atm.

$$CH_3CH_2CH_2CH_3 \rightleftarrows CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$$

The isomerization of hydrocarbons containing five or six carbon atoms per molecule is carried out under 10–30 atmospheres of pressure in the presence of hydrogen and a platinum-alumina catalyst containing some halides.

Oxidation and Chlorination.—Paraffins in the presence of oxygen or strong oxidizing agents at high temperatures undergo complete oxidation to carbon dioxide and water.

$$C_nH_{2n+2} + \frac{3n+1}{2}O_2 \rightarrow nCO_2 + (n+1)H_2O$$

Under certain controlled conditions of contact time and in the presence of air, a partial oxidation of paraffins is feasible. A complex mixture of oxygenated compounds consisting of alcohols, ketones, aldehydes, and acids results from such a reaction.

The chlorination of paraffins occurs at 250° C, or at lower temperatures if induced by light or organic peroxides. The chlorination reaction yields a mixture of chlorinated hydrocarbons.

$$CH_3CH_2CH_2CH_2CH_3 + Cl_2 \rightarrow \begin{cases} CH_3CH_2CH_2CH_2CH_2Cl \\ CH_3CH_2CH_2CHClCH_3 \\ CH_3CH_2CHClCH_2CH_3 \end{cases}$$

Nitric Acid.—Paraffins react with nitric acid in the vapour phase to form nitroparaffins (R = paraffin radical):

$$RH + HONO_2 \xrightarrow{420^\circ\ C} RNO_2 + H_2O$$

The reaction is accompanied by the scission of carbon-carbon bonds. In the nitration of propane, for example, not only 1- and 2-nitropropane ($CH_3CH_2CH_2NO_2$ and $CH_3CHNO_2CH_3$) are formed, but also nitroethane ($CH_3CH_2NO_2$) and nitromethane (CH_3NO_2).

Sulfur Dioxide and Chlorine.—Paraffins form sulfonyl chlorides by reacting with sulfur dioxide and chlorine in the presence of light or organic peroxides.

$$RH + SO_2 + Cl_2 \xrightarrow{\text{light}} RSO_2Cl + HCl$$

The products thus obtained from paraffins with 12 to 16 carbon atoms per molecule can be transformed into sulfonates that are valuable as detergents and wetting agents.

Addition of Carbenes.—Carbene or substituted carbenes which are formed by photochemical or thermal decomposition of the corresponding diazo compounds add to paraffins;

$$RH + CH_2N_2 \xrightarrow{\text{light}} RCH_3 + N_2$$

$$RH + N_2CHCOOR^1 \xrightarrow[\text{or heat}]{\text{light}} RCH_2COOR^1 + N_2$$

Alkylation of Paraffins.—*Thermal.*—Paraffins such as propane, butane, and isobutane react with olefins at elevated temperatures and pressures to form addition products.

$$\underset{\text{isobutane}}{CH_3-\overset{CH_3}{\overset{|}{C}}H-CH_3} + \underset{\text{ethylene}}{CH_2=CH_2} \xrightarrow[290\text{ atm.}]{500^\circ\text{ C}} \underset{\text{2,2-dimethylbutane}}{CH_3-\overset{CH_3}{\overset{|}{\underset{CH_3}{\underset{|}{C}}}}-CH_2-CH_3}$$

Catalytic.—Isobutane reacts catalytically with olefins of lower molecular weight. The catalysts most commonly used are aluminum chloride-hydrogen chloride, hydrogen fluoride, and concentrated sulfuric acid. The catalytic alkylation proceeds at 0° to 35° C and at pressures of 2 to 10 atm.

$$\underset{\text{isobutane}}{CH_3-\overset{CH_3}{\overset{|}{C}}H-CH_3} + \underset{\text{ethylene}}{CH_2=CH_2} \xrightarrow[35^\circ\text{ C}]{AlCl_3.HCl} \underset{\text{2,3-dimethylbutane}}{CH_3-\overset{CH_3}{\overset{|}{C}}H-\overset{CH_3}{\overset{|}{C}}H-CH_3}$$

$$\underset{\text{}}{CH_2-\overset{CH_3}{\overset{|}{C}}H-CH_3} + \underset{\text{2-butene}}{CH_3-CH=CH-CH_3} \xrightarrow[0\text{–}35^\circ\text{ C}]{H_2SO_4\text{ or HF}} C_8H_{18}$$

The outstanding application of this reaction is the production of high-octane gasoline; it was in wide use during World War II.

Dehydrogenation.—Paraffins with two to five carbon atoms per molecule undergo dehydrogenation to olefins when brought into contact with a suitable catalyst at atmospheric pressure.

$$\underset{n\text{-butane}}{CH_3CH_2CH_2CH_3} \xrightarrow[525^\circ\text{ C}]{Cr_2O_3.Al_2O_3} \underset{\text{2-butene}}{CH_3CH=CHCH_3} + H_2$$

Heptanes and hydrocarbons of higher molecular weight undergo dehydrogenation to aromatic hydrocarbons.

$$\underset{n\text{-heptane}}{CH_3CH_2CH_2CH_2CH_2CH_2CH_3} \xrightarrow[500^\circ\text{ C}]{Cr_2O_3,\ Al_2O_3} \underset{\text{toluene}}{\text{C}_6\text{H}_5\text{CH}_3} + 4H_2$$

This aromatization of paraffins has a wide commercial use.

See HYDROCARBON: *General Structure. See* also separate entries on many of the paraffin hydrocarbons mentioned; *e.g.,* BUTANE; PROPANE. (H. Ps.)

PARAGONITE, an uncommon rock-forming mineral belonging to the mica group. It is commonly found as very fine-grained pearly scales in dense masses; single crystals are exceptionally rare. It is colourless and cannot be distinguished optically from muscovite (*q.v.*). Paragonite usually occurs in schists with kyanite, chloritoid, and staurolite.

It is found at Fenestrella, Italy; Alpe Sponda, Switz.; and Chester, Pa. A sodium mica, the chemical composition is close to $NaAl_2(AlSi_3)O_{10}(OH)_2$ with some K substituting for Na; Li, Fe^{+3} and Mg for the first Al; and Si for the second Al. Three polymorphs are recognized. Paragonite and fluoroparagonite have been synthesized. For further discussion *see* MICA. (H. S. Y.)

PARAGUANÁ PENINSULA, extending northward from Falcón state in northwestern Venezuela, lies between the Caribbean and the Gulf of Venezuela. Politically, it is a part of Falcón (*q.v.*); Coro, capital of the state, lies at the base of the isthmus. The peninsula is arid and of little use for agriculture. Lagoons line the coast. Population is sparse. Besides oil operations, the main activities are grazing of goats, fishing for mackerel, shrimp, shark and tuna and diving for pearls. Important petroleum pipelines have been built from the oil fields on the east side of Lake Maracaibo (*q.v.*) to terminals on the west side of the peninsula, where several companies have large oil refineries.

At Amuay terminal, the harbour has been dredged to 41 ft. to handle tankers up to 47,000 tons, and four 1,100-ft. piers have been constructed for handling large tankers. A new international port has been built at Guaranao bay on the western side of the peninsula and large ships can be accommodated.

Guaranao is one of the best sheltered and deepest bays on the peninsula. This port has grown in importance with completion of the hard-surface highways from Coro to Barquisimeto and from Coro to Maracaibo. Pueblo Nuevo is the principal settlement. (L. WE.)

PARAGUARÍ, a department of southern Paraguay. Area 3,187 sq.mi. (8,255 sq.km.). Pop. (1962) 204,220. It is drained by the Tebicuary, tributary of the Paraguay river, and by Lake Ypoá (Laguna Verá), Paraguay's largest lake. The northern area of the department contains part of the forested Asunción prong of the Brazilian plateau. The southern districts are rich agricultural lowlands producing tropical subsistence and cash crops. Population is well distributed. There are many processing and marketing centres and the department is served by the main Asunción-Villarrica railway, which passes through the capital, Paraguarí, and by the Asunción-Encarnación highway. Caapucú is the principal centre of the south of the department and near it are important iron ore resources. (G. J. B.)

PARAGUARÍ, capital of the department of the same name in southern Paraguay, lies 45 mi. (72 km.) SE of Asunción. It is the trading centre of the fertile and active agricultural region which slopes southward and westward from the Paraguayan extension of the Brazilian plateau to the Paraguay river. Pop. (1960 est.) 5,040. It is connected with Asunción by road and rail, with Villarrica by the Central Paraguayan railway and with Encarnación by a new trunk road.

Cotton, tobacco, sugar, oranges, rice, maize and hides are among the products which it handles or produces. Ceramic works, tanneries and food-processing plants are located in the area. Essence of petitgrain, a base for perfume from bitter orange leaves, is an important product.

Originally a Jesuit mission, the city was formally organized in 1775 by Agustín Fernando de Pinedo. In 1811, when Paraguay decided not to join with the Argentine colonies in their revolt against Spain, Paraguarí was the scene of an important battle in which the Argentines under Manuel Belgrano were repulsed and Paraguay's independence was secured. It is the headquarters of Paraguay's artillery regiment and school. Santo Tomás grottoes, on a hill near the city, are noted for their hieroglyphic inscriptions, presumably the work of early indigenous peoples. The 75-ft. (23 m.) long cavern is a centre of Good Friday pilgrimage. (G. J. B.)

PARAGUAY, a republic in the south central part of South America. Area 157,047 sq.mi. (406,752 sq.km.). Pop. (1962) 1,816,890. Paraguay is bounded on the northeast by Brazil, on the northwest by Bolivia, and on the south, west and east by Argentina. No part of the country lies within 600 mi. (965 km.) of the ocean, and this landlocked situation distinguishes and conditions Paraguay's economic and political life.

This article is divided into the following sections and subsections:

I. Physical Geography
1. Physiography and Geology
2. Climate
3. Vegetation
4. Animal Life
II. Geographical Regions
1. Central Region
2. Eastern Region
3. The Chaco
III. The People
IV. History
V. Population
VI. Administration and Social Conditions
VII. The Economy
1. Production and Trade
2. Finance
3. Communications

I. PHYSICAL GEOGRAPHY

With an area of 157,047 sq.mi., Paraguay is almost as large as California. It straddles the Tropic of Capricorn, its northern part lying in the south tropical zone in the heart of South America. Its name is said to have derived from the Guaraní Indian word *pararaguay*, meaning "a place with a great river," which describes the country well. Rivers form most of the country's boundaries and are still its principal, most convenient, and most pleasant means of commercial transportation, despite airline service, the construction of some modern highways in recent decades, and the earlier construction of the railroad from Asunción to Encarnación.

In the east, and along part of its southern edge, Paraguay is bounded by the Alto (Upper) Paraná River, which separates it from Brazil and Argentina. At the country's southwestern corner, where this river is joined by the Paraguay River, the Alto Paraná becomes the Paraná and turns southward to carry much of the country's commerce to Argentina and the Atlantic Ocean. The Paraguay River rises far in the north, in the Mato Grosso region of Brazil, forms part of Paraguay's border with Brazil for about 100 mi. (161 km.), then cuts Paraguay roughly into its two main parts —the Oriental (East) and Occidental (West)—for another 200 mi. (322 km.), and finally forms the border with Argentina for another 150 mi. (241 km.). At Asunción it receives the Pilcomayo from the west, a sluggish river, not commercially navigable, which forms a part of Paraguay's border with Argentina. In the north, eastern Paraguay is separated from Brazil by the Apa River, flowing into the Paraguay from the east.

PRINCIPAL CITIES AND PHYSICAL FEATURES OF PARAGUAY

1. Physiography and Geology.—The eastern third of the country, ranging in altitude from 1,000 to 2,000 ft. (305 to 610 m.), is a westward extension of the geologically old Brazilian plateau of crystalline rocks, which are there covered almost everywhere with thick layers of red sandstone into which lavas and other volcanic rocks have intruded. However, along a line running roughly northward from Encarnación, this ancient plateau formation dips down across a fairly well defined cuesta, or escarpment, to be covered, as far west as the Paraguay River, by alluvial soils. In several places the latter are interrupted by exposed "peninsulas" of the old crystalline rock formations, which are weathered, gently rounded, and not very high.

The cuesta divides the watersheds as well as physical formations. Tributary streams flowing westward into the Paraguay are mostly navigable by small boats and flow across open and fertile country, with some large marshy areas in the south. Those flowing eastward into the Paraná traverse more rugged, forested country and are not navigable; the Alto Paraná itself is too rough above Encarnación to serve as a major waterway; its few "ports" are maintained by individual companies for loading mate and lumber.

To the west of the Paraguay River lies the so-called Chaco Boreal, which is Paraguay's portion of the Gran Chaco, a name derived from the Quechuan Indian word *chuco*, meaning hunting ground. The Chaco Boreal, 91,800 sq.mi. (237,800 sq.km.) in extent, is uniformly flat and variously covered with dense jungle growth, grasslands, isolated forest stands, palm groves, and swampy lowlands. It is thought to have been at one time the bed of an ancient sea, later filled with unconsolidated sands and clays brought down by rivers from the eroding Andes. The rivers in the region, of which the largest is the Pilcomayo, are sluggish and not navigable, and much of the country is subject to flooding.

2. Climate.—Except in some parts of the Chaco, Paraguay's climate, largely subtropical, is noted for its general pleasantness. During the summer months, from October through March, temperatures generally range from 26° to 33° C (80° to 90° F), with some hotter spells, though often broken by strong winds that may cause sudden drops of 30°. In winter, April through September, the temperature range is between 15°–26° C (60° and 80° F). Rainfall is highest on the Paraná plateau at the Brazilian border, where it averages about 80 in. (31 cm.) per year. It diminishes toward the west. At Asunción, annual rainfall is about 52 in. (20 cm.), fairly well distributed throughout the year. In the Chaco, west of the Paraguay River, the average amount per year drops to 32 in. (13 cm.); there, too, the high rate of evaporation and the porosity of the soil cause periodic droughts that may often be followed by floods.

3. Vegetation.—The eastern part of Paraguay is largely covered by semideciduous forests, especially in the river valleys. The trees are mostly hardwoods, including such indigenous varieties as urunday, cedron, curupay, and lapacho. The lack of softwoods is a handicap, though there are enough light woods to float the heavy woods in rafts down the Paraná to the Argentine market.

West of the cuesta, to the Paraguay River, the country is covered by well-watered, luxuriant grasses, interspersed by forest clumps on the uplands and by gallery forests along the river courses. The extensive marshy parts of this region are covered by tall grasses between gallery forests.

In the sporadically forested Chaco, largely in the eastern part along the Paraguay River, are scattered stands of quebracho, a hard red tree which yields a tanning extract shipped in large quantities to Great Britain and the U.S. The rest of the Chaco is a land of scrub thorn trees and dwarf shrubs, with giant cacti in the more arid west.

Medical herbs, shrubs and trees (the latter including the paratodo, with some of the properties of quinine), are in profusion and are exploited by European firms, as are also dyewoods to some extent. The famous mate (*q.v.*), or Paraguay tea, a holly (*Ilex paraguariensis*), occurs in the northeast in a wild state, and in the southwest under cultivation.

4. Animal Life.—Among the animals native to Paraguay are the jaguar, quite abundant in the Chaco and known as the *tigre*, the dangerous large wild boar, the water hog or carpincho, varieties

of deer, the armadillo and the anteater. There are many tropical birds such as the ibis, heron, toucan, black duck, doves, partridges, and parakeets and parrots. Insect life is extensive and large anthills are often seen.

II. GEOGRAPHICAL REGIONS

Two lines, extending roughly north and south, divide Paraguay into its three main geographical regions. One is the cuesta running north from the vicinity of Encarnación, and the other is the Paraguay River. The central region, lying between the two, is by far the most important and is the area in which live all but about 100,000 of the country's 1,816,890 inhabitants.

1. Central Region.—From the viewpoint of human geography, this central region is again divided into three parts, the central, the south, and the north. The central part extends eastward from Asunción, about 100 mi. (161 km.), to Paraguay's second city, Villarrica. About 50 mi. (80 km.) wide, this is the "core area" of Paraguay. It is the region where settlement by whites first began, where the first land titles were established and the first towns and cities were located. Most of Paraguay's urban centres, ranches, farms, and orange groves are located in this belt, which is served by the railroad from Encarnación and by the relatively modern Marshal Estigarribia Highway. The country's few manufacturing industries are located almost exclusively in Asunción and Villarrica.

South of the core area is the Misiones territory, which contains some of Paraguay's richest soils, though also some large swamps. This was long held by Jesuit missionaries, who gathered Indians around them to live peaceful, religious, communal lives around settlements called *reducciones*, and who also militantly excluded Spanish settlers and at times even travelers. When the Jesuits were expelled in 1767, most of their *reducciones* fell into ruins, though some, notably Villarrica and Encarnación, grew into cities. During the 20th century, systematic efforts were made, through governmental programs and road construction, to attract immigrant-settlers, largely from Germany, to this part of Paraguay.

The country north of the central core area is scenic and fertile, but quite primitive and sparsely populated. Most of its towns and settlements lie on the Paraguay River, in part because that is the main commercial artery and in part because it is the centre of the quebracho industry. An exception is the town of Pedro Juan Caballero, on the Brazilian border at the northeastern corner, where a major effort is under way to attract settlers through an imaginative development program.

2. Eastern Region.—Large parts of this rugged plateau country are densely forested and inhabited only by scattered Indian tribes and wild animals. Settlements along the Alto Paraná River consist largely of scattered commercial holdings for lumbering or the production of mate.

3. The Chaco.—West of the Paraguay River lies the wilderness called the Chaco. Largely uninhabited, it is of economic value to the country principally because of the rich stands of quebracho trees in its eastern part. A number of narrow-gauge industrial railroads extend from points on the main river inland, for the purpose of hauling out quebracho logs. Five industrial plants for the production of tannin from the quebracho wood have in recent years been established at various river ports.

The Paraguayan Chaco's total population is about 65,000 or approximately 1½ persons for every two square miles, and is composed in large measure of Indians and pioneering ranchers. An exception is a colony of Mennonites occupying a tract of 2,100 sq.mi. (5,440 sq.km.). Attracted from North America and Europe by offers of religious freedom, virtual self-rule, permanent exemption from military service, and generous concessions in matters of taxation, these intensely religious people grow cotton and other crops, and are gradually opening the Chaco for uses other than hunting, grazing, and the extraction of quebracho.

Some petroleum is known to exist in the Paraguayan Chaco, though at present it is too remote for exploitation. (E. P. Ha.)

III. THE PEOPLE

The Paraguayan people are a fairly homogeneous ethnic stock which has resulted from intermixture between the indigenous Guaraní Indians and their Spanish conquerors. This mestizo type is predominantly Indian, for there were relatively few Spanish colonists compared with the large Indian population. About 40,000 Indians inhabit the forests of northeastern Paraguay and the western Chaco.

There have been many immigrant groups, but in total numbers they have contributed little to the racial makeup of Paraguay. The most numerous have been Germans, Spaniards, and Italians, but groups of Japanese have settled in the Alto-Paraná basin, and Australians in the Villarrica area. Most have been assimilated, but this is less true of four Mennonite and Hutterite colonies, mainly of German-speaking refugees, which were established in the period 1927–47 in the Chaco and northeast of Asunción. They are examples of pacifist, self-supporting communities which have survived many tribulations with persistence and faith, aided by generous concessions from the Paraguayan government.

The nation's loss of people has been greater than the gain, and it is estimated that at least half a million Paraguayans live in Argentina and Brazil, where they have been either driven by political persecution or attracted by greater economic opportunities.

The indigenous Tupi-Guaraní tongue is spoken by most people outside the capital, but Spanish is the official language and is more commonly spoken in Asunción. There is, however, a considerable modern literature in Guaraní, and no South American country is as bilingual as Paraguay. The problem of instructing Guaraní-speaking children in a school system based on the Spanish language increases the educational difficulties of the nation.

Although Roman Catholicism is the established religion of the country, the constitution permits the practice of other religions and denominations, and there are about 25,000 Protestants. There is a close connection between Church and state. The president must be a Roman Catholic; the archbishop of Asunción and the bishops of Villarrica and Concepción (the three dioceses) must be Paraguayans; and their appointments must be ratified by the state. The archbishop is also ex officio a member of the council of state. Many of the clergy belong to religious orders, the Salesians and Franciscans being especially numerous.

Three-quarters of the people live outside the capital and the four provincial towns of Encarnación, Concepción, Coronel Oviedo, and Villarrica. The way of life, therefore, is predominantly rural, with families maintaining themselves by subsistence farming, pastoralism and forestry. Living conditions are primitive, illiteracy widespread, and social, economic, and cultural life still largely feudal in character. Yet Paraguayan isolation has resulted in the development of a strong cultural and political nationality.

Some aspects of peasant belief and family life are Guaraní in tradition, as are also some items of material culture, such as the child's hammock, a wooden mortar, and maté drinking; but more important is the preservation of the political, military, economic, and religious institutions of the Spanish colonial culture that have fused themselves onto the language and customs of the Guaraní communities.

IV. HISTORY

Indian tribes speaking the Guaraní language had occupied the region between the Paraguay and Paraná rivers long before the arrival of Europeans in the area. They were seminomadic peoples practising agriculture, hunting, and fishing in a naturally well-endowed land. In the 15th century raiders from the poorer Gran Chaco region made frequent attacks upon them. The Guaraní in retaliation crossed the Paraguay River, subdued their enemies, and carried the conflict into the margins of the Inca Empire. They were, therefore, the natural allies of the early European explorers who were seeking short routes to the mineral wealth of Peru. Alejo García, making his way from the Brazilian coast in 1524, and Sebastian Cabot, sailing up the Paraná in 1526, were the earliest of these pioneers to reach the area, but the first colonial settlements were established by Domingo Martínez de Irala in the period 1536–56. With Asunción as his principal base he laid the foundations of Paraguay and made it the centre of Spanish power in southeastern South America. From it were founded such cities as Santa Fé, Corrientes, and Buenos Aires, and not until the es-

DAVIS PRATT—RAPHO GUILLUMETTE

GOVERNMENT PALACE IN ASUNCIÓN, THE CAPITAL OF PARAGUAY. BUILT BY FRANCISCO SOLANO LÓPEZ IN THE LATE 1860'S, THIS BUILDING NOW HOUSES THE ADMINISTRATIVE OFFICES OF THE GOVERNMENT

tablishment of the viceroyalty of La Plata in 1776 did Asunción become a dependent city of its offspring, Buenos Aires. Irala's colonization policy involved the delimitation of the boundary with Brazil by a line of forts against Portuguese expansion, the foundation of villages, the reduction of the Guaraní to provide food, labour, and soldiers, and extensive Guaraní-Spanish intermarriage that supplied the characteristic Paraguayan mestizo population. Rapidly a national and fairly homogeneous amalgam of Indian and Spanish cultures came into being.

From early in the 17th century, for more than 150 years, Jesuit communal missions in the Alto Paraná and Uruguay basins of southeastern Paraguay governed the lives of 100,000 Indians in 32 *reducciones*. These were centres of conversion, agricultural and pastoral production, manufacturing and trade, which served also as strategic outposts against Portuguese expansion from southern Brazil. Isolated from the heart of Paraguay, which centred on Asunción, the missions became an autonomous military, political, and economic "state within a state" which increasingly excited the envy of the Spanish landowners in the Asunción area. In the period 1721–35 the latter waged a struggle to overthrow the Jesuit monopoly of Indian trade. Unaided, the *reducciones* had to defend themselves also against slave raiders from São Paulo and, in 1754–57, a combined Spanish-Portuguese attack designed to enforce a territorial partition of the mission settlements. Defiance of such powerful groups paved the way for the expulsion of the Jesuits in 1767. The *reducciones* were abandoned; the Indians were absorbed either by the landed estates or the jungle; the settlements fell into ruin; economic activity ceased; and little permanent result survived of this period of Paraguayan history.

As the power of Buenos Aires grew, the leaders of Paraguay resented the decline in their province's significance, and, although they had early challenged Spanish authority, they refused to accept the declaration of Argentine independence in 1810 as applying to Paraguay. Nor could an Argentine army under Gen. Manuel Belgrano enforce Paraguayan acceptance. Later, however, when the Spanish governor of Paraguay sought Portuguese assistance to defend the colony against further attacks from Buenos Aires, he underestimated the national spirit of the Paraguayans. They promptly deposed him and declared their independence on May 14, 1811.

After a short period of anarchy, José Gaspar Rodríguez Francia, called by the Indians "El Supremo," set up a dictatorship which he maintained from 1814 to 1840. During this period he sealed off Paraguay from the outside world and created an isolation based on ignorance and complete obedience to his rule. He forbade emigration and immigration, and maintained neither diplomatic nor commercial contacts with foreign countries. Using this policy as a means of checking the expansionist ambitions of Argentina and Brazil and foreign economic penetration, he also secured internal peace by curbing the power of the Church, of political rivals, and of education, all potential sources of opposition to him. To prevent the necessity for external trade he encouraged self-sufficiency, introducing new crops, the development of hand industries, and the establishment of a sound economic basis for the nation. This isolationist policy also helped to preserve the homogeneous character of the Paraguayan people and to strengthen their spirit of self-reliant independence.

Two more dictators followed, Carlos Antonio López (1840–62) and his son Francisco Solano López (1862–70). Francia's isolationism was abandoned; education was extended; and the nation was opened up for trade and development by foreign technicians and immigrants. Friction increased, however, with Paraguay's two powerful neighbours, Argentina and Brazil. Argentina's dictator Juan Manuel de Rosas largely thwarted Paraguayan efforts to trade by imposing an economic blockade, and a dispute also began over Paraguay's northern boundary. Aware of his country's peril the elder López strengthened the army, which his ambitious son soon found ample opportunities to use. Trained by Germans and supplied with European equipment, it became a formidable force which Argentina and Brazil thought would be used to extend the territory of Paraguay. The Paraguayans similarly feared the designs of Buenos Aires and Rio de Janeiro. The increasing domination of Uruguay by Brazil sparked off the war. López attacked Brazil and in so doing violated Argentine territory. The Triple Alliance of Brazil, Argentina, and Uruguay followed. Paraguay was invaded, but army and citizens fought a tenacious defensive war from 1865 to 1870, which ended in the death of López and more than half of Paraguay's people. Brazil annexed territory north of the Apa River, and Argentina part of the Chaco south of the Pilcomayo, and the salient of the Misiones territory between the Paraná and Uruguay rivers. Paraguay was devastated and occupied by foreign troops for six years, and its national survival was the result only of the mutual rivalries of Brazil and Argentina. Economic recovery was inevitably a slow process, and the chaotic conditions prevailing did little to encourage immigrants to rebuild the country. Political clashes, *coups d'état*, and civil wars succeeded one another, although the constitution of 1870 in theory regulated the government of the country until 1940. Two parties, the Colorados and the Liberales, emerged, but palace revolutions and military intervention decided their fortunes more often than the ballot box. Paraguayan writers participated actively in political life, and all forms of literature had a political complexion. J. S. Godoi, C. Baez, M. Domínguez, M. Gondra, F. R. Moreno, J. E. O'Leary, and the brothers Eligio and Eusebio Ayala were the leading men of letters in the golden age of Paraguayan literature which flourished at the turn of the 19th century. During World War I Paraguay was neutral, and there was some economic expansion. The period also saw the growth of a reform movement which grew in strength as the worst effects of the world economic depression were felt.

Simultaneously, increasing tension over the western boundary with Paraguay's neighbour Bolivia reached an acute stage. The vast and thinly peopled Chaco was coveted by both nations: by Bolivia as a means of securing a river exit to the Atlantic, by Paraguay in the hope of developing the region's possible petroleum resources. Both countries began constructing forts early in the 20th century, and sporadic skirmishes over many years developed into war during the period 1932–35. The military skill of the Paraguayan leader Col. José Félix Estigarribia and his small guerrilla bands finally won control of the Chaco, but at heavy cost of men and wealth. The peace of 1938, arranged by Argentina, Brazil, Chile, Peru, Uruguay, and the United States, gave Paraguay most of the disputed territory and Bolivia an outlet to the Paraguay River via Puerto Suárez.

The Chaco War not only increased the area and military prestige of Paraguay but permitted the rise of the first important movement to introduce progressive institutions. Col. Rafael Franco, leader

of a new party, which became known as the Febreristas, seized power on Feb. 17, 1936, and received wide support from many sections of Paraguay's population. By dictatorial methods lands were distributed to ex-servicemen; a labour and social welfare organization was instituted; and the raw material and industrial resources of Paraguay were nationalized. Suffering a temporary setback by army *coups d'état*, the reform movement to build a new Paraguay continued with the election of the hero of the Chaco War, Estigarribia, as president in 1939, and the promulgation of a new constitution in the following year. This gave congress greater powers to support labour reforms but maintained the authority of a strong executive. Estigarribia's plans to introduce a program of state socialism, land reform, and economic modernization were ended abruptly by his sudden death in an airplane accident.

Next governed by Gen. Higinio Morínigo, who disregarded the 1940 constitution, Paraguay reverted to its traditional path of oppressive dictatorship, one-party (Colorado) rule, the suppression of civil liberties, and the dominance of the army. In Morínigo's eight years of rule the pattern of dependence on military strength to prevent political reform from overthrowing the entrenched power of the landowners was reestablished, and Paraguay's economic dependence on Argentina was once more underlined. Morínigo did conclude treaties of economic cooperation with Paraguay's other neighbours, Brazil and Bolivia, encourage a modest industrialization of the country, and stimulate agricultural production. During his regime the Inter-American Technical and Co-operative Service for Agriculture (known by its Spanish initials STICA) under United States' auspices carried out a program of agricultural educational and experimental demonstration which raised production, improved diet, and modernized farming equipment and methods, but did nothing to break the land monopoly of Paraguay's oligarchy.

Mounting opposition to Morínigo's dictatorship led to a general strike in 1944, and this was followed by severe reprisals by the government. In 1947 the Liberales and Febreristas, supported by part of the army, raised a major revolt at Concepción and besieged Asunción. Although the rebels for a time controlled much of the country, they were forced to disband when the government seized their capital. Morínigo, faced with a split in the Colorado Party over the issue of punishment of the rebels, resigned the presidency in 1948, and a new series of *coups d'état* produced four presidents of short duration, including the distinguished writer and publisher Juan Natalicio González. In 1949 Federico Chávez, the leader of the Colorados, took over control of the country. Under him Paraguay became closely associated with the regime of Juan Perón in Argentina and its economic policies. The treaty of cooperation between the two nations, signed in 1953, revealed Paraguay's dependence on Argentina for food, transport, and trade, and provided for Argentine investment in the development of Paraguay's mineral resources. Chávez also took steps to improve health and education conditions, largely by means of a joint commission for economic development under the U.S. Point Four program, but Paraguay still remained a one-party state in which opposition forces were held in check. In May 1954 the head of the Paraguayan army, Gen. Alfredo Stroessner, seized power, and the coincident nature of military and political power, which for so long had dominated Paraguay's government, became undisguised. Stroessner's dictatorship, continued by his "reelection" in 1958, faced problems of agricultural depression, continued inflation and smouldering internal opposition to its totalitarian character. Economic cooperation with Argentina was intensified, and when Perón fell from power Stroessner gave him temporary asylum.

Economic developments in Brazil and Bolivia are tending to give Paraguay opportunities partially to overcome its long-standing dependence on Argentina, and financial, trading, and transport treaties have been concluded with these countries.

In the national elections that took place in Feb. 1963 Stroessner, the candidate of the Colorado Party, was reelected president by a margin of about eight to one, over the Liberal Party's Ernesto Gavilán. The election was the first in Paraguay in which women were allowed to vote; it also marked the first time since 1939 that Paraguayans were offered more than one candidate for the presidency. Gavilán was handicapped by lack of money for campaign funds and also by the decision of dissident groups within the Liberal and Febrerista parties to boycott the election.

V. POPULATION

The total population of Paraguay in 1962 was 1,816,890. The eastern two-fifths of the country contains 95% of the total, the vast Chaco area being inhabited by only about 65,000 people, most of whom live on the eastern margins in the lands adjacent to the Paraguay River.

The capital, Asunción, with its major suburb, Lambaré, had a population of 305,160 in 1962. There are four provincial capitals, each with a population of approximately 20,000. These are Concepción, Villarrica, Coronel Oviedo, and Encarnación. Concepción is the only large nucleus of settlement in the northern half of eastern Paraguay. Most Paraguayans live in a belt of territory about 50 mi. in width stretching east and south from Asunción toward Encarnación via Coronel Oviedo and Villarrica, and served by the major railway system of the country.

Area and Population of Departments

Department (capitals in parentheses)	Area (sq.mi.)	Population (1962)	Density (per sq.mi.)
Capital (Asunción) and Lambaré	77	305,160	3963.1
Alto Paraná (Hernandarias)	7,817	26,680	34.1
Amambay (Pedro Juan Caballero)	4,994	33,782	67.6
Boquerón (Mariscal Estigarribia)	64,876	42,223	00.7
Caaguazú (Coronel Oviedo)	8,345	123,590	14.8
Caazapá (Caazapá)	3,667	91,807	25.0
Central (Ypacaraí)	1,024	204,719	199.9
Concepción (Concepción)	6,970	86,336	12.4
Cordillera, La (Caacupe)	1,910	189,041	99.0
Guairá (Villarrica)	1,236	114,297	92.5
Itapúa (Encarnación)	6,380	151,038	23.7
Misiones (San Juan Bautista)	3,025	59,454	19.7
Neembucú (Pilar)	5,355	58,621	10.9
Olimpo (Fuerte Olimpo)	7,882	3,362	00.4
Paraguarí (Paraguarí)	3,187	204,220	64.1
Presidente Hayes (Villa Hayes)	22,579	31,572	01.4
San Pedro (San Pedro)	7,723	90,991	11.8
Total	157,047	1,816,890	11.6

The population of approximately 500,000 before the Paraguayan War (War of the Triple Alliance, 1865–70) was reduced to less than half that number at the end of the conflict, only 13% of whom were men. The recovery in numbers and sex ratio was slow, as the gain by immigration was sporadic and slight. Political and economic dislocation also caused a persistent current of emigration, and the Chaco War, 1932–35, was a further drain on numbers. With a fairly high birth rate and reductions in infant mortality, population increases by about 50,000 annually.

VI. ADMINISTRATION AND SOCIAL CONDITIONS

The constitution of 1940 provides the nation with strong executive power, with the legislature occupying a subordinate role. Both the president and house of representatives are elected by direct suffrage for five-year periods. There is also an advisory council of state whose members are appointed and dismissed by the president. Although in theory capable of a democratic interpretation, the constitution has always been managed to ensure the dominance of the Colorado Party, and elections have been totalitarian in character.

Administratively, the Paraguay River divides the nation into an Oriental (eastern) and an Occidental (Chaco) section. The latter is subdivided into three large departments, and the smaller but more important eastern section into 13 departments. The subdivisions of the departments are known as *partidos* or rural districts. Each unit, including the capital, is under the direct control of the central government, local government being nonexistent. *Partidos* are made up of a number of *compañías*, usually with Guaraní names, and the people in these units have a regional consciousness of belonging to a kin group.

Import and export taxes provide about one-third of the nation's revenue. They were once the principal source of governmental income, but profits and income taxes are now more important. Categories subject to these taxes are those involved in commerce, industry, finance, pastoral farming, and real estate, but arable farming, the professions, public service, and manual labour are exempt. There is little indirect taxation.

BY COURTESY OF PAN AMERICAN UNION

WORKMEN LOADING QUEBRACHO LOGS

The extract obtained from the wood of the tree from the eastern Chaco Boreal region is one of Paraguay's chief exports

Although the capital and larger towns have a large proportion of adequate housing and public services, living conditions in the rural areas, where most Paraguayans live, are for the most part primitive. Adobe huts roofed with reeds and with earthen floors house most of the workers. Water supply is derived from communal wells, and sewage systems are nonexistent. As there is much subsistence farming, money wages frequently have no significance, but the national income per capita averages about $84 per year. Skilled workers are in short supply as they can easily emigrate to Argentina where they can earn higher wages. Inadequate shelter in the winter months results in the Paraguayan's susceptibility to influenza, pneumonia, and tuberculosis, which are the principal causes of death. There are about 500 physicians, but fewer than half of these provide the entire medical service for the whole nation outside Asunción. Some hospitals have been set up in one or two provincial towns, but most facilities are concentrated in the capital. Voluntary organizations have started to work to end leprosy, and an inter-American cooperative service has begun to combat tuberculosis.

Social welfare legislation, first introduced in 1943 and extended in 1950, theoretically provides free medical attention; accident compensation; sickness, maternity, and funeral benefits; and old-age pensions. There is no unemployment insurance, but compensation for dismissal is a partial replacement. Trade unions are weak and strikes illegal.

Justice is administered by a supreme court of three members and by judges and magistrates in local areas. All are appointees of the president, as are the *comisarios*, or police chiefs, who are the principal officials of the *partidos*. Almost as much is spent on the police services as on education.

Primary education is compulsory and free, but there is inadequate financial provision to make this possible. About 40% of the children do not attend school and, as a consequence, there is much illiteracy. Secondary education is supplied by the state *colegios*, by private schools in Asunción, and by vocational and technical schools. Asunción university has more than 2,000 students, the faculties of medicine and law being the largest.

Defense absorbs the greatest part of the budget, more than one-third of the total. Military service is compulsory for all Paraguayan men. Besides an efficient army there are national and territorial guards, a small air force, and river patrol gunboats.

VII. THE ECONOMY

1. Production and Trade.—Most of Paraguay's people live by subsistence farming, pastoralism, and forestry. The economy is essentially a peasant one, each *chacra*, or farm, growing such crops as corn (maize), vegetables, sugarcane, and tobacco, and keeping cows and poultry. Many farmers are squatters on land held by absentee landlords, and when the fertility of a plot is exhausted the land is often abandoned for a new clearing in the forest. Sometimes a farmer's income is supplemented by providing labour on a ranch or selling surplus products in a nearby town. Methods and equipment are still largely primitive but STICA, an experimental and advisory service organized in 1943, has done much to improve agricultural production. Cassava (manioc) and corn occupy the greatest acreage, but cotton, tobacco, and vegetable oils are the principal cash crops. Petitgrain oil, distilled from sour-orange leaves, is a specialty, and maté (Paraguayan tea) is grown mainly for domestic consumption. Cattle raising is a traditional occupation, but some ranches are now being partially converted to cropland. Forest operations are widespread, and although most of the wood is cut for fuel, nearly half of all Paraguay's exports are forest products. These are mainly quebracho extract from the Chaco and cedar from the upper Paraná forests. Exploitation is hindered by lack of modern transport and equipment, but there is little reafforestation.

The country is poor in mineral resources. Even the petroleum potentialities of the Chaco have so far failed to materialize, in spite of several years of exploratory drilling. The hydroelectric power resources of the Paraná are considerable but are distant from population centres. Most electricity production is concentrated in Asunción where wood and oil-burning thermoelectric plants provide power for Paraguay's limited industrial structure. There are factories manufacturing cotton textiles and consumer goods such as shoes, cigarettes, rum, sugar, matches, and soap. Others preparing wood, petitgrain oil, quebracho extract, and meat for export are located near supplies of raw materials.

Canned meat and meat products, wool and hides, quebracho extract, timber, and cotton account for 85% of the exports, but relative amounts of each vary considerably from year to year. The United States, Argentina, and Uruguay are Paraguay's main customers, and with the U.K. and Western Germany supply about 75% of the imports, which consist mainly of textiles, wheat, tinplate, vehicles, machinery, petroleum, chemicals, and paper.

2. Finance.—The currency unit is the guaraní. Persistent inflation has led to its repeated devaluation, and in the early 1960s the exchange rate was more than 120 per $1.00 U.S. There is an elaborate system of subsidies, surcharges, and multiple exchange rates to maintain a favourable balance of trade, but there is much trade which avoids customs or exchange control, as is almost inevitable in such a river-bounded state. The Banco Central exercises the central banking functions of the nation, the commercial banks being the Banco del Paraguay and Argentine, Brazilian, and British institutions. Exchange reserves are extremely limited, but the Export-Import Bank of Washington has helped to finance road construction and a water supply for Asunción, while the International Bank for Reconstruction and Development has supported agricultural development. Argentina, the United States, and the United Kingdom have considerable investments in Paraguay,

mainly in railways, land, and the quebracho, cattle, and meat industries.

3. Communications.—The Central Paraguayan railway, from Asunción to Encarnación, serving the most densely populated region and connecting with the Argentine network by river ferry at Posadas, is the only main railroad system. Narrow-gauge lines serve the quebracho forest lands of the Chaco, the longest leaving the Paraguay River at Puerto Casado. Over much of eastern Paraguay roads are earth tracks, but a trunk road system is slowly being developed, especially east and south of the capital. Except for some strategic roads the Chaco is roadless. Nearly all external trade is carried by river steamers on the Paraná and Paraguay, involving expensive transshipment of goods at Buenos Aires. Most of this traffic is in Argentine-owned boats, but Dutch and British cargo ships now connect Asunción directly with Europe. The capital, benefiting from its central position, has become an important junction for international airlines. There is a government-operated telephone service, with external radiotelegraph connections.

See also references under "Paraguay" in the Index. (G. J. B.)

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Current history and statistics are summarized annually in *Britannica Book of the Year.*

PARAGUAYAN WAR (1864–1870), a conflict that pitted Brazil, Argentina, and Uruguay against landlocked Paraguay. The war had three principal roots: (1) long-standing disputes between the several countries over their boundaries and rights to navigation on the great rivers of the region; (2) the meddling of each country in the internal politics of its neighbours, particularly in faction-torn Uruguay; and (3) the ambition of the Paraguayan dictator, Francisco Solano López (*q.v.*), to extend his own and his nation's fame and power.

The initial acts of war included a Brazilian attack in August 1864 on Uruguay; the Paraguayan seizure of a Brazilian river vessel in November 1864; the attack by López on the Mato Grosso region of Brazil in December 1864; and a second attack by López, this one on the Argentine province of Corrientes in April 1865 after the Argentine government had refused his formal request for permission to cross Argentine territory in order to attack Uruguay. On May 1, 1865, Uruguay joined Brazil and Argentina in the Triple Alliance against Paraguay.

López' army, numbering perhaps 50,000, was probably the strongest in Latin America, and in addition Paraguay was shielded by the Paraná and Paraguay rivers. At the confluence of those rivers was the powerful Paraguayan fortress, Humaitá. López lost many troops in his first attacks against the Triple Alliance, and in a naval action fought in June 1865 he lost control of the Paraná and Paraguay rivers as far north as Humaitá. But not until January 1869, after a bloody siege resulted in the capture of Humaitá, were the allies able to conquer Asunción, the Paraguayan capital.

In addition to the fierce resistance of the Paraguayan soldiers, the allied attack had been slowed by disunity, defective command, and disease. In January 1868, partly because of pressing political conditions in Buenos Aires and partly because victory had escaped him, the Argentine general and president, Bartolomé Mitre, had turned over the allied ground command to the Brazilian Marquis de Caxias, whose forces by then comprised the bulk of the attacking army and navy. The Paraguayan people suffered desperately during the war, not only from the enemy but from malnutrition, disease, and the fearful domination of López, who ordered uncounted numbers of his countrymen tortured and killed in his savage effort to drive them to victory.

Prior to the fall of Asunción, López and the remnant of his army, mostly boys and old men, retreated northward. In March 1870 the allies succeeded in defeating and killing him.

For the allies, the principal result of the peace treaty (June 1870) was the acquisition by Argentina and Brazil of a total of approximately 55,000 sq.mi. of territory, including, for Argentina, much of the present Misiones region and part of the Chaco lying between the Bermejo and Pilcomayo rivers. Brazil occupied Paraguay until 1876, but the large reparations which the latter had agreed to make were never paid by the devastated nation. The greatest price which Paraguay paid was the manhood of the nation: of perhaps 250,000 male inhabitants of Paraguay prior to the war, only 28,000 remained in 1871.

See P. H. Box, *The Origins of the Paraguayan War* (1927); H. G. Warren, *Paraguay, an Informal History* (1949). (T. F. McG.)

PARAGUAY RIVER (Port. RIO PARAGUAI), chief tributary of the Paraná, rises in the Brazilian state of Mato Grosso on the south slope of the Serra dos Parecis and flows southwest and then south for a total of 1,584 mi. (2,549 km.). It is an important artery of the Plate river system serving the interior of South America.

See PLATA, RÍO DE LA.

PARAÍBA, a state of northeast Brazil, bounded on the north by Rio Grande do Norte, on the east by the Atlantic, on the south by Pernambuco, and on the west by Ceará. Area 21,765 sq.mi. (56,371 sq.km.). Pop. (1960) 2,018,023. The chief city and capital is João Pessoa (*q.v.*) with its port Cabedelo. Other important towns are Campina Grande, Cajazeiras, and Patos.

Climate and original vegetation divide Paraíba into two contrasted areas. Along the coast and inland as far as Campina Grande is an area that receives rain each year and was once covered by dense forest. West of Campina Grande is the land of uncertain rainfall, semiarid at best, which was once covered by a deciduous, thorny, scrub woodland called caatinga. In the zone of the caatinga there are only small "islands" of abundant rains and forests on the tops of the higher mountains. There is no coastal plain, but behind a zone of coastal mesas (*taboleiros*) there is a hilly upland known as the Borborema which occupies most of the eastern part of the state. Farther inland Paraíba shares with Ceará the broad plains with erosion remnants.

Originally settled in 1584 as the captaincy of Itamaracá, Paraíba shared in the sugarcane wealth of that period. It still produces some sugar, but cotton, sisal, oiticica oil, goat skins, and minerals are more important. The clearing of the backlands (*sertão*) has produced severe floods and droughts, so that settlement in the caatinga is dependent on irrigation. The federal government built a number of reservoirs, but because of the hilly land, irrigated crops are raised only around the margins of the lakes. Old spellings of the name of the state are Parahyba, Parahiba, or Parahyba do Norte. (P. E. J.)

PARAKEET: *see* PARROT.

PARALDEHYDE (also called paracetaldehyde and paraldehydum), a colourless liquid of disagreeable taste and pungent odour, used in medicine as a hypnotic and sedative and in chemistry as a starting material in the manufacture of organic chemicals. When administered as a medicine, it is largely excreted by the lungs and gives an unpleasant odour to the breath. It is produced for commerce by polymerizing acetaldehyde with a trace of sulfuric acid; with the concentrated acid this reaction is accompanied by the generation of considerable heat. The resulting liquid is neutralized with calcium carbonate and purified by fractional distillation. Paraldehyde, which has the formula $C_6H_{12}O_3$, boils at 124° C and melts at 12.5° C.

See also ALDEHYDES AND KETONES.

PARALIPOMENON, BOOKS OF: *see* CHRONICLES, BOOKS OF THE.

PARALLAX is the difference in direction of an object caused by a change in the position of the observer. This method is used in astronomy as the direct way of measuring the distance of a

celestial body. At the level of theory, the measurement of the distance to an inaccessible point is an elementary exercise in geometry. From a known baseline with known base angles, the apex angle can be arrived at through geometrical proof. This apex angle is the parallax. When the parallax is known, the two sides of the triangle formed by two set points of observation and the object can be calculated. Though this seems straightforward, it is nevertheless difficult when applied to the delicate problem of determining celestial distances because the baseline must be sufficiently long enough to provide the geometrical construction of triangles that will allow precise measurement.

The parallaxes of the sun and the moon are defined as the difference in direction as seen from the observer and from the earth's centre. In fig. 1 let O be the observer on the surface of the earth, E the centre of the earth and M the position of the moon; then the angle OME is the parallax. This varies with the altitude of the moon. If the moon is directly overhead, the parallax is zero, and it is greatest when the body is at the horizon, when z equals 90°. At an angular distance z from Z we find from the triangle OME that $\sin p = a/r \sin z$. When $z = 90°$, $\sin p = a/r$ and this value is called the horizontal parallax or briefly, the parallax. For all bodies except the moon, p is so small that it does not differ appreciably from $\sin p$ and it is usually expressed in angular measure.

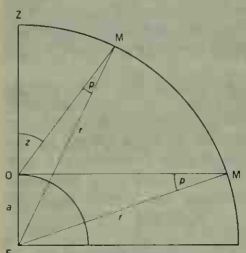

FIG. 1.—CHANGE OF PARALLACTIC ANGLE WITH ALTITUDE

A further refinement is required because of the spheroidal figure of the earth and the numerical values generally given are those of the equatorial horizontal parallax.

Lunar Parallax.—The moon, being by far the nearest of the celestial bodies, was the first to have its parallax determined. Hipparchus (150 B.C.) determined the moon's parallax to be 58′ or at a distance of approximately 59 times the earth's equatorial radius as compared with the modern value of 60.2 times.

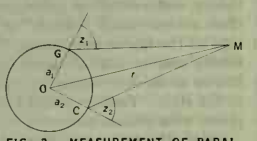

FIG. 2.—MEASUREMENT OF PARALLAX BY OBSERVATIONS FROM A NORTHERN AND A SOUTHERN OBSERVATORY

Parallax of the moon is directly determined from observations (*see* fig. 2) made at two places such as G, Greenwich, Eng., and C, the Cape of Good Hope, which are nearly on the same meridian. Angles z_1 and z_2 are observed and other data are obtained from the latitude of the observatories and the known size and shape of the earth. In practice, stars are observed in positions near the moon to eliminate uncertainties of refraction and instrumental errors. In this way T. Henderson obtained a value of 57′2″.3 for the moon's equatorial horizontal parallax in 1837. From a series of observations of a small lunar crater (1905–10) the value 57′2″.5 was found.

A second method rests on a comparison of the force of gravity at the earth's surface with its value at the moon. If M and m are considered the masses of the earth and moon, r the mean distance, P the sidereal period of revolution of the moon about the earth and k the constant of gravitation, $M + m = 4\pi^2 kr^3/P^2$ where $\pi = 3.14$. Also, g, the value of gravity at the earth's surface, determined accurately from pendulum observations $= kM/a^2$. Hence

$$\left(\frac{a}{r}\right)^3 = 4\pi_2 \frac{M}{M+m} \cdot \frac{a}{gP^2}.$$

As the quantities on the right-hand side are known with great accuracy, a/r is accurately determined as 57′2″.7.

Solar Parallax. Trigonometrical Methods.—In accordance with the law of gravitation the relative distances of the planets are known, and tables of their positions and movements take the distance of the sun from the earth as the unit of length. The measurement of the distance or parallax of any one of the planets will determine the value of this unit. The smaller the distance of the planet, the larger the parallactic displacements to be measured, with a corresponding increase in accuracy of the determined parallax. The most favourable conditions are therefore provided by the observation, near the time of opposition, of planets approaching close to the earth. The determination can be based either on simultaneous or nearly simultaneous observations from two different places on the earth's surface; or on observations made after sunset and before sunrise at the same place, when the displacement of the place of observation produced by the rotation of the earth provides the baseline for the measurements.

The first reasonably accurate determination of the sun's parallax was made in 1672 from observations of Mars at Cayenne, French Guiana, and Paris, France, where a value of 9″.5 was obtained. Venus can approach nearer to the earth than Mars can, but it is then between the sun and the earth. Edmund Halley in 1679 therefore suggested the utilization of the transits of Venus across the sun's disc. The transits of 1761 and 1769 were extensively observed by astronomers dispatched to various parts of the world, but the results were disappointing because of the impossibility of determining with sufficient precision the times of the planet's ingress and egress. The transits of 1874 and 1882 were widely observed for the same purpose, but it proved impossible to secure uniformity of judgment on the part of the observers, and the results fell far short of expectations.

In 1877 Sir David Gill made an expedition to Ascension Island and observed the opposition of Mars, using a heliometer to measure the distance of the planet from neighbouring stars, making observations after sunset and before sunrise. A value of 8″.78 was deduced. The successful result of this series of observations led Gill to make an elaborate series of heliometer observations of the small planets, Victoria, Iris and Sappho, in 1888–89; the starlike images of these small planets are favourable for accurate measurement. The resulting value of the solar parallax was 8″.80.

In 1898 the small planet Eros was discovered; it has an orbit so elliptical that at its nearest approach Eros comes within about 15,000,000 mi. of the earth. The opposition of 1901 (when the least distance was less than 30,000,000 mi.) was extensively observed at many observatories and gave a value for the solar parallax of 8″.804. A more favourable opposition occurred in 1931 when the least distance was only 16,000,000 mi. From observations made photographically at observatories in both hemispheres, Sir Harold Spencer Jones derived a solar parallax of 8″.790 ± 0″.001. This parallax corresponds to a distance of 93,005,000 mi.

Methods Depending on Velocity of Light.—The value of the velocity of light has been determined with very high precision and may be utilized in several different ways. A direct method is the converse of the procedure of Ole Roemer in the discovery of the velocity of light; *i.e.*, to use the light equation, or time taken by the light to reach us at the varying distances of Jupiter. Great accuracy is hardly obtainable in this way. A second method is by means of the constant of aberration which gives the ratio of the velocity of the earth in its orbit to the velocity of light. As aberration produces an annual term of amplitude 20″ in the positions of all stars its amount has been determined in numerous ways. Observations made at Greenwich in the years 1911 to 1936 gave the value 20″.489 ± 0″.003 leading to the value 8″.797 ± 0″.013 for solar parallax. This method is not free from the suspicion of systematic error.

The velocities of stars toward or from the earth are determined from spectroscopic observations. By choosing times when the orbital motion of the earth is carrying it toward or from a star, the velocity of the earth in its orbit may be obtained. In this way the solar parallax was found from observations at the Cape of Good Hope to be 8″.802 ± ″.004.

Gravitational Methods.—In the theory of the moon there is a term of period one month known as the parallactic inequality. The coefficient of the term contains the ratio of the parallaxes of the sun and moon as a factor. The large size of this coefficient makes it of value. From the discussion of occultations of

stars from 1672 to 1908, Spencer Jones found the value 125".023 ± 0".033 for this term giving for the solar parallax 8".796 ± 0".004.

The ratio of the mass of the earth + moon to that of the sun may be determined from the disturbing action of the earth + moon on the elliptic motion of the planets. The ratio of the moon's mass to that of the earth is 1/81.53, and thus the ratio of the earth's mass to that of the sun is found. In a manner similar to that described above for the moon's parallax the solar parallax is then derived. From an exhaustive discussion of the perturbations of the planet Eros from its discovery in 1898 up to and including the favourable opposition of 1931, Eugene Rabe made a very accurate determination of the solar parallax as 8".7984 ± 0".0004.

Stellar Parallax.—The stars are too distant for any difference of position to be perceptible from two places on the earth's surface; but as the earth revolves 93,000,000 mi. from the sun, stars are seen from widely different viewpoints during the year. The effect on their positions is called annual parallax, defined as the difference in position of a star as seen from the earth and sun. Its amount and direction varies with the time of year, and its maximum is a/r where a is the radius of the earth's orbit and r the distance of the star (fig. 3). The quantity is very small and never reaches 1/206,265 in radian or 1" in sexagesimal measure. Unsuccessful attempts to measure the parallax of a star were made continuously after the acceptance of the Copernican system, including one by James Bradley which led to the discovery of aberration (*see* ABERRATION [OF LIGHT]) and by Sir William Herschel which led to the discovery of binary stars. The first successful results were obtained in 1838 when the parallax of α Centauri was announced by Henderson, α Lyrae by Friedrich von Struve and 61 Cygni by F. W. Bessel. For his observations Bessel used the heliometer. He found the parallactic shifts of 61 Cygni relative to two neighbouring stars which from their magnitude and small proper motions were judged to be so distant that no parallactic effect could be perceived. With instruments of this kind having small object glasses of not more than 4 or 6 in. and focal lengths of a few feet, research on stellar parallax was carried on to the end of the 19th century and the parallaxes determined of approximately 75 of the brightest stars and those showing the largest proper motion.

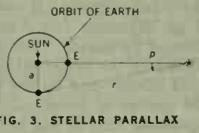

FIG. 3. STELLAR PARALLAX

The introduction of photography at the beginning of the 20th century simplified the problem, and a number of observatories engaged in the work and determined the parallaxes of many stars with great accuracy. Two observational conditions have to be fulfilled: (1) the telescope must be in the same position for observations at different times of the year; (2) by some means (*e.g.*, a rotating shutter with a suitable slit) the photographic image of the star observed must be made equal to that of the stars with whose position it is compared. In practice, a few photographs are taken when the star is on the meridian shortly after sunset at one period of the year and shortly before sunrise at another period. As the stars' positions change as a result of their proper motion, a minimum of three epochs is required, but the possibility of systematic errors makes it desirable to extend the observations over a larger number of epochs. With 25 photographs spread over five epochs, the parallax of a star is obtained with a probable error of less than ±0".010, although the diameter of the photographic disc of the star is seldom less than 2".0. The concerted action of observatories in the northern and southern hemispheres resulted in the determination of the parallaxes of about 6,000 stars, about equally divided between stars north and south of the equator. These include most of the stars brighter than 6m.0 and many fainter stars whose comparative nearness is suggested by their proper motions.

The unit in which stellar distances are expressed by astronomers is the distance of a star whose parallax is 1". This is called a parsec and is equal to 206,265 times the earth's distance from the sun or approximately 19,000,000,000,000 mi. One parsec is equal to 3.26 light years.

The star with the largest known stellar parallax 0".76, is α Centauri. Fifty-six stars are known within a distance of 10 parsecs from the sun. These stars include the bright stars α Centauri, Sirius, Procyon and Altair, but the majority are faint telescopic objects. While 30 stars are single, 20 belong to double-star systems and 6 are grouped into 2 triple systems, of which α Centauri is one.

For the more distant stars, trigonometrical methods are inapplicable, but the parallax can be derived from the apparent magnitude of the star, if there are any means of knowing the absolute magnitude of the star; *i.e.*, the magnitude the star would have at the standard distance of ten parsecs. For Cepheid variables this can be inferred with considerable accuracy from their periods, and for many stars a reasonable guess can be made from the spectral type and proper motion. The formula connecting absolute magnitude and apparent magnitude with parallax is $M = m + 5 + 5\log\pi$ and expresses the condition that the light received from a star varies inversely as the square of the distance.

Spectroscopic Parallaxes.—The spectra of nearly all stars can be grouped into a small number of classes, which form a continuous sequence varying with the effective (surface) temperatures of the stars. The Henry Draper classification, using the letters O–B–A–F–G–K–M, is generally adopted, usually in combination with a decimal subdivision for refined work.

Empirical studies show that the spectra of the stars also include important clues to their true luminosities. A. Maury noticed that stars of the same spectral class often had marked differences in line sharpness; E. Hertzsprung found that the sharp-lined stars were intrinsically brighter than the broader lined objects. In 1914, W. S. Adams and A. Kohlschütter established the spectroscopic differences between giant and dwarf stars of the same spectral type and laid the foundation for the determination of spectroscopic parallaxes. These differences, depending upon the intrinsic brightness of the star, allow an estimate of its absolute magnitude, and the parallax can then be deduced by means of the formula given above. This method has been applied extensively to most of the brighter stars in the northern hemisphere, using stars of known parallax as standards.

In *An Atlas of Stellar Spectra* (1943) W. W. Morgan, P. C. Keenan and E. Kellman at the Yerkes observatory set up a two-dimensional classification system of stellar spectra which was universally adopted and greatly improved the accuracy of spectroscopic parallaxes. The Yerkes system of classification assigns a precise system of Draper classes and five luminosity classes, using the Roman numerals I to V, dividing the stars into supergiants, bright giants, subgiants and dwarf stars, dependent upon intrinsic brightness, as determined from the spectral lines most sensitive to this property. These luminosity classes are then calibrated in terms of absolute magnitude. While for the dwarf stars the calibration of absolute magnitude can be obtained directly by the trigonometric method, the calibration of the other classes must be established indirectly on the basis of distances obtained from statistical methods.

Dynamical Parallaxes.—If the relative orbit of a visual binary system is known, the following relation connects the combined mass, M, of the two stars expressed in the sun's mass as unit, the orbital period, P, expressed in years, the semimajor axis of the relative orbit, a, expressed in seconds of arc and the parallax p:

$$p = a/\sqrt[3]{MP^2}.$$

Both a and P are known but not M; it will be noted that an error in the value of M gives rise to a much smaller error in p. Thus, for instance, increasing M by a factor of 8 only halves the value of p. The value of p obtained by assuming the combined mass to be equal to the mass of the sun is called the hypothetical parallax.

In many visual pairs the complete orbit has not been observed. If s denotes the apparent distance in seconds of arc, w the relative motion in seconds of arc per year, a hypothetical parallax can be derived from the formula

$$p = 0.418 \sqrt[3]{sw^2}$$

By use of the relationship between mass and luminosity of a star, it is possible, knowing the spectral type of the star, to derive a correcting factor which will give a more accurate value of the parallax. Parallaxes so determined are called dynamical parallaxes. Details are given in *The Masses of the Stars* by H. N. Russell and Charlotte E. Moore (1940), which lists the dynamical parallaxes of 166 binaries with determined orbits and of 2,363 pairs showing relative motion.

Average Parallaxes.—The solar system is moving through space with a velocity of 19.5 km./sec., carrying it four times the earth's distance from the sun in one year. This produces a general drift in the angular movement of the stars away from the apex or point in the sky to which the movement is directed. Were the stars at rest, this would give a ready means of determining their individual distances. As the stars are all moving, the method gives the average distance of a group of stars examined, on the assumption that their peculiar motions are eliminated. In this way the mean parallaxes of stars of successive apparent magnitudes of different galactic latitudes and of different spectral types are obtained. Thus the mean parallax of 5th magnitude stars (*i.e.*, of stars just visible to the naked eye) is 0″.018; and of the 10th magnitude stars (*i.e.*, of stars giving $\frac{1}{100}$ of their light) is 0″.0027.

As spectroscopic observations have given the mean peculiar velocities of stars of different types, the average proper motions perpendicular to the direction of the solar motion may also be used as a criterion of parallax. There is great diversity in the parallaxes of individual stars included in these mean values.

See also references under "Parallax" in the Index.

(F. D.; H. S. Js.; K. A. Sd.)

PARALYSIS (Palsy), a medical term usually implying the loss or impairment of voluntary muscular power. This article deals with paralysis from organic disease, including injuries; for paralysis from psychiatric causes, *see* Hysteria.

The different forms of paralysis arising from organic disease can be understood best in terms of the site of the impairment of function within the parts of the body responsible for voluntary movement. There follows therefore, first, a general account of the anatomy of the motor system, and then a survey of some of the more common diseases that affect parts of this system.

The Motor System.—This system includes certain parts of the nervous system and the bodily musculature. Although the anatomy of the muscles is relatively uniform, and their function is more or less apparent from observation of the body in action, the motor portions of the nervous system are concealed and anatomically complex. The pathway over which nerve impulses governing volitional movement must pass consists of two main components, an upper and a lower. The upper has its origin in the giant pyramidal nerve cells of the precentral convolution of each hemisphere of the brain. These nerve cells, or neurons, give rise to long processes (nerve fibres) that descend to end in relation to the neurons of the lower component, located in the brain stem and spinal cord. The long descending fibres of the upper motor neurons are collected together in compact bundles known as the pyramidal tracts. The spinal portion of the lower component of the motor pathway consists of neurons located in the anterior columns or horns of gray matter that extend throughout the length of the spinal cord. The nerve fibres that originate from these anterior horn cells emerge from the spinal cord in the ventral roots and are distributed to the muscles of the trunk, neck, and limbs by the spinal nerves. The neurons of the brain stem, or bulbar portion of the lower component, are arranged in anatomically and functionally distinct collections, or nuclei, and give rise to nerve fibres that are distributed by the motor cranial nerves to the ocular muscles and the muscles of the jaws, face, palate, pharynx, vocal cords, and tongue. Nerve impulses governing voluntary movement originate in upper motor neurons, are transmitted from these to lower motor neurons, and thence to muscles. Although this concept of a motor system consisting of three elements—upper and lower motor neuron and muscle—is somewhat artificial, it is most useful in the differential diagnosis of the wide variety of diseases that produce paralysis.

The most important anatomical factors that determine the extent and distribution of paralysis from diseases of the nervous system are the relationships of the neural pathways to each other and to the two sides of the body. The two components of the neural pathway are bilaterally symmetrical. With few exceptions, lower motor neurons innervate muscles on their own side of the body. The relationship between upper and lower motor neurons, however, is more complex. Most of the fibres of each pyramidal tract that enter the spinal cord undergo a massive crossing at the lower end of the brain stem, known as the pyramidal decussation, and terminate, therefore, in relation to anterior horn cells of the opposite side. For this reason, the motor outflow to the limbs on one side of the body originates from the opposite side of the brain. On the other hand, the motor nuclei on each side of the lower brain stem, or bulb, that innervate the muscles responsible for chewing, speaking, and swallowing receive upper motor nerve fibres derived from both pyramidal tracts. Some of the motor neurons in the brain stem, however, such as those that innervate the lower facial muscles, do not have bilateral pyramidal connections, but, like the anterior horn cells of the spinal cord, receive upper motor nerve fibres chiefly or solely from the opposite pyramidal tract. (The neural mechanisms that control eye movements form a special case because of their great complexity.)

The pyramidal tracts extend from the cerebral cortex to the lower end of the spinal cord, and their extraordinary length alone is an important factor in the frequency with which they are affected by disease. The distribution of paralysis resulting from disease of the pyramidal tracts is accounted for by the side and level affected and by the peculiarities of their connections with the system of lower motor neurons. A lesion implicating the pyramidal tract in one hemisphere of the brain, for example, results in hemiplegia (*i.e.*, paralysis of the muscles of the lower face, arm, and leg) on the opposite side. There is little or no disturbance in speaking, chewing, or swallowing, since the muscles responsible for these functions are innervated from bulbar nuclei having bilateral pyramidal connections. It is as if a factor of safety in the form of a double mechanism were provided for the vital function of swallowing. For the same reason, although the corner of the mouth on the affected side of the body droops from paralysis of the lower facial muscles, there is little or no weakness in those of the upper part of the face, which wrinkle the forehead and close the eye. On the other hand, disease of both pyramidal tracts above the level of the bulb produces not only bilateral hemiplegia but also difficulty in speaking, chewing, and swallowing from weakness or paralysis of the muscles of the jaws, palate, pharynx, vocal cords, and tongue. This is known as pseudobulbar palsy. The term "bulbar palsy" refers to paralysis of these muscles from disease of the corresponding lower motor neurons, either within the bulb itself, as in bulbar poliomyelitis, or affecting their peripheral processes, as in some forms of polyneuritis.

Throughout most of their descent within each cerebral hemisphere, the pyramidal tracts of the right and left sides are widely separated from each other. In the brain stem and spinal cord, however, they are confined within a small space, and both are likely to be damaged even by asymmetrically placed lesions. If the level affected is in the brain stem, or high in the spinal cord, all four limbs will be weak, while a lesion below the cervical segments of the cord will produce paralysis of both legs (paraplegia).

Aside from the extent and distribution of paralysis, there are other associated signs and symptoms that depend on which of the three elements of the motor system is diseased. When paralysis is a result of damage to upper motor neurons, for example, there is an associated increase in the tone of the muscles involved, which is manifested by stiffness, or spasticity, and by an increase in the activity of the tendon reflexes. This is a determinant of disability as well as a clue to diagnosis, for weakness and spasticity do not necessarily parallel one another in degree, and often the major source of disability in a mildly weakened limb is severe spasticity. In hemiplegia, the spasticity is usually greatest in antigravity muscles and contributes to the typical hemiplegic posture and gait, with the upper limb held close to the body at the shoulder and flexed at the elbow, wrist, and fingers, and the leg

maintained in rigid extension at the knee.

When paralysis arises from disease of lower motor neurons or of muscles, the tone of the affected muscles is decreased, and the tendon reflexes are diminished or abolished. Paralysis of this kind is known as flaccid paralysis in contrast with the spastic paralysis of upper motor neuron disease. Two further attributes of lower motor neuron paralysis are: (1) wasting, or atrophy, of the weakened muscles and (2) fasciculations. Atrophy is also a more or less regular accompaniment of primary muscular diseases. Although a certain degree of wasting of muscle mass from disuse may occur in long-standing, severe paralysis from pyramidal tract disease, this never reaches the proportions possible in lower motor neuron and muscle disorders. Fasciculations are spontaneous twitchings, or contractions, of small groups of muscle bundles visible as a rippling play of activity in muscles beneath the skin. They are almost exclusively a sign of lower motor neuron disease and are most prone to occur in slowly developing lesions that affect the cell bodies of motor neurons within the brain stem or spinal cord rather than their peripheral processes. They are sometimes seen, however, in health, especially after muscular exertion and in elderly persons, for reasons that are unknown.

One other characteristic of the lower motor neuron has important clinical implications—the capacity of its peripheral process to regenerate, provided the cell body is intact. This is true of all nerve fibres, both motor and sensory, that lie outside the central nervous system. Paralysis from peripheral nerve affections, such as injury or neuritis, therefore, is not necessarily permanent. This capacity to regenerate is not a property of central nerve fibres, and destructive processes within the central nervous system produce irreversible results. (*See* also BRAIN; NERVE; NERVOUS SYSTEM; NERVE CONDUCTION; SPINAL CORD; SYNAPSE.)

Diseases that Produce Paralysis.—Most of the commonly encountered diseases that produce paralysis can be divided into two main groups depending on whether they (1) entail structural alterations in nervous or muscular tissue or (2) lead to metabolic disturbances in neuromuscular function.

Of the diseases that produce destructive changes in the motor system, some act in a systematic way and affect one of its three elements more or less extensively and exclusively. More often, however, one element or neighbouring portions of two of the three elements are involved over a limited extent by a single focal lesion.

The most common cause of hemiplegia is damage to the pyramidal tract in one hemisphere of the brain from obstruction (blood clot or thrombosis) or rupture (cerebral hemorrhage) of a major cerebral artery. (*See* STROKE; THROMBOSIS AND EMBOLISM.) Brain tumour is another but less common cause of hemiplegia. In contrast with the apoplectic onset of hemiplegia of vascular origin, hemiplegia from a brain tumour develops and increases in severity gradually over a period of weeks or months. Regardless of its nature, when the lesion is in the left hemisphere in a right-handed person, the resulting right hemiplegia is often associated with one of the various forms of aphasia (*see* SPEECH DISORDERS: *Aphasia*).

Bilateral hemiplegia with pseudobulbar palsy results from diffuse, bilateral brain disease such as occurs at times in severe cerebral arteriosclerosis or cerebral vascular syphilis. The terms "cerebral palsy" and "spastic diplegia" refer to bilateral hemiplegia resulting from prenatal developmental brain defects or from injury to the brain at birth. The bilateral hemiplegia of cerebral palsy may or may not be associated with mental retardation, involuntary movements (as in choreoathetosis), and convulsive seizures in any combination. (*See* also CEREBRAL PALSY.)

In contrast with the brain, the spinal cord is rarely the site of vascular obstruction or hemorrhage. The more common causes of damage to the pyramidal tracts in the cord include deformities of the spinal column from bone and joint disease and from injury to the spine with fracture and dislocation, spinal cord tumours, and a number of poorly understood inflammatory and degenerative diseases of the spinal cord such as myelitis, multiple sclerosis, and the cord changes often associated with pernicious anemia. Perhaps one of the most common causes of slowly progressive spastic paraplegia in persons of middle age or older is degenerative arthritis of the spine with protrusion of an intervertebral disk cartilage into the lower cervical portion of the spinal canal. (*See* also SPINE, DISEASES AND DISABILITIES OF; MULTIPLE SCLEROSIS; ARTHRITIS.)

Of the diseases that attack lower motor neurons and result in flaccid paralysis with muscular wasting, the most common are poliomyelitis and polyneuritis, the former affecting the cell bodies of bulbar and spinal motor neurons, the latter their peripheral processes. Bell's palsy is a peripheral neuritis of unknown cause affecting a single nerve trunk—the facial nerve—and resulting in paralysis of all the muscles of one side of the face. It is usually rapid in onset; on the affected side the facial lines are smoothed out, the forehead cannot be wrinkled or the eye closed, and the corner of the mouth droops. It is therefore easily distinguished from the lower facial weakness of a cerebral lesion (with which it is nevertheless sometimes confused and interpreted as a "stroke"). Bell's palsy is a benign condition, and in the majority of cases recovery occurs, though it may take many months. (*See* also POLIOMYELITIS; NEURITIS.)

Amyotrophic lateral sclerosis (*q.v.*) is a rare, chronic, progressive disease of the nervous system of unknown cause in which there is a remarkably systematic and extensive degeneration of both components of the motor pathway, resulting in a combination of bulbar and pseudobulbar palsy, widespread weakness with atrophy and fasciculations, and increased tendon reflexes.

Diseases that result in paralysis through primary changes in muscle tissue are fewer and far less common than those of the nervous system. Of the few conditions belonging in this category, progressive muscular dystrophy is the only one that is apparently confined to the muscles. This is a familial, hereditary disease characterized by slowly progressive, symmetrical muscular weakness and wasting. Typically, the muscles of the pelvic and shoulder girdles and those of the proximal portions of the limbs are the earliest and most severely affected. There are several different forms of the disease. One variety has its onset before puberty, is more common in boys, and usually progresses to severe disability within a few years. It is known as pseudohypertrophic muscular dystrophy because in the early stages there is often a false appearance of excessive muscular development, particularly in the calves, from the deposition of fat and fibrous connective tissue among the degenerating muscle fibres. The other types of dystrophy differ less from each other than from the pseudohypertrophic type. In general, they begin in adolescence or young adult life, and the two sexes are about equally affected. The progress of these other forms is very slow, especially when the onset occurs after the age of 20, and life expectancy, therefore, is not necessarily shortened, nor is severe disability inevitable. Pseudohypertrophy is rare. (*See* also MUSCLES, DISEASES OF.)

Muscular weakness without structural alteration in nerve or muscle tissue may be a symptom of disturbances in metabolism arising from a wide variety of causes, some relatively well understood, others unknown. Among such conditions are included a number of diseases of the endocrine glands, certain intoxications, and several metabolic defects of unknown origin. Weakness, at times reaching severe proportions, is a more or less regularly observed feature of hyperthyroidism and of both adrenal cortical hyperfunction (Cushing's syndrome) and hypofunction (Addison's disease). Among the intoxications that produce muscular paralysis of this kind are botulism, poisoning from certain snake venoms, and tick paralysis. The latter is a rapidly developing generalized paralysis resulting from a toxin elaborated by a species of wood tick; the condition may be fatal in from two to five days unless the tick is discovered and removed from the skin.

The most common example of a metabolic disorder in neuromuscular function of unknown cause is the disease known as myasthenia gravis. In this condition there is muscular weakness, without atrophy, which may be mild or severe and either generalized or restricted to a few muscle groups. Some of the muscles innervated by cranial nerves are affected in almost every case. The weakness of myasthenia gravis results from a remarkably localized defect in the chemical processes involved in the transmission of impulses from motor nerve endings to muscle fibres. Although the cause of

this defect and its precise nature are unknown, several drugs are known to facilitate the transmission of impulses from nerve to muscle. One of these, neostigmine, proved to benefit most patients, but it is not a cure since it does not correct the basic, unknown defect. *See* NERVOUS SYSTEM, DISEASES OF; PARKINSONISM; *see* also references under "Paralysis" in the Index.

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(S. SN.)

PARALYSIS AGITANS: *see* PARKINSONISM.

PARAMAGNETISM is the kind of magnetism associated with a weak attractive force between magnetized bodies. If a body is repelled by the poles of a magnet (*e.g.*, a strong electromagnet) it is diamagnetic (*see* DIAMAGNETISM). If the body (like iron) is attracted strongly, the phenomenon is called ferromagnetism (*q.v.*), a kind of magnetism of great practical importance. If the substance is attracted weakly it is paramagnetic.

The first comprehensive investigation of paramagnetism was begun in 1845 by Michael Faraday. It is known now that most of the elements and many compounds are paramagnetic. Most of the compounds containing iron, palladium, platinum, and the rare-earth elements have strong paramagnetism; this is attributed to incomplete electron shells in the atoms, which behave as small permanent magnets that have a slight tendency to become parallel to an applied magnetic field. The heat motions of the atoms oppose the alignment of the atomic moments by the magnetic field; consequently the paramagnetism becomes weaker at higher temperatures.

Substances of another class, including the alkali metals such as sodium and potassium, have weak paramagnetism; this is independent of temperature and is a function of the free conducting electrons of the metal.

The magnetic susceptibility per atom of most weakly paramagnetic substances is 10 to 100×10^{-6} (*i.e.*, 10 to 100 millionths); that of strongly paramagnetic substances 100 to $10{,}000 \times 10^{-6}$ (*i.e.*, 100 to 10,000 millionths); while a representative diamagnetic susceptibility is -10×10^{-6} (*i.e.*, minus 10 millionths). Ferromagnetic materials in which the atomic moments have a strong tendency to become parallel have enormously larger susceptibilities, ranging from about 1 to 10^6 (*i.e.*, from 1 to 1,000,000). *See* also MAGNETISM; NUCLEAR MOMENTS; ELECTRON PARAMAGNETIC RESONANCE.
(R. M. B.)

PARAMĀNUJIT, PRINCE (1791–1852), prince patriarch of the Siamese Buddhist Church and a prolific writer on patriotic and moralistic themes in verse and prose, was born in 1791, the son of King Rama I. As Prince Vāsukri, he entered a monastery as novice in 1805. He became abbot of Wat Pra Jetubon and was later created Krom Somdeč-pra Paramānujit, prince patriarch of the church. He died on Dec. 9, 1852.

Paramānujit's masterpiece is the *Talengpāi*, a heroic epic of the struggle of King Naresvara of Ayutthaya to liberate his country from Burmese rule and of his famous single combat with the crown prince of Burma in 1590. Its tone is patriotic but never chauvinistic and the Burmese are depicted in a chivalrous and sympathetic manner. His concluding section of the *Samudaghos*, a folktale adapted from the collection called the *Paññasajātaka* which had been left unfinished since the 18th century, is distinguished for the beauty of its descriptive passages. His diction is dignified and heroic. Another widely read work, the "Exhortation of Krishnā to Her Sister," is an example of Buddhist moralist poetry. His prose, *e.g.*, the *Pathomasombodhi*, is equally valued for its eloquence and descriptive power. He also contributed to the collection of literary inscriptions on stone at Wat Pra Jetubon under the patronage of King Rama III, by writing classic models of Siamese poetry which still remain. Notwithstanding the monastic and celibate seclusion of his adult life, Prince Paramānujit was a versatile writer with liberal ideas.
(D. N. K. B. P.)

PARAMARIBO, the capital and only large town of Surinam, or Dutch Guiana (*see* GUIANA), stands 17 mi. (27.4 km.) from the Atlantic Ocean on the left bank of the Suriname River, which is there tidal and nearly one mile broad and 18 ft. deep. Pop. (1962 est.) 124,565. The growth of its population has been especially rapid since World War II (74,337 in 1950). Paramaribo is built on a shingle reef forming a plateau about 16 ft. above the river at low water. Access from the sea is limited by a bar which allows a depth of about 20 ft. Except for a few 18th-century brick buildings and some modern ones in brick or concrete, the city is wholly built of wood. It has a handsome Government House and Botanic Gardens. The broad streets are laid out in a grid pattern and the canals and substantial public buildings recall the Netherlands.

The town is built on the site of an Indian village which became a French settlement about 1640 and was made the capital of the English colonization organized by Lord Willoughby in *c.* 1650. The 18th-century Ft. Zeelandia lies nearby to seaward.
(G. LN.)

PARAMECIUM. In bodies of fresh water throughout the world—especially in quiet ponds having some decaying organic matter—may be found paramecia, free-living microscopic one-celled animals (Protozoa; *q.v.*) roughly slipper-shaped and completely covered with short, fine hairlike filaments or cilia (*q.v.*). They belong to the genus *Paramecium*, which, along with other similarly ciliated protozoans, is included in the holotrichous group of the class Ciliata.

Paramecium includes at least eight well-defined species, all of which can easily be cultivated in the laboratory in a nutritive broth or infusion made by boiling hay or dried powdered lettuce in distilled water. The different species vary in size but most are slightly larger than the period at the end of this sentence. Certain species such as *Paramecium caudatum* are gracefully streamlined and elongate and are frequently referred to as the slipper-shaped animalcules (*see* fig. 1). Others, such as *Paramecium bursaria*, resemble a foot imprint.

BY COURTESY OF RALPH WICHTERMAN

FIG. 1.—LIVING PARAMECIUM CAUDATUM PHOTOGRAPHED ALONGSIDE A HUMAN HAIR

Structure and Function.—Depending on the species, paramecia are rounded or obliquely truncated (squared off) at the anterior end and somewhat pointed, cone-shaped or rounded at the posterior end. On the ventral or oral surface a depression or groove (oral groove) runs obliquely back from the blunt anterior to about one half the body length. The posterior end of the oral groove leads into a small ventral opening, the cell mouth. Leading from the mouth internally is a short S-shaped cylindrical cavity called the gullet, which is widest near the mouth and tapers posteriorly. A flexible membrane, the pellicle, covers the entire body, including the oral groove; it bears lengthwise rows of cilia. A thin layer of clear, firm protoplasm (ectoplasm) lies directly beneath the pellicle and encloses the inner, more fluid portion of the protoplasm (endoplasm). The endoplasm contains granules, food vacuoles and crystals of different sizes. (*See* fig. 2.)

Cilia are of fairly uniform length except at the posterior end where they are longer and less active than elsewhere. Each cilium arises from a small spherical body (basal granule or kinetosome) embedded in the ectoplasm. These basal granules are protoplasmic self-reproducing units which are connected to each other by extremely fine fibrils. Cilia beat in a wavelike rhythmic manner serving to propel the animal through the water and to capture food. The animal is able to reverse its ciliary activity and swim backward as well as forward. Those cilia lining the oral groove sweep a current of water containing food organisms (usually bacteria) into the mouth, down the gullet and into a forming food vacuole. After the food vacuole is full of water and food material, the vacuole breaks away from the gullet, passes into the endoplasm and is

then circulated within the body by the streaming of protoplasm (cyclosis). The food in the vacuoles is acted upon by enzymes secreted by the animal and is converted into more protoplasm. Undigested material is retained in the food vacuoles and is passed out of the body at the anus, located in a region near the posterior end of the gullet. The anus is seen only when the animal is in the process of passing out undigested material.

In the ectoplasm is a layer of thickly set, spindle-shaped bodies (trichocysts) which are placed at right angles to the body surface. Extrusion of the trichocysts may be evoked by different kinds of stimuli—chemical, electrical and mechanical. Upon stimulation, the trichocysts are extruded very quickly, usually within several milliseconds. Some may be partly extruded and attached to the body while others may be fully thrown out, free and needlelike, six to ten times the length of resting unextruded ones. The function of trichocysts is unknown. Originally believed to be a defense reaction, their extrusion now appears to represent a reaction to injury.

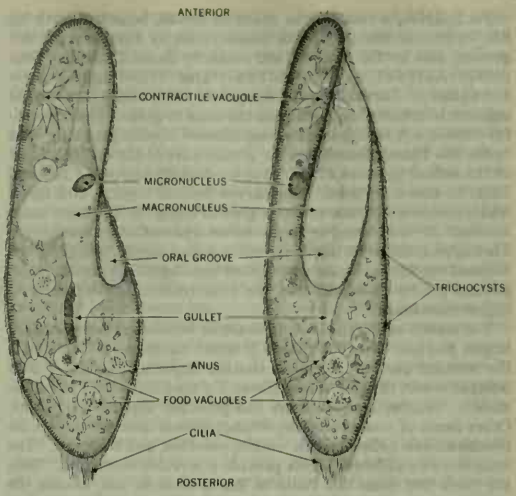
All species of paramecium contain two, occasionally three, contractile vacuoles located close to the surface away from the mouth (aboral surface) and nearer the ends of the body. These vacuoles collapse alternately and each empties its liquid contents to the outside of the body through a small pore. In canal-fed vacuoles a number of small canals radiate from the vacuole and empty into it as seen in *P. caudatum*. Their function is primarily to regulate the water content within the animal. Since the expelled water may also contain some nitrogenous or waste products of metabolism, contractile vacuoles would be considered excretory structures also.

Cells of other animals characteristically possess one nucleus, but in paramecium two kinds of nuclei are present: a large ellipsoidal macronucleus and one or more small micronuclei which are generally close to or impressed against the macronucleus. The paramecium cannot live without its macronucleus but can survive without the micronuclei. The macronucleus is the centre of all metabolic activities and, like the micronucleus, possesses genes which are the bearers of hereditary characteristics. In the various sexual processes, the micronucleus plays an active part in heredity; it is this nucleus which gives rise to new macronuclei.

Reproduction.—*Binary Fission.*—The commonest type of reproduction in paramecia is binary fission: one fully grown animal divides into two daughters with the result that there may be two, three or more generations a day. The micronuclei undergo mitosis but unlike mitosis in other animal cells, the nuclear membrane does not break down during the process. As with other cells during mitosis, each daughter in a paramecium receives an equal set of chromosomes. In binary fission, the macronucleus elongates, constricts, then divides directly into two, one passing to each daughter cell. As a result of fission, each daughter has self-duplicated itself from the nuclear and cytoplasmic material of the parent to grow into an adult.

Sexual.—Paramecia also undergo the following types of sexual reproduction: conjugation, autogamy (discovered by W. F. Diller in 1934) and cytogamy (discovered by R. Wichterman in 1939). Conjugation (cross-fertilization) is characterized by the temporary union of two animals and involves micronuclear divisions, exchange and fusion of micronuclear elements (*see* below). Autogamy (self-fertilization) involves similar micronuclear divisions but occurs in single animals without the co-operation of another individual. Cytogamy (another type of self-fertilization) resembles conjugation in that two animals join together but do not undergo nuclear exchange—nuclear events are similar to those which occur in autogamy and conjugation.

Mating Types.—The two paramecia joined in conjugation are to the onlooker identical in structure—no difference which might suggest sexes are noticeable. However, the discovery by T. M. Sonneborn in 1937 of paramecia which are morphologically the same but physiologically different made it clear that there are definite mating types. With this discovery it became possible to crossbreed the members of pure lines of paramecia, those derived from one isolated individual by simple fission alone (clones) and in the absence of all sexual processes.



BY COURTESY OF RALPH WICHTERMAN

FIG. 2.—PARAMECIUM CAUDATUM: (LEFT) LATERAL VIEW AND (RIGHT) VENTRAL VIEW, GREATLY MAGNIFIED

In a clonal culture, all the progeny as a result of this uniparental reproduction are of a given mating type. Upon mixing together animals from two different clones, the animals either mate or do not mate. If they are of opposite mating type, paramecia may clump or agglutinate into large masses. From these masses emerge pairs of joined individuals that enter into and complete conjugation. And by using special methods it is possible to show that each member of a pair in conjugation is from an opposite mating type. By extensive experimental mixing (two paramecia at a time) of all possible combinations of clones of paramecia that were isolated from nature, it was possible to determine many different mating types which have been placed in larger specific groups called varieties. Animals of opposite mating type within a variety will mate and conjugate when mixed, but paramecia of one variety ordinarily will not mate with those of other varieties. Opposite mating types have been discovered in most species of paramecium and in other ciliate Protozoa. Details of the systems of mating types and varieties for the different species are quite complex.

Besides being useful for general study and teaching purposes, paramecium has proved to be an important research organism widely employed in cytogenetics, nutrition, serology, radiation biology and many other fields of biology. Particularly interesting are the so-called "killer" races of paramecia, which illustrate one of the best known examples of cytoplasmic inheritance (*see* HEREDITY: *Cytoplasmic Inheritance*).

See R. Wichterman, *Biology of Paramecium* (1953); G. H. Beale, *Genetics of Paramecium aurelia* (1954). (R. Wi.)

PARAMOUNT, a city of Los Angeles county, Calif., U.S., just east of Los Angeles and abutting Long Beach on the south. The site was once a part of the Nieto Spanish land grant. As the first settlement, under the Cooperative Colony Trust company (1866–67), it was called Clearwater and began as a dairy centre. In 1891–92 the southern portion of the Clearwater community created a separate town called Hynes, which subsequently became the collecting and distributing centre of a large hay business. In 1949, the two communities were consolidated as Paramount, which was certified as a city in 1957. Industries (aluminum awnings, furniture, plastics, machine shops, resins) moved into the area and replaced much of the original dairying. The city has been governed from its inception by a council of five citizens who select a mayor and vice-mayor and appoint a city manager, other administrators and commissioners. For comparative population figures *see* table in CALIFORNIA: *Population.* (H. P. Jo.)

PARANÁ, a state in the south of Brazil, bounded north by São Paulo, northwest by Mato Grosso, west by Paraguay and Argentina, east by the Atlantic, and south by Santa Catarina. Pop. (1950) 2,115,547, (1960) 4,277,763; area 77,048 sq.mi. (199,555 sq.km.). Paraná is in the temperate zone, except for a small segment in the extreme north, and the state in general has a healthful climate. A well-drained rolling plateau sloping gradually west to the Rio Paraná constitutes the greater part of the region. Most of the settled portions of the state are located between 2,000 and 3,000 ft. above sea level. The narrow belt of tropical rain forest which presents a screen of dense growth along the Brazilian coast to about 30° S is found between the escarpment and the seacoast. Throughout the state there is uniform and ample precipitation. Natural vegetation consists mainly of semideciduous forest, intermittent prairie grassland, and the frost-resistant pine forests at higher elevations.

The stands of Paraná pine (*Araucaria brasiliana*) represent the largest and best softwood forests in South America. The plains in the western part of the state contain important tracts of *Ilex paraguayensis*, the tree whose leaves are used for maté (or hervamaté). Lumber and maté are the principal exports of Paraná. Other items of commercial importance grown there at various altitudes include coffee, cereals, cotton, potatoes, and livestock. The state has two railroads which provide a serviceable system. One, the trunk line from São Paulo to Rio Grande do Sul, crosses the eastern portion of the state; it has branches east to Curitiba and Paranaguá and north to Ourinhos. The other, in the north, extends from Mandaguari to Ourinhos and São Paulo. Important rivers are the Paranapanema, the Ivaí, Pequiri, Chopin, and the Iguassú. The territory of Iguassú, provided for in the federal constitution of 1937 and created by decree law in 1943, was abolished in 1946 and its area incorporated into the state of Paraná.

Northwestern Paraná, developed chiefly by Paraná Plantations Ltd., a British company organized in 1925, is one of Brazil's latest zones of pioneer settlement and the far west extension of the coffee frontier. Exceptionally fertile soils, favourable climatic and terrain features, and satisfactory transportation facilities make this a valuable area. Londrina (pop. [1960] 74,110), a modern city, is the commercial, political, and cultural centre of this zone.

The racial composition of Paraná tends to be heterogeneous since in addition to the Latin races represented, there are Germans and Slavic peoples, the latter being notably Poles, Russians, Ukrainians, and Ruthenians. The Japanese population is considerable and continues to grow.

Curitiba, the capital (pop. [1960] 344,560 [city]), lying at 2,979 ft. elevation, has an average annual temperature of about 62° F. Commercially it is important as a centre for the maté trade and to a lesser extent for coffee and Paraná pine. Other cities include Ponta Grossa, Paranaguá, and Cornélio Procópio.

Paraná was settled in the 17th century by *bandeirantes* (prospectors) following the discovery of gold near Curitiba in 1645. The region was a district of São Paulo from 1668 until 1853 when it was created a province of the empire. Paraná became a state of the federal union in 1889. (J. L. Tr.)

PARANÁ, Argentine city and capital of the province of Entre Ríos, is located on the east bank of the Paraná River, 240 mi. NW of Buenos Aires (365 mi. by navigable channel). Pop. (1947) 84,153; (1960) 111,258. The climate is mild (mean annual temperature 66° F) with adequate rainfall for crops and grazing. The gently rolling hills are admirably suited as vast grazing tracts for cattle, sheep and horses and the raising of corn and flax. The city was founded in the late 16th century with the name of Bajada by Spanish settlers from Santa Fé. During the 19th century it served as provincial capital except for the period 1854–82 when Concepción on the Uruguay River was declared the capital. From 1852 to 1862, while Buenos Aires was separated from the Argentine confederation, Paraná became the residence of the national authorities. Because of flood danger the city is situated on high ground 2 mi. from the riverbank but it is closely connected with the port of Bajada Grande by railroad and highway. Although this port is classified as a seaport, only oceangoing vessels of less than 12-ft. draft can ascend the channel. Several ferry services connect Paraná with the city of Santa Fé on the opposite bank.

The eastern part of the province and the cities along the Uruguay River are linked to the capital by a provincial railroad net. Air communication is facilitated by a municipal airport. (Js. R. S.)

PARAÑAQUE, a small municipality of Rizal Province, Luzon, Republic of the Philippines, on Manila bay south of Manila; although it is politically separate from Manila it is part of the metropolitan urban area. Pop. (1948) 28,884; (1960) 61,898. In 1948 nearly 300 small farms still produced rice and vegetable crops, but a decade later most of these had become urban area or were included in the expanded Manila International Airport established at Nichols field, former U.S. air base.

Parañaque has long been famous for its fine hand embroideries, a continuing household industry. (J. E. Sr.)

PARANÁ RIVER forms, with its tributaries, the larger of the two river systems that empty into the Río de la Plata estuary. An important commercial artery, the Paraná rises on the plateau of southeast central Brazil and generally flows south for 1,827 mi. to join the Uruguay River. *See* Plata, Río de la.

PARANOID REACTIONS. Under this term are included paranoia and paranoid states. The word paranoia was used by the ancient Greeks, apparently in much the same sense as the modern popular term insanity. Since then it has had a variety of meanings. Toward the end of the 19th century it came to mean a delusional psychosis, in which the delusions develop slowly into a complex, intricate and logically elaborated system, without hallucination and without general personality disorganization. Sometimes the fixed delusional system, which may be grandiose, persecutory or erotic, is more or less encapsulated, thus leaving the rest of the personality relatively intact. Though a great many patients with paranoia have to be hospitalized, some do not, and among these an occasional one succeeds in building up a following of persons who believe him to be a genius or inspired. Today the term paranoia is reserved for all rare, extreme cases of chronic, fixed and highly systematized delusions. All the rest are called paranoid states; *i.e.*, states resembling paranoia but less severe.

Paranoid states are relatively common psychotic disorders, characterized by persistent delusions and by behaviour and emotional responses that are consistent with the delusional ideas. Hallucinations are absent; and there is no general personality disorganization, such as that commonly seen in schizophrenia. Paranoid states may develop gradually or appear suddenly; they may remain chronic or clear up. Complete recovery is not rare, although, of course, if a person has always been distrustful before his illness he is likely to remain distrustful afterward. The delusions in paranoid states are usually delusions of persecution, and to these this article will devote most of its attention.

Persecutory Paranoid State.—Individual susceptibility to paranoid developments varies greatly. The person most vulnerable to a persecutory paranoid state is the tense, insecure, suspicious person who has little basic trust in other persons, who has always found it difficult to confide in others, tends to be secretive, usually has few close friends and is addicted to solitary rumination. These characteristics are sometimes hidden behind a façade of superficial sociability and talkativeness. Above all, there is a rigidity about such a person's thinking which becomes most obvious when he is under emotional stress. This may give an impression of certainty and self-assurance, but actually it is based upon profound insecurity, upon a need to be dogmatic because of an inability to tolerate suspended judgment.

The insecure, distrustful, solitary person finds his world unsafe, something that needs watching. Characteristically, he does not understand motivation well, either in others or in himself. Because of this he easily misinterprets what others do and say, and fails to recognize hostile overtones in his own behaviour, even when they are obvious to others. An ambitious person with paranoid trends, for example, may push ahead without due regard for others' feelings, which he does not understand, and then become deeply hurt or enraged when others oppose him or snub him. A passive person, similarly, may unconsciously invite domination or encroachment by others, and then react with angry resentment

or fright when it comes. A common result of all this is that a person with these personality trends unintentionally creates an atmosphere of tension around himself, even when he is relatively well.

Self-Reference.—A chief contributing factor to this atmosphere of tension is the tendency to self-reference; *i.e.*, to misinterpret remarks, gestures and acts of others as intentional slights or as signs of derision and contempt, directed at the hypersensitive person. It is normal, of course, to assume occasionally that criticism, contempt or derision is directed at oneself when actually it is not. But the average person is able to shrug it off, after a brief period of resentment, or to challenge it, and thus find out his error of interpretation. The person who can neither shake off his hurt feelings nor correct his mistakes of self-reference is in more than average danger of developing delusions.

Self-reference becomes paranoid delusion when a person persists in believing that he is the target of hostile actions or insinuations, aimed at him by some enemy or band of enemies, when this is actually not the case. The identifying marks of delusional conviction are (1) readiness to accept the flimsiest evidence in support of the belief, and (2) inability to entertain seriously any evidence that contradicts it. It is this biased selection of available evidence that gives to paranoid development its appearance of irresistible progression.

Paranoid self-reference is never a purely random matter; it always has some kind of pattern. The patient is always selectively hypersensitive to certain kinds of implied threat, to certain kinds of situations and personalities. This selectivity actually corresponds to the patient's own pattern of fears, wishes, guilt, weaknesses and frustrations. The persecution he anticipates may be sexual in character, it may be a direct assault or it may be some threat to his freedom, reputation or security. The immediate effect of increased delusions of self-reference is to increase the patient's vigilance, to make him look for possible clues as to what seems to be going on around him, and to make him prepare to defend himself or to counterattack.

Precipitating Factors.—Paranoid states often develop so gradually that, on looking back, it is not possible to be sure just when mere suspicion changed into delusional conviction. Even when the onset seems abrupt, in retrospect it often can be seen that the onset actually was preceded by a rising tide of anxiety and distrust that finally got out of control and broke out as delusional belief. The commonest precipitating factors are temptation and frustration. Temptation to commit or to fantasy some forbidden hostile or erotic action may arouse primitive impulses and intolerable guilt. Frustration also can arouse intolerable guilt because of the hostility it stimulates. The frustration may come from actual failure and humiliation, from feelings of intense rivalry and jealousy or from the loss of a major source of gratification. There may be real or imagined rebuff, neglect or hostile treatment by others. Frustration also comes when youth begins to disappear or health fails, or when the person is incapacitated, isolated or subjected to socio-economic downgrading, as in losing his job, status or income.

The paranoid patient gets rid of his intolerable sense of guilt through unconscious mechanisms of denial and projection. He denies his primitive hostile or erotic impulses and projects them —that is, he ascribes them to other persons. Projection is rarely done at random. Usually the patient unwittingly selects as the alleged carriers of his own impulses and his own guilt, persons who have corresponding minimal unconscious trends. These trends he magnifies and sees as dominant, conscious characteristics of the person he accuses. Someone who actually dislikes the patient, for example, someone who may not even realize it, is selected as a major hater and tormentor—even as a potential murderer; or someone of the same sex, who is fond of the patient or who has minimal unconscious homosexual trends, becomes for the patient a frightening homosexual threat.

Clinical Course.—The clinical course of a paranoid development may be as follows. The stimulation of erotic and hostile impulses, directly or indirectly through frustration or temptation, results in a high level of anxiety. This anxiety the patient ascribes to external danger of attack; but actually it signals internal danger from poorly repressed impulses. It seems to him that things around him have somehow changed, and he tries to understand what is happening. He becomes increasingly uneasy and vigilant, scrutinizing his environment with growing suspicion and distrust. In trying to understand his situation, he does what he has always done: he observes silently, looks for hidden meanings and watches for clues in the little things others say and do, their gestures and facial expressions, their tone of voice, their smiles and frowns.

Unfortunately, a person who is already convinced that something strange is going on around him, or that he is in personal danger, always can find confirmation of his suspicions and fears if he looks hard enough. The anxious paranoid person may begin by noticing little things. His personal effects may seem to him to have been disturbed, as though someone had been rummaging through them, perhaps looking for evidence of some kind. The feeling he has is vague but uncomfortable. When he cannot find something that he himself may have misplaced, he concludes that someone must have deliberately taken it or moved it to annoy him or make him look stupid. If he finds a book upside down he may interpret it as a sign that someone is testing his intelligence (to see if he can notice things) or is casting a derisive slur on him by indicating that he cannot even read.

As the patient notices such details it seems to him clearer and clearer that he is the victim of some plot, that he has been singled out for some reason to be persecuted. Self-reference becomes still more intense. Strangers in the street seem to be talking about him or laughing at him and they signal to each other about him by gestures. He feels watched and followed and he sees signs that his movements are being reported. A magazine seems purposely left open at a certain page so that a story, picture or advertisement will communicate something to him, or will further anger or arouse him. Some patients are convinced that their telephone wires are being tapped or that microphones are hidden in the walls. If the process progresses, the patient begins to hear specific references to him on radio and television, in the cinema and at sermons. This apparent publicity frightens and angers him further.

When apparent persecution reaches this degree of intensity and complexity it is natural to assume an organized source. The search for some unifying explanation leads many paranoid patients to conclude that the "plot" is being engineered by certain specific persons, some of them actual persons who can be pointed out, some of them imaginary. Such an imagined community of alleged conspirators is called a paranoid pseudo-community. Its make-up often follows the familiar patterns of mystery stories. The patient may speak of criminals, gangsters, dope rings and spy rings, of political, racial and religious haters. He may complain of plots at work to deprive him of job, reputation or life, or of enemy neighbours who are trying to ruin him and drive him from his home.

Abnormal as it is, this organized delusion of a hostile pseudo-community has certain immediate advantages for the patient. It substitutes a definite, known delusional danger for a vague unknown one, and most human beings find known dangers easier to endure. It is also easier to prepare oneself to meet a specific known danger than to meet a diffuse threat. And, finally, the hostile pseudo-community seems real enough to the paranoid patient for him to be able to make it the target of his hostility. Now he can discharge some of his unmanageable aggression directly by combating the supposed band of persecutors. His destructive impulses, instead of disorganizing him as they easily might, are turned outward against his imaginary enemies. This does not solve his problems by any means, but for the time it does preserve him from personality disorganization.

Persecutory paranoid illnesses have more than one possible outcome. A great many patients, even those with well-marked delusions, regain their premorbid level completely; they become clinically well. Others remain chronically delusional. Some of these seem merely morose, suspicious and resentful, concealing their delusions behind complaints of never getting a square deal or behind assertions that the world is full of hatred and immorality. Some chronically paranoid persons suffer occasional out-

bursts of hostility that make others fear them or avoid them. Some spend a great deal of energy and money in pressing an endless succession of lawsuits (litigious paranoia), which are really attempts to combat an unconscious sense of guilt by forcing courts to demonstrate the litigant's innocence, at the same time punishing the persons he accuses in place of himself.

Occasionally a paranoid person explodes into action, either fleeing from his alleged persecutors or attacking them. In either case the explosive action is inappropriate to the real social context, since the plot and the persecutors are imaginary. As a rule, society takes steps, vigorous or even violent, to interfere with the flight or the attack. The patient then feels that his worst fears are being confirmed, that he is at last actually being attacked.

Therapy.—In persecutory paranoid reactions the primary therapeutic aims are a reduction in anxiety and the re-establishment of genuine communication. Excessive anxiety lies behind excessive paranoid projection; and the delusions themselves are only products and indirect expressions of these more basic processes. If anxiety and projection subside, the patient becomes able to communicate profitably. His greatest need then is for someone in whom he can confide safely. Friends, relatives and others have by this time already tried reassurance, argument, reasoning and demonstration without success.

To be able to meet a paranoid patient's needs, the therapist must be a neutral person, one who is not driven by his own anxiety to offer too much reassurance, to belittle the patient's fears or to argue with him. If the patient can form a relationship with a neutral therapist who does not take sides, but listens with appropriate considerateness and respect, the generalized paranoid suspicion may give way to a specific trust. If this occurs, it may then become possible to work through some of the ramifications and origins of the paranoid illness, and the patient may modify or replace his pseudo-community with something approaching the real community.

Other Paranoid States.—In addition to the common persecutory type of paranoid reaction, four others deserve mention: (1) delusional jealousy; (2) erotic delusions; (3) paranoid grandiosity; and (4) *folie à deux.*

Delusional Jealousy.—Even normal jealousy is made up of an irrational mixture of anger toward both the beloved and the rival, of sorrow and of a painful loss of self-esteem. Delusional jealousy goes further, exhibiting some of the definitely paranoid characteristics present in persecutory delusions. There is, for example, hypersensitivity to even the most minute evidence confirming the patient's suspicions, and unreasonable resistance to all contradictory evidence. The patient watches intently for signs that he is right, as if he wants to be. In some cases it is obvious to an observer that he has an unconscious attachment for his rival, and that he identifies with his beloved. Primitive defensive operations of denial and projection are basic to all delusional jealousy.

Erotic Delusions.—These are fixed beliefs that one is loved sexually by another person who is indicating his affection through innumerable little signs. The alleged lover is usually of the opposite sex, and is often someone prominent in politics or in the field of public speech or entertainment. Prominent persons often receive letters and telephone calls expressing erotic delusions, and occasionally are accosted at public meetings by a paranoid person who makes an avowal and expects an acknowledgment. Such action on the part of the patient may lead the person who is the focus of the delusion to complain to the police. The erotic delusions are sometimes manifestations of self-love which is denied and projected onto another person. Sometimes the erotic delusion is a defensive maneuver which replaces the denied unconscious real homosexual trends with a more acceptable delusional heterosexual attachment. It is to the last-mentioned defensive maneuver that Freud's classical formulation refers: denial, "I don't love him," and delusional substitution, "I love her because she loves me." Some persons with erotic delusions suffer also from personality disorganization, and belong rather to the schizophrenic group than to the more organized paranoid reactions.

Paranoid Grandiosity.—This is much less common than delusions of persecution, and when it occurs the paranoid illness is usually more severe. Unlike the grandiose delusions in mania and in schizophrenia, paranoid grandiosity tends to be well-organized, relatively stable and persistent. The complexity of delusional conviction varies from rather simple beliefs in one's alleged talent, attractiveness or inspiration to highly complex, systematized beliefs that one is a great prophet, author, poet, inventor or scientist. The latter extreme belongs to classical paranoia. Very rarely does a patient with paranoid grandiosity actually contribute something useful to the social environment. More often he joins some fanatical movement in current vogue, in this way succeeding sometimes in sublimating his excessive zeal and saving himself from further illness.

Folie à Deux.—This name is given to an interesting development in which a dominant psychotic person induces a delusion, usually persecutory, in a dependent, submissive person. If the two are separated, the dependent member of the pair usually recovers rather quickly. As a rule, the two members have been living for a long time in close contact. The commonest combinations are two sisters, husband and wife, mother and child, in that order. The preponderance of women and children seems related to a relationship of dominance and submission between the one who induces the delusion and the one who adopts it. Cases of *folie à deux* in which personality disorganization occurs are considered to be schizophrenic. In these, the outlook for recovery of the dependent member after separation is also good.

See also PSYCHIATRY; PSYCHOTHERAPY; PSYCHOSES; PSYCHOLOGY, ABNORMAL; SCHIZOPHRENIA.

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PARAPET, a dwarf wall or heavy railing around the edge of a roof, balcony, terrace, stairway, etc., either to prevent those behind it from falling over or to shelter them from attack from the outside. Thus battlements (*q.v.*) are merely one form of defensive parapet arranged to allow those within to discharge missiles without exposing themselves. In many cases roof and terrace parapets are only continuations of the wall below, but in some instances they are projected forward beyond the face of the wall and carried upon brackets or a molded cornice.

Parapets, during the classic ages, were often formed of large slabs of marble pierced with holes, forming a pattern of squares and diagonals; an example still exists in the ruins of the palace of Tiberius on the Palatine hill at Rome. Parapets with fish-scale patterns were also used and are indicated in extant wall paintings in Pompeii. English late Gothic parapets frequently adopted the battlement form. During the Renaissance, the use of the balustrade largely superseded the parapet, but in north Europe, the transitional early Renaissance styles offer many examples of fantastically scrolled and pierced parapets.

PARAPSYCHOLOGY, the study of alleged paranormal human abilities such as, for example, telepathy, clairvoyance, and precognition. A modern offspring of older interests in spiritualism and psychical research, parapsychology generally encompasses experimental tests of extrasensory perception (ESP: perception beyond the range of known sensory processes) and psychokinesis (PK: a synonym for the older term telekinesis, in which the movements of different objects are held to be influenced by thinking about them).

The modern period of interest in these ancient beliefs may be

dated from the formation of the Society for Psychical Research in London (1882). Experimental tests with such methods as card guessing were introduced by the end of the 19th century by C. Richet and further quantified at Stanford University by J. E. Coover (1917). After 1930, the best-known work was that of J. B. Rhine at Duke University (the affiliation was severed in 1965) where the parapsychology laboratory produced work that received major attention; experiments were carried out there as outlined below. However, considerable experimental research has originated elsewhere; in addition to the efforts supported by the London and U.S. societies for psychical research, there is the work of W. H. Tenhaeff in the University of Utrecht, Neth., and of M. Ryzl at Prague, Czech. In Leningrad a state-supported laboratory for telepathic research has been established under L. L. Vasilyev.

Tests of Paranormal Ability.—A special (Zener) deck of 25 cards, each bearing one symbol in the form of a cross, circle, star, wavy lines, or a square, is used to give a probability of 5 correct guesses out of 25 as the symbols are turned up to view. Rhine and others obtained results that are unlikely to have occurred (both higher and lower accuracy) through guessing alone; both types of statistically significant results have been offered as evidence for the paranormal effect.

Telepathy.—The tests for telepathy represent an attempt to verify so-called thought transference. In the pure-telepathy test one person (the agent or sender) simply thinks of a random order of the five ESP symbols while another (the receiver or percipient) tries to determine the order on which the agent is concentrating. In the general ESP test the sender concentrates on the face of one Zener card at a time while the receiver attempts to think of the symbol; and so on through the deck.

In the two methods above, the sender and receiver are usually in the same room. In the distance-telepathy test participants are separated by several rooms or by a greater distance. A few experiments showed statistically significant departures from chance success with a separation of many miles.

Clairvoyance.—Clairvoyance is defined as knowledge of information not necessarily known to any other person, obtained independently of ordinary channels of perceiving or reasoning. In typical clairvoyance tests the subject seeks the order in which symbols occur in a shuffled deck. In the open-matching test the five key symbols are shown and the subject tries to match each face-down card in the deck with the proper symbol. The blind-matching test is identical except that the key symbols are face down and their position is unknown.

The single card-calling test is conducted by guessing the symbol on the top card of a shuffled ESP deck, removing that card still face down, and so on. In the pack-calling test the subject makes 25 consecutive calls directed at a shuffled ESP deck. Usually the deck is in front of the subject, but sometimes is not in the same room.

Precognition.—The hypothesis of precognition assumes supernormal knowledge of future events. When cards are used, the percipient tries to call the future order of cards just before the deck is shuffled mechanically. In another procedure each card is presented to the sender two or three seconds after the receiver announces his guess. When dice are used, the subject decides which face or combination of faces is to appear most frequently. The dice are then tossed enough times by the subject or by machine for statistical verification of the prediction made by the subject.

Psychokinesis.—In PK (so-called mind-over-matter) tests, the subject attempts by thinking or willing to influence hand-cast or mechanically thrown dice. Another variation involves wishing for thrown objects to land in specified areas.

There has been difficulty in determining whether the concepts of ESP or PK are applicable in tests of infrahuman animals. Sometimes all of these hypothetical abilities are lumped together under the term psi phenomena, because of the difficulty in clearly distinguishing among them.

Experimental Results.—High-scoring subjects such as Shackleton and Stewart (reported by S. G. Soal) are rare, and their performances would scarcely impress the casual observer as spectacular (averaging about 7½ correct card guesses when 5 would be expected by chance). Nevertheless, there have been reports of such subjects who can, at least for a year or two, succeed fairly consistently in making more correct guesses than could readily be attributed to lucky coincidences. In these cases the odds are many millions to one against an explanation in terms of chance. In experiments on psychokinesis no experimenter seems to have discovered similar persisting subjects.

Sources of Error.—The data reported from parapsychological experiments have been subjected to continual critical comment. Criticism essentially is directed at questioning the adequacy of these data as evidence for the actual existence of what are called psi phenomena.

Sensory Cues.—Human behaviour is known to be modified by faint sounds, weak visual stimuli, subliminal odours and so on, of which the subject may be unaware (*e.g., see* SUGGESTION AND SUGGESTIBILITY). These phenomena appear to have been responsible for some of the so-called significant scores in telepathy and clairvoyance experiments. For example, some of the early sets of ESP cards were so printed that the symbol on the face of the card could be read from the back if the reflected light entered the eye at an angle of about 60°. Experiments in which all participants are in the same room also permit such normal factors as minimal auditory communication to operate. These defects in procedure persisted for many years after the early reports in the 1930s.

Habits of Thinking.—It is well known that people do not call the ESP symbols randomly; instead, during the experiments they tend to form habits in which the same sequence of symbols is repeated. If the target and call series are both products of human thinking, apparently significant results can arise in the complete absence of paranormal communication. The target series in ESP or PK tests must be determined either by machine shuffling, electronic-randomizing device, or (as became common after the 1940s) by the use of an appropriate table of random numbers (*see* RANDOMIZATION).

Recording Practices.—In many parapsychological techniques, the experimenter also serves as the recorder of data; expectancy of successes, excitement, and divided attention can produce erroneous records. When human recorders are used, one obvious safeguard is to have agent and percipient, with their respective observers, in different rooms. In any case, separate records of target and call series should be routine in every experiment. It is undesirable for the experimenter to act as agent himself, unless another observer records his calls. Electrical or photographic recording devices have shown that experimenters who favour paranormal claims tend to record more correct responses (hits) than actually occur; those of adverse bias tend to misrecord in favour of misses. When the preferable machine-recording techniques are not practical, control subjects should be used to prevent the recorder from knowing who, for example, is trying for ESP and who is not. People are not objective recording devices, as the history of error in experimental psychology and in psychical research amply testifies; the effects of observer bias are so widely known that double-blind designs, where the recorder of data is kept unaware of the underlying experimental conditions, is becoming standard procedure in much behavioural and medical research.

Statistical Methods; Experimental Design.—The early critical comment directed at ESP experiments particularly had to do with the designation of the theoretical probability of success. It is now commonly agreed that statistical methods used in such research, if properly applied, can adequately test the hypothesis of chance expectancy. However, if enough individuals are tested, apparently significant scores can be expected to occur by chance. Similarly, with sufficient testing, a single subject can have a run of luck, as happens regularly in gambling. The selection of such instances, or arbitrary stopping when favourable results are obtained, is misleading. The striking early ESP reports and the first PK data from the Duke University laboratory consisted largely of positive findings. Some of the initial controversy was among

parapsychologists themselves; British psychical researchers, for whom the finding of a so-called sensitive (a paranormal person) was a rare event, were faced with the report of an incredibly large number of sensitives from the Duke laboratory. Obviously, all data (positive and negative) should be reported to avoid misleading conclusions.

The criticism has been made (even by parapsychologists) that the early reports of so many successful subjects arose from inadequate experimental controls. Application of such basic principles of design as control groups, and avoidance of experimenter error, is not yet general practice; although an assessment of data collected since the first Duke reports clearly demonstrated a tendency for improved design. But the most serious difficulty is that there is no way of determining whether a given statistically significant result is paranormal or not. Scientific insight essentially rests on the isolation of some reasonably invariant relationship, a regular effect evoked by the manipulation of a given variable. In general, the predicted effect of a given variable constitutes the basic hypothesis about which an experimental design is structured. The ESP hypothesis assumes that, with all known factors controlled, scores deviating from chance are due to ESP.

This dependency for proof upon a statistical probability model from which a causal basis is inferred has been sharply criticized, as has been much behavioural research (L. Hogben). One source of the well-established scientists' disdain for some of the data in behavioural research and for their antagonism to ESP rests on this issue; *i.e.*, the failure to isolate variables that show predictable effects and the growing tendency to resort to statistical inferences. In the search for invariant relationships, the *sine qua non* is replication; *i.e.*, results should be repeatable and predictable. The answer has been that ESP is evanescent in nature; but this cannot deny that inadequate test designs generally have failed to distinguish between possible ESP and runs of luck.

Fraud.—Although not strictly an error in experimentation, the question of fraud has intruded in this area. The history of psychical research is permeated with cases of unscrupulous people; *e.g.*, those who, for monetary considerations, played on some of the deepest of human motives concerned with survival after death. Evidence of such actions rarely becomes public, although criminal prosecutions of allegedly fraudulent mediums occur in Great Britain. In the U.S., practice as a medium (except for entertainment) is itself illegal. Charges of fraud have also been made in parapsychology—a commonly groundless denigration of many sincere individuals pursuing a path not generally popular in scientific circles; nonetheless, opportunities for fraud are present. Fraud rarely is a problem in conventional scientific practice outside of parapsychology because the acceptance of reported results depends on competent replication by other investigators. Morality is thus maintained by functional practice. However, since ESP results lack replication, there have been demands for fraudproof experiments (G. R. Price). In the middle 1950s, Soal, author of the Shackleton-Stewart tests, was engaged in what was perhaps his last major effort in this field. As reported later, two extremely high-scoring Welsh cousins were observed to have signaled each other during some of the card calls (Soal and H. T. Bowden); independent examination demonstrated experimental weaknesses in this particular study. Some of the most frequently quoted data offered in support of ESP have been criticized because the tests were made under conditions that permitted of fraud (C. E. M. Hansel, J. F. Nicol). It can be anticipated that fraud will remain an issue until replication of reported findings becomes common.

Recent Trends.—Critics of the early technics induced a progressive tightening of test conditions. With the separation of Rhine's parapsychology laboratory from Duke University, no new high-scoring subjects had been reported in the U.S. since the early dramatic successes. G. Murphy, long associated with psychical research, has remarked on the progressive decline in successful experimentation in general in this field, including spontaneous and mediumistic effects as well as quantitative data (quoted in Girden, 1962). Experimental testing continued in the 1960s at some educational institutions, and by individuals working on their own or supported by interested societies. Considerable effort has been directed to determining the role of personality variables and belief in psi upon test scores. Investigations of the possible effect of hypnosis and drugs have been carried out; some studies have used nonhuman subjects.

During the mid-1960s there was increased concern with the nonquantitative aspects of psychical research such as spontaneous phenomena. Mediumistic investigations also appeared to have increased, particularly in Great Britain and continental countries, although much less publicly than at the end of the 19th century. In any case, the lack of trustworthy quantitative data severely hampered the development of theoretical formulations in the field of parapsychology.

Parapsychology in Contemporary Science.—For most professional scientists, parapsychology is of little interest; very few are acquainted with the research, most of which appears in journals with which they are not familiar. The great majority of U.S. psychologists do not accept psi as fact. Within the parapsychological movement itself criteria for establishing the validity of paranormal phenomena are in dispute. For some, the conviction is based on spontaneous cases (*e.g.*, paranormal cognition appearing in the course of daily life); they remain unconvinced by the laboratory tests. Others are convinced by ESP data but reject PK reports; and so on.

Many scientists remain unimpressed by and are even scornful of the statistical methodology of parapsychology. Another serious difficulty for many scientists is the almost complete lack of any plausible theoretical account of underlying processes. Concern about these problems was shown by parapsychologists in interviews conducted by E. Girden; some expressed the wish for consistently high-scoring subjects, while others exhibited a need for a satisfying theoretical framework. For U.S. psychologists (who are generally monistic in approach) the challenge of ESP is largely metaphysical in that the alleged phenomena seem to challenge modern psychophysiological views. The British, on the other hand, demonstrate less hesitancy in considering dualistic theories of "mind" and body.

Philosophical critics have pointed out the dilemma involved in the view that a future event can influence the present; scientists tend to reject such an idea out of hand. Until data become compelling, scientists are unlikely to accept purported evidence outside the established scientific mainstream. The rejection is reinforced by objections to violating the basic rules of the scientific method. The situation is unlikely to change unless independently verifiable findings are offered that meet the criteria of empirical rigour, a view not confined to skeptics and critics. Murphy himself has commented that the real beginning of a science of parapsychology must await the appearance of a repeatable experiment (quoted in Girden, 1962).

In the view of one eminent philosopher, former president of the British psychical research group, there will be no progress "unless and until someone hits upon methods of inducing paranormal powers in ordinary persons and sustaining them thereafter at a high level for some considerable time." (C. D. Broad, *Lectures on Psychical Research*, Humanities Press Inc., New York, N.Y., 1962.) Some insightful believers in paranormal powers say that the findings are still erratic only because the underlying conditions are still unknown, requiring an essentially explorative and tentative approach at this stage. For many, however, the data now available are conclusive and paranormal phenomena are firmly established. This raises the ancillary problem of the nature of belief in general and the psychology of scientific controversies (E. G. Boring).

See also PSYCHICAL RESEARCH; SPIRITUALISM.

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PARASCHOS, ACHILLES (1838–1895), Greek poet, born at Nauplia in the Peloponnese on March 6, 1838, was the central figure of the Greek romantic school of poetry in its second and last period (*c.* 1850–80). His models were Alfred de Musset, Victor Hugo, and Lord Byron, but he fell far short of their achievement. His manner is unrestrained and his language grandiloquent, owing much to the Phanariote poets, whose tradition he continued (*see* GREEK LITERATURE). He touched on all the usual romantic subjects, but love and patriotism were his favourites. In his numerous lyrics he made use of both *katharevousa*, the "refined" Greek, inherited from the Byzantine scholars, and the demotic, the spoken language, but his vocabulary remained as limited as his ideas. Perhaps no other modern Greek poet was more admired by his contemporaries. His poems were published in Greek in two volumes (1881, 1904). He died at Athens on Jan. 26, 1895.

See C. A. Trypanis, *Medieval and Modern Greek Poetry* (1951). (CE. A. T.)

PARASELENE (MOCK MOON), a bright spot on a lunar halo resembling the moon, appearing at the intersection of the inner halo and the parhelic circle. *See* HALO.

PARASITOLOGY deals with parasites and with the nature of parasitism and its effects on both the parasite and host. Broadly defined, a parasite is an organism that lives for all or part of its life on (ectoparasite) or in (endoparasite) another living organism (host) from which it derives some benefit such as food, shelter, or protection. In general, however, the concept is restricted to those associations in which the organisms differ in size—the parasite being the smaller and the host the larger.

Parasitism is common in nature; most animals and plants harbour parasites of some sort. Parasites may even invade other parasites, a condition that is termed hyperparasitism and is common among parasitic insects, parasitic crustaceans, and parasitic worms.

Parasites that produce damage to their hosts are called pathogens, and the condition resulting from the damage constitutes disease. In a broad sense, every disease produced by a microorganism —virus, bacterium, rickettsia, spirochete, fungus, or animal parasite—is considered a parasitic disease, but conventionally parasitic diseases are restricted to morbid states resulting from animal parasites.

Diseases caused by animal parasites may, for convenience, be grouped as those caused by protozoans, the microscopic forms usually consisting of a single cell that performs all the functions of the animal body, and those caused by metazoans, the multicelled animals in which the cells and tissues are specialized in function.

In general, the bacteria, viruses, and fungi parasitic on man and animals are studied by bacteriologists, medical scientists, and veterinarians; the bacteria and fungi parasitic on plants are studied by plant pathologists; and parasites of animals are studied by zoologists, medical and veterinary scientists, and parasitologists. Frequently, microbiologists are concerned with all types of parasites.

Further information on parasitology will be found in many other articles; for example, BACTERIAL AND INFECTIOUS DISEASES; BIOLOGY; BIRD: *Parasites;* CATTLE: *Parasites of Cattle;* ECOLOGY, ANIMAL; ENTOMOLOGY; FUNGUS INFECTIONS; IMMUNITY AND IMMUNIZATION; PLANT DISEASES; POULTRY AND POULTRY FARMING: *Diseases and Parasites of Poultry;* SHEEP: *Parasitic Infestations;* TROPICAL MEDICINE; ZOOLOGY: *Animal Interrelationships.*

In addition, individual parasitic diseases, parasitic agents, and groups of these subjects are discussed in separate articles; *e.g.*, ARTHROPODA; BACTERIOLOGY; FLATWORM; FLUKE; FUNGI; HOOKWORM; MALARIA; MYCORRHIZA; PROTOZOA; ROUNDWORM; TAPEWORM; VIRUSES.

Still further information can be found by consulting the references under "Parasitism" in the Index.

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  4. Morphology of Parasites
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I. GENERAL ASPECTS OF PARASITISM

Parasitism is largely concerned with securing food and is one manifestation of the universal nutritional interdependence of living organisms. Most animals are directly dependent on the bodies of plants or other animals for food, and all living organisms are eventually dependent on other living organisms for essential components of their protoplasm. In general, parasites obtain their food directly from the tissues, waste products, or partially digested food within the host.

1. Types of Parasitism.—Parasitism probably arose chiefly through three kinds of food habits, and its probable evolution can be indicated among modern species. The first of these habits is that of saprophytism or saprozoism; *i.e.*, plants and animals, respectively, living on dead plants and animals. This habit may have led to the establishment of certain species within body cavities, such as the intestine, and finally to a true invasion of the body. A progressive series of such species may be seen in: (1) the free-living putrefactive bacteria living on decaying matter; (2) the putrefactive organisms living in the lower intestine of animals; (3) the tetanus organism, which is so poorly invasive that it lives on necrotic tissue resulting from injury and produces its ill effects by a toxin that diffuses into the body; and, finally, (4) the true parasites, such as the typhoid bacillus, which establish themselves in the tissues.

A second food habit leading to parasitism is represented by predacious animals that capture and devour living prey. There seems to be little difference between this mode of life by the free-living protozoans and the ingestion of the host's red blood cells by the parasitic amoeba *Entamoeba histolytica*.

A third type of food habit giving rise to parasitism involves feeding upon the blood and other fluids of plants and animals. The common housefly, *Musca domestica*, for example, feeds on many liquid materials, including serous exudates and exuded blood. This genus has no piercing mouthparts for obtaining blood; however, other flies show the development, in graded series, of piercing mouthparts and bloodsucking habits. Many common ectoparasites, such as fleas, lice, mites, and ticks, are bloodsucking. (*See* also FLEA; FLY; LOUSE; MITE; TICKS.)

Some typical ectoparasites have become more or less endoparasites. Thus, the adult female of the jigger or chigoe flea, *Tunga penetrans,* burrows far enough into the skin of man or animals to cover most of its body, but extrudes eggs to the exterior. Sarcoptic mites, such as the itch mite of man, *Sarcoptes scabiei,* burrow into the skin and make long tunnels in which they feed and complete their life cycle. Finally, certain mites crawl down the trachea and invade the lungs of seals and old world monkeys. These habits represent unequivocal endoparasitism.

Many habits of free-living organisms may have led to or hastened the development of the phenomenon of parasitism. The flies' habit of laying their eggs or larvae in meat may easily have led to the deposition of larvae in wounds and in time to the larvae penetrating the skin and becoming true parasites, as in the myiasis-producing flies. A recently acquired habit of this type is seen in the important disease of sheep known as strike. It is produced by maggots from carrion-feeding flies that lay eggs in wool soiled by feces and urine. The maggots penetrate the flesh and are often fatal to the host.

Some free-living animals are cryptozoic and hide in various passages and cavities of other animals to which they have access. In addition, biotic associations between free-living organisms grade into parasitism. Typically, the epiphytic plants grow on other plants without deriving food from them, as seen in orchids attached to trees. Similar epizoic animals are common. Various marine hydroids attach themselves to seaweeds without deriving any nutritive benefit. When epizoic animals attach themselves to mobile animals, the association may be termed phoresy, or phoresis. Epiphytic, epizoic, and phoretic associations grade into true parasitism. Parasitism, therefore, cannot be sharply demarcated from many associations of free-living species, nor can the parasitic methods of obtaining food be separated unequivocally from the methods used by saprophytes, scavengers, and predators.

Parasitism can, however, be roughly divided into three types. In commensalism the association is highly beneficial to the parasite but is of no consequence to the host. An example is seen in the nonpathogenic amoebae of the human intestine, which feed on intestinal debris and other material but which, as far as is known, neither help nor harm the host. Parenthetically, it should be noted that the term commensalism is used by some authors in a different sense; *i.e.,* to designate mutualism in an external partnership, such as is seen in certain sea anemones attached to the hermit crab. In true parasitism the parasite is potentially harmful, since it feeds on tissues or materials of value to the host. In general, however, true parasites tend not to kill their hosts but to live in a more or less reciprocally adjusted balance with them. In mutualism, both host and parasite benefit from the association. The two partners in the association have become so highly adapted to each other that they are mutually dependent. The cellulose-digesting protozoans of certain wood-eating insects are examples of mutualism and will be considered below. (*See* also SYMBIOSIS.)

2. Distribution, Characteristics, and Examples of Parasites.—The parasitic mode of life is widely distributed throughout the plant and animal kingdoms, but parasites themselves are mainly lower plants and animals. Thus, most parasites are viruses, bacteria (including the spirochetes and rickettsias), fungi, protozoa, helminths, or arthropods.

The viruses are characterized by their inability to grow outside living cells. Most of them are small enough to pass through filters that remove ordinary bacteria. They give rise to many diseases, such as smallpox, yellow fever, and poliomyelitis of man; rabies and foot-and-mouth disease of animals; wilt disease of caterpillars; and various diseases of plants. Parasitic bacteria likewise initiate various diseases in man, animals, and plants. In man, they cause such diseases as tuberculosis, leprosy, diphtheria, pneumonia, enteric fever, tetanus, and plague. Spirochetes cause, among other diseases, syphilis, relapsing fever, and leptospirosis; and a rickettsia produces typhus fever. In addition, many saprophytic forms under unusual conditions may cause serious diseases. The entire class of fungi live on either dead or living organisms or organic matter derived from them. Parasitic fungi cause smuts and rusts of cereals, mildews of grapes, and blights of potatoes. In animals and man they produce such infections as ringworm, actinomycosis, and coccidioidomycosis.

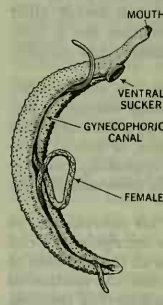
Among the parasitic protozoa are the causative agents of human malaria, amoebiasis, and African sleeping sickness.

The helminths, or worm parasites, include the flukes, tapeworms, and nematodes. A few representative species of these are: among the flukes, the blood fluke of man, *Schistosoma haematobium* (fig. 1), and the liver fluke of sheep, *Fasciola hepatica,* and of man, *Clonorchis sinensis;* among the tapeworms, the beef tapeworm of man, *Taenia saginata,* and the larval stage of *Echinococcus granulosus,* which produces hydatid disease in man, sheep, and pigs; among the nematodes, various hookworms, such as *Necator americanus* and *Ancylostoma duodenale* of man, and various filarial worms of man, such as *Wuchereria bancrofti.*

Many arthropods parasitize plants (*e.g.,* scale insects) and animals (fleas, lice, etc.) as ectoparasites, and a few are endoparasites. Large numbers of insects, such as the chalcid and ichneumon flies (Hymenoptera) and the tachinid flies (Diptera), feed internally on the eggs or larvae of insect hosts and ultimately cause the death of the hosts. These are called parasitoids. In addition to these groups, numerous parasitic forms occur among the Crustacea, Coelenterata, Rotifera, Annelida, and Mollusca. Even the vertebrates include phoretic forms such as the remoras, which attach themselves to sharks and other large fish and turtles by a sucking disc evolved from the spinous dorsal fin.

Among the flowering plants, some obligate parasites, such as mistletoe, are known as hemiparasites. They are autotrophic in that they manufacture their carbohydrates photosynthetically, but they are dependent on their hosts for water, mineral nutrients, and certain organic materials.

A parasite and its host are not necessarily of different species. Degenerate males may parasitize normal females in an association that is termed sexual parasitism. This type of association occurs as endoparasitism in the marine worm *Bonellia.* It is encountered as a form of hyperparasitism in the nematode *Trichosomoides crassicauda.* The female of this species lives as a parasite in the bladder of the rat, and the degenerate male lives inside the uterus of the female. Ectoparasitism occurs in certain of the angler fishes such as *Photocorynus spiniceps.* The female carries the greatly reduced male attached to her body. This is true parasitism, because the male establishes an organic connection with the blood vessels of the female. What might be termed sexual phoresis is seen in the blood fluke *Schistosoma haematobium,* in which the smaller female is carried in a ventral body-wall groove, the gynecophoric canal, of the male (fig. 1).



FROM SIR PATRICK MANSON, "TROPICAL DISEASES"

FIG. 1.—SCHISTOSOMA HAEMATOBIUM, × 5.5
The male carries the female in a ventral groove, the gynecophoric canal

Parasitism frequently occurs at a social level and thereby becomes social parasitism. Thus, some wasps, bees, and ants have lost their worker castes. The fertilized female enters the nest of social insects, kills the host queen, and usurps her place. The size of parasites varies over a tremendous range. Among those that can infect man, the fish tapeworm, *Diphyllobothrium latum,* is from 0.4 to 0.8 in. wide and from 10 to 30 ft. long, whereas the virus of foot-and-mouth disease, an occasional parasite of man, is about $\frac{1}{2,500,000}$ in. in diameter.

3. Life Cycles of Parasites.—Complicated life cycles, sometimes involving more than one host, occur among the parasites, especially among the viruses, fungi, protozoa, helminths, and insects. An example of a parasite that utilizes three hosts is the fish tapeworm. The adult tapeworm lives in the intestine of man, dog, cat, fox, bear, or swine. Its eggs are discharged in large numbers in the host's feces and undergo the following development if suitable conditions occur: in fresh water, a free-swimming ciliated embryo (coracidium) hatches from the egg; if swallowed by one of several copepods, the coracidium develops into a procercoid and,

if the infected copepod is swallowed by a susceptible fish, the procercoid in turn develops within the muscles into a plerocercoid. Man and other definitive hosts become infected from eating infected fish.

4. Morphology of Parasites.—Parasitic bacteria and some parasitic protozoa, such as the parasitic amoebae, are similar morphologically to their free-living relatives, whereas other protozoa have lost structures (*e.g.*, a mouth in the astomatous ciliates) or gained organelles (*e.g.*, an undulating membrane in the trypanosomes) supposedly as adaptations to the parasitic mode of life. Metazoan parasites, on the other hand, are usually markedly different from their free-living relatives. The changes are often degenerative in nature and are associated with the fact that parasites no longer have to do all the things their free-living relatives do. Organs of locomotion, such as wings, legs, and other appendages, tend to disappear, and the alimentary canal may become less and less specialized or may disappear entirely, as in the tapeworm. On the other hand, organs associated with attachment to the host, especially in ectoparasites and parasites in the intestine, tend to become highly developed, and reproductive functions increase. Thus, enormous numbers of eggs are laid by parasitic worms, and larval stages of many worms reproduce asexually by budding.

5. Metabolism of Parasites.—The habit of parasitism is sometimes transitory, sometimes optional, and at other times obligatory. There is considerable ground for accepting the popular theory that as organisms become more and more obligate in their parasitism they tend to lose abilities to synthesize essential materials for their protoplasm and, as a consequence, become more and more dependent on their hosts for these substances.

The loss of metabolic activity is carried furthest in the viruses. The true viruses are obligate intracellular parasites; *i.e.*, they reproduce only within a living cell. The living cells, however, may grow in a host or in tissue cultures. The simplest of the viruses consist only of nucleic acid and protein and are not living in the ordinary sense, but they can, in conjunction with the metabolic systems of the host, propagate themselves and behave as organized living parasites.

Sometimes the infected cell is killed by the virus; *e.g.*, by the bacteriophages and most of the disease-producing plant and animal viruses. At other times, the infected cell is not noticeably harmed. Thus, the temperate, or latent, viruses after entering a cell become practically indistinguishable from the cell components and reproduce with them. The temperate phages may exist as prophages in a stable parasitic equilibrium and appear to be incorporated into the genetic structure (chromosome?) of the host cell. Occasionally when the parasitic equilibrium is disturbed, the virus rapidly reproduces and kills the host cell. Often a virus that is latent and produces no disease in one organism produces a disease in another. For example, the virus paracrinkle, when it infects the King Edward potato, can be detected only when the infected King Edward stock is grafted onto a susceptible potato stock.

6. Host-Endoparasite Relationships.—Every known parasite is limited in its range of hosts and, within the range of susceptible hosts, is more or less restricted in its site of colonization and in its power to invade, reproduce, and survive. A part of this host limitation is attributable to purely ecological factors, which keep parasite and potential host apart. The protozoan parasite *Trypanosoma gambiense*, which causes African sleeping sickness in man, cannot naturally infect man outside Africa because its obligatory insect host and vector, certain species of the fly *Glossina*, occurs only in Africa.

Assuming effective contact between endoparasite and potential host, biochemical and physiological aspects of the host-parasite relationship fall into two main categories. These are: (1) factors of parasite invasiveness aimed at penetration of the host and maintenance within the host, and (2) factors of host immunity, both innate and acquired, that tend to prevent invasion and colonization by the parasite. Although invasiveness is associated with parasite factors and immunity with the host, the reciprocal relationship between the two often makes it impossible to establish clear-cut differentiations. Thus, certain hosts deficient in pantothenic acid do not suffer from malaria as do normal hosts. Assuming that the parasites need this vitamin, the situation can be considered either as an athreptic host immunity (*i.e.*, immunity resulting from nutrition conditions unfavourable for the parasite) or as a lack of virulence of the parasite resulting from its inability to synthesize the vitamin.

The interplay of such diverse factors results in all degrees of parasitism between a given parasite and a potential host. At one extreme, there are unquestionably many cases of absolute innate immunity in which the parasite cannot make the initial invasion of the potential host. These may arise from any number of physical or chemical barriers of the host or from some deficiency of the parasite. At the other extreme, there are a few cases, especially in experimental infections, in which the parasite invades and reproduces at maximum capacity and, in addition, almost all its progeny survive. Such associations cannot last long, as they inevitably result in the death of both host and parasite. In fact, no host infected with any endoparasite or with most ectoparasites can continue to survive in the absence of some mechanism limiting increase of the parasites.

Most endoparasitism falls within an intermediate zone in which host immunity and parasite invasiveness hold each other in check. The net result is that neither the host nor all of the parasites are killed. Although these successful host-parasite relationships may appear static, they actually rest on a complex, shifting, dynamic balance between the factors of parasite invasiveness and host immunity. Some of these factors will be considered below.

The nonlethal type of host-parasite equilibrium would be expected to have evolved through natural selection because of its survival value to the host and the parasite. It is hastened because once a parasite invades a specific host it becomes more or less isolated, just as free-living species become geographically isolated when they are segregated on islands or behind other ecological barriers. The effective isolation of a parasite generally increases as parasitism becomes obligatory and as it involves the entire life cycle of the parasite. In this sense the host becomes equivalent to the biotope of the free-living species. The biotope is peculiar, however, in that it involves a living organism that may respond specifically to the parasite. As a corollary, it is probably safe to assume that the longer a given parasite is associated with a host in geological time the less pathogenic it becomes. It does not follow, however, that because a parasite is nonpathogenic it must have been associated with its host for a long time. Experience indicates that first contacts may show all degrees of parasite virulence. Hence, a presently nonpathogenic parasite may never have been pathogenic.

Invasiveness.—Parasite invasiveness arises from the summation of a heterogeneous collection of factors involving specialized structures and specific biochemical entities produced by the parasite. Frequently, however, a single factor may be eliminated without markedly modifying invasiveness, and, therefore, specific factors are often difficult to associate with a specific activity of a parasite. Among the more likely invasive factors are the following:

1. The association of invasiveness by certain bacteria and their power to encapsulate has long been recognized. The best-known capsules are polysaccharide in nature, although some contain amino acids. The possession of a capsule inhibits phagocytosis of the organisms by leukocytes or prevents digestion after phagocytosis. Also, injection of capsular material, by inhibiting phagocytosis, may allow invasion by the ordinarily noninvasive unencapsulated organism. On the other hand, immunization with the capsular material gives rise to antibodies, as does infection, and protects against infection by the encapsulated organism. That the prevention of phagocytosis and digestion by leukocytes is the important factor is further indicated by the fact that an unencapsulated noninvasive organism becomes invasive if the host is deprived of its leukocytes.

2. Toxins, which will be considered below in greater detail under *Disease of the Host*, probably increase invasiveness by breaking down various physiological mechanisms involved in immunity.

3. Leukocidins are produced by a number of bacteria and kill the circulating leukocytes, but their activity in increasing invasiveness, although likely, is obscure.

4. The ability of most parasites to pass through the external barriers and to spread through the denser tissues is generally believed to be a matter more of enzymatic activity than of mechanical force. The best known of the enzymes involved is hyaluronidase, or the "spreading factor," which depolymerizes and hydrolyzes hyaluronic acid, one of the carbohydrate cement substances of connective tissue. Another enzyme, collagenase, may split collagen, the protein that occurs in connective tissue.

5. Once antibodies have started to function, parasites are frequently able to overcome their effects either by producing new heritable antigens or by continuing to produce enough phenotypically resistant individuals to keep the infection alive (*see* discussion of trypanosome infections and malaria, below).

6. The requirements of parasites may be a limiting factor in invasiveness. The case of hosts deficient in pantothenic acid has already been mentioned as an advantage in certain malarias. A further instance is that of persons with the heterozygous trait for sickle-cell hemoglobin: they withstand infection from the malarial parasite *Plasmodium falciparum* much better than normal persons do.

Localization of Parasites Within the Host.—Invasiveness is closely related to the elective localization of endoparasites in certain cells, tissues, or organs within the host. Thus, among the fungi, the parasite of loose smut of wheat, *Ustilago tritici*, is localized in the embryo and growing points of the developing plant. For most of their development in man, the parasites of malaria live within red blood cells. *Leishmania donovani*, the parasite of human visceral leishmaniasis, or kala azar, lives in macrophages widely dispersed over the body. Adult hookworms of man are largely localized to the small intestine. Such predilections are almost certainly associated in part with the availability of suitable nutrients or specific enzyme systems that the parasite can utilize. Little is known about the fundamental mechanisms involved.

Highly potent factors in invasiveness are the genetic mechanisms whereby parasites acquire new heritable characteristics that permit them to invade hosts previously immune to them or that allow them to become resistant to the immune factors the host acquires during the infection. All parasites have to a greater or lesser degree the power to mutate and produce heritable variations. Genetic variability is further increased by the constant mixing of different parental strains.

Those bacteria and viruses that usually reproduce asexually may at times undergo sexual recombination and other processes of genetic change. Thus, the common enteric bacterium of man, *Escherichia coli*, mates not only with other strains of the same species but also with several species of the genus *Shigella*, a group of dysentery-producing bacteria. The offspring of the various matings show features of both parents. Genetic exchange can also occur between bacteria by transduction; *i.e.*, genetic material from one host cell is transferred to another by a suitable virus. In some organisms, such as the pneumococcus, genetic exchange by transformation occurs when the genetic material, deoxyribonucleic acid, is isolated from one strain and added to another. Apparently, the donor deoxyribonucleic acid enters into the recipient cell and becomes incorporated into its genetic apparatus. Mating and genetic exchange are known to occur in the viruses, such as the virus that produces influenza in man.

Disease of the Host.—Before discussing the parasitic production of disease in the host, it should be pointed out that some persons harbour parasites without having noticeable symptoms. Such a host, called a carrier, may unknowingly disseminate disease-producing organisms and thus present an important public health problem.

Some, but by no means all, of the methods by which parasites injure or produce symptoms in the host are known. A few parasites, particularly among the bacteria, elaborate poisons, so-called toxins, which induce antibodies known as antitoxins within the host. Examples of organisms producing true toxins are the diphtheria organism, the gas gangrene organism, and the streptococcus that causes scarlet fever. In addition to true soluble toxins, sometimes called exotoxins, cell substances of certain parasites seem to be toxic but they are liberated only when the parasites break up. These so-called endotoxins are difficult to distinguish from the proteins of the parasites themselves. Many symptoms produced by them may be the result of a hypersensitivity, similar to the sensitivity to pollen in asthma and hay fever.

In addition to poisoning, many parasites destroy tissues or cells. This may cause anemia, necrosis, and other damage, and may lead to concurrent and intercurrent infections by other parasites. For example, the plasmodia that cause malaria destroy large numbers of the red blood cells in which they live and reproduce. They may also agglutinate in small blood vessels of such organs as the brain. The parasite of amoebic dysentery and the hookworm destroy intestinal mucosa and ingest blood cells. Some parasites also deprive their hosts of essential food materials and, in overwhelming infections, may compete with the host for essential metabolic substances.

Parasitic virulence depends upon toxigenicity and invasiveness. These may vary markedly. At one extreme, the free-living saprophyte that produces botulism in man is rarely invasive and ordinarily produces no infection at all. It is classed as highly virulent, however, because in improperly canned foods it produces an exotoxin that is highly poisonous when ingested. Only slightly more invasive is the bacillus *Clostridium tetani*, which produces lockjaw in man and is extremely toxigenic. It generally gains admission to tissues in deep, dirty wounds, where it is accompanied by common saprophytic bacteria and frequently by irritating chemicals. Under such conditions, it germinates (which it cannot do in healthy tissue) and locally secretes a powerful toxin that diffuses into the body and produces the disease symptoms.

At the other extreme, the virulent parasite *Plasmodium falciparum* is extremely invasive and practically nontoxigenic. This parasite seems to produce no significantly active toxin but is so invasive that the majority of the red blood cells in a fatal infection may be parasitized just before the host dies. When the parasite is nontoxigenic, a moderate invasiveness may be associated with low virulence. The essentially nonpathogenic blood parasite of the rat, *Trypanosoma lewisi*, is moderately invasive (*see* below) but rarely produces symptoms except in very young hosts.

Reactions of the Host.—The host resists infection by reacting both passively and actively against the invasion and proliferation of the parasite. These capacities to react are collectively termed immunity. Immunity may be innate (*i.e.*, a natural characteristic of the host) or acquired as the result of infection or immunizing procedure.

Upon initial contact of a parasite with an animal host and before acquired immunity develops, factors of innate immunity operate. The unbroken skin and the outward flow of mucus, urine, etc., act as mechanical barriers to an initial invasion. After the mechanical barriers have been passed, many factors of the host act together to make the nonimmunized host an unsuitable medium for a given parasite.

When infective stages or oöcysts of certain coccidia are fed to nonsusceptible hosts, they often go through the alimentary tract without hatching or liberating their merozoites. Here it seems probable that the oöcysts are unable to hatch in the digestive juices of the nonsusceptible host. In other nonsusceptible hosts, certain properties of the blood may be inimical to the parasite. The resistance of man to many trypanosomes that infect animals in Africa is almost certainly in part attributable to a trypanocidal property of normal human serum. Thus, normal human serum is a potent curative agent for many of the trypanosomes of animals, but it does not harm the commonest trypanosome, *Trypanosoma gambiense*, which produces sleeping sickness, or African trypanosomiasis, of man. Interestingly enough, it also does not harm another trypanosome, *Trypanosoma rhodesiense* (which produces a sleeping sickness in man and which is probably an animal strain partially adapted to life in man), unless the strain has undergone several passages in animals. In plants, innate immunity may be associated with the action of so-called antibiotic substances.

As would be expected, innate immunity is, to a large extent, genetically determined. This has been put to practical use in the

development of resistant strains of plants and breeds of animals. In addition, small animals with desired degrees of susceptibility to certain parasitic organisms have been developed for laboratory testing.

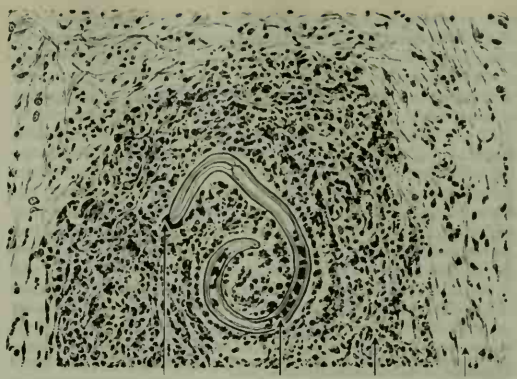
During the course of an infection in man or vertebrate animals, acquired immunity appears and owes its highly specific character to antigen-antibody reactions. Any given antigen (usually a protein) from a parasite induces the formation of a spectrum of antibodies by the host. Generally, these antibodies react specifically with the antigen that stimulated their production and react to varying degrees with antigens of related chemical structure. Antibodies are named according to how they react with the antigen or what effect they produce on the parasite. As a consequence, a single antibody may have several names. In some plant infections, acquired immunity has been described, but it is not associated with antibodies.

Antibodies fall into two groups: antitoxic and antiparasitic. The latter term can be further subdivided into antibacterial, antifungal, etc. When a parasite secretes a toxin, the resulting antibody or antitoxin that neutralizes the toxin may account for all or practically all of the acquired immunity. Whether or not a parasite secretes a toxin, each of its body proteins may stimulate an antibody, which in turn may produce antiparasitic effects, depending upon the position of the antigen in the parasite. Thus, when the antigen is associated with some locomotor organ of the parasite, such as the flagella, an antibody acting as an agglutinin may agglutinate the organism. When the antigen is on the surface of the parasite, the antibody, acting as a lysin in conjunction with complement, a normal component of serum, may lyse the parasite (*i.e.*, injure the cell so that essential cellular constituents are lost) or, acting as an opsonin, may sensitize the parasite so that it is more easily eaten (*i.e.*, phagocytized). When the antigen is a soluble material extruded from the parasite, the antibody acting as a precipitin may react with soluble parasitic materials to form precipitates. Precipitins are particularly common in metazoan infections and probably are involved in certain types of hypersensitivity that speed up the walling off of parasites by producing inflammation.

Both antibody and nonspecific factors of immunity in an animal host are associated with phagocytosis by cells of the blood and connective tissue. Some cells, particularly the polymorphonuclear leukocytes of the blood and the macrophages of the connective tissue, phagocytize small organisms and various debris resulting from the destruction of host tissue. Macrophages, together with fibroblasts and endothelial cells, also form encapsulating connective tissue around large parasites or other material too large to be phagocytized. In addition, many cells of the blood and connective tissue possess embryonic (*i.e.*, mesenchymal) potencies to develop into other cells. This characteristic permits them to assume an important role in the regeneration of destroyed connective tissue and in the formation of new phagocytes. The activities involved in removing parasites and repairing injuries are closely connected with the process of inflammation. Inflammation, which is often evident superficially by a reddening and swelling of the skin, is a complicated reaction involving edema and phagocytosis together with the migration, transformation, and division of certain cells of the blood and connective tissue. At the first contact of a parasite with its host, the parasite generally moves more or less rapidly through the tissues of the host, and inflammation with its mobilization of phagocytic cells is comparatively mild. At a second, third, or later contact of the same parasite with the host, specific antibodies, such as precipitins and agglutinins, localize the parasite or its noxious materials, and opsonins make the parasites more susceptible to phagocytosis. (*See* also INFLAMMATION; PHAGOCYTOSIS.)

The interplay of antibody and cellular factors is clearly seen in the suppression of many bacterial infections by opsonin-induced phagocytosis; such suppression has been studied in detail in malaria. Agglutinins also assist in localizing various organisms and thereby probably aid in phagocytosis.

Acquired immunity to *Nippostrongylus muris*, the small, hookwormlike nematode (roundworm) of the rat, illustrates the direct



ADAPTED FROM W. H. TALIAFERRO AND N. P. SARLES, "THE CELLULAR REACTIONS IN THE SKIN, LUNGS AND INTESTINE OF NORMAL AND IMMUNE RATS AFTER INFECTION WITH NIPPOSTRONGYLUS MURIS," "JOURNAL OF INFECTIOUS DISEASES", BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

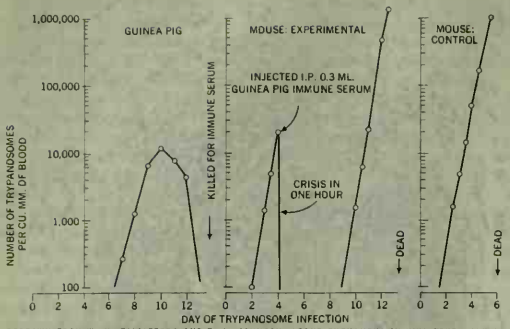
FIG. 2.—A LARVA OF NIPPOSTRONGYLUS MURIS IN THE SKIN OF AN IMMUNE RAT. × 165

Antibody has immobilized the larva and reacted with larval antigens to form a cap of precipitate over the larva's mouth and masses of precipitate in its intestine. Inflammatory processes have resulted in the formation of a granulomatous nodule around the larva

antiparasitic action of antibodies acting as precipitins with the secondary cooperation of inflammatory cells. Eggs of this nematode are passed out of an infected host with the feces and develop into infective larvae after about a week. The infective larvae may then penetrate the skin of nonimmune rats. There they feed and develop for about 20 hours, until they migrate via the blood stream and reach the lungs. In the lungs, they further feed and develop and then migrate to the mouth. After being swallowed, they reach the intestine between the second and third day. There they feed by piercing the intestinal mucosa. They develop to sexual maturity by about the end of the first week and lay large numbers of eggs, but many worms are expelled from the gut after another week as a result of the development of acquired immunity. It is mainly associated with antibodies that are produced by the host in response to the secretions and excretions that pass from the mouth, anus, and excretory pore of the worm and antigens liberated at the time of molting. During superinfections, these precipitins cause precipitates to form at all orifices and throughout the gut of the parasite. The larvae are stunted and more or less immobilized by antibodies, probably as a secondary result of the precipitate formation. Furthermore, intense antigen-antibody reactions in the tissues produce tissue damage and set up inflammation, which in turn results in the formation of nodules around the immobilized parasites (fig. 2). Some worms die in these nodules and the disintegrating worms are removed by macrophages. Others may escape from the nodules and resume their migration but they are stunted and immobilized to the extent that they cannot withstand peristalsis and are forced out of the rat's gut. The females, if they reach the intestine, lay fewer eggs than normally.

Certain of the pathogenic trypanosomes, such as *Trypanosoma equiperdum*, *T. brucei*, and *T. gambiense*, reproduce at a constant rate in a series of experimental hosts and increase in number essentially logarithmically in mice and sometimes in rats until death occurs (*see* control mouse in fig. 3). In such infections there seems to be no evidence of antibody formation. In other hosts, such as the guinea pig, the parasitemia periodically decreases as a result of the production of typical trypanolysins. Lysins rarely eradicate the infection, however, because after each trypanolytic crisis, a few trypanosomes are resistant, continue to reproduce, and repopulate the blood stream (*see* experimental mouse in fig. 3).

A unique antibody mechanism specifically inhibits growth and reproduction in the *Trypanosoma lewisi* group of nonpathogenic trypanosomes. *Trypanosoma lewisi* undergoes reproduction by



REDRAWN FROM W. N. TALIAFERRO AND T. L. JOHNSON, "ZONE PHENOMENA IN VIVO TRYPANOLYSIS AND THE THERAPEUTIC VALUE OF TRYPANOLYTIC SERA," "JOURNAL OF PREVENTIVE MEDICINE"; BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

FIG. 3.—ANTIBODY-INDUCED LYSIS IN AN INFECTION WITH TRYPANOSOMA EQUINUM

After the trypanosomes had largely disappeared because of a lysin formed in the guinea pig, its serum was injected intraperitoneally to induce a similar population decrease in a mouse, which nevertheless suffered a fatal relapse

division only in the first part of its infection and thereafter remains in the blood in the nonreproducing adult form (fig. 4). This seemingly inherent life cycle results from the formation by the host of an antibody, ablastin, which inhibits reproduction of the parasites without exerting any apparent effect on their general vitality, mobility, or infectivity. Biochemical investigations indicate that the inhibited parasites are prevented from synthesizing nucleic acids and protein, and their carbohydrate metabolism is changed from an assimilative type to one of maintenance. Nonreproducing trypanosomes may persist up to a year but may be destroyed in batches periodically by specific lysins. Trypanosomes that are resistant to lysins, however, do not repopulate the blood because they cannot reproduce in the presence of ablastin. Ablastin-resistant organisms have not as yet been found.

7. Host-Ectoparasite Relationships.—The ectoparasite is obviously less closely associated with its host than is the endoparasite. Nevertheless, there is a high degree of host specificity in ectoparasitism based on an interplay of invasive factors of the parasite and immune reactions of the host.

An interesting situation is seen in the unionid clams. The larval stages of these mollusks, known as glochidia, are expelled in large masses into the water and fix themselves to various parts of fish. Because of the respiratory currents produced by the fish, many find their way to and attach themselves to the gills. This attachment is effected by a closing of the valves and is reinforced by hooks or spines in some species. The host epidermis responds by growing over and completely covering the parasite. Each enclosed glochidium then undergoes a complete metamorphosis into a young mussel, which breaks out of its cyst and falls to the bottom of the sea to begin its growth into an adult clam. The glochidia require a specific fish host for normal development. When they attach themselves to other species of fish, innate immunity operates to cause the sloughing off of the parasite before metamorphosis is complete. In addition, under experimental conditions, repeated infestations result in an acquired immunity that also causes the glochidia to be sloughed off prematurely. This antiparasitic action is associated with a lytic antibody in the serum.

Ticks are firmly attached by their mouth parts, which are inserted into the skin. Immunologically, they behave in the same manner as a nematode worm that lives in the intestine and pierces the mucosa to feed. During feeding, both inject antigens, which stimulate the formation of antiparasitic antibodies. It has been shown that guinea pigs acquire an immunity to ticks. In immune animals, fewer ticks attach themselves and, of those that do, many are prevented from engorging themselves and some die. This immunity can be passively transferred to nonimmune (*i.e.*, normal) animals by injecting blood serum from immune animals.

The female of the dipterous fly *Cordylobia anthropophaga* deposits its eggs, preferably, in sand. The first-stage larva burrows into the skin of man or animals and after attaining the third stage drops to the ground and pupates. The infected area of the skin looks like a boil. Heavy infestation of these maggots on guinea pigs results in a high degree of acquired immunity in which antibodies affect the larvae in much the same way as has been described for the larvae of *Nippostrongylus muris*. Immune precipitates are formed throughout the gut and at the ends of the larvae, and the maggots eventually die before they complete their development.

8. Mutualistic Host-Parasite Relationships.—In true mutualism, where both host and parasite are benefited, an optimal invasion may have survival value for the host as well as for the parasite. A remarkable example is seen in certain termites whose intestines contain a teeming menagerie of protozoa, mostly flagellates. Experimental studies by L. R. Cleveland, R. E. Hungate, and others indicate that from the termites the flagellates receive shelter, an optimal oxygen tension, wood particles finely enough divided to be eaten, and utilizable nitrogenous materials. The flagellates in turn furnish their host with various degradation products of cellulose that can be utilized metabolically by the host. Even in these ideal host-parasite relationships there must be some mechanism for preventing an unlimited increase in the parasite population. Three phases of flagellate infection have been recognized in the case of *Termopsis angusticollis:* (1) infection of a recently molted termite followed by a period of rapid flagellate multiplication; (2) a long period between molts when reproduction and death of the flagellates are low or practically nil; and (3) the end of the infection during molting when the flagellates are eliminated or die. It has been suggested that the lack of reproduction between molts and the rapid reproduction just after molting is associated with the availability of nitrogenous materials necessary for protozoan growth. The restraint of the flagellates during the intermolting periods by a lack of nitrogenous food would represent an athreptic immunity.

Molting may have other profound effects on the protozoan partner in these mutualistic associations. Thus, in *Cryptocercus punctulatus,* one of the wood-feeding roaches, molting is associated with sexual cycles in several of the flagellates of its hind gut. The sexual behaviour of the flagellates varies but is apparently induced by a molting hormone secreted by the prothoracic glands of the roach.

9. Population Ecology.—The statistical study of parasites has proceeded chiefly along two lines involving: (1) changes in the population census of single species of parasites within a single host; and (2) the interaction between parasite population and host population. The first of these considers the changes in parasite population resulting from the interaction of parasite virulence and host immunity, whereas the second considers the reciprocal relation that is established when host and parasite populations interact in a specific time period.

Certain blood-induced malarias are ideal for studying the net result of the interplay of host immunity and parasite invasiveness on the parasite population. In the malarial infection of monkeys with *Plasmodium brasilianum,* the parasites are more or less evenly distributed in the red blood cells and can, therefore, be studied

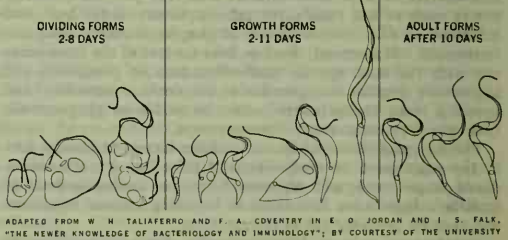


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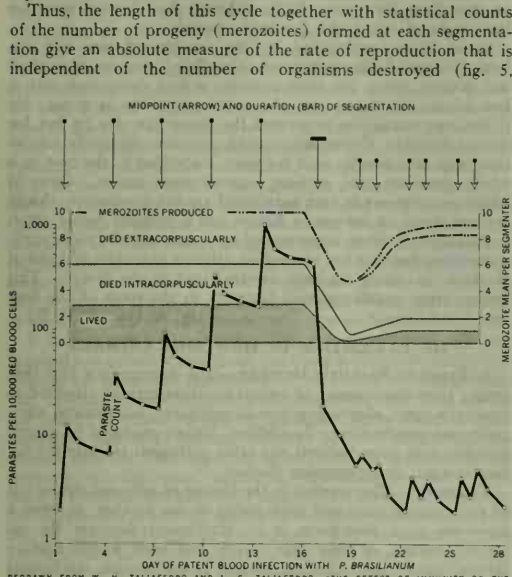
FIG. 4.—TRYPANOSOMA LEWISI IN THE RAT. ×1,100

by means of frequent blood samples without injuring the host. The asexual parasites reproduce synchronously (*i.e.*, they develop almost simultaneously) and ordinarily take three days to grow and segment into approximately ten merozoites (fig. 5). This sequence permits a remarkably accurate determination of the rate of reproduction.

Thus, the length of this cycle together with statistical counts of the number of progeny (merozoites) formed at each segmentation give an absolute measure of the rate of reproduction that is independent of the number of organisms destroyed (fig. 5,



REDRAWN FROM W. H. TALIAFERRO AND L. G. TALIAFERRO, "THE EFFECT OF IMMUNITY ON THE ASEXUAL REPRODUCTION OF PLASMODIUM BRASILIANUM," JOURNAL OF INFECTIOUS DISEASES

FIG. 5.—POPULATION CURVE OF PLASMODIUM BRASILIANUM IN THE BLOOD OF THE MONKEY CEBUS CAPUCINUS

"Merozoites produced" shows the number of progeny formed at each segmentation. The number of parasites in the blood indicates what proportions of the progeny died extracorpuscularly and intracorpuscularly, and what proportion survived

"merozoites produced"). Examination of fig. 5 indicates that the population curve during the first four segmentations of the parasite in this particular infection rises and falls in a regular steplike fashion and is the net result of the rate of reproduction by one brood of parasites minus its death rate. Analysis of this curve indicates that only three of the ten merozoites produced per segmenter live, while four die during segmentation and three during growth.

Decrease in the population of parasites between the 13th and 19th day (fig. 5) is apparently composed of two phases. The first part of the drop is the expected intracorpuscular death of the parasites, whereas the second precipitous decrease results from the first evidences of acquired immunity. During this so-called crisis, parasitic reproduction is markedly deranged. The asexual cycle is lengthened, the number of merozoites produced is decreased, and many of the circulating parasites are markedly damaged. Within a few days, however, the surviving parasites become normal in appearance and almost produce their normal quota of merozoites. Interestingly, though not cogent to the present discussion, the parasites rearrange themselves after the crisis into two broods instead of one brood, each with a typical three-day asexual cycle (*see* arrows in fig. 5). For a long time there is a net survival of only one parasite per segmenter with a resultant static population. The surviving parasites are resistant to the circulating antibodies that produced the crisis. This resistance, however, is phenotypic and is not inherited because most of the parasites continue to be susceptible at each segmentation and no resistant strain arises as in the trypanosome infections noted previously.

The epidemiological aspects of the interaction between human populations and parasites comprise a branch of medicine (*see* EPIDEMIOLOGY). The epidemiological effects of parasites on subhuman host populations have been studied by entomologists and ecologists (*see* POPULATION ECOLOGY). This type of study is exemplified by the work of T. Park on the interspecies competition of two flour beetles, *Tribolium confusum* and *T. castaneum*, as influenced by parasitism with the sporozoan *Adelina tribolii*. Each parasitized host species studied individually eventually reaches an equilibrium under certain standard environmental conditions. Of the two species, however, *T. castaneum* is much more susceptible to the parasite and the population of the host markedly decreases and then recovers about the 300th day. When the two beetles and the parasite were studied together over a four-year period, one host species always became extinct and the surviving one assumed a population trend statistically identical to that found in the particular parasitized species when studied individually. The same species, however, did not always survive when various environmental conditions were modified.

10. Prevention of Disease.—Innate immunity has been used by plant pathologists to great advantage in controlling plant diseases. Strains of economic plants that are specifically resistant to certain infectious diseases are deliberately bred.

Artificially produced acquired immunity has been highly successful in controlling some viral and bacterial diseases of man and animals. It can be produced passively by the injection of serum from an immunized animal (or man) or actively by the injection of parts of or entire dead organisms. Passive immunity is acquired almost immediately but lasts only a short time. When quick acquisition is not important, active immunity is employed because it is much more enduring and is generally stronger. Antitetanic serum is frequently administered as soon as possible after deep wounds to prevent the possible occurrence of lockjaw. Toxoid, a preparation of toxin that has lost its toxicity but retains its antigenicity, is widely used to protect against diphtheria. A vaccine of killed bacteria produces an artificial immunity against typhoid fever. Attenuated strains of viruses induce artificial active immunization against such viral diseases of man as smallpox, rabies, and yellow fever. (*See* also IMMUNITY AND IMMUNIZATION; TOXIN; VACCINATION.)

Until 1957, attempts to immunize against most protozoan and helminth infections were on the whole disappointing. In 1957, a team of investigators at the University of Glasgow Veterinary School began the testing of an artificial vaccine for immunizing cattle against the lungworm *Dictyocaulus viviparus*. This vaccine consisted of worm larvae attenuated by X or γ radiation to the extent that they did not produce serious effects on the host but could still give off antigens in sufficient quantities to immunize the host. These results led to the development of a commercially produced vaccine. Vaccines for other worm parasites are still being sought.

Many diseases can be controlled by preventing contact between the invading organism and its host. Diseases such as tuberculosis, diphtheria, measles, scarlet fever, whooping cough, mumps, colds, and related respiratory infections are spread by discharges from the mouth and nose. Such infectious discharges may be directly transmitted to uninfected persons by kissing and by contaminated eating and drinking utensils, or may be transmitted indirectly as droplets dispersed in the air by coughing and sneezing. These methods of transmission are difficult to control.

Other diseases are transmitted from man to man by intestinal discharges. Among these are typhoid fever, cholera, and amoebic dysentery. The organisms of these diseases are generally acquired through water, milk, or food that have been contaminated with the feces of infected persons. At times, the disease organisms are mechanically transmitted by houseflies and other insects that carry the fecal material to human food or drink. Some diseases have been successfully controlled by isolating sick persons and carriers, properly disposing of fecal material, purifying water, and pasteurizing milk.

Many parasites are transmitted by insects and other arthropods, either mechanically or after they develop in the body of the vector. Certain diseases in this category have been checked with remarka-

ble success by controlling the arthropod host. Thus, Texas fever in cattle has been eradicated in many areas by dipping the cattle and thereby destroying the adult ticks.

Urban epidemic yellow fever has been temporarily largely eliminated from the western hemisphere by controlling the mosquito *Aëdes aegypti*, but vaccination is becoming increasingly important in control. Malaria has been eliminated in certain areas by an attack on anopheline mosquitoes.

11. Chemotherapy.—The number of drugs that cure or suppress parasitic diseases of man and animals is increasing. Since 1910, when Paul Ehrlich prepared arsphenamine (Salvarsan, *q.v.*), and especially since the 1940s, more and more have been synthesized or, in the case of the antibiotics, formed in controlled cultures of microorganisms. A few of the most important remedies will be mentioned here. (Others are noted in section III, subsections on agents of disease.)

Emetine, the alkaloid that occurs in the ipecac root, is helpful against amoebic dysentery. Tetrachloroethylene successfully eradicates hookworm. Quinine from cinchona bark, which was discovered by the South American Indians, is still used for malaria, but is supplemented by synthetic compounds such as primaquine, chloroquine, and pyrimethamine. Several arsenicals and other synthetic compounds are effective against trypanosomes that produce diseases of man and animals in Africa. Penicillin, broad-spectrum antibiotics such as the tetracyclines, and some arsenicals are used to treat the spirochete diseases, such as relapsing fever and syphilis.

Sulfonamides and particularly the antibiotics cure a wide range of bacterial infections. Certain antibiotics are effective against the rickettsial diseases, but none so far is satisfactory against any virus except the group, probably closely related to the bacteria, that produces psittacosis, lymphogranuloma venereum, and trachoma. Penicillin, the first successfully developed antibiotic with low toxicity and high effectiveness, is supplemented by streptomycin, chlortetracycline (Aureomycin), oxytetracycline (Terramycin), and others.

The genetic versatility of parasites in overcoming the action of antibodies is also frequently encountered in drug and antibiotic treatment. In work on the arsenicals, which were the first drugs developed against the trypanosomes, arsenic-resistant strains of parasites were noted. Sulfonamide- and antibiotic-resistant strains of bacteria also are encountered. A remarkable situation occurs occasionally. Certain mutant strains of bacteria have been found to be both streptomycin-resistant and streptomycin-dependent. They grow sparsely in culture media ideal for the parent stock or in animals, but luxuriantly in media to which the antibiotic is added or in animals treated with it. *See* also ANTIBIOTICS; CHEMOTHERAPY; SULFONAMIDES. (W. H. T.)

II. PARASITISM IN PLANTS

The parasitic habit is found in widely differing plant groups, from the simplest bacteria to trees such as the much-valued sandalwoods. It is very common among the bacteria and the fungi. In man, bacteria cause tuberculosis, abscesses; gangrene, and many other diseases, while in plants they give rise to leaf spots, blights, wilts, soft rots, cankers, and galls, or tumours. Because of some resemblances to cancer tissue in human beings, the tumours of crown gall, induced by *Agrobacterium tumefaciens*, have been widely studied. Most parasitic fungi inhabit other plants, including algae, but a few parasitize nematodes, insects, crustaceans, fish, and the higher animals. The dead bodies of houseflies, surrounded by a whitish halo of spores, may often be seen fixed to the glass of unused windows in the fall, victims of *Entomophthora muscae*. Another fungus of this group is very destructive to grasshoppers. Fish, especially if injured in any way, may be attacked by *Saprolegnia parasitica* or related water molds, and man is subject to such well-known disorders as ringworm of the scalp and "athlete's foot," which are caused by parasitic fungi. Fungus parasites of higher plants cause many types of diseases, including blights, rusts, smuts, mildews, root rots, and tree decays, that are of great economic importance because of the damage they do to crops and timber.

Relatively few seed plants are parasites, but the few include very interesting forms. All are parasitic on other plants, some being limited to specific hosts and others with a wide host range. The parasitism may be either partial, as in the common leafy mistletoes, or complete or nearly so, as in dodder. The broomrapes, parasitic on roots of many plants, are totally dependent on their hosts for organic foods, although they develop roots for the uptake of water and dissolved minerals.

Some plants, exemplified by the sandalwood tree and the brightly tipped Indian paintbrush (*Castilleja*), contain chlorophyll and develop roots, but they maintain a root connection with a host plant. In these cases the actual parasitism is minor, for if the host connection is severed the plants are able to live for several months. Conversely, partial parasites, especially mistletoes, may occasionally exist for years embedded in the host in a wholly parasitic state, without external green shoots. Cases in which parasites are in turn parasitized are not uncommon, chiefly between fungi, or between a fungus and a parasitic higher plant.

Parasitism is often accompanied by a reduction in plant parts, a simplification that has reached an extreme in species of tropical *Rafflesia*, in which the only external part is the flower. This springs from undifferentiated filaments in the roots of the host (species of *Cissus*). (W. W. WR.; W. H. T.)

III. PARASITISM IN MAN AND ANIMALS

1. Types of Parasitic Damage.—The damage to a host that results from the presence of animal parasites may be classified as traumatic, lytic, obstructive, loss of nutriment, intoxicative, allergenic, and proliferative. In addition, lesions produced by animal parasites may allow bacteria and other pathogens to enter the tissues and set up supervening diseases.

Traumatic.—This consists in the tearing of cells and tissues out of their normal state and relationship to one another, as when a tapeworm or a hookworm in its attachment damages the intestinal mucosa, or when eggs, larvae, and adult worms migrate through tissues, producing microscopic or macroscopic mechanical injury.

Lytic.—This is the digestion of cells and tissues by enzymes secreted by the parasite and is illustrated by the action of the pathogenic amoeba *Entamoeba histolytica* or by the larvae of the blood fluke as they enter the skin and make a pathway into the cutaneous blood vessels.

Obstructive.—A mass of the giant intestinal roundworm *Ascaris lumbricoides*, or a 25-ft. length of tangled tapeworm (*e.g.*, *Taenia saginata*) may produce massive obstruction in the intestinal tract, or a single large worm may obstruct the common bile duct (*e.g.*, *Ascaris*), a ureter (*Dioctophyme renale*), or a bronchus (the leech *Limnatis nilotica*).

Loss of Nutriment.—Most parasites live in locations within the host where they have ready access to predigested food, or they sap nutritive substance from the tissues. Many microscopic parasites, even in large numbers, cause no appreciable nutritional drain on the host, but others, such as the larger tapeworms, constitute a real burden, particularly if the nutritional threshold of the host is already critical. Moreover, hookworms may suck blood from the intestinal blood capillaries in amounts sufficient to produce anemia.

Intoxicative.—The metabolic products of the parasite, both secretions and excretions, cause localized and generalized irritation of the host's tissues, with resultant toxic manifestations. The worst of these products are the bacterial exotoxins.

Allergenic.—This is essentially a host sensitization reaction to proteins and other substances elaborated by the parasite. It is evidenced by the chills and fever of malaria following cyclic release of the plasmodia into the blood plasma, and by the systemic reaction in many of the helminthic infections.

Proliferative.—In some parasitic diseases, such as amoebic colitis, there is practically no tissue reaction to the invader. On the other hand, in visceral leishmaniasis, caused by the flagellate *Leishmania donovani*, macrophage production is stimulated to a degree where it embarrasses normal production of neutrophils and red blood corpuscles. In helminthic infections such as Ozzard's

filariasis, schistosomiasis, and clonorchiasis, host tissue proliferation is so extensive as to cause growths that seriously reduce normal function of tissues and organs.

2. Influence of Strain Differences.—The disease process varies not only with respect to the species of pathogenic microorganism but also according to the pathogenicity of a particular strain of the parasite for the particular host. Thus, *Entamoeba histolytica*, always an actual or potential tissue invader, may produce no detectable symptoms in one person who may temporarily be considered as an asymptomatic carrier, while another person exposed to the same strain may develop acute dysentery or amoebic liver abscess. This difference results from variations in the dose of inoculum of the same strain (*i.e.*, number of organisms), from enhancement in the pathogenicity of the amoeba by serial passage, from differences in tolerance between the two hosts, or from intrinsic differences in pathogenicity. Another striking example is that of the vivax malaria encountered by U.S. and Australian troops in parts of New Guinea during 1943–45. This strain proved to be much more pathogenic than the strains previously encountered elsewhere in malarious areas, as demonstrated by the severity of the clinical manifestations, the tendency to repeated relapse, and resistance to chemotherapy that had proved effective in the treatment of other strains of vivax malaria.

3. Immunity.—In general, there is neither racial nor age immunity to parasitic infections, yet there are notable exceptions. Negroes are essentially resistant to certain strains of vivax malaria that produce serious symptoms in Caucasians, but they are as susceptible as whites to quartan malaria. Again, there is some suggestion that small children are more likely to acquire *Giardia lamblia* infection than are their elders, and the same is true of infection with the dwarf tapeworm (*Hymenolepis nana*). And there is evidence that prolonged exposure to infections of certain parasites results in varying degrees of immunity, that in some cases may be substantial—though the immunity is to the infecting strain only and does not extend appreciably to other strains of the same species of parasite. This phenomenon is especially striking in some of the viral and bacterial diseases.

4. Hosts.—In some parasitic diseases man is the only known satisfactory host of the pathogen. This holds true for the four species of plasmodia that produce human malaria; for the flagellate protozoan that causes Rhodesian, or East African, trypanosomiasis; for the hookworm *Ancylostoma duodenale;* and for the blood fluke *Schistosoma haematobium*. In other instances domestic and wild animals are as susceptible as is man. Examples are found in *Entamoeba histolytica*, which parasitizes monkeys, kittens, and rats as readily as it does man; *Leishmania donovani*, for which the Chinese and golden hamsters are highly susceptible; *Trypanosoma cruzi* of tropical America, of which the mammalian reservoir hosts are legion; and *Schistosoma japonicum*, which is infective for dogs, cats, hogs, cattle, sheep, goats, horses, and many species of rodents in endemic areas. In a few known instances (for example, with *Ascaris lumbricoides* of man and the pig and *Hymenolepis nana* of man, the rat, and the mouse), the parasites found in the different hosts are morphologically indistinguishable, yet the respective hosts are highly refractory to cross infection. This suggests that within recent biological time immunological host differences have been developed. Still other parasites that occasionally are found in man commonly occur in domestic or wild animals. The situation here results from differences in habits and customs governing degrees of exposure to infection; it is not one of susceptibility.

A. Protozoan Agents of Disease

The major classes of Protozoa (*q.v.*) include the rhizopods, ciliates, flagellates, and sporozoans.

1. Rhizopods.—The rhizopods move by extending their ectoplasm. The forms of greatest human interest are the amoebae, naked protoplasts that divide by binary fission and in several species have an encysted stage. Among the parasitic species a complete life cycle consists in (1) the trophozoite, the growing and multiplicative form; (2) the precyst (a rounded-up trophozoite that has evacuated all its undigested foods); (3) the cyst, which has a thin, tough wall and serves as the source of infection for the next host; (4) the metacyst, or recently excysted multinucleate trophozoite; and (5) the metacystic trophozoite, which initiates the new infection. Six species of amoebae may live in man; viz., *Entamoeba histolytica*, the only amoeba known to produce disease in man by tissue invasion; *E. gingivalis; E. coli; Endolimax nana; Iodamoeba bütschlii;* and *Dientamoeba fragilis*. *E. gingivalis* and *Dientamoeba fragilis* apparently have only a trophozoite stage. *E. gingivalis* lives along the gingival margins of the gums, especially in unhygienic mouths, but there is no substantial evidence that it is responsible for diseased conditions of the mouth. It is probably transmitted by droplet spray or by kissing.

The other five species inhabit the large bowel and the distalmost portion of the small bowel. Except for *E. histolytica* they are lumen parasites and with the possible additional exception of *D. fragilis* produce no detectable pathology.

Entamoeba histolytica is a tissue parasite, entering the intestinal mucosa at separate pinpoint sites and typically penetrating by lysis down into the submucosa, where the lesions tend to develop radially, at times extending into the muscular coats and in rare cases producing perforation. Frequently there is subsurface tunneling, so that the mucosal blood supply is cut off and an indolent ulcer develops or denudation occurs. Erosion of small blood vessels produces hemorrhage, so that dysentery is frequently, although by no means always, an accompaniment of the infection. The lesions develop first and most commonly in the caecal and in the sigmoidorectal areas, although at times the entire large bowel may be ulcerated. The appearance of the individual lesion as seen through a proctoscope, the cellular elements in the stool, the normal blood picture, and the lack of prostrating symptoms all serve to differentiate intestinal amoebiasis from acute bacillary dysentery (*e.g.*, shigellosis). At times the amoebae get into mesenteric venules and are carried to the liver, where they may colonize and cause amoebic hepatitis or liver abscess; or they may reach the lungs, brain, and other organs and tissues and produce lesions.

Amoebiasis is practically worldwide in its distribution. Surveys in Canada, southern Argentina, and Sweden indicate its presence and clinical importance in cool temperate regions. Nevertheless, it is usually more prevalent and the symptoms are more pronounced in warm climates. Possibly as much as 10% of the earth's population harbours *E. histolytica*, although a much smaller percentage suffers from clinical amoebiasis. The infection is transmitted by water, food and food handlers, flies, and person-to-person contact. Control of amoebiasis and possible ultimate eradication depend on attacking these sources of exposure. Diagnosis of amoebiasis depends specifically on recovery and recognition of *E. histolytica* in the patient's stools or tissues. (*See* also Amoeba; Dysentery.)

2. Ciliates.—The ciliates have an ectodermal covering of many short, hairlike structures called cilia. Only one species, *Balantidium coli*, parasitizes man, with resultant diarrhea or dysentery that at times is even more severe than that produced by *E. histolytica*. It is typically an infection of warm climates, where hogs and monkeys are reservoirs.

3. Flagellates.—The flagellated protozoans possess one or more long flagella, which are threadlike extensions of their ectoplasm. The common intestinal flagellates of man are *Giardia lamblia, Chilomastix mesnili*, and *Trichomonas hominis*, all of which are lumen parasites. None of these is primarily pathogenic, although at times *Giardia* produces an irritation of the duodenum with attendant mucous diarrhea. It may be controlled by administration of quinacrine hydrochloride (Atabrine, or Mepacrine). *Trichomonas vaginalis* is frequently associated with vaginitis and at times causes a vaginal discharge.

Six species of extraintestinal flagellate Protozoa produce human disease; namely, *Leishmania donovani*, causing kala azar, or visceral leishmaniasis; *L. tropica*, causing cutaneous leishmaniasis; *L. braziliensis*, causing mucocutaneous leishmaniasis; *Trypanosoma gambiense* and *T. rhodesiense*, causing African trypanosomiasis, or sleeping sickness; and *T. cruzi*, causing American trypanosomiasis, or Chagas' disease.

The three species of *Leishmania* are transmitted by blood-sucking gnats belonging to the genus *Phlebotomus;* the African trypanosomes are spread by species of *Glossina* (tsetse flies); and *T. cruzi* is carried by species of hemophagous bugs (*Triatoma, Panstrongylus,* etc.). Visceral leishmaniasis produces a profound increase in the macrophages, with compensatory reduction in neutrophils and anemia. There are enlarged liver and spleen, engorged bone marrow, edema, an undulant type of fever, and high susceptibility to supervening bronchopneumonia, dysentery, and, in children, gangrenous inflammation of the mucosa of the mouth. This disease is particularly prevalent among children in China and Mediterranean countries. (*See* also LEISHMANIASIS.)

The trypanosomiases of Africa first develop as a bloodstream infection, then involve the lymph nodes, especially those of the posterior cervical triangle of the neck, and, in the Gambian infection, the central nervous system ("sleeping sickness" stage). The parasites never enter tissue cells but by their metabolites produce profound systemic intoxication and cellular inflammation. The Rhodesian type is fulminating, and, unless effective chemotherapy is administered early, the patient invariably succumbs before the parasites enter the central nervous system.

American trypanosomiasis, commonly referred to as Chagas' disease, has an initial lesion at or near the site where the organisms are discharged in the bug's feces and are rubbed into the skin or mucous membrane. This is frequently at the outer canthus of the eye or angle of the mouth. The parasites first multiply in macrophages within the superficial lymph nodes, then are disseminated in the flagellate stage through the blood stream to the spleen, liver, bone marrow, myocardium, thyroid gland, adrenal gland, and brain. In each of these organs the parasites become intracellular leishmania-type bodies and multiply, producing proliferative and necrotic damage. (*See* also TRYPANOSOMIASIS.)

4. Sporozoans.—In the sporozoans, asexual development (schizogony) alternates with sexual generation (gametogony and sporogony). The only sporozoan parasites of the human digestive tract are *Isospora belli* and *I. hominis.* They are endemic in the southwest Pacific region and South America, and require no intermediate host. The parasite invades the epithelial layer of the lower portion of the small intestine and possibly the caecum, causing considerable tissue damage and producing an exhausting diarrhea. (*See* also COCCIDIOSIS.)

The most important tropical disease is malaria, which is produced by four sporozoan parasites, *Plasmodium vivax,* causing vivax malaria (so-called benign tertian malaria); *P. malariae,* causing quartan malaria; *P. falciparum,* causing falciparum malaria (tropical, estivo-autumnal, subtertian, or malignant tertian malaria); and *P. ovale,* causing ovale tertian malaria. Vivax malaria is widely distributed throughout the tropical and temperate zones; quartan malaria is a relatively minor disease except in isolated focuses and in tropical Africa; falciparum malaria is a disease of the tropics and subtropics; and ovale malaria is confined mostly to central East Africa. All human strains of *Plasmodium* are transmitted by species of *Anopheles* mosquitoes. (*See* MALARIA.)

B. METAZOAN AGENTS OF DISEASE

The metazoa comprise a large number of phyla and include both invertebrate and vertebrate groups. Those that contain important disease-producing parasites are the helminths, or parasitic worms, and the arthropods, consisting of the insects and their allies. Except insofar as arthropods are involved as vectors in the transmission of protozoans and helminths, this medically and economically important phylum is not considered here. (*See* ENTOMOLOGY.) Helminths are not a single assemblage of closely related species but belong to five separate phyla: Nematoda (roundworms); Nematomorpha (class Gordiacea, or gordian worms); Platyhelminthes (class Trematoda, or flukes, and class Cestoidea, or tapeworms); Acanthocephala (spiny-headed worms); and Annelida (class Hirudinea, or leeches).

1. Roundworms.—The true roundworms constitute many thousands of species, of which the majority probably are free living, others are of considerable economic importance as parasites of vegetables, grains, flower bulbs, and tubers, and still others parasitize animals. They are typically cylindrical in shape, with a somewhat attenuated anterior end and a posterior end that is distinctly pointed in the female and ventrally turned or coiled in the male. There is a complete digestive tract, a body cavity that is not lined with mesothelium, and an elaborate set of reproductive organs. The males are typically somewhat smaller than the females; in a few species the male genitalia are parasitic in the female body (*i.e.,* syngonic), or males are wanting and the females produce progeny by parthenogenesis. The females are usually egg-laying (oviparous) but in some species they deposit living young (larviparous). There are characteristically four larval stages between egg and adult.

By far the largest number of parasitic roundworms inhabit the digestive tract. They may live free in the lumen (*Ascaris*), attached by their heads to the mucosa (*Enterobius vermicularis,* hookworms, *Trichuris trichiura*), embedded in the glands and stroma (*Strongyloides stercoralis*), or within tumours in the intestinal wall (*Oesophagostomum, Gnathostoma* in cats, *Spirocerca* in dogs). The majority enter the body by being swallowed in the fully embryonated egg stage or as free infective-stage larvae, but hookworms and *Strongyloides* actively penetrate the skin. Hookworms, *Strongyloides,* and *Ascaris* undergo an obligatory migration through the lungs before they settle down and develop into adults in the intestinal tract.

One type of nematode (*Gongylonema*) lives in the esophageal and buccal mucosa; another (*Syngamus*) is attached to the mucous membrane of the bronchi, trachea, or Eustachian tubes; still another (*Metastrongylus*) inhabits the smaller bronchioles, and one giant species (*Dioctophyma renale*) inhabits the kidneys and other viscera of the abdomen. A very important group, the filariae, live in a variety of extraintestinal locations. These worms produce microscopic snakelike embryos, called microfilariae, which reach blood vessels or interstitial tissues of the skin, are taken up by sucking insects in which they mature into infective-stage larvae, are then deposited by the insect on the skin of the definitive host, and actively enter its tissues to develop in several months into mature worms. The female Guinea worm, *Dracunculus medinensis,* upon becoming gravid, migrates from the viscera to the skin and produces a small blister. On contact with fresh water the blister bursts, discharging many active larvae. If these are eaten by a little water flea, *Cyclops,* they develop and serve as a source of infection for the next individual who drinks raw water containing the infected *Cyclops.* A few of the most important nematodes are described below.

Intestinal Roundworms.—Ascaris lumbricoides, the large intestinal roundworm of man, is about the size of a lead pencil. Under favourable conditions the fertile eggs, after being evacuated in the feces onto the soil, require two to three weeks to mature. Thereafter, if taken into the mouth and swallowed, the eggs hatch in the duodenum; the larva then penetrates the gut wall, enters a mesenteric venule or lymphatic vessel, and directly or indirectly migrates to the lungs, where it breaks out of a capillary and into an air sac, ascends the respiratory tree to the epiglottis, is swallowed, and on reaching the small intestine develops into the mature worm. Although a single worm may at times produce acute intestinal symptoms, at other times hundreds of them may occasion only a drain on the nourishment of the host. However, where several worms are present, a careful check on the patient's history will usually reveal that a few weeks previously there was a severe, deep-seated "cold" or bronchopneumonia corresponding to the period when the larvae were migrating through the lungs. At times this same type of pneumonitis develops during the lung migration of *Strongyloides* and hookworm larvae. Even if *Ascaris* does not cause pneumonia, malnutrition, or acute intestinal catastrophe, it is frequently responsible for allergic manifestations. The infection is cosmopolitan, is especially common in children living in warm climates, and is propagated by fecal contamination of the soil. It may be efficiently treated by oral administration of sirup of piperazine citrate, but if children, as well as adults, are not taught to practise personal hygiene, specific medication is useless, since reinfection is bound to occur. (*See* also ROUNDWORM.)

Hookworms.—Hookworms are strongyloid nematodes pos-

sessing a well-developed buccal capsule; the capsule is armed with teeth or cutting plates and is used for attachment. The males have a copulatory bursa, an umbrellalike extension of the caudal extremity. They are moderately stout, threadlike forms varying in length from about 8 to 16 mm. The species of special interest are *Ancylostoma duodenale* (human), *A. braziliense* (canine, feline and human), *A. ceylanicum* (canine and human), *A. caninum* (canine and feline), and *Necator americanus* (human). Species of *Ancylostoma* have two or three pairs of cutting teeth, and *Necator* has paired cutting plates embedded in the buccal capsule, enabling the adult worms to become firmly anchored to the mucosa of the small intestine.

By trauma and secretion of esophageal gland enzymes hookworms digest the tips of the intestinal villi and pump blood through their own intestines far in excess of their maximum nutritional needs. This produces loss of blood at each site of attachment, varying from 0.1 to nearly 1.0 ml. each day. Thus the daily blood loss from 25 worms will not exceed 25 ml., which is usually low enough for complete compensation. From 200 worms, the loss is about 200 ml., or an amount sufficient to cause anemia, especially since most hookworm patients also suffer from nutritional deficiencies; while 500 to 1,000 worms will almost invariably produce profound anemia, with associated severe pain in the epigastrium, diarrhea or tarry stools, loss of strength, dilatation of the chambers of the heart, rough parchmentlike skin and lustreless hair, a fishlike stare, physical, mental and sexual retardation, general dropsy, and frequently death.

Frank hookworm disease may develop from a single exposure of the skin, usually of the bare feet, to a large number of infective-stage (filariform) larvae in the top layer of moist, sandy soil; or it may result from a number of lesser exposures. The loss of blood reduces the number, size, and hemoglobin content of the circulating red blood corpuscles, producing secondary anemia. However, if it continues for a long period of time or if the patient has a constitutional tendency in that direction, a primary anemia may develop as a result of exhaustion of the blood-forming tissues.

Specific treatment includes the administration of one of several anthelmintics (*q.v.*). After about 1935 tetrachloroethylene, which is efficient and safe, became the drug of choice. Nevertheless, it is relatively useless from a public health point of view to treat isolated patients. In heavily endemic areas mass therapy for all infected persons is practised, accompanied by sanitary disposal of human feces and by educational campaigns. In the southern United States intensive hookworm campaigns beginning about 1915 resulted in eradication of the disease (*Necator americanus* infection) from a majority of the urban population, but heavy residual infection persisted in some rural sections of the Carolinas, Georgia, Alabama, Mississippi, and eastern Texas. In the tropics, hookworms, next to malaria, continued to produce widespread sickness and death.

Unlike *Ancylostoma duodenale* and *Necator americanus*, which are exclusively parasites of man, *A. braziliense* is a common helminth of dogs, cats, and their wild relatives in warm climates; it probably never produces intestinal infection in man. The canine and feline varieties do, however, cause human disease. The infective filariform larvae penetrate human skin, and, although unable to enter the cutaneous blood vessels and migrate via the lungs to the intestinal tract, they continue in serpiginous tunnels in the deeper layers of the skin, producing so-called "cutaneous larva migrans" "creeping eruption." (*See* also HOOKWORM.)

Threadworm.—The threadworm *Strongyloides stercoralis* may be either parasitic or partly free-living; the latter type of life-cycle is less frequent, and occurs only in warm, moist climates. Adult parasitic males have not been demonstrated in human infection. The parasitic females are delicate filiform worms measuring about 2 to 2.2 mm. long by 0.03 to 0.075 mm. in greatest diameter. They live in the mucosa of the small intestine, reproducing parthenogenetically. Following an incubation period of about 28 days each female lays several dozen eggs daily for several months. Eggs laid in the intestinal mucosa transform into first-stage (rhabditoid) larvae, which escape to the intestinal lumen, then pass down and out of the bowel. When deposited on moist earth the larvae grow, molt, and metamorphose into infective (filariform) larvae. On contact with human beings the larvae bore into the skin, enter the small blood vessels, journey to the lungs, and ascend to the epiglottis, where they emerge, are swallowed and so pass down the digestive tract to the duodenum. (In the moist tropics the larvae which are evacuated from the intestine may undergo one or more free-living generations on the soil, in which both males and females function. Eventually filariform larvae are produced and, following skin penetration, a new parasitic generation is initiated.) An additional type of parasitic development occurs when rhabditoid larvae transform into filariform larvae within the bowel; they may cause autoinfection by penetrating the intestinal mucosa or perianal skin, then proceed to migrate via the lungs back to the intestinal mucosa. Chronic diarrhea is a common symptom of *Strongyloides* infection. Dithiazanine is an effective but poorly tolerated drug for treatment of this infection.

Pinworm or Seatworm.—This cosmopolitan nematode, *Enterobius vermicularis*, is more common in cool climates and is particularly prevalent in children who belong to large families or institutional groups. The worm has three lips at the anterior end. Males measure 2 to 5 mm. long by 0.1 to 0.2 mm. in maximum diameter and have a strongly curved posterior end. Females measure 8 to 13 mm. long, with a maximum diameter of 0.3 to 0.5 mm., and have a sharply pointed posterior end. The worms live in the caecal region of the intestine, where they are loosely attached to the mucosa. Gravid females migrate down through the colon and out the anus to deposit almost fully embryonated eggs on the perianal and perineal skin. Each female lays about 11,000 eggs, then (usually) dies. When the mature eggs, carried in air currents, on clothing or other fomites, get into the mouth and are swallowed, they hatch in the small intestine. The small larvae pass down to the caecal region and mature into adults in 18 to 28 days. The most common and annoying symptom of pinworm infection is perianal pruritus. Piperazine hexahydrate, the drug of choice in *E. vermicularis* infection, is highly effective and well tolerated.

Trichinae.—The trichina worm, *Trichinella spiralis*, is primarily a parasite of hogs and rats, although it is also parasitic in man, dogs, cats, bears, etc. All stages in the life cycle of this minute nematode occur in the same host, but to continue the cycle an uninfected host must eat the infected flesh of another. The trichinous flesh contains the encysted larvae. When man ingests infected pork that has not been heated to 137° F (about 58° C) or otherwise processed, the organisms excyst in the duodenum and immediately enter the mucosa, where males and females mature in two to three days; they mate and the females begin discharging living young. These larvae enter intestinal venules or lymphatics and migrate into striated muscle, where they begin to encyst about the 20th day. Damage results from entry of the excysted larvae into the duodenal mucosa, migration of the larvae, and the distribution of their toxic by-products through the body, as well as the tissue reaction to the larvae. The first stage mimics acute food poisoning; the migratory stage is accompanied by acute muscular pain and frequently myocarditis suggestive of hypertension; and the intoxicative condition produces edema, especially around the eyes, as well as respiratory difficulties. The infection may be subclinical if the meat is lightly infected, but death may ensue if it is heavily parasitized. There is no specific treatment. The source of human infection can be controlled by preventing hogs from eating garbage containing infected pork trimmings. (*See* also TRICHINOSIS.)

Filariae.—Bancroft's filaria (*Wuchereria bancrofti*) occurs throughout a broad band of the tropics, practically encircling the world. The threadlike parent worms live in subcutaneous and visceral lymphatic vessels and associated lymph nodes. Here the female worms give birth to delicate, elongated embryos provided with a sheath. They are actually the partially matured eggs that have stretched out so that they may travel through the lymphatics and blood capillaries. In most endemic areas these embryos, called the microfilariae, remain in the viscera except at night, when they surge through cutaneous blood vessels. However, in the

South Pacific islands the microfilariae migrate continuously through the peripheral circulation. The embryos are picked up by many species of mosquitoes of the genera *Culex, Aedes,* and *Anopheles,* in the thoracic muscles of which they undergo development and then migrate down the proboscis sheath and are discharged on the human skin when the mosquito alights to take a blood meal. The infective larvae burrow through the skin layers down to the peripheral lymphatics, gain entry to these vessels, and proceed to migrate through the lymphatic system. About 12 months are required before the growing worms settle down and mate and the females begin to produce microfilariae.

Among native populations in endemic areas exposure begins in early childhood, and 10 to 20 years may elapse before marked symptoms appear. In newcomers to an endemic area, however, dramatic manifestations of the disease occur within a few months, and may include acute attacks of lymphatic inflammation wherever the migrating adolescent worms are blocked by lymph nodes.

Histopathological changes in Bancroft's filariasis involve inflammatory reactions, proliferation of the macrophages, and progressive obstruction of lymphatic channels by scar tissue, especially in the vicinity of adult worms. Advanced stages of the obstructive phases lead to elephantiasis which most frequently affects the leg, scrotum, arm, labia of the vulva, or mammae.

Diagnosis is made by finding microfilariae in the circulating blood, by puncture or biopsy of the infected region, and, after calcification of the parent worms, by roentgenography. (*See* also FILARIASIS.)

Another important filaria of the human lymphatics, *Brugia malayi,* is transmitted by species of *Mansonia* and *Anopheles* mosquitoes. Infection is prevalent in India and Indonesia.

2. Gordian Worms.—The gordian worms, or "hair snakes," are parasitic in the hemocelic cavity of grasshoppers during their larval and adolescent stage but escape from their hosts into fresh water to complete development, to mate, and to lay eggs. There are several reports of gordian worms having been vomited or otherwise voided by man. Such temporary "parasitism" may be the result of accidental swallowing of the worms in raw drinking water, but there is no evidence that the adults are ever truly parasitic in habit. (*See* also NEMATOMORPHA.)

3. Flukes.—Like other groups of the platyhelminths, the flukes, or trematodes, are more or less flattened, bilaterally symmetrical invertebrates without true segmentation (*e.g.,* metamerism); also, they lack a body cavity. They differ from other platyhelminths in that they possess suckers for attachment. All trematodes are parasitic, and the great majority are hermaphroditic. The Monogenea are essentially ectoparasitic (*i.e.,* living on the exterior of the host), the Aspidogastrea are in the process of developing an endoparasitic mode of life, and the Digenea are exclusively endoparasitic (*i.e.,* living within the host). The former two groups have a simple type of life cycle, consisting of egg, larva, and adult. The Digenea have a very complicated cycle: eggs are produced by the adult worms in the definitive host, reach water, and produce infection of appropriate species of mollusks (usually snails), in which they metamorphose and multiply, with the eventual escape of tailed larvae (the cercariae), which, in turn, directly or indirectly are the source of infection for the definitive host. Forms of particular interest are *Fasciola hepatica* (sheep liver fluke), *Clonorchis sinensis* (Chinese liver fluke), *Paragonimus westermani* (oriental lung fluke), and species of *Schistosoma* (blood flukes). (*See* also FLUKE.)

Liver Flukes.—Fasciola hepatica is a rather fleshy, broadly elliptical worm measuring up to 30 mm. in length by 13 mm. in breadth. It causes liver disease of sheep throughout extensive areas of the world, is frequently parasitic in other herbivorous mammals, and from time to time is diagnosed as a human parasite. The cercariae that escape from the snail host (species of *Lymnaea*) encyst on vegetation in moist meadows. When ingested, the larvae escape from their cysts in the duodenum, migrate through the intestinal wall, peritoneal cavity, and Glisson's capsule into the liver, and bore their way through to the larger bile ducts, where they develop into adults. En route through the liver parenchyma the young worms produce marked mechanical and necrotic damage ("liver rot"), and in the biliary passages and gall bladder they provoke proliferation of the epithelium, with fibrous encapsulation and pressure necrosis of the parenchyma, resulting in cholecystitis and cholelithiasis. Occasionally the worms, as they pass through the peritoneal cavity, migrate into such locations as the abdominal wall, pleural cavity, or brain. Diagnosis is made by finding the microscopically large hyaline, thin-shelled, operculate eggs in the feces or by aspiration in bile. In sheep and cattle hexachloroethane is used to kill worms that have arrived in the biliary passages; in man emetine hydrochloride has proved to be moderately effective. Control entails destruction of the snail, as, for example, by treating snail-inhabiting areas with solutions of copper sulfate or copper carbonate, but care must be exercised not to poison sheep or other grazing animals.

Clonorchis sinensis, the Chinese liver fluke, which causes clonorchiasis in man, is a delicate, transparent, lanceolate worm measuring 10 to 25 mm. long by 3 to 5 mm. in breadth. It lives primarily in the distalmost bile ducts toward the margins of the liver, but in heavy infections the more proximal bile passages, gall bladder, and even the pancreatic duct may be parasitized. This infection is indigenous to Japan, Korea, China, and Indochina, where all mammals that eat freshwater fish are exposed. Man is most commonly and most heavily infected in south China and Indochina. Minute eggs of this fluke, when evacuated in excreta of man and other hosts into ponds, slowly moving streams, and canals, are eaten by certain snails (*Bulimus, Parafossarulus*), in which the intramolluscan phase of the cycle develops. Cercariae discharged from the snails penetrate under the scales of fishes into their flesh, where encystation occurs. Frankly raw fish or fish heated only on the surface, salted, smoked, dried, or preserved in wine or vinegar constitutes the sources of human infection. Upon being swallowed, the young larvae escape from the cysts in the duodenum and migrate into the distal biliary ducts of the liver, where they mature. The epithelium in the infected bile passages proliferates, with fibrosis around the ducts and pressure necrosis of the liver parenchyma. Hepatic dysfunction and digestive disturbances occur. Diagnosis is made by recovery of the typical minute ovoidal eggs in the feces. Man may remain free of *Clonorchis* in endemic areas if the freshwater fish he eats is well cooked.

Lung Fluke.—Paragonimus westermani, the lung fluke, is a small, fleshy worm measuring 7.5 to 12 mm. long by 4 to 6 mm. broad by 3.5 to 5 mm. thick. The adults live most frequently in little fibrous pockets opening into the bronchioles, but they have been recovered from the abdominal viscera and wall, the groin, and, not infrequently, the brain. The infection is common in Japan, Korea, central and south China, Formosa, and some of the islands of Indonesia, and it is also sparsely endemic in parts of Africa, Venezuela, Colombia, Peru, and Ecuador. In Korea the infection results from eating raw soft tissues of freshwater crayfish (*Astacus*), elsewhere of fresh- or brackish-water crabs. Related species of *Paragonimus* have been reported from rodents in south China, Korea, and Japan, and from crayfish-eating mammals in the United States.

Eggs of these flukes are coughed up and discharged in sputum, or swallowed and evacuated in the feces. After the eggs hatch in fresh water the larvae penetrate certain snails (*Semisulcospira, Tarebia, Assiminea*) where they multiply and from which they later escape as short-tailed cercariae, which penetrate the soft tissues of crayfishes and crabs, in which they encyst. Crayfishes or crabs, when eaten frankly raw or preserved in brine or rice wine, constitute the sources of human infection. Once ingested, the young worms are digested out of the crustacean tissues, excyst, and migrate through the intestinal wall, traverse the peritoneal cavity, penetrate through the diaphragm into the pleural cavity, then enter the lungs and become localized near a bronchiole. Here they mature and begin to lay eggs. The devious route of larval migration explains why the worms so frequently become lodged in abnormal focuses. Pulmonary infection produces moderate to severe local inflammatory reactions; frequently the irritation causes coughing and the rupture of nearby blood vessels, so that bloody sputum is relatively typical. Rupture of pulmonary lesions

into the pleural cavity, with purulent effusion, occurs at times. In the abdomen the worms produce abscesses that may open into the intestinal tract or through the skin. The gravest damage appears when the worms become lodged in the brain or its envelopes, with associated Jacksonian type of epilepsy.

Diagnosis is most frequently made from sputum, which grossly appears peppered with minute particles of iron rust (the golden-brownish eggs) and is frequently blood-tinged; however, in about 40% of patients the eggs are first recovered in the feces. Emetine hydrochloride is helpful. Bithional, first tested in 1961, is curative. Because there are so many nonhuman definitive hosts of *P. westermani*, control is not particularly practical. Man may remain uninfected if the crayfishes and crabs he eats are thoroughly cooked. (*See* also FLUKE.)

The species of *Schistosoma* and the disease they produce are treated separately under SCHISTOSOMIASIS.

4. Tapeworms.—The tapeworms, or Cestoidea, usually consist of a chain of many individual organisms, each of which is comparable with a trematode. This chain (strobila) consists of a scolex, provided with suckers and frequently with hooklets for attachment to the host's tissues; a "neck," which is the region of growth of the individual organisms (proglottids); and proceeding distally a succession of immature, mature, and gravid proglottids intergrading one into another. Mature proglottids contain a full complement of sexual organs; gravid ones are postmature and are crowded with eggs. Each fully developed egg contains an embryo, which in most species of tapeworms is provided with six hooklets and is termed a hexacanth embryo. On hatching from the egg the embryo invades the tissues of the essential intermediate host and develops into a larva. In certain species a second larval stage in a second intermediate is required (*e.g.*, in the fish tapeworm, *Diphyllobothrium latum*, and its relatives). The definitive host usually becomes infected from ingesting the larval host or its infected tissues. One notable exception is found in the dwarf tapeworm, *Hymenolepis nana*, which utilizes the same host for both its larval and adult stages. Tapeworms that produce disease in man include *Hymenolepis nana*, also called the dwarf tapeworm; *Taenia solium*, the pork tapeworm; *Taenia saginata*, the beef tapeworm; *Echinococcus granulosus* and *Echinococcus multilocularis*, the hydatid worms; and *Diphyllobothrium latum*, the broad, or fish, tapeworm.

Dwarf Tapeworm.—Hymenolepis nana and its biological varieties are parasites of man, rats, and mice. The worms are only a few centimetres in length. Fully matured spherical, thin-shelled eggs are voided in the feces. When these eggs, directly or indirectly, get to the mouth and are swallowed, they hatch in the duodenum and the hexacanth embryo invades a duodenal villus, where it develops into a cercocystoid larva; *i.e.*, a cysticeroid with a tail. Thereupon it emerges from the tissues, attaches itself by its suckers and rostellar hooklets, and matures into a complete worm. Man is normally infected only from human sources, rats only from infection previously in rats, and mice only from mouse infection. *H. nana* is common in man in the southern United States, Latin America, India, and Mediterranean countries. It is particularly prevalent in children. Light infections usually produce little damage but occasionally in sensitized children there may be a profound systemic intoxication, with neurological manifestations, including epilepsy. Heavy infections almost invariably cause severe diarrhea and signs of systemic poisoning. Moreover, there is considerable evidence suggesting that, where a large number of worms is present, autoinfection (*e.g.*, from anus to mouth or even internally) occurs. *H. nana* is usually eliminated by the administration of quinacrine (Atabrine). Control of the disease in a family or institutional group, as a children's asylum or mental hospital, is difficult because of the problem of personal and group hygiene.

Pork Tapeworm.—Taenia solium is one of the large human tapeworms, with a length of 2 to 7 m. (6½ to 23 ft.) and somewhat fewer than 1,000 proglottids. It is relatively uncommon in the United States and western Europe but frequently occurs in parts of China, India, and Latin America. Eggs may be shed by gravid proglottids within the intestine, but more frequently proglottids break off from the strobila singly or in groups, are evacuated in the stool, and disintegrate on the ground. They are usually picked up by scavenger hogs; the eggs hatch in the animal's duodenum, and the emerging embryos migrate through the tissues and settle down in the flesh. Here they develop in about three months into small, ovoidal, opalescent larvae, the cysticerci. When man consumes inadequately cooked pork, infection occurs. The adult worm causes a moderate nutritional drain on the host, resulting in diarrhea and dyspepsia. Absorption of the worm's by-products at times causes systemic intoxication. More serious, however, is the fact that man may serve in place of the hog as the larval host. When multiple cysticerci are present in the human tissues, some are likely to lodge in the brain or its envelopes, with resultant neurological pathology, manifestations of Jacksonian epilepsy, and eventual death. Specific treatment of all infections with intestinal *Taenia solium* should be carried out to reduce its ill effects and prevent human cysticercus infection. Quinacrine (Atabrine) is an effective drug for this purpose. Hogs should not be permitted access to human excreta, and all pork should be thoroughly cooked or frozen.

Beef Tapeworm.—Taenia saginata, another large human tapeworm, often measures 5 to 6 m. (16 to 20 ft.) in length and develops more than 1,000 proglottids. Its life cycle parallels that of *T. solium* except that it utilizes cattle rather than hogs as larval hosts. Man is not subject to infection by the larval (cysticercus) stage. Chemotherapy is the same as for *T. solium*.

Echinococcus.—Echinococcus granulosus is one of the few tapeworms parasitizing man in which the adult worm inhabits the intestine of the dog, while man is one of several hosts for the larval stage. Moreover, the adult worm is minute, measuring only 3 to 6 mm. in length and possessing at one time only one immature, one mature, and one or two gravid proglottids. In contrast, the larva, known as a hydatid cyst, may be as large as a football. Man acquires infection from contact with the feces of infected dogs. Exposure most frequently occurs in childhood. During the 18th century the inhabitants of Iceland had heavy infections, but the disease in man has been almost eliminated by the widespread adoption of good personal hygiene. Hydatid disease is prevalent in the human populations of Israel, Lebanon, Syria, north China, central and eastern Europe, Argentina, Uruguay, Chile, southern Australia, and Tasmania. The eggs of *E. granulosus*, when swallowed, hatch in the duodenum, and the emerging embryos penetrate into the mesenteric venules. About 70% are filtered out in the liver, and lesser numbers reach other organs and tissues, including the lungs, brain, and the stroma of long bones. The cyst grows slowly but in five years may be as large as an orange or even a grapefruit. Internally there is a cavity filled with fluid. The wall consists of an inner germinative membrane, which produces fertile daughter cysts that become free in the fluid-filled cavity; an intermediate friable, laminated coat; and an outer fibrous capsule. If the organism gains access to the inner structure of bones, it proceeds as an eroding stream, causing a weakening of the supporting structure and then fracture. A unilocular hydatid cyst causes disease as a result of pressure, by reason of its toxic metabolites, and, on accidental rupture, anaphylactic shock. There is no medical treatment for hydatid cyst, but surgery is relatively satisfactory. Control consists in avoiding contamination of the mouth with dog's feces and, in endemic areas, killing infected dogs or periodically deworming them with arecoline hydrobromide.

Echinococcus multilocularis produces a type of hydatid of the liver in which the germinal tissue is not circumscribed by a laminated membrane, resulting in alveolar enlargement that causes death. This infection is enzootic in Alaska, northern Canada, the U.S.S.R., and central Europe. Sledge dogs and foxes are definitive hosts, and native wild rodents are reservoirs of the hydatid stage. Human infection is relatively common in these areas.

Fish Tapeworm.—Diphyllobothrium latum measures 3 to 10 m. (10 to 32 ft.) in length. It differs from the majority of Cestoidea in having a scolex that is spatulate, with a ventral and a dorsal sucking groove, and a patent uterine port in each mature proglottid, so that eggs are shed in an immature stage and require de-

velopment in fresh water. This worm occurs throughout a large part of the North Temperate Zone in the Eastern Hemisphere and is common in Canada and adjacent parts of Minnesota and Michigan. It seems not to be indigenous to any part of the tropics, but is present in the lake districts of Chile and Argentina. In addition to man, dogs and sometimes bears harbour the parasite. When human or animal excreta containing eggs of *D. latum* are discharged into bodies of cool water, the eggs become fully matured, a little cap separates from the rest of the egg shell, and a ciliated embryo swims out. This attracts the attention of water fleas, *Diaptomus* or *Cyclops,* which eat the active embryos. Instead of being digested, the embryos bore through the gut wall of the water flea and transform into first-stage larvae (procercoids). Then when a fish ingests the water fleas as food the larvae migrate into the musculature and become infective sparganum larvae. A smaller infected fish swallowed by a larger one transfers the infection to the latter. Man acquires the disease by eating infected fish. *D. latum* may produce no appreciable harm to the human host; it may cause mild digestive inconvenience and a low-grade secondary anemia or, in persons with a constitutional tendency, it may precipitate pernicious anemia. Fortunately, however, eradication of the worm by anthelmintic treatment usually restores the patient to the preinfection level of red blood cell production. Control of fish tapeworm infection depends on the thorough cooking of all fresh-water fish caught in endemic areas, but more specifically the elimination of all raw (*i.e.,* untreated) human sewage from lakes and streams in which the fish breed. (*See* also TAPEWORM.)

5. Spiny-Headed Worms.—The Acanthocephala, or spiny-headed worms, have been regarded by some zoologists as relatives of the Nematoda, by others as akin to the Cestoidea. It seems wise, however, to reserve for them a special phylum position. They are more or less flattened, sacculate forms having a protrusible proboscis almost invariably armed with spines. They lack a digestive tract, possess a body cavity not lined with mesothelium, and have separate sexes. The best-known species are *Macracanthorhynchus hirudinaceus* and *Moniliformis moniliformis,* intestinal parasites respectively of the hog and of the rat. Both species have been reported only rarely from man. Infection is acquired from ingestion of beetles (the porcine form) and beetles or cockroaches (the rodent form) that serve as intermediate hosts. (*See* also ACANTHOCEPHALA.)

6. Leeches.—The Hirudinea, or leeches, are annelids and therefore are true segmented worms. They have a large sucker at the posterior end for attachment, a smaller sucker surrounding the mouth for feeding, and a digestive tract with 11 pairs of caeca that store blood sucked from their victims. Most leeches are aquatic and attach themselves to fishes, frogs, salamanders, and turtles, but some are terrestrial like the notorious *Haemadipsa ceylonica* of Ceylon, India, and Malaya, which may take blood from man or beast. Aquatic leeches, such as *Limnatis nilotica* of the North African coast and Bible lands, when taken into the mouth in unfiltered water, lodge in the throat, nasopharynx, larynx, upper esophagus, or trachea and cause congestion, excruciating pain, and at times death from suffocation. These leeches, like the medicinal species, *Hirudo medicinalis,* secrete hirudin from their buccal glands, which prevents the coagulation of blood for some time after the leech has become engorged and has abandoned its feeding site. DDT dusted into clothing and boots has considerable repellent properties. Internal leech infestation is a condition requiring the attention of a skilled surgeon. *See* LEECH.

See also references under "Parasitology" in the Index.

(E. C. F.)

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PARATHYROID GLANDS. The parathyroid glands occur in all species from amphibia upward. In man they are tiny, brownish-red structures (approximately $6 \times 4 \times 2$ mm.), usually situated behind the lateral thyroid lobes, two on each side. However, there may be as few as two, and as many as eight parathyroids have been found, sometimes in atypical locations anywhere in the deeper tissues of the neck or upper chest. Their embryonic origin is from the third and fourth pharyngeal pouches. Microscopically they are made up of closely packed epithelial cells separated by thin fibrous bands; occasionally the cells are arranged in circles with an open centre (alveolar arrangement) which may contain a colloid material.

In the latter half of the 19th century the parathyroids were recognized to play an important physiological role when it became apparent that the convulsive seizures and death which sometimes followed experimental thyroid operations were due to the inadvertent removal of the parathyroid glands. In 1908 their relationship to calcium metabolism was discovered when W. G. MacCallum and C. Voegtlin demonstrated that removal of these structures was followed by a fall in the calcium concentration of the blood serum, and that administration of calcium salts prevented or corrected the ill effects of the operation. In 1925 J. B. Collip developed a method of preparing a physiologically active extract of the parathyroid with which experimental animals could be tested.

The exact action of the internal secretion of these glands is not clear. It is believed that the parathyroid hormone plays an important role in stabilizing the calcium concentration of the body fluids—a very important function, since a lowering of the calcium ion concentration results in a condition of increased excitability of nerves and muscles known as tetany, in which there occur muscular spasms, convulsions, and sometimes dementia. Under normal conditions a small drop in the calcium concentration of the body fluids results in increased activity of the parathyroid glands, which raises the calcium concentration by mobilizing some of the skeletal calcium.

On the other hand, a rise in body fluid calcium concentration above the normal is counteracted by a reduction or cessation of secretion of parathyroid hormone. The internal secretion of the parathyroids also affects the metabolism of phosphorus, an excess of the hormone resulting in a lowering of inorganic phosphate con-

centration in the blood serum and an increased excretion of phosphate in the urine. Reduced parathyroid function is accompanied by a rise in the inorganic phosphate of the serum and a lessened urinary output of phosphate. Both overfunction and underfunction of the parathyroid glands produce important disease entities.

See ENDOCRINE GLANDS; ENDOCRINOLOGY; HORMONES, VERTEBRATE. (J. E. HD.)

PARATHYROID GLANDS, DISEASES OF, comprise hyperparathyroidism (production of excessive amounts of parathyroid hormone) and hypoparathyroidism (underactivity of the glands). The symptoms they produce result from disturbances in metabolism of calcium and phosphorus which is regulated by the parathyroid glands (*q.v.*).

The calcium in the body is confined for the most part (99%) to the bones and teeth and is excreted through the urine and feces. Under conditions of pregnancy and lactation it is excreted also through the placenta and breast. Since the amount in the body fluids is small and relatively constant, the difference between the calcium intake and output is represented by the calcium deposited or withdrawn from the bony structure. Ordinarily there is a constant movement of calcium between the blood and skeleton which is regulated by the difference between calcium intake and output. The normal level of blood calcium is 9–11 mg. per 100 ml. Phosphorus is likewise found largely in the bones. Its blood level is 3–5 mg. per 100 ml., and it exists in both inorganic (as a mineral) and organic forms (combined with other compounds), so that the relationship between intake and output is not so direct as with calcium.

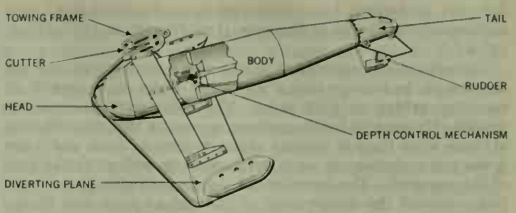
Hyperparathyroidism.—Hyperparathyroidism is usually due to a tumour in one or more of the glands or to generalized overactivity of the parathyroid tissue. The characteristic features of the disease are elevation of the blood calcium level with lowering of the blood phosphorus level, together with increased excretion of both calcium and phosphorus in the urine. This condition results in symptoms and signs of three types: (1) those due to bone disease, such as softening of the bones with collapse of the spinal vertebrae or fracture of the long bones; (2) those due to kidney disease, such as the formation of kidney stones; (3) those due to the effect of the increase in blood calcium level per se, among them decreased neuromuscular excitability, fatigue, drowsiness, loss of appetite and constipation. The treatment is the removal of the tumour or of most of the overactive parathyroid tissue, with a consequent tendency for most of the disease process to be reversed by healing.

Hypoparathyroidism.—Hypoparathyroidism usually occurs as a result of removal of excessive amounts of parathyroid tissue during thyroid operations. It results in a low blood calcium and a high blood phosphorus. The condition produces tetany, a state of hyperexcitable neuromuscular activity with localized or generalized muscular spasms or convulsions. The bones become more dense and cataracts form in the lenses of the eyes. The treatment is to raise the blood calcium by a high calcium diet, by the administration of vitamin D or dihydrotachysterol by mouth or by the injection of parathyroid hormone. (HY. F.)

PARATYPHOID FEVER: *see* TYPHOID AND PARATYPHOID FEVERS.

PARAVANE, a type of water kite which was developed during World War I by Lieut. (later Comdr.) C. D. Burney of the Royal Navy as an antisubmarine and antimine weapon. It consists of a buoyant body, towing frame, diverting plane, cutter, horizontal and vertical tail fins, a rudder and a depth-control mechanism. When towed the water plane diverts the paravane normal to the ship's course. The hydrostatically actuated rudder maintains the paravane at a preset depth.

Paravanes are employed primarily to protect ships against moored mines. Towed on each side by means of a wire towrope attached to a fitting at the forefoot of the ship, paravanes and their towropes form a protective wedge which contacts the mine mooring, deflects it from the ship's path and severs it with the cutter. The mine then rises to the surface, where it may be destroyed by gunfire.



PARAVANE SHOWING DEPTH CONTROL MECHANISM

Paravanes operate from 5 to 15 ft. below the depth of the keel. The area swept depends upon speed, length of the towrope and the type of paravane employed. The two-speed paravane, employed in high-speed minesweeping during World War II, differed from the standard paravane by a speed adjustment feature which automatically shifted the angle of the diverting plane to either a high- or low-speed position, as determined by the speed of the paravane through the water.

Depth Control Mechanism.—An important part of the paravane is the depth control mechanism, consisting of a hydrostatic valve and a mercury oscillator. The hydrostatic valve is a rubber diaphragm held between the tail housing and the body, and connected at its centre to the valve rod which is linked to the rudder. A compressed spring opposes the hydrostatic pressure applied to the diaphragm. The desired operating depth is obtained by compressing the spring, thus moving the rudder to the diving position. Upon reaching the proper depth, hydrostatic pressure overcomes the spring and shifts the rudder, causing the paravane to rise. From this action the paravane follows a sinusoidal path through the water. At high speeds this motion becomes excessive; therefore, a damping device (mercury oscillator) is provided to reduce depth variation. The mercury oscillator consists of a column of mercury enclosed in a steel tube by a diaphragm at each end connected to the valve rod. When the paravane is inclined by action of the hydrostatic valve, the column of mercury applies pressure to the appropriate diaphragm. This pressure is transmitted to the rudder through the valve rod to restore the paravane to the horizontal. In this manner the mercury oscillator anticipates the action of the hydrostatic valve and prevents excessive changes in depth.

Paravanes were used extensively during World Wars I and II both for bow protection and minesweeping, but by the second half of the 20th century they were rapidly becoming obsolescent. (R. T. C.)

PARAZOA, the name sometimes used in zoology to denote the grade of organization represented by the sponges (*q.v.*), in contradistinction to Protozoa and Metazoa (*qq.v.*).

PARBHANI, a town and district in the Aurangabad division of Maharashtra, India. The town, headquarters of the district, lies about 10 mi. S of the right bank of the Dudna River, a tributary of the Godavari. Pop. (1961) 36,795. It is connected by rail with Aurangabad, 110 mi. NW, with Hyderabad, 231 mi. SE, and by another line with the south.

PARBHANI DISTRICT is roughly triangular in shape. Area 4,853 sq.mi. Pop. (1961) 1,206,236. Spurs of the Sahyadriparvat or Ajanta Range in the north, separated by the Purna, Dudna, and Godavari rivers, reach approximately halfway down the western part of the district; the Nirmal Range crosses the eastern part. The rest of the district is a plain, draining toward the southeast. Mean annual temperature is 27° C (80° F); average annual rainfall is 35 in. The soil is partly black cotton soil and partly laterite. The valleys and the southeastern plain are cultivated; cotton is the chief crop, and millets, maize (corn), oilseeds, and fodder are also grown. Forest covers about 5% of the total area. Cotton ginning and pressing is the main industry of the district. (M. N. K.)

PARCHMENT. Skins of certain animals, prepared by particular methods, have supplied writing material on which has been inscribed the literature of centuries. The preparation of such skins, in a manner that gave the material the name it possesses to-

day (Gr. *pergamene*, Lat. *charta pegamena*, Fr. *parchemin*), was traditionally attributed to Eumenes II of Pergamum (197–159 or 160 B.C.).

The principal improvement in the new manufacture was the dressing of the skins in such a way as to render them capable of receiving writing on both sides. The older methods probably treated only one side for the purpose, a practice that was sufficient in times when the roll was the ordinary form of book and when it was not customary to write on the back as well as on the face of the material. The invention of parchment, with its two surfaces, ensured the development of the codex. (*See* also BOOK: *Vellum and the Codex: Vellum and Parchment.*)

The animals whose skins were found appropriate for the manufacture of the new parchment were chiefly sheep, goats, and calves. But in the course of time there has arisen a distinction between the coarser and finer qualities of the material; and while parchment made from ordinary skins of sheep and goats continued to bear the name, the finer kinds of manufacture produced from the more delicate skins of the calf or kid, or of stillborn or newly born calves or lambs, came to be generally known as vellum. Since the skin codices of the Early and Middle Ages were for the most part composed of the finer kinds of material, it has become the custom to describe them as of vellum, although in some instances it would be more correct to call the material parchment.

The ordinary modern process of preparing the skins is by washing, liming, unhairing, scraping, washing a second time, stretching evenly on a frame, scraping a second time and paring down inequalities, dusting with sifted chalk, and rubbing with pumice. Similar methods must have been employed from the first.

The comparatively large number of ancient and medieval manuscripts that have survived provide some knowledge of the varieties of the material in different periods and in different countries. It is known from references in Roman authors that parchment or vellum was entering into competition with papyrus as a writing material as early as the 2nd century A.D., though at that time it was probably not so skilfully prepared as to be a dangerous rival. But the surviving examples of the 3rd and 4th centuries show that a rapid improvement must almost at once have been effected, for the vellum of that age is generally of a thin and delicate texture, firm and crisp, smooth and glossy. There was always a difference in colour between the surface of the skin from which the hair had been removed and the surface next to the flesh of the animal, the latter being whiter. This difference is generally more noticeable in the older examples, those of a later period having usually been treated more thoroughly with chalk and pumice. To obviate any unsightly contrast, it was customary, when making up the quires for a volume, to lay hairside next to hairside and fleshside to fleshside, so that, no matter where the codex was opened, the tint of the open pages should be uniform.

As a rule, the vellum of early manuscripts, down to and including the 6th century, is of good quality and well prepared. After this, a greater amount of inferior material came into the market as demand increased. The manufacture necessarily varied in different countries. In Ireland and England the early vellum is usually of a stouter quality than that of other countries. In Italy and Greece and in the European countries generally bordering on the Mediterranean, a highly polished surface came into favour in the Middle Ages; the hardness of the material resisted absorption with the result that there was a tendency for ink and paint to flake off. On the other hand, in Western Europe a soft pliant vellum was in vogue for the better manuscripts from the 12th century onward. In the Italian Renaissance a material of extreme whiteness was developed.

Examples of uterine vellum, prepared from stillborn or newly born young, are found in choice volumes. A remarkable instance of a codex composed of this delicate substance is the Additional Manuscript 23935, of the 13th and 14th centuries, in the British Museum, which is made up of as many as 579 leaves without being a volume of abnormal bulk.

Vellum of a sumptuous character was employed to add splendour to specially choice codices of the early Middle Ages. The art of dyeing the material with a rich purple colour was practised both in Constantinople and in Rome; and, at least as far back as the 3rd century, manuscripts, generally of the Scriptures, were produced in silver and gold on the precious stained vellum; this practice was denounced as a useless luxury by St. Jerome in a well-known passage in his preface to the Book of Job. A certain number of early examples still survive, in a more or less perfect condition; these include the manuscript of the Gospels in the Old Latin Version at Verona of the 4th or 5th century; the celebrated codex of Genesis in the National Library at Vienna; the Rossano Manuscript and the Patmos Manuscript of the Gospels in Greek; the Gothic Gospels of Ulfilas at Uppsala, Swed., and others of the 6th century, besides a few somewhat later specimens. In the revival of learning under Charlemagne a further encouragement was given to the production of such codices; but soon afterward the art of purple-staining appears to have been lost or abandoned. A last trace of it is found in a few instances of stained vellum leaves inserted for ornament in manuscripts of the period of the Renaissance.

See also ILLUMINATED MANUSCRIPTS. (E. M. T.)

PARDO BAZÁN, EMILIA, CONDESA DE (1851–1921), Spanish writer of novels adapting naturalism to traditional Spanish realism, and of critical works which made foreign literary movements known in Spain, was born at Corunna (La Coruña) on Sept. 16, 1851. She early attained celebrity as a writer, and took a leading part in literary polemics. In 1916 she was accorded the distinction—unusual for a woman—of a chair of literature at Madrid. She died there on May 12, 1921.

She did much to familiarize the Spanish public with foreign literary trends, notably in the essays entitled *La cuestión palpitante* (1882–83), in which she championed naturalism. Hers, however, was a naturalism stripped of its materialistic philosophical basis and scientific pretensions, and many saw in it merely reaffirmation of Spanish realism. She strove to put her theories into practice in *Un viaje de novios* (1881), *La tribuna* (1883), *Insolación* (1889), and *Morriña* (1889; English translation *Homesickness*, 1891). Her greatest achievements in this vein are *Los Pazos de Ulloa* (1886) and its sequel, *La madre naturaleza* (1887), which show the social and moral degeneracy of the Galician squirearchy and the brutishness of the peasantry against a beautiful natural background of sinister, corrupting potency. Her later novels—*e.g.*, *Una cristiana* (1890; English translation *A Christian Woman*, 1891), *La quimera* (1905), *La sirena negra* (1908), *Dulce dueño* (1911)—reveal a turning away from naturalism and an emphasis on Christian idealism, but they are artistically less satisfying. Although by no means a purely regional writer, she is most successful when dealing with her native Galicia. She also wrote many accomplished short stories.

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PARDON, the release from guilt or the remission of punishment by an authoritative body. In criminal law the power of pardon is generally exercised by the chief executive officer of the state. So in England pardons are granted by the crown, in the United States by the president, and in the states of the U.S. by the governors. They may be granted also, however, by the legislature, and this is not uncommon in the form of an act of indemnity, a form of pardon, anticipatory or retrospective, for acts done in the public interest that might be illegal and the subject of prosecution.

In England the pardon was formerly made under the great seal, but now a sign manual warrant countersigned by a principal secretary of state is effective. In practice the crown acts on the advice of the home secretary with respect to England and Wales and on the advice of the secretary of state for Scotland with respect to that country. As a result of the 17th-century struggle between crown and Parliament, the crown is by statute deprived of its power to pardon for the offense of sending a subject to prison outside the kingdom and in the case of an impeachment by Parliament (3 Charles II, ch. 2 and 12, and 13 William III, ch. 2).

A pardon may be full or conditional. It is conditional when its

effectiveness depends on the fulfillment of a condition by the offender, usually the serving of a lesser substituted punishment, as in the commutation of the death sentence. The effect of a full pardon, where the punishment is unconditionally remitted, is unclear in some jurisdictions and has given rise to difficulties. In England it is said that the effect of a full pardon is to clear the person from all infamy and to remove all disqualifications and other obloquy attending on a conviction. So it has been held that a pardoned person may maintain an action for defamation against anyone who thereafter refers to him as a convict.

In the United States the matter is much less clear in spite of a pronouncement by the supreme court that a pardon blots out guilt and makes the offender "as innocent as if he had never committed the offense" (*Ex Parte Garland* 4 Wall. 333,380 [1866]). Some states have held that a pardon does not remove the disqualification from office resulting from a conviction and that the pardoned offender may still be refused a licence to engage in a business or profession. In 1941 a New York court held that a pardoned conviction may count as a previous offense for the purpose of sentencing the offender under a habitual criminal statute (*People ex rel. Prisament* v. *Brophy* 287 N.Y. 132). Several states provide expressly against this.

The difficulty stems from the lack of any differentiation between pardons granted for reasons of clemency and those granted from a belief in the accused's innocence. New York attempted to solve this dilemma by providing that where a governor's pardon is based on a finding of innocence the court must upon motion set aside the judgment of conviction (New York Laws 1946, c. 60), but this solution presents the constitutional difficulty of being construed as executive interference with the independence of the courts.

Another problem is presented by the question of compensating the person who has served all or part of his sentence and is then pardoned on the ground of innocence. In England there is no right of compensation, though a small *ex gratia* payment is commonly made. In the United States the federal jurisdiction gives a right of suit in the court of claims for compensation up to a maximum of $5,000. A few states give similar rights with similar ceilings, and New York gives a right of compensation without a fixed maximum. In the remaining states, which offer no right of compensation, a special statute would be necessary in each case to give redress.

Continental European and Latin-American countries generally have detailed statutory provisions governing the law of pardon and providing for compensation in proper cases.

The granting of a pardon is a matter between the offender and the state and has no adverse effect on any civil actions that might be brought against the one pardoned. *See* also PAROLE; PROBATION.

See D. Weihofen, "The Effect of a Pardon," *University of Pennsylvania Law Review*, 88:177 (1939); R. C. Donnelly, "Unconvicting the Innocent," *Vanderbilt Law Review*, 6:20 (1952). (G. B. J. H.)

PARDUBICE, a town in East Bohemian *kraj* (region), Czechoslovakia, lies at the confluence of the Elbe and Chrudimka rivers, 104 km. (65 mi.) E of Prague by rail. Pop. (1961) 54,746. There are some fine buildings (mainly 16th century) in the old part of the town; these include the Namesti Vilema z Pernstejna, a big square containing some old houses, the castle (Zamek Pernstejnsky), and the old walls (Zelena brana). Kuneticka Castle is 4 mi. N. The surrounding countryside is extremely fertile, although subject to recurrent drought.

Pardubice is a local grain market and there are several sugar factories and breweries. Machinery, rubber, and building materials are manufactured. The chemical industry is one of the country's most important, and oil refineries have been developed since World War II. The town is an important railway junction on the Brno-Prague line. (H. G. S.)

PARÉ, AMBROISE (1510–1590), French surgeon, ranked by the medical historian F. H. Garrison as one of the three (with John Hunter and Lord Lister) greatest surgeons of all time, is noted for his contributions to surgery in general, to military surgery, and to the aseptic care of wounds. He was born at Laval in 1510, and, as a rustic barber's apprentice, went to Paris in 1529 at the age of 19 to work at the Hôtel Dieu, probably the world's oldest hospital. His lack of scholarly training forced him to write in his native tongue, rather than in Latin, and thus he was ridiculed by his more educated but less practically schooled confrères. The campaigns in Italy from 1536 to 1545 gave him a great experience in military surgery and led to the classic *La Méthode de traicter les playes fuetes pur les arquebuses et aultres bastons à feu* (Paris, 1545 and 1552). He became surgeon to Henry II, Francis II, Charles IX (who is said to have protected him, a Huguenot, during the Massacre of St. Bartholemew's Day by hiding him in his bedchamber), and also to Henry III.

Much of surgery in the day of Paré was wound surgery, and much of that was war wound surgery. While use of the ligature in tying arteries for the control of hemorrhage had been introduced earlier, it was Paré who first put his technique on a firm, systematic, and practical basis. This contribution, however, is overshadowed by his disruption of the false doctrine of Renaissance surgery that gunshot wounds, because of their supposedly poisonous nature, should be routinely cauterized with boiling oil. It is said that one night in camp, Paré's supply of burning oil gave out and that he was quick to notice that the wounds treated without the oil did better than those treated with it.

The statement of Paré most often quoted is his reply when he was congratulated on the outcome of a successful case, "*Je le pansay, Dieu le guarit*" ("I treated him, God cured him"). This is inscribed on his statue and reflects the humility of one who, although of humble origin, attained the position of the greatest surgeon of his day, "nor yet lost the common touch." He died at Paris on Dec. 20, 1590.

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(H. N. Hs.)

PAREJA, JUAN DE (called EL ESCLAVO) (*c.* 1605–*c.* 1670), Spanish painter, native of Seville, was a mulatto. The legend that he was Velázquez' slave has been discredited by a letter from Seville dated May 12, 1630, asking permission to go to Madrid to continue his studies as a painter with his brother. Later, he probably became Velázquez' assistant and accompanied him on his second visit to Italy (1649–51), where Velázquez painted his portrait (Longford Castle, Wiltshire), said to have been exhibited in the Pantheon to the admiration of all the painters in Rome. According to early writers, Pareja painted portraits in the manner of Velázquez, but his only known portrait, of José Rates (private collection, Granada), is a crude reflection of Velázquez' style. From other works, Pareja appears to have been a mediocre follower of the Madrid school. The "Calling of St. Matthew" (1661; Prado museum, Madrid) contains a self-portrait based on the portrait by Velázquez that made Pareja famous. (E. Hs.)

PARENTS AND TEACHERS, NATIONAL CONGRESS OF, commonly known as the PTA, was founded in the United States on Feb. 17, 1897, as the National Congress of Mothers. Membership was later broadened to include teachers, fathers, and other citizens. The organization had enrolled about 1,500,000 persons by 1930. Since that time membership has, on the average, doubled each decade, numbering something over 12,000,000 in the 1960s, when there were 52 state branches, including the District of Columbia branch and the European Congress of American Parents and Teachers, and about 47,000 local PTA's.

The stated purposes of the National Congress are to promote the welfare of children and youth in home, school, church, and community; to raise the standards of home life; to secure adequate laws for the care and protection of children and youth; to bring into closer relation the home and the school, that parents and teachers may cooperate intelligently in the training of the child; and to develop between educators and the general public such united efforts as will secure for every child the highest advantages in physical, mental, social, and spiritual education.

The National Congress is concerned with the educational, social, and economic well-being of children, including legislation affecting their welfare, as, for example, laws regulating child labour; environmental factors such as radio, television, motion pictures, published materials, recreation, and safety education; federal agencies in education, health, juvenile protection, and homemaking; and promotion of international understanding and peace among nations.

The National Congress' statement of basic policies that govern the national organization and all its divisions, state and local, affirms that the organization shall be educational, nonsectarian, noncommercial, and nonpartisan; that it shall seek neither to direct the administrative activities of the schools nor to control their policies; and that it shall not enter into membership with other organizations except such national and international organizations as may be approved by the National Board of Managers. Within this framework local organizations have a large measure of autonomy. The Congress has, however, made its position known on a broad framework of issues of wide concern, such as federal aid for education, parents' responsibility for spiritual education, and the necessity of raising the standards of the mass media; also on the need for school libraries, preventive programs against juvenile delinquency, special services for disadvantaged children, adequate fluoridation of community water supplies, teachers' salaries and standards of employment, community use of school buildings and facilities, and the strengthening of teacher preparation.

Publications include *The PTA Magazine; The National PTA Bulletin;* manuals designed to help local organizations; and other publications on children's emotional health, moral and spiritual guidance, home-school relations, and other subjects of special concern to parents and teachers. (J. Mo.)

PARESIS: *see* Venereal Diseases: *Neurosyphilis.*

PARETO, VILFREDO (1848–1923), Italian economist and sociologist who, like Leon Walras (*q.v.*), made extensive use of mathematics in analyzing economic problems. He was born on July 15, 1848, in Paris, where his father, a Genoese nobleman and member of Mazzini's party, had been obliged to emigrate because of his revolutionary activities. The Paretos returned to Italy in 1858 under the political amnesty of that year. After his graduation from the University of Turin, where he studied mathematics and physics, Pareto became an engineer and later a director of an Italian railway and was also employed by a large iron works. Residing in Florence, he found time and inspiration not only to write many valuable periodical articles on economic subjects, applying therein his mathematical training, but also to study the classics, philosophy, and politics and thus equip himself to deal critically with sociological and humanitarian questions. Chosen to succeed Leon Walras in the chair of political economy at the University of Lausanne, Switz., in 1893, Pareto carried on Walras's now famous mathematical approach to political economy, sharpening the latter's exposition, introducing concrete matter, distinguishing the role of abstract reasoning from that of empirical inquiry, and analyzing economic systems upon monopolistic and collectivist as well as upon competitive assumptions.

Pareto's first work, *Cours d'Économie Politique* (1896–97), included, besides its sometimes original mathematical formulation of economic principles, his famous but much criticized law of income distribution. In his compact *Manuale d'economia politica* (1906), with its splendid mathematical appendix, he further developed his pure theory of economics and his analysis of ophelimity (power to give satisfaction); he also introduced "curves of indifference," analytical instruments that did not become popular until the 1930s. In 1911 he contributed a concise "Économie Mathématique" to the *Encyclopédie des Sciences Mathématiques.*

Realizing that there existed many concrete problems that could not be solved by economics, since it dealt only with logical, want-satisfying action, Pareto turned to sociology, publishing in 1916 what he considered his greatest work, *Trattato di Sociologia generale* (later published in English as *Mind and Society*). Herein are developed ideas foreshadowed in his economic writings, in his critique of socialism, *Les systèmes socialistes* (1902–03), and in *Le Myte vertuïste et la littérature immorale* (1911)—ideas that appear also in *Fatti e teorie* (1920) and *Trasformazioni della democrazia* (1921). In the *Trattato* he inquired into the nature and bases of individual and social action, the methodology of economics and sociology, and the degree to which physical-science methods are applicable in the study of man's behaviour. He distinguished ideal or social ends from the individual wants of economics, thereby contributing importantly to the analysis of "welfare." He also developed a cyclical theory of social change and a sociological case for protectionism. Pareto died in Geneva on Aug. 20, 1923.

Bibliography.—Pareto's work is treated in *Revue d'économie politique*, 59:517–652 (1949) and in *Giornale degli economisti*, 64:1–153 (1924), with bibliography. *See* also Umberto Ricci, *Tre Economisti Italiani* (1939); Talcott Parsons, *The Structure of Social Action* (1937); Joseph Schumpeter, *Ten Great Economists from Marx to Keynes* (1951). (J. J. S.)

PÁRGA, a seaport in the *nomos* (department) of Préveza, southern Epirus, Greece, on the Ionian Sea, 16 mi. SSE of Igoumenítsa. Pop. (1961) 1,586. Párga has a rock-built citadel and a harbour formed by a mole which the Venetians constructed in 1572. The site of the ancient Toryne may lie a short distance to the west; Párga was probably moved to its present location in the late 14th century. Under Venetian protection from 1401, the inhabitants maintained their municipal independence and commercial prosperity down to the destruction of the Venetian Republic in 1797, despite repeated Turkish attacks. The attempts of Ali, pasha of Janina (Ioánnina), to make himself master of the place were thwarted, partly by the presence of a French garrison in the citadel from 1807 and partly by the Pargiotes themselves, who were anxious to join the Ionian Republic (*see* Ionian Islands). In 1814 they expelled the French garrison and accepted British protection; but the British government in 1815 determined to go back to the Russo-Turkish Convention of 1800 by which Párga was to be surrendered to Turkey, though no mosque was to be built or Muslim to settle there.

Rather than submit to Ali, the Pargiotes decided to forsake their country; and in 1819 the majority migrated to the Ionian Islands. The Turkish government was constrained to pay them nearly £150,000 compensation. A few families returned after Ali's death (1822); Turks, Albanians, and Greeks from the neighboring countryside also settled there. Párga was taken by the Greeks in the First Balkan War and annexed to Greece with most of Epirus in 1913.

See Archduke Ludwig Salvator, *Parga* (1907), *Versuch einer Geschichte von Parga* (1908).

PARHELION (Mock Sun), a spot on a solar halo reflected at various angles near the sun. The most brilliant are situated at the intersections of the inner halo and the parhelic circle, and are particularly brilliant when the sun is setting. They are caused by refraction through a pair of alternate faces of a vertical prism. When the sun is on the horizon the rays fall from the principal section of the prisms and the parhelia are therefore not only on the inner halo but also on the parhelic circle. The different values of the angle of minimum deviation for differently coloured rays give rise to most effective colourings. *See* Halo.

PARIA, GULF OF, an inlet of the Atlantic Ocean between the Venezuelan mainland and the western coast of Trinidad. It is separated from the Atlantic by the southwestern peninsula of Trinidad and the large delta of the Orinoco River and from the Caribbean Sea by the long, mountainous Paria Peninsula of Venezuela. It is about 100 mi. east-west and about 40 mi. north-south. Entrance is made from the Atlantic through a 10-mi.-wide strait, Serpent's Mouth, and from the Caribbean through a 10-mi.-wide, island-strewn strait, Dragon's Mouth. The gulf is used for shipping petroleum (Venezuela, Trinidad), iron ore (Venezuela), bauxite, and general cargo. Port-of-Spain, Trinidad, is the chief city. (D. R. D.)

PARIAH, a word derived from *Paraiyan*, the name of a Tamil caste group of labourers and village servants of low status. Pariah is a generic term applied by Westerners to all the untouchables (*q.v.*) of the Indian subcontinent, whom *Mahatma* Gandhi renamed Harijan. The term pariah embraces many groups which, though all outside the pale of the so-called clean caste groups, are

of widely varying degrees of status deriving from dietary habits, occupational association with polluting materials, or disapproved customs such as widow marriage. The disabilities under which the lowest caste groups suffer have been a source of embarrassment to the government of India since independence in 1947, mainly because statutory devices to improve their lot shatter against the bastions of Hindu belief. Ideas about purity and pollution still permeated so many aspects of Hindu life in the 1960s that much effort and time would be required to eradicate the notion of untouchability from Hindu thinking. *See* also CASTE (INDIAN).

See H. N. C. Stevenson, "Status Evaluation in the Hindu Caste System," *Journal of the Royal Anthropological Institute*, vol. 84 (1954); S. Fuchs, *The Children of Hari* (1950); J. H. Hutton, *Caste in India*, 4th ed. (1963); G. D. Bereman, "Caste and Community Development," *Human Organization*, vol. 22, pp. 83–89 (1963); B. Saraswati, "Caste, Craft and Change," *Man in India*, vol. 43, pp. 218–224 (1963).
(H. N. C. S.)

PARIAN CHRONICLE. This document, inscribed on marble in the Attic Greek dialect, was an outline of Greek history from the reign of Cecrops, legendary king of Athens, down to the archonship of Diognetus at Athens (264/263 B.C.). The years are reckoned backward from the archonship of Diognetus, and further specified by the kings or by the archons of Athens; *e.g.*, "From the year [400/399] when the Greeks who went up with Cyrus returned and Socrates the philosopher died at the age of seventy, 137 years; Laches was archon at Athens."

The author of the chronicle has given much attention to the festivals, and to poetry and music; he has recorded the dates of the establishment of festivals, of the introduction of various kinds of poetry, the births and deaths of the poets, and of their victories in contests of poetic skill. He shows little interest in constitutional history and records few battles. The Theban victory at Leuctra is included, but the battles of Cnidus and Naxos are omitted. One large fragment was bought at Smyrna in the early 17th century and is now with the Arundel marbles in the Ashmolean Museum, Oxford. Another large fragment, found on Paros in 1897, is now in the Paros Museum.

For an extract with notes *see* M. N. Tod, *Selection of Greek Historical Inscriptions*, vol. ii, pp. 308 ff. (1948). (R. ME.)

PARIMA, SIERRA (Port. SERRA PARIMA) is the tabular upland that surmounts the Guiana Highlands (*q.v.*) along the border between Brazil and Venezuela. It runs for approximately 200 mi. NNW to SSE along the divide between the headwaters of the Rio Branco and the head of the Orinoco (*q.v.*). At its northern end it connects with the Serra Pacaraima (*q.v.*), which it resembles in surface form and geologic structure. Its height is about 5,000 ft. (P. E. J.)

PARINI, GIUSEPPE (1729–1799), Italian poet and moralist, esteemed as "the Pope or the Boileau of Italy," was born at Bosisio, in Brianza, on May 22 or 23, 1729, the son of a silk trader. As a boy he was sent to Milan and educated by the Barnabites (1740–52). *Alcune poesie di Ripano Eupilino* (1752) secured his admittance to intellectual circles. He entered the Accademia dei Trasformati (1753), took holy orders (1754), and became a tutor in the household of Duke Gabrio Serbelloni (1754–62). In 1768 Parini edited the *Gazzetta di Milano;* then, for about 30 years, he taught the humanities in the Palatine schools and the Brera *ginnasio*. After the creation of the Cisalpine Republic (1796), he worked for three unhappy years in the municipality.

Parini is best known for *Il Giorno*, a satire in four parts—*Mattino* (1763), *Mezzogiorno* (1765), *Vespro*, and *Notte* (1801)—in which, with exquisite irony, he presents a day in the life of a dissolute young nobleman and reveals the superficiality and profligacy of the life of fashion. The *Odi* (1757–95), about 20 in number, deal with civil, social, and personal themes, and are among the classics of Italian poetry. His other works include *Ascanio in Alba* (1771)—a libretto set by Mozart—and various prose discourses: *Dialogo sopra la nobiltà* (1757) and *I principi delle Belle Lettere* (1801). Parini died at Milan on Aug. 15, 1799.

For a portrait of Parini *see* ITALIAN LITERATURE.

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PARIS, also called ALEXANDROS ("defender"), son of Priam and Hecuba (*qq.v.*). Before Paris' birth Hecuba dreamed that she gave birth to a firebrand which set fire to Troy, and the dream was interpreted as warning the Trojans about her child. The baby, then, was exposed immediately upon birth. However, a bear nursed it or shepherds found it; Paris was raised as a shepherd, unknown to his parents. As a young man he entered a boxing contest at a Trojan festival, defeated Priam's other sons, and his identity became revealed. Priam received him home again.

As shepherd, Paris delivers the "judgment" which forms so popular a theme of ancient art. Rejecting offers of kingly power from Hera and military might from Athena, he awards the "apple of discord" (*see* ERIS) to Aphrodite. According to her promise, Aphrodite helps Paris win the most beautiful woman alive, seducing Helen. When Paris refuses to restore Helen and the Trojans support him, the Greeks set out for the Trojan War. During the war, Homer assigns Paris a secondary role: a good warrior, but inferior to his brother Hector and to the Greek leaders whom he faces. Symbolically, Menelaus defeats Paris in single combat, but Aphrodite rescues him and the war continues. Hector, the opposite of Paris, an innocent victim of Paris' marital irresponsibility, must return to Troy, urge his brother to leave Helen and fight.

Near the end of the war, Paris shoots the arrow which, by Apollo's help, hits a vulnerable spot and causes Achilles' death. Paris himself, soon after, receives a fatal wound from Philoctetes' arrow. A later story tells how Oenone, once the beloved of Paris, and abandoned for Helen, could have cured the wound but refused. Paris died and Oenone killed herself. (WM. S. A.)

PARIS, COMTES DE. In Merovingian France the counts of Paris were officials appointed by the kings to administer the pagus or district of Paris (*q.v.*). The first Carolingian kings likewise appointed men whom they could trust as counts. For most of Charles II the Bald's reign, however, the real power in France north of the Loire belonged to the magnate Robert the Strong (d. 866); and in the 880s Robert's son Eudes (*q.v.*) was count of Paris which he defended heroically against the Norman invaders. On becoming king of France himself in 888, Eudes transferred the countship to his brother, who retained it during the Carolingian Restoration (898–922) and finally became king in turn as Robert I (*q.v.*). Robert's son Hugh (*q.v.*) the Great was likewise count of Paris; and his son Hugh (*q.v.*) Capet succeeded him as count before winning the royal crown in 987. Hugh Capet assigned the countship of Paris to Bouchard the Old, count of Vendôme and Corbeil; but after Bouchard's retirement (*c.* 1005) the countship reverted to the royal domain, and the use of the title lapsed.

The title of comte de Paris was revived under the July Monarchy (1830–48) for the eldest son of King Louis Philippe's heir apparent: namely for LOUIS PHILIPPE ALBERT, born on Aug. 24, 1838, son of Ferdinand, duc d'Orléans (*see* BOURBON: *Table IV*). His father's death (1842) made the child heir to Louis Philippe's throne; on the revolution of 1848 he was taken into exile in England; Louis Philippe's death (1850) made him head of the house of Orléans. He and his brother Robert, duc de Chartres, served as volunteers under the Federal Gen. G. B. McClellan in the American Civil War in 1861–62. Back in England, the comte married his cousin, Isabelle d'Orléans-Montpensier, in 1864. After the downfall of Napoleon III (1870) he returned to France as a private person. At Frohsdorf, in Austria, he recognized the right of the comte de Chambord (*q.v.*) to the French crown (August 1873); but this Legitimist-Orleanist entente broke down in 1875. When the comte de Chambord died (1883), most French Royalists acknowledged the comte de Paris; but the success of his Paris reception celebrating his daughter Marie Amélie's marriage in Lisbon to the future Carlos I of Portugal provoked the republican government to pass the law of June 1886 expelling the heads of all formerly sovereign houses from France. The comte retired to England, and when General Boulanger (*q.v.*) failed in his machinations all hopes of an early restoration were extinguished. The comte de Paris died at Stow House, Twickenham, on Sept. 8, 1894.

Besides political manifestos, he left a work on English trade unions (1869) and a history of the American Civil War (1874–90).

HENRI, comte de Paris, was born at Nouvion-en-Thiérache, Aisne, on July 5, 1908, the son of Jean, duc de Guise (*see* BOURBON: *Table IV*). The death of the former comte's son Louis Philippe Robert, duc d'Orléans, in 1926 made the duc de Guise head of the house, whereupon he had to leave France; and his death, at Larache in Spanish Morocco on Aug. 27, 1940, made the comte de Paris head. The comte meanwhile had married his third cousin, Isabelle d'Orléans-Braganza in 1931, but had disappointed extremists by the democratic character of his monarchism. On the outbreak of World War II he had served for some months in the Foreign Legion under a pseudonym. The repeal of the law of June 1886 in June 1950 enabled him to return to France.

PARIS, (BRUNO PAULIN) GASTON (1839–1903), French scholar, one of the founders of the modern science of philology, was born at Avenay (Marne), Aug. 9, 1839. Educated at Bonn (1856–57), Göttingen (1857–58), and the École des Chartres (1858–61), he specialized in language and medieval literature. He was appointed to the École des Hautes Études (1868) and succeeded his father in the chair of medieval French literature at the Collège de France (1872), becoming director in 1895.

He was elected to the Académie des Inscriptions (1876) and to the Académie Française (1896). He died at Cannes on March 6, 1903. He helped found and direct the *Revue critique* (1866) and the *Romania* (1872) and made notable contributions to these periodicals, to the *Journal des savants* and to the *Histoire littéraire de la France*. By his high standards, vast erudition, and exceptionally retentive mind, he established principles of exact research which won him many disciples and still dominate work in philology and medieval studies. His numerous writings, listed by J. Bédier and M. Roques in *Bibliographie des travaux de Gaston Paris* (1904), include: *Le Rôle de l'accent latin dans la langue française* (1862); *Les Plus Anciens Monuments de la langue française* (1875); *La Littérature française au moyen âge* (1888 *et seq.*); and *François Villon* (1910). (F. J. WE.)

PARIS, MATTHEW (d. 1259), English monk and chronicler, is known only through his voluminous writings, which constitute one of the most important sources of knowledge of European events between 1235 and 1259. He was admitted a monk at St. Albans in the year 1217, and in 1248 he was sent to Norway to reform the Benedictine monastery of St. Benet Holm on the Island of Nidarholm. Apart from this mission and occasional visits to the royal court at Westminster, Winchester, and elsewhere, he remained at St. Albans, assiduously recording contemporary events. His *Chronica majora* incorporates Roger Wendover's *Flores historiarum* and continues it from 1235 to 1259. His other chronicles—the *Historia Anglorum*, the *Flores historiarum* (formerly attributed to the fictitious "Matthew of Westminster" and not to be confused with Roger Wendover's work), and the *Abbreviatio chronicorum*—are all abridged from his *Chronica majora* but contain some additional matter. Matthew also wrote a history of his own house, the *Gesta abbatum monasterii Sancti Albani*, which, like the *Chronica majora*, embodies the work of a predecessor and which he prefaced with the lives of the two King Offas. Autograph manuscripts of all these works survive. Matthew also wrote lives of Saint Alban, Edward the Confessor, Thomas Becket, and Edmund Rich, in Anglo-Norman verse, and of Stephen Langton and Edmund Rich, in Latin prose.

As a chronicler, Matthew is noteworthy for his detailed knowledge of events all over Europe; for his use of information obtained from the leading figures of his day, such as Henry III and Earl Richard of Cornwall, both of whom he knew well; for the large number of documents which he included either in his chronicle or in an appendix to it, the *Liber additamentorum;* and for the outspoken expression of his prejudices against, in particular, the king, the foreign favourites at court and the papacy. Matthew's chronicle, however, must be used with caution, for he is frequently careless; he sometimes tampers with the texts of the documents he transcribes, or wilfully misrepresents the facts; and his violent prejudices colour his whole work. It is partly because of this that he gives us a more vivid and readable picture of his age than any other medieval English chronicler. Matthew was also an artist of considerable skill and, besides inserting a number of lively line-and-wash drawings in the margins of his historical manuscripts, he illustrated his Anglo-Norman verse saints' lives. In the history of cartography, his remarkable maps of England and Palestine and his famous illustrated itinerary from London to Apulia have an important place. In addition he is the earliest source for English heraldry: about 130 shields are depicted in his manuscripts, many of them with correct heraldic descriptions.

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PARIS, the capital of France, is situated on the Seine River, 375 km. (233 mi.) upstream from its entry into the English Channel, on latitude 48°50′14″ N and longitude 2°20′14″ E. The city itself (Ville de Paris) occupies a central position in the rich agricultural country of the Paris Basin (*see* FRANCE) and covers an area of approximately 105 sq.km. (41 sq.mi.). With its outer suburbs and satellite towns it came to occupy the whole of the Seine *département* and spread into the Seine-et-Oise and Seine-et-Marne *départements*. In 1964 the French government took measures to reform the administration of the whole Paris area: the Seine and Seine-et-Oise *départements* were to be replaced by seven new *départements* (see *Administration*, below) and these with Seine-et-Marne *département* were to form the Paris administrative and economic region (*Région Parisienne*).

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I. PHYSICAL CHARACTERISTICS AND CLIMATE

The immediate topographical characteristics of the city's surroundings exercised an influence on its early development. Near the site of the ancient settlement the plateaus of Beauce, Brie, and Valois converged upon the Seine Valley. To the south the relief of the hills was moderate (45 to 60 m.; 150 to 200 ft.), but these hills approached close to the river, a fact which tended to hamper the expansion of the city's Left Bank, though to the west a floodplain did facilitate development. Today, the city area on this bank amounts to slightly more than one-third of the whole. On the Right Bank a semicircle of heights (reaching about 106 m.; 350 ft.), stretching from the Seine at what is now Charonne, wheeled from east to west through present-day Ménilmontant, Belleville, Montmartre, and Chaillot to Passy, to constitute at first the boundary of the river. A change in course, however, created a bordering meander plain, which offered the city a better opportunity for expansion when it began to push out its foothold on the banks. The northern heights are breached on either side of Montmartre and gave at an early time easy communications to the north. (*See* further *Communications*, below.)

The Paris zone has a temperate maritime type of climate with warm summers and not too rigorous winters. Prevailing winds blow from the southwest, but are varied in winter and spring by northeasterly or easterly ones, which bring periods of cold dry weather, sometimes of long duration. The mean temperature of Paris itself is about 10.25° C (50.5° F), that for February being 2.5° C (36.5° F) and that for July 18.5° C (65.5° F). Frost occurs roughly on half the nights between December and February, and snow falls about 15 days in the year. The zone is one of the driest in France, and rainfall is fairly evenly distributed though somewhat heavier in summer and autumn; the average yearly fall is about 550 mm. (21 in.).

II. HISTORY

1. Lutetia and Gallo-Roman Paris.—Paris, in prehistoric times, was on an island, the modern Île de la Cité, standing in the marshes of the Seine River at the intersection between that great natural highway and a land route which diametrically traversed the surrounding circle of hills. This land route, the line of which is represented by the Rue Saint-Martin on the Right Bank of the Seine and the Rue Saint-Jacques on the Left, served to connect the Low Countries and the mouth of the Rhine in the northeast with Orléans and the Loire Valley in the south. Later, two wooden bridges, where the Pont Notre-Dame and the Petit-Pont now stand, carried the line of the road across the island from the opposite banks. The island was a natural stronghold and a settlement was in existence there by the end of the 3rd century B.C. Called by a name which the Romans reproduced as Lutetia, it belonged to a Gallic tribe, the Parisii, who controlled the local commerce in tin from the British Isles. In the 1st century B.C. the Parisii were a small autonomous community whose prosperity is suggested by the remarkably high quality of their gold coins. Julius Caesar describes (in his *Commentaries*) the burning of Lutetia, by the Gauls themselves, in 52 B.C., during his Gallic War.

In the 1st century A.D. Lutetia grew up again, but now as a Roman town. Whereas the original site had been chosen primarily for defensive purposes (the island was then about half the size of the present Île and was menaced by flood), the peace imposed by the Romans encouraged development on the Left Bank of the Seine, on the Montagne Sainte-Geneviève, beginning probably at the top of the slopes and spreading down toward the river. The straight streets and the public buildings in this locale were characteristically Roman, including a forum (Rue Soufflot), three baths (one in the Rue Gay-Lussac, one on the site of the Collège de France, one on that of the Musée de Cluny), an amphitheatre (the so-called Arènes, off the Rue Monge), a theatre (beneath the Lycée Saint-Louis, near the junction of the Rue Racine with the Boulevard Saint-Michel), and perhaps a circus.

At this time Lutetia was a town of middling importance. It was the urban part of the *civitas Parisiorum*, or community of the Parisii, which, though the smallest of the 26 *civitates* of the province of Gallia Lugdunensis (*see* GAUL), was prosperous and always independent of its neighbours. Lutetia experienced civil warfare at the end of the 2nd century and at the beginning of the 3rd, and barbarian invaders devastated the area between *c.* 250 and 275. As the whole town on the Left Bank was burned, the inhabitants took refuge on the island, where they enclosed 20 acres of the Cité within a wall, 7½ ft. thick, built partly of stone from the ruined town, standing about 30 yd. from the water's edge, and having neither bastion nor tower. Bridges to either bank of the river still stood. Within the enclosure, there may have been a temple to the east and a governor's palace to the west. A milestone of the years 305–310 is the first record of the name Paris (Parisii) instead of Lutetia.

Meanwhile Paris felt the first influence of Christianity. A 10th-century sacramentary cites St. Denis (Lat. Dionysius) as having been the first bishop of Paris *c.* A.D. 250. A graveyard excavated near the Carrefour des Gobelins shows that there was a Christian community in very early times on the banks of the Bièvre (a left-bank tributary of the Seine); but it was probably under St. Marcel, the ninth bishop (*c.* 360–436), that the first Christian church, a wooden structure, was built on the island.

2. The Merovingians.—By the end of the 5th century the Salian Franks under Clovis had conquered Paris and the rest of the kingdom of Syagrius. The conquerors not only fell under the influence of Roman culture but also were converted to Christianity. As later victories made Clovis master of nearly all Gaul, he moved his capital from the northeast to Paris, to be nearer his newly acquired territories. Several of his successors also made Paris their capital: Childebert in 511, Clotaire in 558, then Chilperic and Charibert, who fought for possession of it (in 583 Chilperic restored the Arènes). The Merovingians, however, did not take up permanent residence in Paris, which consequently played only a minor political role.

At this time the Cité contained the king's palace, the bishop's palace, some churches, the prison, and shops. Some sizeable suburbs grew up again outside the wall, especially on the Left Bank, on the site of the former Gallo-Roman town. By the time of the sons of Clovis, there were six churches outside the walls, four on the Left Bank and two on the Right. At the summit of the Montagne Sainte-Geneviève, beside the tomb of Ste. Geneviève (remembered for her fortitude during the invasion of Paris by the Huns in the 5th century), Clovis began to build the Basilica of the Holy Apostles, intending it to house his own tomb; it later became the Church of Sainte-Geneviève (where the Lycée Henri IV is now, behind the Panthéon). Childebert founded Saint-Vincent, which in 576 received the tomb of the bishop of Paris, St. Germain, and later became the Abbey of Saint-Germain-des-Prés. The two other left-bank churches were that of the former Christian hamlet on the Bièvre, near St. Marcel's tomb, and the Church of Saint-Julien, near the Petit-Pont, where Gregory of Tours lived in 587. On the Right Bank, which was linked to the island by the Grand Pont (on the site of the modern Pont-au-Change, to the west of the old wooden bridge), the two new churches were Saint-Gervais and Saint-Laurent. Before the end of the Merovingian dynasty in the middle of the 8th century there were eight more churches: in the south, Saint-Séverin, Saints-Serge-et-Bacchus, Saint-Étienne-des-Grès, Saint-Symphorien-des-Vignes, Saint-Victor, and Saint-Père; in the north, Saint-Germain-le-Rond (later Saint-Germain-l'Auxerrois) and Saint-Martin (later the Priory of Saint-Martin-des-Champs). The town seems to have enjoyed some prosperity; the existence of a Jewish and Oriental colony suggests active commerce, mainly along the waterway.

3. Carolingian and Robertian Paris.—Under the Carolingian sovereigns, kings of the Franks or Holy Roman emperors, who usually did not live there, Paris was of scarcely any political importance. Their local representative was the count (*see* PARIS, COMTES DE), but the real administration was mainly in the hands of the bishop. The Vikings or Normans sacked the defenseless town on several occasions (845, 856–57, and 861). From 877, however, on the orders of the emperor Charles II the Bald, the Parisians began to restore the fortifications of the Cité. Bishop Gozlin and Count Eudes, son of Robert the Strong, were

able thus to withstand a siege by the Normans for more than a year (885–886); but the emperor Charles III the Fat was unable to halt the Norman drive toward Burgundy, and finally the West Frankish king Charles III the Simple, by the Treaty of Saint-Clair-sur-Epte (911) allowed the invaders to settle at a distance of 20 leagues from the walls.

In 888, meanwhile, after the deposition of Charles the Fat, Count Eudes, the hero of the recent siege, was elected king of the West Franks, the first king of the Robertian dynasty. After intermittent restorations of the Carolingians, the Capetian branch of the Robertians secured the crown for itself in permanence from 987, when Hugh Capet was elected king.

4. The Early Capetians.—As the Capetian monarchy grew more powerful, so Paris, its capital, grew in importance. At the end of the 10th century, the outskirts of the town were still complete ruins; but a new church, Saint-Jacques-de-la-Boucherie, had appeared on the Right Bank, foreshadowing the shift of development to the north, more marked in the following centuries.

The population and the commerce of Paris increased with the gradual return of political stability and public order. The maintenance of order was entrusted to a special representative of the king, the *prévôt de Paris*, first mentioned in 1050, who from the 12th century onward had his fixed seat in the Châtelet (*q.v.*). In the 11th century the first guilds or corporations were formed, among them those of the butchers and of the *marchands de l'eau*, or river traders, who worked the Seine; on the Right Bank, near the Porte de Paris at the end of the Grand Pont, a mercantile quarter, known as Outre Grand Pont, grew up. Extending northward to Saint-Merri and eastward to Saint-Gervais and so including the market place on the Grève (*i.e.*, "strand"; where the Hôtel de Ville now stands), this quarter was soon surrounded by a rampart; in Louis VI's reign (1108–37) the market was transferred to the site west of the Rue Saint-Denis where the Halles Centrales were to be till the third quarter of the 20th century. The Grand Pont was rebuilt, with stone abutments, probably early in the 12th century; from 1142 money changers had their shops in it. In 1121 Louis VI granted to the *marchands de l'eau* the right of levying a duty on boatloads of wine entering Paris; in 1170 Louis VII accorded them the monopoly of river traffic between Corbeil and Mantes.

Paris spread rapidly along the lines of traffic from the gates: from the Porte de Paris, from the little archway of Saint-Merri, and from the Porte Baudoyer in the east. About 1080 the Priory of Saint-Martin-des-Champs was serving as a parish church, but two or three decades later the Chapel of Saint-Nicolas-des-Champs was made the church of this parish. The road to Saint-Denis, of which the Rue Saint-Denis forms part, became more important with the Lendit Fair held on it from the early 12th century. The leper hospital of Saint-Lazare (on the site of the later prison) is first mentioned in 1124. To the south, nearer to Louis VI's new market, the Abbey of Saint-Magloire was in existence by 1117 and the Church of the Innocents by 1150. To the east, a very ancient chapel, around which a bourg or township had grown up, was replaced by the Church of Saint-Paul (on the corner of the modern Rue Saint-Paul and the Rue Saint-Antoine), which was a parish church by 1080. About 100 years later a new centre of activity was created by the foundation of the Temple, south of the modern Place de la République; the Couture du Temple is mentioned in 1184, and the Ville Neuve du Temple came into existence in the following century.

Rural settlements gathered around churches and abbeys; for example, the village of La Villette-Saint-Ladre (later to become the district of Villette) rose on the land of the leper hospital in the second half of the 12th century. As early as *c.* 1110 there was a bourg around Saint-Germain-l'Auxerrois; since this community, as well as the church, depended on the bishop of Paris, it was called Ville-l'Évêque. From the end of the 12th century, moreover, there are records of a new bourg belonging to the bishop, at the start of the road to Montmartre and within easy reach of the Halles and the Cemetery of the Innocents.

On the Île de la Cité, meanwhile, one of the great masterpieces of Gothic architecture, the Cathedral of Notre-Dame, was begun in 1163, but not completed for 100 years.

On the Left Bank, much of which was devoted to viticulture, the Bourg Saint-Germain, formed around the Abbey of Saint-Germain-des-Prés, is mentioned from 1159; there was also an agglomeration of buildings around Sainte-Geneviève. On the Bièvre stood the village of Saint-Médard; farther south a bourg grew around the Church of Saint-Marcel. The Abbey of Saint-Victor, founded in 1113, near the modern Halle-aux-Vins, formed yet another nucleus of rural population; so also did the church of Notre-Dame-des-Champs, on the plateau adjacent to the continuation of the Rue Saint-Jacques.

5. Philip II Augustus and His Successors.—It was in the reign of Philip II Augustus (d. 1223) that the ever-expanding Paris was organized as a unit; the king settled its limits by erecting ramparts, one on the Right Bank (1190), and on the Left (1210). In terms of modern topography, the right-bank wall started in the west at the end of the Pont-des-Arts, reached the Rue Saint-Honoré opposite the Oratoire, ran parallel to the Rue Jean-Jacques-Rousseau as far as the Rue Montmartre, passed along the Rue Étienne-Marcel to the Rue Saint-Martin, then bent along the Rue des Francs-Bourgeois and down the southern end of the Rue de Sévigné to cross the Rue Saint-Antoine and rejoined the Seine. There were gates on the modern Quai du Louvre, Rue Saint-Honoré, Rue Saint-Denis, Rue Saint-Martin, Rue Vieille-du-Temple, and Rue Saint-Antoine. Outside this wall, near its western end, was a defensive tower, which Philip Augustus called "our tower of the Louvre," the precursor of the later palace. The left-bank wall starting from the Seine in the east, ran up the Rue des Fossés-Saint-Bernard,

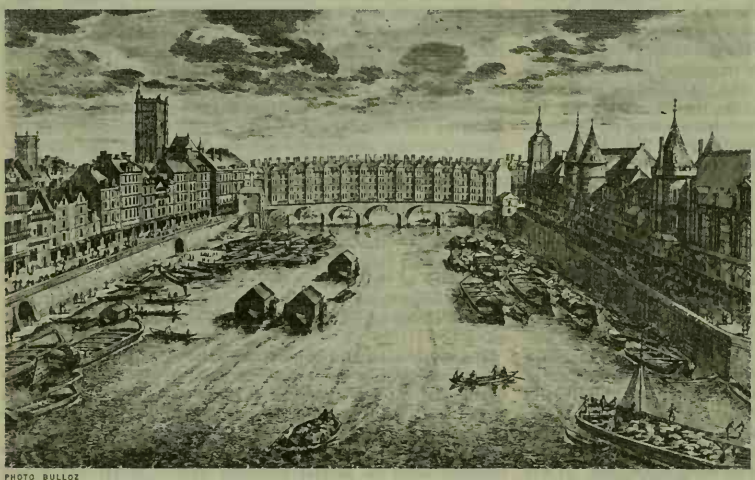


PHOTO BULLOZ

THE PONT AU CHANGE WHERE, BY ORDER OF LOUIS VII IN 1141, THE MONEY CHANGERS OPENED THEIR SHOPS. THE BRIDGE WAS REBUILT IN 1639–47 WITH FIVE-STORY STONE HOUSES ON EACH SIDE. FROM AN ENGRAVING BY JEAN MARIETTE

turned west around the Place du Panthéon, ran along the Rue Soufflot, and then followed a line slightly to the east of the Rue Monsieur-le-Prince, the Rue de l'Ancienne-Comédie, and the Rue Mazarine to the Seine at the Tour de Nesle, opposite the start of the right-bank wall.

The king's formal recognition of the University of Paris (*q.v.*), with its seat on the Montagne Sainte-Geneviève, in 1200 was also a recognition of the division of Paris into three parts, corresponding to the natural division of the site: on the Right Bank was the mercantile quarter, the town or *ville* in the strict sense of the term; on the island was the Cité; on the Left Bank was the university. The church, on which the university depended, became particularly strong on the Left Bank: two new parishes, Saint-Côme and Saint-André-des-Arts, were made out of the recently founded parish of Saint-Sulpice (*c.* 1215); Saint-Étienne-du-Mont (1222) and Saint-Nicolas-du-Chardonnet (1243) were founded; and various religious orders established themselves within the new wall: the Dominicans, or Jacobins, near the junction of the Rue Saint-Jacques and the modern Rue Soufflot (1219), the Cordeliers in the modern Rue de l'École-de-Médecine (1290), the Augustinian Friars on the Quai des Augustins (1293), and the Carmelites in the Place Maubert (1319). Outside the wall, the Carthusians settled in 1259 where the Avenue de l'Observatoire now is. Numerous colleges were also founded, including the Sorbonne, named after Robert de Sorbon (1257).

On the Right Bank within the new wall two new churches soon appeared, Saint-Honoré (1205) and Saint-Eustache (1223; rebuilt in the 1530s), but the chief new development was in commercial administrative organization. In 1204 Philip Augustus confirmed the monopoly that the *marchands de l'eau* had obtained in 1170; *c.* 1220 their corporation began to undertake the role of a municipality. In Louis IX's reign, by 1260 at the latest, the master of this corporation was at the head of the municipal body, with the title of *prévôt des marchands*, or provost of the merchants. His council, called the *parloir aux bourgeois*, had its seat at first near the Châtelet, but was moved in 1357 to the Maison-aux-Piliers, on the Grève. The enforcement of law, however, remained in the hands of the king's *prévôt de Paris* (*see* above). An ultimate sanction was the gibbet at Montfaucon, on the Buttes-Chaumont, far outside the wall to the northeast.

6. Charles V.—In the 14th century, under the first Valois kings, the development of Paris was arrested not only by the Black Death (1348–49), but also by the outbreak of the Hundred Years' War and by internal disturbances resulting from it. In 1356–58, while the dauphin Charles was regent of France for his captive father John II the Good, the municipality, led by the *prévôt des marchands*, Étienne Marcel (*q.v.*), adopted a revolutionary attitude against the royal authority. The regent, however, overcame the sedition. On beginning his reign as Charles V (1364–80) the king applied himself to restoring the prosperity of Paris. On the Right Bank, where Paris had outgrown the perimeter of Philip Augustus, Charles built a new rampart (*c.* 1367–70), starting, in modern terms, at the Pont du Carrousel, running across the Place du Carrousel, the Palais-Royal, and the Place des Victoires to the Porte Saint-Denis and then veering southeastward to the end of the Rue Saint-Antoine. It had six gates (Portes Saint-Honoré, Montmartre, Saint-Denis, Saint-Martin, du Temple, and Saint-Antoine); and the Porte Saint-Antoine was protected by a great fortress, the Bastille (*q.v.*).

In the east the new fortification embraced the Marais (marsh), in the vicinity of the Temple. In the west it embraced the Louvre, which Charles rebuilt as a magnificent palace, though he preferred to reside in his own creation, the Hôtel Saint-Paul, south of the Rue Saint-Antoine. Henceforth the kings of France no longer lived in the old palace in the Cité, which was now given over almost entirely to the *parlement* (*q.v.*) of Paris, already long established in it. At the end of Charles's reign the Pont Saint-Michel was built, linking the Cité with the Left Bank along the line of the Right Bank's Grand Pont or Pont-au-Change.

7. The 15th Century.—Charles VI's reign (1380–1422) was a period of unrest. The revolt of the Maillotins (1382) against oppressive taxation was ruthlessly put down early in 1383, and the municipal regime was then suspended till 1412. The dynastic and political vendetta between the Burgundian and the Armagnac factions (1407–35) had continual repercussions in Paris; in the course of it, the butchers and skinners, led by Simon Caboche, momentarily seized power there (1413). The resumption of the Hundred Years' War by the English (1415) made matters worse. After a revolt of the Parisians (1418), the Burgundians occupied Paris; and the Anglo-Burgundian Alliance (1419) was followed by the installation of John Plantagenet, duke of Bedford, as regent of France for the English king Henry VI (1422). Whereas Charles VI had lived in his father's Hôtel Saint-Paul, Bedford lived in the Hôtel des Tournelles, on the southeastern edge of the Marais, which was to be the Paris residence of later kings till 1559. One feature of Charles VI's reign was the construction of the Pont Notre-Dame (1413; on the site of the most ancient wooden bridge from the island to the Right Bank).

Joan of Arc failed to capture Paris (1429) (*see* JOAN, SAINT). Only in 1436 did it fall to the forces of Charles VII, who reentered it in person in 1437. Successive disturbances had reduced the population, but the Anglo-French truce of 1444 allowed Charles to begin restoring prosperity. The municipality was reorganized in 1450. During Louis XI's reign (1461–83), notwithstanding the intellectual stagnation of the university, the Sorbonne in 1469 installed the first Parisian printing press. Churches were rehabilitated and new houses built; from 1480 splendid private mansions began to appear, such as the Hôtel de Sens and the Hôtel de Cluny.

8. The 16th Century.—The influence of the Italian Renaissance on town architecture appeared in the new building for the *chambre des comptes* and in the reconstruction of the Pont Notre-Dame (1500–10) in Louis XII's reign. Under Francis I (1515–47) this influence grew stronger, finding notable expression in the new Hôtel de Ville. Furthermore, whereas from Charles VII's time the kings of France had been residing by preference in Touraine, Francis showed himself willing to make Paris the chief seat of royalty again. (*See* FRANCIS I.) With this in mind he had extensive alterations made to the Louvre from 1528 onward. The new splendour of the monarchy, now well on its way toward absolute rule, was reflected in the capital of an increasingly centralized state. The population increased and the town expanded again. Rigorous measures were taken to stamp out Protestantism, which first appeared in Paris during Francis I's reign.

The culmination of the Renaissance in Paris came with Henry II, who made his solemn entry into the capital in 1549. In that year Jean Goujon completed his magnificent work on the statuary of the Fontaine des Innocents. The new impulse given to the building of mansions for the nobility and the bourgeoisie began to transform Paris from a medieval into a modern city. In 1548 the Brothers of the Passion started performing secular plays at the Hôtel de Bourgogne, in the Rue Française, thus giving rise to the first theatre in Paris; in the 17th century, this Hôtel de Bourgogne was to be famous for its troupe of actors.

The definitive transfer of the royal residence from the Hôtel des Tournelles to the Louvre took place after Henry II's death (1559). This move inaugurated the development of the western outskirts of Paris, hitherto rather neglected. Catherine de Médicis in 1564 began to build the Palace of the Tuileries, the gardens of which were soon to become a meeting place for elegant society. Classical taste was brilliantly exemplified by the Pont-Neuf, begun in 1577–78 but not completed till 1603. It was constructed from the Right to the Left bank by way of the island, and was kept free of houses which were built on the other bridges.

The Wars of Religion did not spare Paris: witness the outbreak of the Massacre of St. Bartholomew's Day (1572); the Day of the Barricades (May 12, 1588), when the people rose for the Holy League against Henry III; and the Parisians' long resistance to Henry IV, in the course of which the oligarchy of the Sixteen, representing the 16 districts of Paris, took control of the administration for the League. Henry IV's siege (May–August 1590) was unsuccessful, and it was only after Henry's conversion to Catholicism that Paris submitted to him (March 22, 1594).

PHOTO BULLOZ

THE PALACE OF THE TUILERIES IN THE REIGN OF LOUIS XIV (1638–1715). FROM AN ENGRAVING BY GABRIEL PÉRELLE

9. Henry IV and Louis XIII.—Henry IV planned the Place Royale (now Place des Vosges), between the Marais and the Rue Saint-Antoine, and the Place Dauphine, on the island beside the Pont-Neuf, with the Quai de l'Horloge and the Quai des Orfèvres north and south of it respectively. In his reign also the Louvre was linked to the Tuileries; the Hôpital Saint-Louis (1607) was built for victims of the plague; and a supply of spring water (which had been brought to the Right Bank late in the 12th century) was carried over to the Cité. The Left Bank was not supplied with spring water till the following reign.

In Louis XIII's reign (1610–43) Paris expanded further. On the Left Bank, outside the wall, the queen mother, Marie de Médicis, built the Luxembourg Palace (1615–27), with its spacious gardens; and along the Right Bank, west of the Tuileries, she laid out the Cours-la-Reine as a promenade for carriages (1616). While the Marais north of the Place Royale was being reclaimed and developed, two uninhabited islets east of the Cité were united to form the Île Saint-Louis, which was linked to the Right Bank by the Pont Marie and to the Left by the Pont de la Tournelle. On the western fringe of the town a quarter with straight streets was laid out north of the Cardinal de Richelieu's new palace, the Palais-Cardinal (1624–36; later the Palais-Royal), which also had a magnificent garden; west of this there was more building off the continuation of the Rue Saint-Honoré. To embrace these new western suburbs a new fortification was erected, extending Charles V's rampart from the Porte Saint-Denis along the line of the modern Grands Boulevards to a point just east of the Place de la Madeleine and there turning south to join the Seine at the southwestern corner of the Tuileries Gardens. The Palace of the Tuileries was connected with the Faubourg Saint-Germain by a wooden bridge, the Pont Royal (1632), spanning the Seine. On the Left Bank, far to the east, on the lower reaches of the Bièvre, the Jardin des Plantes was founded in 1635–36.

10. Louis XIV.—For the Parisians, the Fronde (*q.v.*) was the major event of the first two decades of Louis XIV's reign. From 1661, when Louis started his personal rule upon Cardinal Mazarin's death, Paris was dedicated to reflecting the glory of the monarch, even though he was early resolved to establish himself and the seat of his government at Versailles. For the planning of the new splendours of Paris, the greatest part of the credit must go to J. B. Colbert (*q.v.*), the king's superintendent of buildings.

The Louvre, work on which had been resumed in 1624, was completed by Claude Perrault's magnificent colonnade (1667–74). The Tuileries Palace was altered, completed, and sumptuously decorated; its gardens were transformed by André Le Nôtre. Beyond them, outside Paris, the tree-planted avenues of the Champs-Élysées were laid out (1667); these were balanced, at the opposite end of Paris, by the Cours de Vincennes. No longer afraid of attack, Louis XIV and Colbert had the line of fortifications replaced by a course of boulevards flanked by trees to form a walk (1670). In the north, the line of the Grands Boulevards was pierced by the Porte Saint-Denis (1672) and the Porte Saint-Martin (1674), triumphal arches that are still admired. Other monuments were the Place des Victoires (1685–86) and the Place Vendôme (1699), each with a statue of Louis XIV.

On the Left Bank, the Collège des Quatre-Nations (1662–74; the modern Institut), endowed by Mazarin's will and open to young men from four recently conquered countries, and the Hôtel des Invalides (1671–76) were a counterpart to the Louvre and the Tuileries. Magnificent quays were constructed along the north side of the Faubourg Saint-Germain; in 1685 the Pont Royal was rebuilt in stone. To the south, where the fortifications of Philip Augustus were now obsolete, a course of boulevards like that on the Right Bank was planned to run in a great arc from the Invalides to the Jardin des Plantes. Beyond this course, the Observatoire was built in 1667–72 and the Gobelins factory (tapestries) was organized in 1667.

Paris had become very large; in 1702 the marquis d'Argenson (Marc René de Voyer), who as *lieutenant général de police* was the successor of the *prévôts de Paris*, raised the number of districts from 16 to 20 (15 on the Right Bank, 5 on the Left). Paris had nearly 600,000 inhabitants, and from the Left Bank new suburbs were advancing toward the villages on the surrounding hills.

11. The 18th Century.—During the 18th century a great deal was done to improve and beautify Paris. Louis XV's temporary residence in the Tuileries during his younger days encouraged development nearby, so that the Faubourg Saint-Honoré expanded and became, like the Faubourg Saint-Germain, an aristocratic quarter. The Rue Royale was begun in 1732, and the Place Louis XV (later Place de la Concorde) was laid out around the statue of the king set up in 1763. The construction of the parish church of the Madeleine was begun in 1764 at the end of the Rue Royale, and the Pont Louis XVI (Pont de la Concorde) was begun in 1788. The garden of the Palais-Royal, around which the duc d'Orléans built arcades in Louis XVI's reign, became a centre of smart life. The Grands Boulevards now began to be bordered with houses, including some fine mansions, and the eastern stretch became a fashionable promenade with little theatres and cafés. Beyond the boulevards the Rue de Provence and Rue d'Artois (or Laffitte) were laid out in 1770, the Rue Taitbout in 1773, the Rue Chauchat in 1779, the Rue Richer in 1782, and the Rue Le Peletier in 1786. Villas built by nobles and financiers were scattered around this outlying part. On the Left Bank the work of laying out the southern course of boulevards and planting it with trees was continued, and houses were soon built along it. The École Militaire, with the Champ-de-Mars, dates from 1751. Germain Soufflot built a new church (now the Panthéon) for the Abbey of Sainte-Geneviève; and Saint-Sulpice, the rebuilding of which had been begun in the 1640s, was completed. The Petit Châtelet was demolished and replaced by a quay (1782).

Some of the houses on the bridges were razed in 1786–88; some, however, remained until 1808. Water was supplied to both banks by the two fire pumps of the brothers J. C. and A. C. Périer (1779 and 1787), which were the precursors of steam-driven machinery.

The wall of the *fermiers généraux* (farmers-general), built in the 1780s to facilitate the levying of *octrois* or duties on imports, bore witness to the extension and to the unity of Paris. On the modern map this wall would run from the Étoile northeastward to the Place de Clichy and Villette, then southeastward to the Place de la Nation, returning to the Étoile via Place Denfert-Rocherau and the Trocadéro.

12. The Revolution and Napoleon I.—The French Revolution of 1789, on the one hand, destroyed those vestiges of the seigneurial system which had remained in Paris and, on the other, consolidated the status of Paris as the capital of a centralized France. Of the events of the Revolution which were Parisian it must suffice here to cite the storming of the Bastille (July 14, 1789); the conveying of the king and of the National Constituent Assembly from Versailles to Paris (October); the establishment of the numerous clubs in the convents of the old religious orders, Jacobins, Cordeliers, and Feuillants (*qq.v.*); the insurrection that overthrew the monarchy (Aug. 10, 1792); the execution of the king in the Place de la Révolution, not yet named Place de la Concorde (Jan. 21, 1793); the most prolonged manifestation of the Terror (1793–94); and the series of *coups d'état*, from that of 9 Thermidor (1794) to that of 18 Brumaire (1799), which preceded the institution of the Consulate for Napoleon Bonaparte. (*See* FRENCH REVOLUTION; NAPOLEON I.)

Under the Thermidorians and the Directory the Boulevard des Italiens became a resort of the fashionable and of the frivolous, whereas the populace favoured the Boulevard du Temple. The first consul's installation of himself in the Tuileries resulted in the construction of the arcades of the Rue de Rivoli (1802), with adjoining streets named after his military victories. After the inauguration of the First Empire, Napoleon in 1806 ordered the triumphal arches of the Carrousel and of the Étoile to be erected; the latter, however, was completed only in 1836. The Madeleine was designed anew as a "Temple of Glory," but it too was not completed until 1842. The Neoclassical style recalled imperial Rome, but at the same time great works of public utility served to modernize Paris: the Bourse; new quays and bridges (Ponts-des-Arts, d'Iéna, d'Austerlitz, and Saint-Louis); the Canal de l'Ourcq and the Canal Saint-Martin; numerous fountains (such as the Fontaine du Palmier, on the site of the Châtelet; as well as slaughterhouses, marketplaces, the Halle-aux-Vins, the warehouses of Bercy, and the large cemeteries outside the town (for instance that of Père-Lachaise, inaugurated in 1804).

13. The Restoration and the July Monarchy.—Industrialization, already in progress in the Napoleonic period, advanced rapidly under the Restoration (1814–30) and the July Monarchy (1830–48). Gas lighting was introduced; omnibus services began in 1828; and Paris got its first railway, which ran to Le Pecq, near Saint-Germain-en-Laye, in 1837. New districts grew up on the outskirts of Paris: the *quartier* Francois Ier at the western end of the Cours-la-Reine (from 1823), the *quartier* Notre-Dame-de-Lorette at the southern approaches to Montmartre (from 1824), and the *quartier* de l'Europe on the southwesternmost slopes of Montmartre (from 1826). More bridges appeared, and two notable monuments were set up: the column commemorating the Revolution in the Place de la Bastille (1830); and the Obelisk of Luxor in the Place de la Concorde (1836).

Though the wall of the *fermiers généraux* was to remain the administrative boundary of Paris till 1859, it was decided in 1840 to refortify the capital with a military wall of a much longer perimeter. Louis Philippe's fortifications, completed in 1845, embraced the surrounding hamlets of Vaugirard, Grenelle, Auteuil, Passy, Les Batignolles, Montmartre, Chapelle, Villette, Belleville, Charonne, and Bercy, together with the southern area of the Gobelins and the Observatoire.

14. Napoleon III and Haussmann.—By the middle of the 19th century there still remained areas of Paris which had not been improved substantially for hundreds of years; access from one centre to another and to the railway stations (now the effective gateways of Paris) was difficult; and overpopulation together with the social effects of rapid industrialization had brought squalor and conditions of misery which account in part for the dominant role played by Paris in the revolutions of 1830 and 1848. Napoleon III, emperor from 1852 to 1870, enjoined his prefect of the Seine, Baron Haussmann (*q.v.*), to remedy all this.

Haussmann was the creator of modern Paris. A planner on the grand scale, he advocated straight arterial thoroughfares, symmetry, and advantageous vistas. In meeting the call for hygiene and slum clearance he also tried to facilitate the free movement of troops into those districts which formerly had been the sources of insurrection. The west-east axis of Paris, from the Étoile to the Place de la Bastille and thence to the Place du Trône or Place de la Nation, was made continuous by extending the Rue de Rivoli onward from Napoleon I's arcades to the Rue Saint-Antoine; and a new north-south axis was established with the Boulevards de Strasbourg, de Sébastopol, du Palais, and Saint-Michel. At the ends of the west-east axis, the radiation of roads from the Étoile was to be balanced by a similar radiation from the Place de la Nation; the Place Voltaire, midway between the Places de la Nation and de la République, was made the centre of a third great radiation, covering the whole of eastern Paris. In the centre of the town the system of the Grands Boulevards was supplemented by the Avenue de l'Opéra, the Rue Auber, the Boulevard Haussmann, and the Boulevard Malesherbes. On the Left Bank, the Boulevard Saint-Germain was made to correspond to the Grands Boulevards, with the Rue de Rennes crossing it on a line parallel to the Boulevard Saint-Michel. The Ponts National, de Solférino, and de l'Alma and the Viaduc d'Auteuil were constructed. The Boulevards Extérieurs were made to follow the curve of the wall of the *fermiers généraux*.

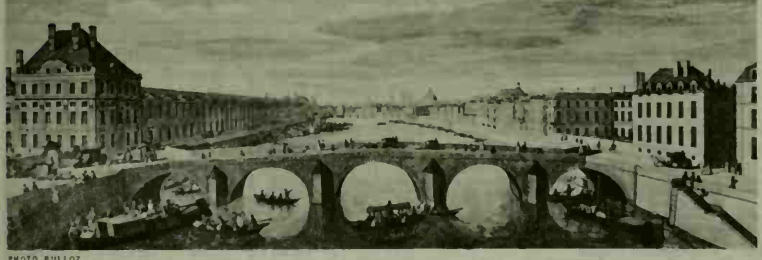


PHOTO BULLOZ

VIEW OF THE SEINE FROM THE PONT ROYAL, LOOKING TOWARD THE PONT NEUF AND THE COLLÈGE DES QUATRE-NATIONS; THE LOUVRE AND PART OF THE TUILERIES CAN BE SEEN ON THE LEFT. FROM AN ENGRAVING BY HYACINTHE RIGAUD

Among the architectural monuments of the Second Empire were: the Opéra; the additions to the wings of the forecourt of the Louvre; the pioneering "umbrella" in iron for the Halles Centrales; the Churches of La Trinité, Saint-Augustin, and Sainte-Clotilde; and the many public buildings on the Île de la Cité. Many squares were laid out on the English model. The Bois de Boulogne, the Bois de Vincennes, the Buttes-Chaumont, the Parc de Montsouris, and what remained of the Parc Monceau, after the laying out of the adjacent boulevards, were developed as open spaces.

Haussmann's taste, his theory of town planning, and his disregard for the historic value of any buildings or quarters that obstructed his projects are matters of controversy. His service to the water supply and sewage systems is incontestable. For domestic use, he brought the water of the Dhuis to the reservoir at Ménilmontant and the water of the Vanne to the reservoir at Montsouris; he also constructed the main drain with its terminal at Asnières.

The brilliance and prosperity of Paris under Napoleon III were exemplified in the exhibitions held there in 1855 and 1867.

15. The Third Republic and After.—The Franco-German War, which brought the fall of the Second Empire and the siege of Paris, was followed by the Commune (*q.v.*) of Paris, during which the Palace of the Tuileries was destroyed by fire. Under the Third Republic Haussmann's projects were continued. Further international exhibitions (1878, 1889, 1900, and 1937) were the occasions for the building of the Trocadéro (1878), the Eiffel Tower (1889), and the Grand and Petit Palais, with the Pont Alexandre III (1900); and for the reconstruction of the Trocadéro as the Palais de Chaillot (1937; later used occasionally for general assemblies of the United Nations). The Basilica of the Sacré-Coeur was built in Montmartre. The Métropolitain Railway was constructed. Commerce and industry annexed formerly residential districts, and the ever-expanding population overflowed the old limits of Paris. After World War I, Louis Philippe's fortifications were abolished by a law of April 1919.

During the German occupation of Paris (1940–44) in World War II the city suffered from some material privations. It was a centre for the activities of the Resistance, which culminated in the liberation of the city by the people, under the direction of the civil police, as Gen. Jacques Leclerc's troops approached.

The 2,000th anniversary of Lutetia was celebrated in 1951. Meanwhile it had become apparent that the existing organization of Paris was no longer adequate to its needs. Overcrowding, difficulties of transport, and the traffic congestion called for new measures. The municipal council voted a master plan for the town (1959) and the government approved a plan for the organization and development of the Paris Region (1960). Moreover, in the field of administrative reform, the "district of the Paris region," created in 1959, was extended in 1961 to include the three *départements* of Seine, Seine-et-Oise, and Seine-et-Marne (with an aggregate population of 8,500,000, or 20% of the population of France). Commercial and industrial decentralization, an accelerated program of housing, the renovation of decaying quarters, the provision of more open spaces, and the settling of new communities outside Paris were envisaged. A new transport system including express trains on the Métropolitain as well as new auto routes and bypasses were planned.

Between 1945 and 1959 more than 250,000 new housing units were constructed (about 60,000 in Paris and 190,000 in the suburban area) mostly round the periphery of the town grouped in huge blocks. One new quarter is situated near the Gare Montparnasse, another outside the old Paris at the Rondpoint de la Défense, across the Seine beyond Neuilly. Bold examples of modern architecture for international organizations (UNESCO and NATO), for the university, and for commercial enterprises altered the appearance of the more central areas.

For the great plan of reorganization of 1964 *see* below, *Administration.*

III. TOPOGRAPHY AND MONUMENTS

1. General.—In considering the topography of the city of Paris it is essential to remember the history of its development (*see* above). The nucleus of the city lay on the Île de la Cité in the Seine, and for many centuries this island provided protection for the seats of royal and ecclesiastical power. It is here, therefore, that the most ancient sites and some of the oldest architectural monuments of Paris or their remains are found. In addition, however, ancient religious foundations were established both on the Right and Left banks, and around these sprang up small but growing communities which subsequently formed the core of later quarters. The Left Bank opposite the Île de la Cité became at an early date the professional quarter through the establishment of places of study, such as colleges and convents. Scribes, booksellers, printers, etc., were attracted to those areas. The Right Bank, on the other hand, became the commercial and industrial area of the city, with individual trades often tending to predominate in certain quarters. Thus, there was an early division of Paris into three parts: the official and religious centre on the Île de la Cité, the university on the Left Bank, and the "town" on the Right. Though modified with the passage of time, the basic characteristics of each persisted.

When eventually the kings transferred their residence to the Right Bank, moving in various centuries to differing spots not far from the river, they attracted an aristocracy which erected several temporarily fashionable districts, many of whose architectural features survived though the areas themselves were largely adapted to commercial uses or fell into a certain degree of squalor. To the west sprang up newer quarters, but the area within the walls was never completely built over, and open spaces gave opportunity for the bold replanning of Baron Haussmann. Haussmann's works transformed the face of Paris and fashioned it into its present appearance. The fundamental principles were: the creation of spacious squares from which radiated broad avenues to various parts of the city; the transformation of the external fortifications into a ring of surrounding boulevards; the construction of wide and straight transversal thoroughfares; the addition in the west of new well-planned quarters; and the provision of open spaces such as parks and gardens. The result was to give the city in its main outlines, particularly in the west and centre, an appearance of impressive beauty and sometimes grandeur and at the same time to make its internal communications easy. This effective planning contrasts with the haphazard incorporation of existing suburbs and the creation of the new ones beyond the city proper.

The Paris area was subsequently divided into 20 *arrondissements* (there had previously been 12). The first seven in numerical order roughly cover the three historic parts of old Paris, the *cité,* the town, and the university. (*See* Table.)

2. The River.—The Seine itself, whose breadth (except where it divides into two arms around the Île de la Cité and the Île Saint-

Arrondissements and Quarters of Paris

Arrondissements	Quarters	Population			
		1936	1946	1954	1962
I. Louvre	Saint-Germain-l'Auxerrois, Les Halles, Palais-Royal, Place Vendôme	42,166	36,003	38,827	36,535
II. Bourse	Gaillon, Vivienne, Mail, Bonne-Nouvelle	44,311	41,419	43,857	40,864
III. Temple	Arts-et-Métiers, Enfants-Rouges, Archives, Sainte-Avoie	70,971	64,356	65,312	62,680
IV. Hôtel-de-Ville	Saint-Merri, Saint-Gervais, Arsenal, Notre-Dame	83,063	59,807	66,284	61,591
V. Panthéon	Saint-Victor, Jardin des Plantes, Val de Grâce, Sorbonne	117,770	100,153	104,466	95,825
VI. Luxembourg	Monnaie, Odéon, Notre-Dame-des-Champs, Saint-Germain-des-Prés	100,046	80,931	86,324	80,092
VII. Palais-Bourbon	Saint-Thomas-d'Aquin, Invalides, École Militaire, Gros-Caillou	107,567	99,880	103,134	99,456
VIII. Élysée	Champs-Élysées, Faubourg du Roule, Madeleine, Europe	84,854	71,660	79,740	74,384
IX. Opéra	Saint-Georges, Chaussée-d'Antin, Faubourg Montmartre, Rochechouart	102,797	96,617	102,170	94,094
X. Enclos-Saint-Laurent	Saint-Vincent-de-Paul, Porte Saint-Denis, Porte Saint-Martin, Hôpital Saint-Louis	131,150	122,225	128,274	124,493
XI. Popincourt	Folie-Méricourt, Saint-Ambroise, Roquette, Sainte-Marguerite	219,471	187,715	199,828	192,953
XII. Reuilly	Bel-Air, Picpus, Bercy, Quinze-Vingts	157,277	151,695	154,167	161,091
XIII. Gobelins	Salpêtrière, Gare, Maison-Blanche, Croulebarbe	164,671	156,390	164,631	166,556
XIV. Observatoire	Montparnasse, Parc Montsouris, Petit-Montrouge, Plaisance	178,230	167,302	177,422	173,975
XV. Vaugirard	Saint-Lambert, Necker, Grenelle, Javel	238,797	242,546	243,634	249,676
XVI. Passy	Auteuil, Muette, Porte Dauphine, Chaillot	176,868	195,343	211,559	224,503
XVII. Batignolles-Monceau	Ternes, Plaine Monceau, Batignolles, Épinettes	220,716	217,906	230,890	227,635
XVIII. Montmartre	Grandes-Carrières, Clignancourt, Goutte-d'Or, Chapelle	288,810	258,744	265,875	254,840
XIX. Buttes-Chaumont	Villette, Pont-de-Flandre, Amérique, Combat	165,757	148,740	154,806	159,485
XX. Ménilmontant	Belleville, Saint-Fargeau, Père-Lachaise, Charonne	195,731	192,041	199,334	199,229

Louis) varies between 136 and 164 m. (446 and 540 ft.), forms one of the most attractive and useful highways of the capital. It sweeps in a pronounced loop of nearly eight miles from the Pont-National, its eastern limit within the city, to the Pont d'Auteuil in the west, passing in its course under 32 bridges. Of these the oldest is the Pont-Neuf (1578–1606) at the western tongue of the Île de la Cité, with its equestrian statue of Henry IV. Other famous bridges are the Pont d'Austerlitz, on which are inscribed the names of the principal officers who fell at Austerlitz, the Pont Alexandre III, the Pont du Carrousel, and the Pont de l'Alma, all noteworthy for their sculpture.

The more easterly quays of the river, which is flanked by landing stages and towpaths, are used for handling merchandise sent to or brought from the north, east, and southeast by rail and canal. The river then divides around the ancient part of Paris, the Île de la Cité and the Île Saint-Louis, which was only extensively built on during the 17th century. The two islands are joined together by the Pont Saint-Louis (destroyed in 1939 and replaced by a temporary structure). Their quays and those of the adjacent and immediately westerly banks were once lined with the shops of craftsmen—goldsmiths, watchmakers, etc.—but are now more usually occupied by traders or booksellers. The parapets of the river walls are filled with boxes for secondhand books, paintings, and prints; their tree-lined walks form a pleasant locality both for the bibliophile and the saunterer. The river quays are bordered by the Palais du Louvre and the Jardin des Tuileries to the north and various official buildings on the south. The river later begins to curve southwest with the Palais de Chaillot and the Trocadéro gardens on the Right Bank and the Eiffel Tower and the Champ de Mars on the Left and passes through the western suburbs. The quays constitute a downstream port for various kinds of river craft. There are huge floating swimming pools moored to the banks. Less conspicuous is the optimistic angler who reels his rod on the broad towpath below.

3. The Right Bank.—On the Right or North Bank, roughly parallel to the river's course, runs another central artery of Paris, the east-west thoroughfare planned by Haussmann. Beginning in the east at the Place de la Nation and running to the Place de la Bastille, this thoroughfare today coincides with the Rue du Faubourg Saint-Antoine. Both the Faubourg Saint-Antoine and the quarter of Sainte-Marguerite just to the north of it are working-class districts in which are concentrated numerous small establishments specializing in such occupations as furniture making and metalwork. On the riverside the area is chiefly devoted to the needs of traffic to and from the quays. From the Place de la Bastille, where it intersects with a major north-south artery, the thoroughfare continues westward along the Rue Saint-Antoine and the magnificent colonnaded Rue de Rivoli in a long straight line to the Place de la Concorde. North of the Rue Saint-Antoine lies the ancient district of the Marais, formerly an area of high fashion but now one of commerce and small industries, though retaining much of its 17th-century architecture. Northwest of the Marais lies the district of the Temple. The Rue de Rivoli cuts across a second north-south artery formed by the Boulevards de Strasbourg and de Sébastopol on the Right Bank and continued by the Boulevards du Palais (on the Île de la Cité) and Saint-Michel (on the Left Bank); not far from this intersection stand the Hôtel de Ville and the Châtelet. The first part of the western half of the Rue de Rivoli is bordered on the north by yet another former fashionable quarter, that of the Palais-Royal, now occupied by such buildings as the Halles, the Théâtre Français (the Comédie Française), and various banking establishments; farther west, it is also one of the centres of *haute couture*. On the south of the Rue de Rivoli are the Louvre and the Jardin des Tuileries.

The transversal westward thrust continues from the spacious Place de la Concorde along the tree-lined Champs-Élysées to the Place de l'Étoile, on to the extremity of Paris proper, the Porte Maillot, then to the Rond-Point de la Defense. The western districts, both to the north (Faubourg Saint-Honoré, Monceau, Courcelles) and to the south along the now curving river (Passy and Auteuil), are areas of fashionable hotels, apartments, and residences.

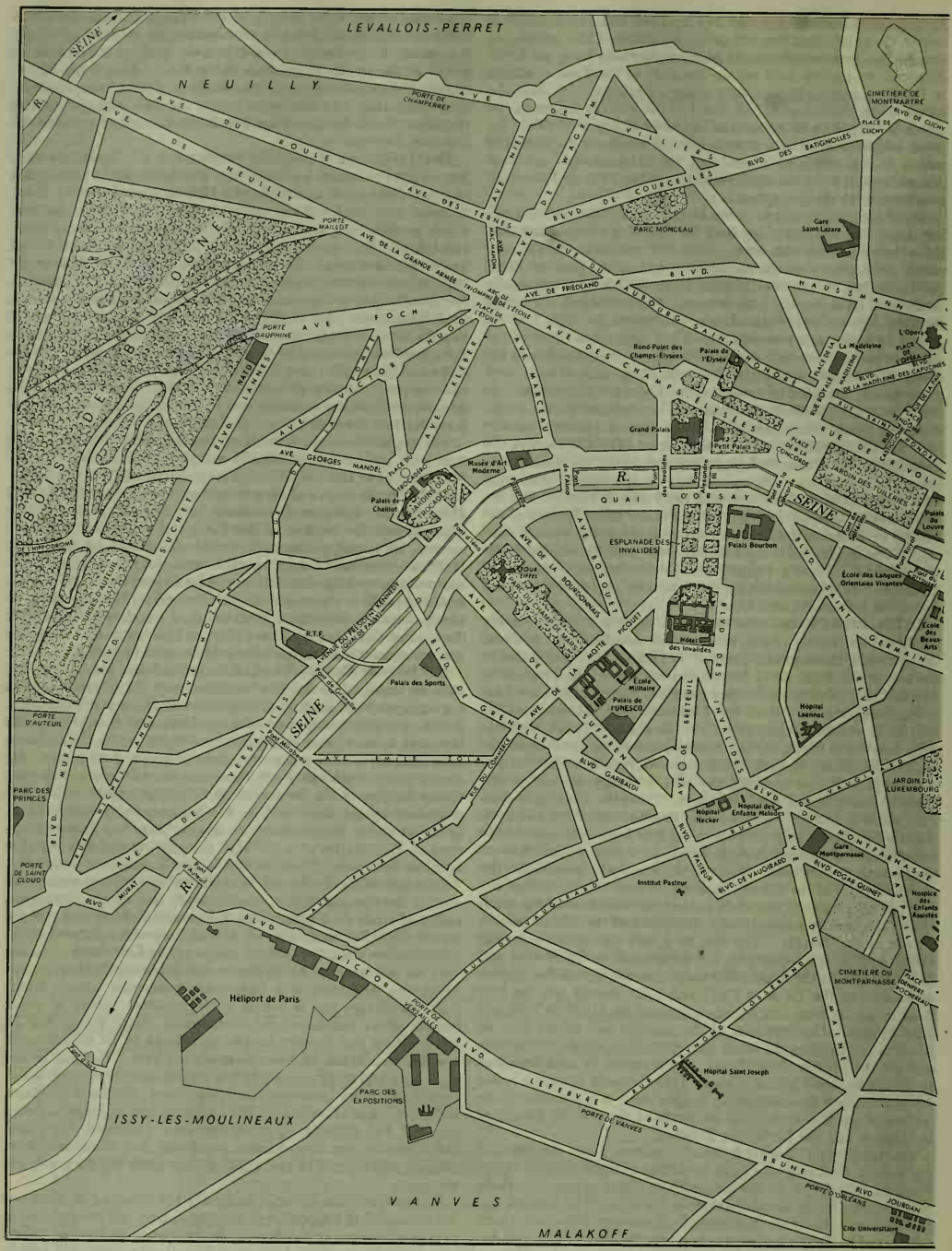
North of the Place de la Concorde is the Place de la Madeleine, a terminal point in the system of the Grands Boulevards, which strike northeastward from it (Boulevards de la Madeleine, des Capucines, des Italiens) to run eventually parallel to the Rue de Rivoli as far as the Place de la République (Boulevards Montmartre, Poissonnière, Bonne-Nouvelle, Saint-Denis, Saint-Martin), after which they turn southward to join the main east-west axis at the Place de la Bastille (Boulevards du Temple, des Filles-du-Calvaire, Beaumarchais).

The Théâtre de l'Opéra, the masterpiece of Charles Garnier, just off the Boulevard des Capucines, was chosen as the nodal point of a new fashionable quarter by the 19th-century planners. From it broad tree-lined avenues were constructed to other centres, which in their turn were connected with points in the city's circumference, thus joining up with an inner and an outer arc of boulevards and using the city gates as exits. The Avenue de l'Opéra itself runs southeast almost to the Louvre and the Tuileries, the Rue du Quatre-Septembre east toward the Bourse, the Boulevard Haussmann west to the Place de l'Étoile, and the Rue La Fayette towards the Gares du Nord and de l'Est. These thoroughfares were supplemented by others. The area is now one of restaurants and open cafes, smart shops, and also large stores, theatres, and cinemas, catering primarily to tourists. Toward the Place de la République the working-class Faubourg Saint-Martin begins, lying between the districts of the Temple and Villette.

The arc of the outer districts on the Right Bank begins in the west with Batignolles, principally a middle-class residential area. Montmartre, to the east of it, is a varied area: there is the Montmartre of night clubs and cabarets around the Place de Clichy and Place Pigalle; and the Montmartre of the poets and painters leavened with the workers of the Butte and the Tertre with their narrow, hilly, and picturesque streets, dominated by the white Basilica of the Sacré-Coeur. Farther east, along the heights of the city, are the working-class districts of La Chapelle and La Villette, with Belleville to the southeast and, beyond it, Ménilmontant, in which there are industries, abattoirs, and warehouses. Through these outer districts runs an arc of inner boulevards that form lateral communications through the middle areas of Paris.

4. The Left Bank.—The Left or South Bank has neither any vista so imposing as the Rue de Rivoli and the Champs-Élysées nor any system of avenues so impressive as the grand boulevards. But it contains many fine thoroughfares and is set out with the same arcs of inner and outer boulevards as the Right Bank, with probably a more adequate system of north-south routes. Its central north-south axis is the Boulevard Saint-Michel. This continues the line of the Boulevard de Sébastopol (with which it is connected by the Boulevard du Palais across the Île de la Cité) as far south as Montparnasse, a quarter that was formerly the rival of Montmartre as a "village" for painters and artists but is now less favoured by them though it is still popular with tourists. To the east of the Boulevard Saint-Michel and spilling over to the west is the Quartier Latin, originally the site of the component places of study that became the University of Paris and still the seat of many faculties. Farther east lie the commercial and industrial districts along the eastern quays of the Left Bank. To the west of the Quartier Latin begins the Faubourg Saint-Germain, which was developed as a fashionable residential suburb during the 18th century and is full of noble mansions (many of which became official buildings) and monuments. Since World War II, many artists and literary people have lived in its eastern part, around the Church of Saint-Germain-des-Prés. Beyond lie the more open and modern areas of fine avenues and gardens, in which are the Hôtel des Invalides, the Eiffel Tower, the École Militaire, and the UNESCO building. The east-west belt of outer southern districts, Les Gobelins, Petit-Montrouge, Plaisance, Vaugirard, and Grenelle, are less densely populated and somewhat more pleasant equivalents of the working-class areas of the north and northeast.

5. Squares.—An essential feature in the planning of Paris was the utilization or adaptation of existing squares and the creation of new ones to serve as focal points in the system of boulevards and roads. Some mention of the more important squares will help to give a clearer picture of the general layout of the city. Some of



PARIS CITY LIMITS; SHOWING "CITY GATES."

PRINCIPAL STREETS, PARKS AND BUILDINGS

them deserve attention also from architectural or historical viewpoints. The northern east-west axis is marked by a succession of these squares. Almost at its terminal point in the extreme east is the Place de la Nation with its monument dedicated to the achievements of the First Republic. Roads connect it to the eastern outer boulevards; through it runs the inner arc of northern boulevards; from it radiate various routes, northwest to the extensions of the grand boulevards and to the northern suburbs, south or southwest to the river. The next square of the east-west axis is the Place de la Bastille, originally the site of the ancient fortress of Charles V that was converted into the state prison and eventually destroyed by the revolutionary mob in 1789. In its centre rises the July Column, erected in memory of the victims of the 1830 Revolution. It, again, is the hub of a system similar to that of the previous *place*. Farther west along the east-west axis is the Place de l'Hôtel de Ville and nearby the Place du Châtelet and gardens, at the point of its intersection with the north-south axis of the Boulevards de Sébastopol, du Palais, and Saint-Michel. At the end of the long Rue de Rivoli lies the Place de la Concorde, one of the largest and most impressive squares in the world, bounded on the north by buildings, the east by the Tuileries Gardens, the south by the Seine, and the west by the Champs-Élysées. In its centre is an obelisk, and around it are monuments representing the chief cities of France. There was set up the guillotine for Louis XVI, Marie Antoinette, Danton, Robespierre, and others. From the square, roads strike north to the grand boulevards and south to the river. Westward, the city's artery continues along the Champs-Élysées to the Place de l'Étoile. This place contains the Arc de Triomphe (begun in 1806) under which lies the body of France's Unknown Soldier; and from it radiate the spokes of numerous broad and beautiful avenues in all directions, making it the western counterpart of the Place de la Nation.

Other squares, most of them important focal points, lie in the north centre. The Place de la Madeleine contains the large classical Corinthian-pillared church of the same name. A little to the east lies the more secluded Place Vendôme, with its column in memory of the Grande Armée, on which are bas-reliefs constructed from Austrian and Russian cannon captured at Austerlitz depicting the campaigns of 1805–07; it offers an example of excellent 17th-century town planning and is now one of the centres of the luxury trade. The Place de l'Opéra, a little farther north, is the chief nodal point of the system of grand boulevards, from which stem the broad tree-lined, busy avenues leading to the more immediate city centres, many of which constitute the hubs of new networks. In the exterior suburbs the same use of squares is made; they serve as foci to connect the inner ring of boulevards with roads to the centre and with roads leading out of Paris.

The squares of the Left Bank arc are less impressive and notable. In the east, balancing the Places de la Nation and de la Bastille is the busy Place d'Italie, from which radiate arteries in all directions. The Place Denfert-Rochereau lies near the southern end of the north-south axis of which the Boulevard Saint-Michel is part. Farther west again, the planning of streets is dictated more by the extensive rectilinear gardens and enclosures of the Esplanade des Invalides and the Champ de Mars.

6. Public Buildings.—The chambers of both houses of the French Parliament are situated some distance apart on the Left Bank of the river. The National Assembly or lower house is in the Palais Bourbon overlooking the river on the Quai d'Orsay and opposite the Place de la Concorde. It is a mansion in classical style, with Corinthian columns, begun in 1722 by the dowager duchess of Bourbon and later extended by her grandson the prince of Condé. It became the property of the nation in 1790, and was readapted to serve as a seat of legislature. The Senate sits in the Palais du Luxembourg in the Jardin du Luxembourg on the west side of the Boulevard Saint-Michel. This palace was built between 1615 and 1627 by Marie de Médicis. Turned into a prison at the outbreak of the Revolution, it became the seat of the Directory and later, under the 19th-century monarchs, of the upper house of Parliament; its galleries contain the works of modern artists and of distinguished sculptors. The official residence of the president of the republic, the Palais de l'Élysée, in the Faubourg Saint-Honoré, was built in 1718 and later acquired by Mme de Pompadour; many other famous people lived there.

The headquarters of the municipal authorities is in the Hôtel de Ville on the Right Bank opposite the Île de la Cité. The original building, begun in 1533, was largely destroyed by the Communards in 1871; the present one was built in 1874–82 in French Renaissance style with elaborate sculptures. Occupying most of the western end of the Île de la Cité itself stands the Palais de Justice (law courts). The site was occupied in Gallo-Roman times by a citadel and later by the palace of the Merovingian and Capetian kings. It was handed over to the *parlement* of Paris by Charles VII but was destroyed by successive fires so that little is left of the medieval buildings except the Sainte-Chapelle, the Conciergerie (the old prison in which Marie Antoinette was imprisoned), and some 13th-century halls and kitchens. The western end of the present buildings has a fine façade in the Greek style, on the Place Dauphine. The northern side, overlooking the wider branch of the Seine, has four towers which partly date from the Capetian era; the Tour de l'Horloge at the eastern angle is reputed to contain the oldest public clock (1370) in France.

Preeminent among the public buildings, since it is the oldest except for Notre-Dame and the most impressive monument of the city, is the Palais du Louvre, which extends for about half a mile between the Seine and the Rue de Rivoli. On its site was originally a keep erected by Philip Augustus, which Charles V enlarged and made into a fortress, and which Francis I transformed into a palace. Under Francis and his successors portions of the wings to the south and west courtyard were built; these rank among the finest examples of Renaissance architecture. The remaining buildings of the courtyard date from Louis XIII and XIV. The two wings projecting westward, each consisting of two parallel galleries with pavilions at intervals, were completed under Napoleon III (though the Grande Galerie and, at right angles to it, the pavilion of Henry IV, had been erected on the river front by Catherine de Médicis and Henry IV). The adjacent Palace of the Tuileries was begun by Catherine de Médicis, and Henry IV constructed a wing (rebuilt by Napoleon III), uniting it with the Grande Galerie of the Louvre (a corresponding wing on the north side dates from various periods of the 19th century). The Palace of the Tuileries was burned down by the Communards in 1871, except for the terminal Pavillon de Flore. The corresponding Pavillon de Marsan was later rebuilt. The site of the destroyed palace, for three centuries the residence of French monarchs, is now occupied by the Jardin des Tuileries. Just north of the Louvre is the smaller but magnificent Palais-Royal, built in 1629–34 by Lemercier for Richelieu and bequeathed by him to Louis XIII; the Comédie Française is now housed in the Théâtre Français at its southwestern angle. Official bodies such as the Conseil d'État and the Conseil Constitutionnel occupy the main building.

The Hôtel des Invalides, on the Left Bank a little way to the west, was founded by Louis XIV in 1670 as a retreat for infirm soldiers. It contains museums of military history. Within its courts are the parish church of Saint-Louis-des-Invalides, with various marshals of France buried in its vaults, and the *dôme,* in the central crypt of which is the tomb of Napoleon I.

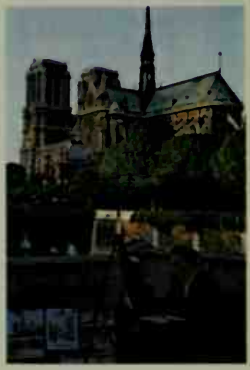
The Panthéon is now a civil building. It is situated off the Boulevard Saint-Michel, and was intended to replace the abbey sanctuary of Sainte-Geneviève. Begun in 1764, it was secularized during the Revolution and dedicated to the memory of great Frenchmen. During the 19th century it was several times reconsecrated and resecularized. The Panthéon is an imposing domed building in the form of a Greek cross, its facade adorned with Corinthian pillars. Inside are pictures and mosaics representing scenes of French history.

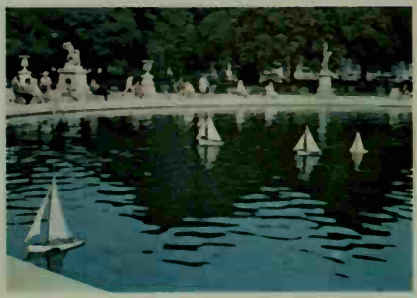
The Palais de Chaillot was built in 1937 on the site of the old Trocadéro, on the Right Bank opposite the Eiffel Tower, and now contains several museums and a vast underground theatre.

Since the end of World War II several monumental buildings have been put up which have given Paris some works characteristic of the architecture of the mid-20th century. Behind the École Militaire now rises the UNESCO building with its huge blocks in the shape of a Y; it was planned by an international group of archi-

The Champs-Elysées at night, ascending to the Arc de Triomphe

A pictorial sampling of the city's appearance: (left) bookstalls on the left bank of the Seine River opposite the Île de la Cité; (right) the cathedral Church of Notre-Dame situated on the Île de la Cité; (bottom left) Place de l'Opéra, one of the busiest centres of traffic in Paris, with part of the Théâtre de l'Opéra built from designs of Charles Garnier; (bottom centre) sidewalk cafes and shops along the tree-lined Avenue des Champs-Élysées; (bottom right) toy sailing boats in a pool in the Jardin des Tuileries

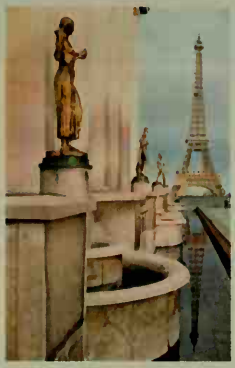




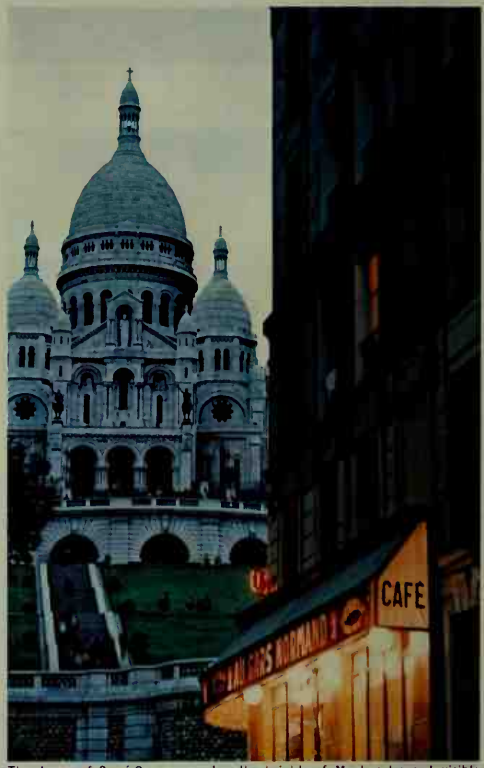
PHOTOGRAPHS (CENTRE LEFT) J. R. JOHNSON—RAPHO GUILLUMETTE (BOTTOM LEFT) PAUL HUENER—SHOSTAL—OTHERS JERRY COHEN

PARIS

The Pont Alexandre III across the Seine River. The pillars at opposite ends are surmounted by gilded figures of "Fame" and "Pegasus"



(Left) The Place Vendôme with the Vendôme Column, built in the style of Trajan's Column at Rome. (Right) A view of the Eiffel Tower from the Palais de Chaillot in the Place du Trocadéro. (Below) The Louvre seen from the Jardin des Tuileries



The domes of Sacré-Coeur crowning the heights of Montmartre and visible from almost every part of the city

PHOTOGRAPHS, (TOP) MANLEY—SHOSTAL, (BOTTOM LEFT) NED HAINES—RAPHO GUILLUMETTE, (OTHERS) JERRY COOKE

tects and decorated by well-known artists. The Porte Dauphine, headquarters of NATO, with an A-shaped ground plan, is similarly the result of international collaboration by architects, engineers, and contractors from the 15 member countries of NATO. The most striking new building was built at the Rond-Point de la Défense: it is the building of the C.N.I.T. (Centre National des Industries et des Techniques), intended for the most important technical exhibitions. It is triangular in ground plan and covered by an immense vault resting on the three points of a triangle (which covering 21,000 sq.m. [25,000 sq.yd.] of ground surface represents the largest pitch in the world for a thin reinforced concrete dome), with three facades entirely made of glass.

7. Centres of Commerce.—The principal financial and commercial district is around La Bourse, a huge building modeled on the Temple of Vespasian a little way east of the Place de l'Opéra. Just east of the Palais-Royal is the Banque de France, founded in 1800.

The slaughterhouses, cattleyards, and most of the markets belong to the municipality. The chief abattoirs are in La Villette (near the Marché aux Bestiaux) and in Vaugirard. The principal market is the Halles Centrales (between the Palais-Royal and the Boulevard de Sébastopol), called by Zola the "bowels of Paris." They were first established there by Philip Augustus. The modern series of buildings (*pavillons*) was built between 1851 and 1868 and enlarged in 1936. The 12 *pavillons* cover more than eight acres. All types of food products are sold there: about 40,000 tons in 1856; more than 1,700,000 tons in 1962. The *pavillons* had long been inadequate; in 1962 it was decided to move the fruit and vegetable market to Rungis near Orly, and the meat market to La Villette in the northeast suburbs. At the western end of the Halles Centrales is the Bourse de Commerce, the centre for the sale of spirits, grain, oils, sugar, etc. The vast Halle aux Vins, for wines, is on the Left Bank opposite the eastern end of the Île Saint-Louis. Above its warehouses now rise the huge buildings erected for the faculty of sciences of the university (*see* below). There are other provision markets owned by the municipality in other quarters of the city, as well as numerous flower, bird, and live-animal markets, and the "Flea Market" held daily near the Porte de Clignancourt.

Special fairs or markets of ancient origin are still held every year: in the spring, in the Boulevard Richard Lenoir, the Ham Fair; in the Place de la Nation, during Easter week, the Honeybread Fair (*pain d'épices*). The picturesque Scrap-Iron Fair also takes place biannually on the Boulevard Richard Lenoir, first at the same time as the Ham Fair and second in the autumn. Others, like the Fair of the Throne and the Fair of Saint-Laurent, are composed of sideshows, such as are produced successively throughout the year either on the squares, on the boulevards, or at the gates of Paris. Important modern trade shows are: the Foire de Paris, founded in 1904 (which takes place in May at the Parc des Expositions at the Porte de Versailles) and the *salons* which were held in the Grand Palais but more recently in the CNIT: the Salon de l'Automobile (in October), the Salon des Arts Ménagers (February–March), and the Salon de l'Enfance.

8. Hospitals.—Paris has about 25 principal hospitals and the urban region of Paris about 120 general and 13 psychiatric hospitals and others for the congenitally disabled, for children, and for the aged. Most of these hospitals depend on the general administration of the *Assistance Publique* in Paris, which has 37,000 hospital beds and 10,500 beds in homes for old people.

The Hôtel-Dieu on the Île de la Cité is the Paris hospital with the longest tradition (the generic name *hôtel-Dieu* was applied from the earliest times to hospitals in cathedral cities): an *hôtel-Dieu* near Notre-Dame is mentioned in 829, but since then there have been several demolitions and reconstructions; the present building dates from 1868. The Hospice des Quinze-Vingts, for the blind, founded by Louis IX in 1260, was moved in 1780 from the Faubourg Saint-Honoré to the Faubourg Saint-Antoine; its ophthalmological clinic dates from 1880. Farther to the east, in the same *faubourg*, the Hôpital Saint-Antoine occupies the former Abbey of Saint-Antoine-des-Champs, whose buildings were rebuilt about 1770. Near the Gare du Nord is the Hôpital Lariboisière, built on the former Enclos-Saint-Lazare between 1846 and 1853 and still in the 1960s (with about 1,260 beds) one of the largest in Paris. In the former northeastern suburbs the Hôpital Tenon has since 1878 risen on the heights of Ménilmontant. In the former northern suburbs the Hôpital Bichat was installed in 1882 and rebuilt after 1928. The Hôpital Saint-Louis, in the Faubourg Saint-Martin, founded by Henry IV for victims of the plague, now specializes in diseases of the skin and in syphilis and has a dermatological, syphilographic, and surgical museum. The Hôpital Beaujon at the end of the Boulevard Haussmann in the Faubourg Saint-Honoré was opened for foundlings in 1784 and converted into a general hospital in 1795; the old buildings are no longer in use, having been replaced by magnificent new ones (1935) just outside Paris, in Clichy. The Hôpital Bretonneau (1901) for children, in Montmartre, is also notable for its pleasing architecture. The major isolation hospital is the Hôpital Claude-Bernard (1905), the buildings of which extend from the old Porte d'Aubervilliers to the Canal Saint-Denis in Villette (Buttes-Chaumont).

A large number of the major hospitals are on the Left Bank. La Salpêtrière, a large establishment beyond the Jardin des Plantes and the Gare d'Austerlitz, was founded as a hospice for beggars in 1656 and then assigned to sick or fallen women, and is now a hospital specializing in mental diseases; it is associated with J. M. Charcot. Adjacent to it is La Pitié, founded for [illegible]

general purposes in 1809, and rebuilt on its present site in 1912. Farther to the west, around the southern end of the Boulevard Saint-Michel, are clustered the Hôpital Militaire du Val-de-Grâce, originally a nunnery (1621) with a splendid church (1645–1710) but converted into a military hospital in 1790; the Hôpital Cochin, originally a hospice for the poor of the parish of Saint-Jacques-du-Haut-Pas (1780); the Baudelocque maternity hospital; and the Hospice des Enfants Assistés (1814), which has an *annexe* at Antony (Seine). To the southwest, in the Plaisance district, are the contiguous Hôpital Saint-Joseph (Sisters of Saint-Vincent-de-Paul, 1884) and Hôpital Broussais (opened in 1883, rebuilt 1928–38). In Montparnasse is the Institut Pasteur, with the Hôpital Pasteur and the Hôpital Saint-Jacques adjacent. The Hôpital Necker (1776; general and urinary), contiguous with the Hôpital des Enfants Malades (1802), stands a little way to the north. Farther north is the Hôpital Laënnec, so named in 1878 but founded as the Hospice des Incurables in 1634 (it is now a general hospital specializing in tuberculosis).

9. Religious Architecture.—The cathedral Church of Notre-Dame is the most famous and impressive of the city's religious establishments. Situated on the Île de la Cité, the present building, which occupies the site of earlier foundations (the first dating from the 4th century), was begun in 1163. During succeeding centuries there have been extensive renovations and alterations. Now measuring 127 m. (139 yd.) in length and 48 m. (52 yd.) in breadth, the building consists of a choir and apse, a short transept, and a nave flanked by double aisles and square chapels. Its central spire was added during 19th-century restoration. The two massive square towers crown the western facade, which is divided into three stories and has its doors adorned with fine early Gothic carvings and surmounted by a row of figures of Old Testament kings. Above the central door is a rose window.

The Sainte-Chapelle is a smaller exquisite piece of ecclesiastical architecture situated near to Notre-Dame and now within the precincts of the Palais de Justice. It was built by Louis IX to shelter holy relics brought from the crusade in 1239 and is one of the finest existing specimens of Gothic art, richly decorated, with beautiful stained-glass windows. Other famous churches include Saint-Germain-des-Prés (11th century), the oldest church in Paris; Saint-Pierre-de-Montmartre (12th century); Saint-Germain-l'Auxerrois (13th century); Saint-Étienne-du-Mont (16th century), containing Saint Genevieve's sarcophagus; Saint-Sulpice (17th century), with a classical facade and frescoes by Eugène Delacroix; the Madeleine, built on the lines of a Roman temple by Napoleon I in honour of the French armies; and the Sacré-Coeur (19th century), a spacious basilica in Romanesque-Byzantine style on the heights of Montmartre, where, according to legend, Saint Denis was martyred.

10. Centres of Learning and Libraries.—The University of Paris (*q.v.*) is by far the largest of France's universities, catering for one-third of the total student population of France. Residential accommodation for 5,500 of these students is provided in the Cité Universitaire erected in the southernmost part of Paris, opposite Gentilly, on a site once occupied by the fortifications; and for 3,000 in the southern suburbs in the Jean-Zay university residence, built during 1954–56 near the Parc de Sceaux at Antony. The university comprises the faculties of law (law and economic science), medicine, letters (literature and humanities), science, and pharmacy. The faculty of law (14,165 students in 1959) is established in a separate building near the Sorbonne. The Sorbonne itself, off the Boulevard Saint-Michel, houses the faculty of letters (26,029 students in 1963) and is also the administrative quarters of the educational district (*académie*) of which Paris is the centre. The faculty of science (19,578 students in 1963) was transferred in 1961 from the Sorbonne to the Quai Saint-Bernard, where buildings had been constructed over the Halle aux Vins. These are supplemented by the Centre d'Orsay, outside Paris in the Chevreuse Valley, which was opened in 1958. The faculty of medicine (9,682 students in 1963) and that of pharmacy (2,778) occupy buildings in the Quartier Latin or adjacent areas of Saint-Germain-des-Prés. In addition there is the School of Medicine and Pharmacy at Reims (379 students in 1962). To the Collège de France, founded by Francis I in 1530 and situated opposite the Sorbonne, are elected distinguished scholars who give public lectures; it has physics and chemistry laboratories attached. Other institutes of higher education are: the École Normale Supérieure, the École des Chartes (sciences related to history), the École Pratique des Hautes Études, and the École des Langues Orientales Vivantes. Specialized institutes for

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training in industry and government service are numerous, and a large proportion comes under the various ministries; *e.g.*, the École Polytechnique, the École Nationale d'Administration (1945), the Institut Agronomique, and the École Nationale des Mines. These are supplemented by other state institutions for music and acting (Conservatoire National Supérieur de Musique et de Déclamation), painting, sculpture, architecture (École Nationale Supérieure des Beaux-Arts, École Spéciale d'Architecture), etc.

The Institut de France was founded in 1795 for the encouragement of research, arts, and sciences. It comprises the Académie Française, the Académie des Sciences Morales et Politiques, the Académie des Inscriptions et Belles-Lettres. Other independent academies include the Académie Nationale de Médicine, the Académie de Chirurgie, the Académie de Pharmacie de Paris, the Académie Goncourt (literary), the Académie d'Agriculture, and the Académie Diplomatique Internationale.

The Académie Française was founded by Louis XIII in 1635 to act as the arbiter of the French language and literature, for which purpose it began the compilation of its celebrated dictionary. Suppressed under the Revolution, it was refounded as a section of the Institut in 1803. On the Restoration its former title was restored to it. It has 40 elective members and, in addition to its linguistic duties, awards a number of literary prizes.

For secondary education there were in 1963–64, in the Seine *département*, 80 *lycées* (44 in Paris), 32 *lycées techniques*, and 688 *collèges*, all controlled by the state; and also *libre* (private) establishments, *i.e.*, not state controlled, which are for the most part directed by the Roman Catholic Church. Some of the old-established colleges that survived the Revolution have been reconstructed as *lycées; e.g.*, the Collège d'Harcourt (1280), now the Lycée Saint-Louis, and the Collège de Clermont (1550), now the Lycée Louis-le-Grand. Lower education is provided by the usual school system, both state and private, down to the kindergarten *écoles maternelles*. In the mid-20th century the private schools experienced increasing financial difficulties; by a law of 1959 they obtained, under certain conditions, state subsidies.

The Bibliothèque Nationale or national library is housed in the former palace of Mazarin in the Rue de Richelieu near the Palais-Royal; the national archives are in the former Hôtel Soubise. Other libraries include the Bibliothèque Mazarine, the Bibliothèque Thiers, and the Bibliothèque Forney (*see* also LIBRARY).

11. Theatres.—The Opéra (National Academy of Music), the central landmark of the Right Bank at the Place de l'Opéra, was founded in 1669–71. It is run by the state and presents opera and ballet. Lighter musical productions are presented at the Opéra Comique (founded in the early 18th century and also run by the state), a little to the east, off the Boulevard des Italiens. The Théâtre Français or Comédie Française was formed in 1680 by the union of Molière's company with two others. Now housed in part of the Palais-Royal and run by the state, it has a repertory consisting chiefly of the French classical drama. The Théâtre Français also has a company which plays at the Théâtre de France, formerly the Odéon, just north of the Luxembourg Gardens. The Theâtre National Populaire, housed in the Palais de Chaillot, presents classic international works. Numerous smaller theatres specializing in modern productions are found near the grand boulevards. There are popular music halls in the amusement quarter of Montmartre (Place Pigalle). Expensive night clubs are off the Champs-Élysées and those of a more popular type in Montmartre and Montparnasse. Since 1957, for a spring season the Théâtre des Nations, in which the best foreign companies take part, is held at the Théâtre Sarah-Bernhardt, in the Place du Châtelet.

12. Hôtels (Mansions).—Numerous examples of beautiful old *hôtels* (the mansions of noble families) are to be found throughout the older quarters of Paris. Many of them are used as museums, embassies, and for other official purposes. Others have been put to more commercial uses. The Île Saint-Louis still preserves within its quiet sanctuary several 17th-century *hôtels* untouched by progress, including the Hôtel Lambert, which has associations with Voltaire and George Sand (it now houses works of art), and the Hôtel Lauzun. The Marais district to the north of the Rue Saint-Antoine, with the Right Bank north of the Île Saint-Louis, has become a commercial area, but there are still many beautiful structures; for instance, the Rue Saint-Antoine itself, full of formerly splendid private houses with beautiful courtyards (such as the Hôtel Sully); and the Place des Vosges with its 17th-century red-brick houses (it was formerly a courtyard of the Hôtel Royal des Tournelles, in which Henry II was killed while tilting; later it became the duelling ground of the city). There, too, the new Cité Internationale des Arts (CNIT) will serve as an exhibition gallery. Also in this quarter are the Hôtel Carnavalet, once the home of Mme de Sévigné, now a museum, and the Hôtel de Lamoignon, formerly the Hôtel d'Angoulême, which was restored between 1948 and 1960 to house the Bibliothèque Historique of Paris. Two mansions on the Left Bank now turned into museums are the Hôtel Biron (Musée Rodin) and the Musée de Cluny.

13. Museums.—Paris has an exceptionally large number of museums; many are outstanding for their rich and specialized collections. The famous Louvre collections include Greek, Roman, Egyptian, and Near Eastern antiquities in sculpture; paintings of the Flemish, Italian, Spanish, Dutch, and French schools, and also sculptures of the same period extending to the beginning of the 19th century. Later paintings are housed in the Musée National d'Art Moderne. Adjoining the Louvre is the Musée des Arts Décoratifs, and near it are the Musée du Jeu de Paume, specializing in the Impressionists, and the Orangerie, devoted to works of Claude Monet and used for exhibitions. A special collection of pottery is exhibited at the Musée des Arts Céramiques de Sèvres. The Palais de Chaillot houses the Musée de la Marine; the Musée des Arts Populaires; the Musée des Monuments Français (specializing largely in plaster casts of medieval sculpture), and the Musée de l'Homme with its splendid ethnographic and prehistoric collections. The principal pre- and protohistoric material is at the Musée des Antiquités Nationales at Saint-Germain-en-Laye, west of Paris. The Musée de l'Armée is in the Hôtel des Invalides. The Musée Guimet is devoted solely to Far Eastern antiquities; the Musée Carnavalet deals with the history and development of Paris; the important Musée de Cluny has collections of medieval and Renaissance *objets d'art*, etc.; and the Petit Palais houses the Musée des Beaux-Arts de la Ville de Paris.

IV. ADMINISTRATION AND ECONOMY

1. Population and Town Planning.—From the beginning of the 14th century Paris was undoubtedly the largest town in France, but the size of its population at that time is not known: the figure of 275,000 inhabitants, once thought a plausible estimate, is perhaps too high. Under Louis XIV, in the 17th century, Paris must have had about 500,000 inhabitants; in 1789, about 600,000. In 1801 the first census gives the figure of 548,000. Population increase was rapid during the 19th century, particularly in the decade after the Franco-German War, but leveled off during the 20th century. Indeed the population was tending to decline (as throughout the whole of France) in the years between World Wars I and II. Figures (to the nearest thousand) for representative years since the beginning of the 19th century are: 548,000 in 1801; 786,000 in 1831; 1,053,000 in 1851; 1,851,000 in 1872; 2,447,000 in 1891; 2,888,000 in 1911; 2,906,000 in 1921; 2,830,000 in 1936; 2,691,000 in 1946; 2,821,000 in 1954. The 1962 census indicated a population of 2,779,935.

The large growth of population during the 19th century was due chiefly to migration from the provinces and to the incorporation of outer suburbs in the city proper. This accounted, for example, for 96.5% of the city's increase between 1846 and 1856, and for 92% between 1867 and 1881. The movement from the provinces became still more marked in the 20th century.

Because of the relatively restricted area of the city itself, the density of its population, particularly since the end of the 19th century, has been very high. However, with the movement of certain industries into the industrial belt beyond the city boundaries there came a lowering of this density. Since 1920 much effort has been put into slum clearance, the building of housing estates along the outer boulevards, and (more recently) the creation of *grands ensembles* (housing estates for 30,000–35,000) on the outer fringes.

2. Administration.—The rapid growth of the Paris agglomeration in the 20th century, during which it spread itself over three *départements*, made necessary a thorough administrative reorganization, and in 1964 the government presented a bill whose provisions were to be gradually implemented. Under this the former Seine *département* is divided into four smaller ones: the Ville de Paris, corresponding to the former Ville; Seine-Saint-Denis (proposed administrative centre La Courneuve), Val-de-Marne (Creteil), les Hauts-de-Seine (Nanterre). The former Seine-et-Oise *département* is divided into three: Essonne (Corbeil), Yvelines (Versailles), Val d'Oise (Pontoise). The Seine-et-Marne *département* remains unchanged, though it becomes united in the Paris Region (*see* below).

The unity of urban Paris will be preserved in the Ville de Paris, retaining the 20 *arrondissements* defined in 1860, grouped into nine sectors. Each *arrondissement* has its own mayor and aldermen, who will continue to be appointed by the minister of the interior, and who deal with births, deaths, marriages, etc. The present *conseil général* and the municipal council is to be replaced by one single body, the *Conseil de Paris*, its members being elected by a majority ballot and not, as formerly, on proportional representation. This assembly will retain on the whole the powers of the previous municipal council; *i.e.*, to vote the city budget and advise the *Préfet de Paris* (formerly *Préfet de la Seine*). The

powers of the *Préfet* also remain unchanged in nature or extent; in him are vested the public control of finance, education, highways, etc. He is appointed by the minister of the interior and is responsible to him. Supervision by the government will continue to be exercised over all local government, in keeping with centuries-old traditions.

Police duties, however, are entrusted to the *Préfet de police,* whose new jurisdiction encompasses not only the Ville de Paris, but also the three suburban *départements* and will extend into the former Seine-et-Oise and the Seine-et-Marne *départements* (the latter also being part of the new *Région Parisienne*).

To meet the long-felt need for a body to coordinate the economic and administrative activities of the local authorities, a first step was taken in 1961 by the creation of the *District de Paris,* grouping together the 1,305 communes of the former Seine, Seine-et-Oise, and Seine-et-Marne *départements,* and further measures were taken in 1964 to establish the Paris Region (*Région Parisienne*), a community of more than 8,000,000 inhabitants.

Justice.—Courts of more or less local competence, sitting in each *arrondissement,* are the Tribunaux d'Instance de Paris, for the city's *arrondissements,* which deal with the minor infractions in their areas. The Tribunal de Grande Instance de la Seine has jurisdiction throughout the whole *département* and is divided into 27 chambers (15 civil, 10 correctional, the children's court, and the pensions court). The Cour d'Appel de Paris hears appeals from the two courts just mentioned, in both civil and criminal cases; its jurisdiction extends over not only the whole former *département* of the Seine but also to 6 other adjoining *départements;* it comprises 22 chambers, not including the court of assizes, formed of magistrates taken in turn from each of the chambers, to which is joined a popular jury, to judge criminal cases; it has its seat at the Palais de Justice. The Tribunal Administratif de Paris, which comprises six sections, sits provisionally opposite the Palais de Justice. The Tribunal de Police sits at the Palais de Justice.

Besides these local courts, Paris is the seat of central judicatures for the whole of France. These are: for civil jurisdiction, the Cour de Cassation, sitting in the Palais de Justice; for administrative jurisdiction, the Conseil d'Etat, sitting in the Palais-Royal; and the Cours des Comptes, with jurisdiction over the expenditure of the public *départements* and the larger communes, which is situated between the Place Vendôme and the Place de la Concorde.

Other tribunals for arbitration of commercial, industrial, and professional disputes are: the Tribunal de Commerce de la Seine, composed of prominent businessmen; and the Conseils des Prud'-hommes de la Seine, joint bodies of employers and workers.

Police.—Before 1800, the police in Paris essentially were used to control the political activities of the citizens, though *officiers de paix* were created in 1791. In 1800, the prefecture of police was created, but public order was entrusted for some time to the *gendarmerie,* a military body, under the orders of the *préfet de police.* A hundred uniformed *sergents de ville* were appointed in 1829. They became the 1,500 municipal guards in 1830 and were renamed in 1848 for a short time *gardiens de Paris* (nicknamed *montagnards*). In 1870, the force was known as *gardiens de la paix.* At the end of the century the police numbered 7,500 and the bases of the present organization were being established.

The jurisdiction of the *préfet de police* hitherto extended over the whole Seine *département.* The police *commissaires* (who sit in 92 *commissariats* for the quarters of Paris and the *cantons* of the suburbs) fulfill the offices of municipal and of judiciary police. The municipal police employ a corps of *brigadiers* and *gardiens de la paix.* Its main function is to maintain public order (in this it is helped by the Garde Républicaine, a corps of *gendarmerie* specially allotted to Paris). It controls traffic (through the *gardiens de la paix* of the *compagnies des voitures*), carries road casualties in the *policesecours* vans, and arrests wrongdoers. Its *agents* patrol on foot and use bicycles, motorcycles, and vans. The judicial police, whose headquarters are on the Quai des Orfèvres, intervene when criminal investigation is required. More serious crimes and those difficult to solve are usually handled by the specialist services at headquarters; minor ones may be tackled by the local *commissaires* who rank both as municipal and judicial police.

KLAUS ESCHEN

THE HÔTEL DE VILLE, THE TOWN HALL OF PARIS, SITUATED ON THE RIGHT BANK OPPOSITE THE ÎLE DE LA CITÉ

3. Communications.—Paris developed as the country's outstanding centre of inland communications, both because of its geographical position and because of the policy of extreme centralization adopted by the state. Certain physical features assisted in this development. The flat plateaus of Brie to the east and Beauce to the south were easily covered by roads and later by railways. The hills farther to the east are traversed by the Rivers Seine, Marne, Aisne, and Oise. To the west the plain of the Seine is broad, and the land rises gradually to the hills of Perche and eastern Normandy.

Roads.—Since the 17th century the nation's roads have been designed chiefly to converge on the capital from all directions. Measures to ease traffic congestion include the construction of roads along many stretches of the quays at river level, and of a peripheral motorway (36 km., or 22 mi., long) with underground tunnels, which, in the course of the 1960s, would encircle Paris and give access to the south- and westbound motorways.

(For internal thoroughfares *see* above, *General.*)

Railways and Buses.—As with the roads, Paris is the outstanding hub of the national and continental system; a detour via Paris is often much better than relying upon cross-country services. Main line stations in the capital are: the Gare du Nord, the Gare de l'Est, the Gare de Lyon (serving the south and southeast), the Gare d'Austerlitz (serving the southwest and Spain), the Gare Montparnasse (serving the west and southwest), and the Gare Saint-Lazare (serving Normandy). Each of these stations, but especially Saint-Lazare, are commuter terminals.

Communications in Paris and its inner suburbs are organized by the R.A.T.P. (Régie Autonome des Transports Parisiens) through the double network of the Métro (underground railway) and the buses. The Métro runs mainly underground, although parts of certain lines run above ground on viaducts. It came into use from 1900, at first with a single line from the Porte de Vincennes in the east to the Porte Maillot in the west. It has (1964) 14 lines with a total length of 169 km. (105 mi.). The bus network covers 1,465 km. (870 mi.) over 52 urban and 95 suburban lines. In addition there is a suburban railway network.

Airports.—Paris airport is, after London, the second largest in Europe. Since 1945 it has been a public concern charged with organizing all the civil air transport in the Paris region: the international airports of Orly (15 km. [9 mi.] S) and of Le Bourget (9.6 km. [6 mi.] N), the heliport of Paris-Issy, and about ten minor aerodromes. The equipment and buildings at Orly, installed during 1957–62, can handle 12,000 passengers daily.

Waterways and the Port of Paris.—Paris is served by an excellent system of waterways. The lower Seine connects it with the channel coast. Its area is linked to northeastern France and Belgium through the Oise and to eastern France and Germany through the Marne. The upper Seine is connected by canal with the Rhône and so with the Mediterranean. Moreover, three canals supplement the rivers and provide places for ports within the immediate area in or about the city: the Saint-Denis Canal from a northern point on the Seine to Villette and the Saint-Martin Canal from Villette to a southern point obviate the journey along the large western loop of the Seine; and the Canal de l'Ourcq runs from Villette eastward to Meaux (thus short-circuiting the southward loops of the Marne) and then proceeds in a northward direction to link up with the Ourcq River itself.

The economic life of Paris and its suburbs, since the beginning of the 19th century, has been closely associated with the Seine because the river has always been the cheapest and safest means of transporting goods. Because of the network of waterways converging from all parts of the country, Paris has been and still is the largest inland port in France, handling about a quarter of France's inland water traffic. Its port possesses about 160 km. (100 mi.) of quays along the Seine and the Marne, and the Canals of Saint-Martin, Saint-Denis, and the Ourcq. Besides the *quais* in the city and greater Paris, a port area was begun in 1926 to cover 400 ha. (988 ac.), with 13 km. (8 mi.) of additional quays at Gennevilliers. Barges up to 1,500 tons could thus reach the edge of the great western industrial region without having to pass through the lock at Suresnes. By the early 1960s, five docks had been constructed for this port and traffic through Gennevilliers increased from 35,000 tons in 1948 to over 1,600,000 tons in 1962.

The idea of putting the river to a greater use by making the city a seaport was conceived in the 18th century and taken up again in the 20th century; subsequently work was begun on dredging a deep channel to Le Havre. A channel 4.2 m. (14 ft.) deep now exists, capable of taking large barges (many self-propelled) and tugs. Small oceangoing vessels of 300 to 500 tons from England, the Benelux countries, and Scandinavia dock only at the ports of Austerlitz and Gennevilliers.

4. Parks, Gardens, and Cemeteries.—In the centre of Paris are the public gardens of the Tuileries, designed for Louis XIV and later enlarged when the palace of that name was destroyed. Farther westward beyond the Place de la Concorde stretch the open spaces of the Champs-Élysées. In front of the Hôtel des Invalides and running down to the Seine is the Esplanade des Invalides. A little westward is the Parc du Champ de Mars (laid out *c.* 1770), with the Eiffel Tower standing at one end by the river and the École Militaire at the other. Across the river are the Jardins du Trocadéro in front of the Palais de Chaillot. On the west of the Boulevard Saint-Michel is the Jardin du Luxembourg. On the river bank, immediately southeast of the Halle aux Vins, lies the Jardin des Plantes (founded early in the 17th century), which contains a museum of natural history, zoological gardens, and an important collection of plants in nurseries, hothouses and greenhouses. On the way from the Étoile to Batignolles is the Parc Monceau. Between Villette and Belleville is the Parc des Buttes-Chaumont. Other larger open spaces are the Bois de Boulogne (890 ha.; 2,200 ac.), west of the old fortifications beyond Passy and Auteuil, once the hunting ground of the Valois kings, given to the municipality by Napoleon III in 1852; and the Bois de Vincennes (930 ha.; 2,300 ac.), beyond Bercy, the extreme southeastern quarter of the Right Bank, with its open-air zoo. Well-known cemeteries are the Cimetière Montparnasse (including the graves of Baudelaire, Maupassant, Saint-Saëns, and Sainte-Beuve), the Cimetière Montmartre (including the graves of Heine, Stendhal, Théophile Gautier, Dumas fils, and the brothers Goncourt), and the Cimitière du Père-Lachaise between Ménilmontant and the Place de la Nation (which contains the graves of Abelard and Heloïse, Molière, Balzac, Chopin, Rossini, and Wilde).

INGE MORATH—MAGNUM

VIEW OF THE EIFFEL TOWER (BACKGROUND) AND THE OBELISK OF LUXOR IN THE CENTRE OF THE PLACE DE LA CONCORDE, TAKEN FROM BEHIND ONE OF THE EIGHT STATUES ON THE SQUARE REPRESENTING MAJOR CITIES OF FRANCE

5. Sports.—The principal sports of Paris are horse racing, football, cycling, and swimming. Race meetings are held at Auteuil and Longchamp in the Bois de Boulogne, at the more distant courses of Saint-Cloud, Vincennes, and Enghien, and at those, still more distant, of Chantilly and Le Tremblay. Association and rugby football take place at the Stade de Colombes (across the Seine, to the northwest), at the Parc des Princes, and at other locations. The Parc des Princes is also the site of certain bicycle races. The Vélodrome d'Hiver, where races were once held, has been replaced by a provisional building at the Porte de Versailles, called the Palais des Sports. Motor racing takes place at Montlhéry, 25 km. (15.5 mi.) south of Paris; athletic sports at the Stade de Colombes, tennis at the Stade Roland-Garros.

6. The Press.—The Paris press in the years after World War II suffered in its circulation from the increasing competition of the provincial newspapers. This drop was accelerated by the tendency of the public to make the press one object of their minor economies. Several journals went out of circulation altogether. The chief Paris daily papers and their approximate circulation in 1963–64 were: *France-Soir* (1,250,000); *Le Parisien Libéré* (790,000); *L'Aurore* (450,000); *Le Figaro* (475,000); *Le Monde* (250,000); *Paris-Jour* (267,000); *Paris-Presse* (95,000); *La Croix* (110,000); and *Combat* (42,000). These reflected opinions from the right to the left centre, with *Le Figaro* and *Le Monde* representing non-party, moderate, and independent views. Communist papers were

L'Humanité (190,000) and *Libération* (95,000; ceased publication in 1964).

7. Water Supply.—The growth of the city has been accompanied by improvements in its water supply. The earliest water supply was initiated by the Romans, who built an aqueduct from Rungis into the city. Until the 19th century, domestic water was obtained chiefly from wells and from the Seine. A pump (called La Samaritaine) was built by Henry IV on the Pont-Neuf, and in the 17th century another was erected at Notre-Dame. Public fountains were supplied by the construction of other aqueducts. Early in the 19th century the newly constructed Canal de l'Ourcq served as an aqueduct, and others were constructed from neighbouring rivers. During the Second Empire the foundations of the present system were laid by the engineer Eugène Belgrand. Earlier sources were used for public and industrial purposes, and purer domestic water was obtained by tapping the sources of distant streams, whose supplies were led to reservoirs in the higher suburbs. To supplement them with water from the Marne and from the Seine modern pumping and filtering stations were constructed (Saint-Maur and Ivry-sur-Seine). The total length of the water supply system is 3,200 km. (1,988 mi.; crude water and drinking water).

8. Fuel, Power, and Urban Heating.—The first gasworks in Paris was built in 1819. Since 1949 distribution has been handled by the nationalized company Gaz de France (GDF). Paris and its suburbs are fed from three stations (La Plaine–Saint-Denis, Gennevilliers–Villeneuve-la-Garenne, and Alfortville) through a system originating in the coke works in Lorraine and, since 1956, by natural gas from Lacq (Basses-Pyrénées) which is stored underground at Beynes, near Versailles. The distribution network inside Paris covers more than 12,000 km. (7,455 mi.), 72% of it going for domestic purposes and 28% to industry and trade.

Electricité de France (EDF) is a nationalized service. Eleven large power stations on the outskirts of Paris provide four-fifths of the consumption, the remainder being supplied by hydroelectric power from the Alps. Current is distributed by underground cables. Public and street lighting is provided almost entirely by electricity. The total light flux has more than tripled in 30 years. The chief monuments and fountains are floodlit.

Urban heating, installed after 1930, covers 13 *arrondissements* in a network of 65 km. (40 mi.). Steam is produced by three special heating plants (two in Paris and the third at Saint-Ouen), by the rubbish incinerators at Saint-Ouen and at Ivry, and by the electric power station at Ivry.

9. Sanitation.—The city was slow in developing any adequate system of sanitation. Streets were not paved until the time of Philip Augustus, who also ordered the inhabitants to transport their refuse outside the city walls. Streams rising in the surrounding heights were used as primitive sewers, and their pollution gave rise to repeated infection. Under Henry IV the first covered sewer was constructed (1605), but later progress was slow: even in 1663 the city had less than 3 km. (1.6 mi.) of underground drainage and 8 km. (5 mi.) of open canals. In 1737 Turgot undertook the work of improving the city's sanitation. By 1800, however, underground sewers were only 26 km. (16 mi.) in length, and much water still drained into swamps and ponds within the city area. An outbreak of cholera inspired a further development of various kinds of drainage, particularly in the 1860s and 1870s under the planning of Belgrand, who undertook extensive improvements covering the whole area. By 1878 a network of 620 km. (385 mi.) of sewers had been constructed, other accessories created, and the Seine freed from pollution.

Since the beginning of the 20th century the sewage system has increased to 2,000 km. (about 1,250 mi.), a large part of the waste water from Paris being diverted to sewage farms in the north-western suburbs (Achères). After World War I, a system of purification of waste water was developed to help prevent the increase in sewage farms. The program was initiated about 1933, its principal achievements being the overflow from Sèvres to Achères, extending into Paris as far as the Pont de l'Alma (19 km. [12 mi.], the longest in Europe) and the first section of the Achères plant. In Paris the sewers serve also as conduits for gas and water pipes, telephone and telegraph wires, etc.

Street cleaning in Paris is undertaken by special motor vehicles and sweepers. Half the household waste is taken away daily by dust carts, or unloaded on tips in certain outlying districts; the rest is burned in factories at Ivry, Saint-Ouen, and Romainville, which provide the steam used for urban heating (*see* above) and electricity.

10. Industry.—Paris is not only by far the most important administrative and cultural city of France but also its leading industrial and commercial city. Though it is not situated near to any sources of mineral wealth, it possesses considerable sources of

PAUL ALMASY

THE CHAMPS-ÉLYSÉES, LOOKING WEST TOWARD THE ARC DE TRIOMPHE FROM THE PLACE DE LA CONCORDE

labour, which was initially turned to a variety of luxury and secondary industries. With the development of railways and canals early in the 19th century the resources of the northern coalfields were more accessible, and the city began to develop heavier industries; *e.g.*, engineering and chemicals. The outer quarters, which had grown rapidly during the middle decades of the century under the impetus of this industrialization and had been incorporated within the municipality itself, proved insufficient to contain the new industries. Thus, Paris rapidly overflowed beyond encircling heights which were its natural boundaries to become greater Paris. During the 20th century there was an increasing tendency for new industries to be concentrated in the outer districts and in the satellite towns, to which, moreover, the heavier industries were inclined to migrate.

Manufacturing industries predominate in the Paris region. Among the most highly developed are: the automobile industry, which accounts for 64% of French production in this field; electrical industries, which employ more than half the total effective labour force in the country; chemical and pharmaceutical industries; and food industries. The greater Paris area also produces three-quarters of the French motion pictures. Finally, the subsoil of the Paris region provides an abundance of certain building materials: 15% of the cement, 25% of the sand, and 70% of the gypsum produced in France.

The chief industry of the city itself is that which caters to the tourist trade—hotels, restaurants, and entertainment. Foreign tourists numbered 1,700,000 in 1959. A second type of industry is the manufacture of luxury articles demanding highly skilled workmanship and capable of being produced in small establishments or even within the home. These luxury articles include precious metalware, leather articles, gloves, china, and *haute couture*. Such occupations are usually concentrated within the central *arrondissements* as for example in the Faubourg Saint-Honoré and around the Place Vendôme. In addition, the outlying *arrondissements* often specialize in particular trades such as furniture making around the Place de la Bastille, heavier metalwork in the Marais and Temple quarters, tanning in the southeast, shoemaking at Belleville, and a variety of lighter industries, such as the making of precision tools, optical instruments, radio apparatus, and office equipment, in other *arrondissements*. Printing and publishing are found in the Quartier Latin and the Rue Réaumur. A fair proportion of the Paris population is also concerned with the manufacture and sale of food, liquor, and other commodities brought from the country or abroad.

In the 20th century the development of Paris took place mainly along the lines of communication. Industries are especially concentrated in the northern suburbs, Gennevilliers, Saint-Ouen, Saint-Denis, La Courneuve, Pantin (northeast), and Aubervilliers, and grew up because of the Saint-Denis Canal. Saint-Denis (*q.v.*) has heavy industries producing locomotives and rolling stock and marine and factory equipment. It also makes light metal and electrical equipment and chemical by-products. Saint-Ouen has more diversified and lighter trades. Aubervilliers (*q.v.*) and Pantin concentrate on the production of both heavy and light chemicals. At Pantin are large flour mills. Aircraft are built at La Courneuve. Minor industries in the area include the manufacture of glass and pottery. In the west and northwest industrial development has been chiefly along the Valley of the Seine. The west is the centre of the motor and aircraft industries, including the Citroën works at Grenelle within Paris itself and the Renault works at Boulogne-Billancourt. Farther northwest, along the Seine loop from Suresnes (opposite the Bois de Boulogne) to Gennevilliers, are armament factories, heavy engineering works, and chemical plants. Among these industrial areas, however, are growing residential suburbs such as Neuilly-sur-Seine, Nanterre, and Colombes. The southeastern suburbs duplicate on a somewhat smaller scale those of the Seine Valley in the west. To the south and southwest along the valley of the Bièvre River are tanneries, cement works, breweries, and tobacco factories, but these suburbs are mainly residential. The main film studios are at Boulogne, Joinville-le-Pont, and Épinay-sur-Seine. The eastern suburbs are relatively untouched by industrialization and remain largely a residential area. After 1955 authority for further industrial construction, and after 1960 for office building, had to be obtained at ministry level, in order to encourage decentralization and to curb the growth of greater Paris.

See also references under "Paris" in the Index.

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(J. D. L.; H. DE S.-R.; X.)

PARIS, the commercial and industrial centre for much of northeast Texas, U.S., and seat of Lamar county, located 100 mi. NE of Dallas. It was settled in 1841, incorporated as a town in 1874, and chartered in 1905. The city was replanned after a disastrous fire in 1916. Paris Junior college (municipally owned) was founded in 1924. Manufactures include lamps, furniture, boilers, business forms, garments, crates, vinegar, stock feed, cottonseed oil, and dairy products. Paris is also a shipping point for cotton, grain, and livestock.

For comparative population figures *see* table in TEXAS: *Population.*

(C. A. W.)

PARIS, CONFERENCE OF, the conference for framing the treaties which ended World War I, held in Paris in 1919–20.

PRELIMINARIES

The Pre-Armistice Agreement.—Germany faced complete defeat and unconditional surrender when, one after the other, its allies—Bulgaria, Turkey, and Austria-Hungary—broke under the strain of war in September and October 1918 and sought terms with the enemy. Germany saw its best chance in overtures to the president of the United States, whose speeches during months past had underlined the principles necessary to the restoration and preservation of world peace (*see* FOURTEEN POINTS). Accordingly, on Oct. 4 the German government dispatched a note to Woodrow Wilson through the Swiss government requesting an armistice.

In reply, President Wilson laid down the stipulations to be complied with before negotiations for peace could be opened: (1) Germany must accept without qualification the principles of the Fourteen Points, leaving for discussion only the practical details of their application; (2) the German armies must be withdrawn from all territories of the Allies under the direction of the Allied military authorities; (3) Germany must cease all illegal and inhuman practices and abandon unlimited submarine warfare; (4) the German nation must free itself of the arbitrary government which had conducted the war. Gen. Erich Ludendorff resigned rather than accede to those conditions, but the civil government, although it protested against the charges of illegal and inhuman practices, dispatched a note on Oct. 20 accepting the stipulations of President Wilson as preliminary to the Armistice. Wilson then

presented the matter to the Allies. The president had already sent Col. Edward M. House to Paris as U.S. representative on the Supreme War Council. He met the Allied leaders, David Lloyd George, Georges Clemenceau and Vittorio Orlando, to discuss, first, whether an armistice should be granted, and second, whether Germany's request that the Fourteen Points be used as the basis of peace should be accepted.

President Wilson has been much criticized on the ground that he was responsible for too early a peace, and that had it not been for him terms would have been dictated in Berlin. This is far from the truth. The Allied council agreed to grant the Armistice on the recommendation of the military leaders; the Americans were in fact less eager than the French and the British for the cessation of hostilities. To be certain of Allied sentiment regarding the Armistice, House asked Marshal Ferdinand Foch directly whether or not from a purely military point of view he would prefer hostilities to cease on the terms proposed. Foch replied that, since the terms demanded of Germany were practically the same as those that would be demanded at Berlin, he was opposed to the useless sacrifice of even one more life.

The Allied leaders were doubtful as to whether President Wilson's Fourteen Points should be taken as the basis of the peace, as Germany asked. Clemenceau, Lloyd George, Paul Hymans, and Orlando each raised objections. They finally agreed, however, upon the strong insistence of House, to accept the Fourteen Points with two reservations regarding the freedom of the seas and restoration of invaded territory. Acknowledging these reservations, Wilson on Nov. 5 communicated the reply of the Allies to the German government. This note is of vital importance. According to H. W. V. Temperley, "It constitutes the formal and written offer of the Allied and Associated States to conclude with Germany (*a*) an armistice convention and (*b*) a treaty of peace. This offer, it is conceived, was accepted by Germany by the act of sending representatives, through military channels, to meet Marshal Foch for the purpose of arranging an armistice. By the acceptance of the offer a solemn Agreement was reached which served, both morally and legally, as the basis of the armistice convention and the treaty of peace." (*A History of the Peace Conference of Paris*, vol. 1, p. 382, Oxford [1920].)

The note of Nov. 5, in which Wilson stated that Marshal Foch would communicate the conditions of the Armistice, contained the text of the memorandum of observations by the Allied governments on the correspondence between President Wilson and Germany. In this memorandum those governments "declare their willingness to make peace with the government of Germany on the terms of peace laid down in the President's address of Jan. 8, 1918 (the Fourteen Points), and the principles of settlement enunciated in his subsequent Addresses," subject to two qualifications. These reserved complete liberty, as regards the "freedom of the seas," and interpreted "restoration of invaded territory" as meaning that "compensation will be made by Germany for all damage done to the civilian population of the Allies and their property by the aggression of Germany by land, by sea and from the air."

Both the Allied and Associated Powers and the Germans accepted this pre-Armistice agreement as the basis of the peace. The protests of the German delegation against the Versailles treaty in May 1919 were based upon their allegation that the treaty was not in accord with the principles of the agreement. The Allied and Associated Powers, although they denied the validity of the allegation, explicitly acknowledged the validity of the basis: "The Allied and Associated Powers are in complete accord with the German delegation in their insistence that the basis for the negotiation of the treaty of peace is to be found in the correspondence which immediately preceded the signing of the Armistice of Nov. 11, 1918."

ORGANIZATION OF THE PEACE CONFERENCE

Representatives of the Chief Allied Powers.—Representatives of the chief Allied and Associated Powers—France, Great Britain, Italy, Japan, and the United States—held consultations in December and the first plenary session of the peace conference did not take place until Jan. 18, 1919. President Wilson did not reach Europe until Dec. 13, 1918. The British prime minister, Lloyd George, was detained at home by the political uncertainties of a general election until after the new year. So important to any negotiations was the participation of these two heads of governments that nothing definite could be attempted until their arrival. In the meantime, the smaller powers which had been overrun by the armies of Germany had time to reorganize their governments and to send plenipotentiaries to the conference.

The Council of Ten.—Upon the arrival of Lloyd George in Paris, a meeting of the Supreme War Council was held Jan. 12 at the Quai d'Orsay. France was represented by Clemenceau and S. Pichon, Great Britain by Lloyd George and A. J. Balfour, Italy by Orlando and Baron Sidney Sonnino, the United States by Wilson and Robert Lansing. Though ostensibly an informal conversation among plenipotentiaries of the four leading powers, the meeting was the occasion of the significant decision to add only the representatives of Japan to the Supreme Council and to exclude all others from the major decisions of the peace conference. Thus the Supreme Council of the conference, or Council of Ten, sprang from the Supreme War Council.

Other Delegations.—Representatives of Belgium, Serbia, Rumania, Greece, and the other states—32 in all—which had fought against the Central Powers or had broken off diplomatic relations with them also came to Paris. Obviously it was impossible for all to have an equal part in determining the conditions of peace. To each, seats and a vote were allotted in the plenary sessions of the conference. Representatives of those states which had remained neutral during the war, and yet had interests to safeguard or to advance at the peace conference, were permitted to attend only those sessions which were arranged for discussion of their claims, whenever they were specially summoned by the five chief powers. It had been the intention of the latter at first to put on the same footing the new states which were rising from the ruins of the Central Powers. Before the first plenary session, Poland and Czechoslovakia were conceded representation at the conference; but Yugoslavia—including Serbia, Montenegro, and the South Slav provinces of Austria-Hungary—was not officially recognized until the end of May, chiefly because of the opposition of Italy.

The Delegates.—Outstanding among the delegates from the smaller powers were Paul Hymans, foreign minister of Belgium; Ignace Jan Paderewski, premier of Poland, and Roman Dmowski, president of the Polish National committee in Paris; and Ion C. Bratianu, premier of Rumania. For Serbia and the South Slavs came Nikola Pasic, Milenko Vesnic and Ante Trumbic. Eleutherios Venizelos came to speak for Greece. For Czechoslovakia came its premier, Karel Kramar and its foreign minister, Edvard Benes. The new kingdom of the Hejaz was represented by Emir Faisal.

But there was considerable dispute before the five principal powers finally assigned places in the conference to each state in accordance with its military strength and its share in the war. Five seats were given to each of the five chief powers; three apiece were assigned to Belgium, Serbia, and Brazil; two each to Canada, Australia, South Africa, India, China, Czechoslovakia, Poland, Greece, the Hejaz, Portugal, Rumania, and Siam; one each to New Zealand, Bolivia, Cuba, Ecuador, Guatemala, Haiti, Honduras, Liberia, Nicaragua, Panama, Peru, and Uruguay. Many delegates were thus left out, but the panel system was adopted so that all powers could use their plenipotentiaries in rotation if they desired. Representatives of the British dominions, for example, more than once shared in important decisions of the Supreme Council by reason of their membership in the panel of the British Empire. Other work was found for excess members of several delegations on commissions and subcommittees.

When the plenary assembly of the conference met for the first time on Jan. 18 it proved to be only a body for the approval of actions that had already been determined in the Supreme Council. Clemenceau was elected president of the conference. A secretary-general previously selected by the Supreme Council was appointed. A drafting committee was approved, on which had been placed only representatives of the five chief powers. The smaller powers

endeavoured to protest against such rigid control by the five. But at the second plenary session on Jan. 25 Clemenceau bluntly dismissed their objections with allusion to the 12,000,000 soldiers behind the five powers.

Administrative Work.—With this matter of authority arbitrarily arranged, the peace conference settled to the work of constructing a peace. Peacemaking, however, was not to be its sole task. It was obliged also to assume executive duties of tremendous consequence. It was to direct the Allied Armistice Commission at Spa. It was to set up and control the Supreme Economic Council at Paris. It had to maintain its own authority over Poland, Germany, Hungary, Czechoslovakia, and Rumania. The Supreme Council of the conference administered the Armistice by instructions to Marshal Foch, who in turn forwarded them to the international commission at Spa. The Allied members of the commission consequently had no authority to make any decision beyond their instructions. They had full power to explain and to stress important points in the Allied interpretation of the Armistice and, by personal intercourse, to prevail upon the German representatives to accept the decisions of the Supreme Council at Paris. The matters that chiefly concerned the Armistice commission were: the withdrawal of German forces from the territory of the Allies and their demobilization; the repatriation of prisoners interned in Germany; surrender by Germany of the required amounts of arms, airplanes, mercantile and agricultural machinery, and railroad equipment; and the delivery of other commodities stipulated in the Armistice.

Supreme Economic Council.—At the instance of President Wilson, on Feb. 8 the Supreme Council resolved to create a Supreme Economic Council of five members from each interested power to advise the conference on the temporary economic measures necessary pending the completion of peace negotiations.

At its first meeting on Feb. 17 the Supreme Economic Council decided to co-ordinate the work of all the former war boards and to direct them as sections of its own organization. As a result, matters of food and relief were placed under Herbert Hoover of the United States as director-general; matters of finance under Norman Davis of the United States; the problems of communications were ultimately assigned to Brig. Gen. H. O. Mance of Great Britain; raw materials to Louis Loucheur of France; problems of blockade to Vance McCormick of the United States; and shipping to Kimball Cooke of Great Britain.

The Supreme Economic Council endeavoured to supply devastated areas with materials necessary for reconstruction and to revive the economic activity of those countries which were victims of the war. It was especially concerned with the problem of relieving the famine-stricken areas of eastern Europe—a situation recognized as dangerous to political stability and likely to encourage the spread of Bolshevism. It arranged the Brussels agreement by which Germany was provided with foodstuffs, to carry out that provision in the armistice which pledged the Allies to revictual Germany in return for cash payments. It delegated to a subcommittee the special task of economic administration in the territories of Germany occupied by Allied armies. It carried on direct negotiations with the German finance commission, studied the economic effects of the Allied blockades of Bolshevik Russia and Hungary, and urged the Supreme Council of the conference to relax those blockades for the benefit of the peoples of other states near by. It relaxed the blockade against Germany and reorganized the transportation systems of Austria, Hungary, and Poland.

In short, the Supreme Economic Council under the efficient chairmanship of Lord Robert Cecil, established only as a temporary commission to administer economic affairs until the advent of peace, became one of the most important international bodies directing the reorganization of Europe. After the Treaty of Versailles had been signed, the council continued to act as agent for the Allies. The last meeting was held in Feb. 1920.

Official Language and Publication.—Two preliminary questions of procedure for a time disturbed the plenipotentiaries at Paris. What was to be the official language of the conference? Should its proceedings be made public? It was decided that French and English texts, of equal authority, should be presented in the treaty with Germany, which included the covenant. Italian texts, along with English and French, were presented in the Austrian, Hungarian, and Bulgarian treaties; and in all these the French version was declared to prevail in case of divergence. The languages of the enemy states were denied admission to the texts of the treaties. The decision was reached to withhold details of discussions as much as possible until definite understandings had been secured.

THE WORK OF THE PEACE CONFERENCE

Problems in Eastern Europe.—The authority of the peace conference was menaced seriously by the hostility of Germany and also by the resistance of Rumania and the new governments of Poland and Czechoslovakia. Early in November 1918 hostilities had broken out between the Poles and the Ruthenians in east Galicia where Polish proprietors constituted a landed minority, and Ruthenian peasants—closely related to the Ukrainians in Russia—were a majority. During February 1919 an Allied mission intervened, but the Ukrainian commander refused to accept the proposed truce. In March the Supreme Council of the peace conference arranged another truce with the Ukrainian commander, and on April 2 set up an inter-Allied commission at Paris to arrange the terms of an armistice concerning east Galicia. The Polish delegation rejected this armistice on the ground that Poland's safety required military occupation of east Galicia. The Supreme Council sanctioned the Polish occupation. The status of east Galicia was left for later decision. (*See* POLAND: *History.*)

To safeguard Poland on its western border, the peace conference imposed an obligation upon Germany that had not been stipulated in the Armistice. In Poznania the Poles rose against the German garrisons at the end of December 1918. In January the Supreme Council dispatched an inter-Allied commission to stop these hostilities and served notice of that intention upon Germany through Marshal Foch. Germany protested but accepted the provisional line of demarcation as laid down by the Allied Commission until the boundaries of Germany and Poland were determined by treaty. Germany also objected to the transport of Gen. Jozef Haller's Polish army from France to Poland via Danzig on the ground that its presence would prejudice the ultimate disposition of Danzig. The conference forced Germany to admit the technical right of the Allies to use Danzig as such a port of entry to Poland, but allowed Germany to route Haller's army via railway without touching Danzig.

Still more vexatious to the peace conference, perhaps, was the situation that developed in Hungary after the establishment of a Bolshevik regime under Béla Kun and the conflict between Hungary and Rumania. (*See* HUNGARY: *History.*) Other matters to distract the Supreme Council of the peace conference from its major task of peacemaking were the sharp controversies between Czechoslovakia and Poland over Teschen and between Austria and Yugoslavia over Klagenfurt. The situation in Russia caused much discussion during the first days. Decision was reached on Jan. 22 that all the Russian factions should be summoned into consultation on the island of Prinkipo, in order to determine who was to be responsible for Russian interests at the peace conference. But nothing came of the effort. Neither the old tsarist order, the revolutionary government of Alexander Kerensky, nor the Bolshevik regime of Nicolai Lenin was represented at the peace conference. Nor were the new Baltic states—Finland, Estonia, Latvia, Lithuania—which were breaking away from the old Russian empire.

Special Commissions.—Among the special agents established to assist in making a peace were commissions on: (1) responsibility for war and guarantees, with Robert Lansing of the United States as president and subcommittees on criminal acts, responsibility for war, responsibility for violation of laws and customs of war; (2) reparation for damage, with L. L. Klotz of France presiding and subcommittees on estimation of damages, financial capacity of the enemy, and means of payment and reparation; (3) international labour legislation, with Samuel Gompers of the United States presiding (*see* INTERNATIONAL LABOUR ORGANIZATION); (4) international control of ports, waterways and railways, with Silvio

Crespi of Italy as president and subcommittees on transit and control of routes of communication; (5) financial questions, with Edwin Samuel Montagu of Great Britain presiding and subcommittees on financial problems preliminary to peace, on monetary questions, enemy debts, and so on; (6) economic questions, with Étienne Clémentel of France as president and subcommittees on permanent commercial relations, tariffs and customs, navigation, industrial property, and others; (7) aeronautics, with Colonel Dhé of France as president; (8) inter-Allied naval and military affairs, under the presidency of Marshal Foch; (9) the central commission on territorial questions, over which André Tardieu of France presided, to coordinate the work of the committees and commissions examining the complex problems of Czechoslovakia, Poland, Rumania, Yugoslavia, Greece, Albania, Belgium, Denmark, the Saar territory, and Alsace-Lorraine.

In all these agencies of the peace conference the five associated powers kept for themselves either the entire membership or at least a majority over the smaller powers.

League of Nations Commission.—First and most important of all was the Commission on the League of Nations, chosen on Jan. 25 at the second plenary session of the conference upon the recommendation of the Supreme Council. The membership of this commission was drawn from the political leaders of 14 nations. Among them were Lord Robert Cecil and Gen. Jan Christiaan Smuts of the British Empire, Léon Bourgeois of France, Orlando of Italy, Hymans of Belgium, Venizelos of Greece, Vesnic of Serbia, Wilson and House of the United States. The commission met on Feb. 3, and after daily sessions in the Hôtel Crillon (held at hours that did not conflict with the meetings of the Council of Ten) presented to the plenary session of the conference on Feb. 14 the first draft of the covenant. The usual procedure at the conference of translating into French when English was used and into English when French was spoken lengthened the sittings twofold and, though necessary, consumed much time. On the other hand, at the meetings of the commission to form the covenant for the League of Nations, interpreters, sitting by those who did not speak both languages, kept them informed in an undertone of the progress of the discussion. It was agreed by the commission to use as a basis for discussion the U.S. plan for the covenant prepared by Wilson and House, which had, by consent, been put into legal phraseology by Sir Cecil Hurst and David Hunter Miller, legal advisers respectively of the British and U.S. delegations. There were difficult problems to solve. The question of political equality and that of having a league with an army at its command to enforce its decisions, advocated by the Japanese and French respectively, caused acrimonious debates.

The debate in the plenary session—the one important discussion in that body throughout the period of the conference—resulted in approval of the principle of the covenant and brought forward various suggestions for amendment. President Wilson left on the following day for the United States. The covenant was revised by the commission and finally approved by the fifth plenary session of the conference on April 28, without change of a single word. The covenant specifically provided for safeguarding the Monroe Doctrine against actions by the League; it contained a clause to permit any state to withdraw upon giving notice of its intention two years in advance. The chief objection to the covenant raised in the United States was passed over. With the full support of President Wilson, article 10 was retained in the covenant. (*See* also LEAGUE OF NATIONS.)

Council of Four.—Four days after President Wilson left for the United States (Feb. 18), Clemenceau was shot by a fanatic. Although not dangerously wounded, he was confined to his home. House, who had been delegated to take Wilson's place, came to meet him there and, with the return of Lloyd George from England, the same group was again formed which had worked with celerity and success during the Armistice proceedings. Thus the Council of Four took form. The Japanese plenipotentiary, Kimmochi Saionji, held to the policy of not participating when Japanese interests were not concerned, especially when the matters under discussion pertained purely to a European problem.

Upon Wilson's return to Paris (March 14) he replaced House in these informal conferences. The four heads of states abandoned the Council of Ten. It was reduced to the five foreign ministers. Whenever they desired, the four assumed the authority of the ten as the Supreme Council of the peace conference and drew apart to confer in private. The ministers of foreign affairs continued to sit as a Council of Five, although they were concerned chiefly with minor executive duties and other matters of routine. But, while the four were still engrossed in negotiation with the recalcitrant German delegation, the five went ahead with discussion of the terms to be given to Austria. The power of the peace conference had been drawn into the hands of four men, and the Italian, Orlando, found that final decision belonged really to the three—Clemenceau, Lloyd George, and Wilson.

No one heard the arguments of the four except their interpreter, Paul Mantoux, and later their secretary, Sir Maurice Hankey, who kept the minutes of their discussions and drafted the resolutions upon which they agreed. On occasion, experts were summoned to give data and technical advice. Inter-Allied commissions were formed directly by the four and ordered to report to them.

Claims of France and Poland.—When Wilson returned to Paris, the problem of meeting the claims of France, Italy, Belgium, and Japan immediately became acute. The French asked for continued occupation by the Allies of the Rhineland and the bridgeheads of Cologne, Coblenz, and Mainz. Unauthorized demands were made for the permanent separation from the reich of German territory on the left bank of the Rhine. France asked further for complete sovereignty over the Saar territory as compensation for its own mines which had been deliberately ruined by the German forces. The French representatives pressed vehemently for "integral reparation," assessment of actual damages done by the enemy and exaction of the total amount in reparation. France supported Poland's claim to complete sovereignty over Danzig and the approaches to that city.

Although at one time (April 7) President Wilson threatened to break off negotiations over these questions and return to the United States without finishing the task of peacemaking, compromises that he could accept were found one after another. The scheme for a republic on the Rhine was repudiated, but agreement was reached that the left bank of the Rhine and a wide strip on the right bank should be demilitarized and all fortifications razed, and that the Allies should maintain their joint military occupation for 15 years. It was to be continued if France, in the opinion of the Allies, was not then sufficiently secured against an unprovoked attack. The decision to prohibit union of Germany with Austria, described by André Tardieu as one of Clemenceau's fundamentals, was inserted in the first draft of the German treaty in May and remained there in the definite text of June 28.

As for the French claim to the Saar territory, the compromise was reached that France should have full ownership of the coal mines but that, because of the 650,000 German inhabitants, government of the region should not be given to France but should be put under the control of the League for 15 years. At the end of that time, the inhabitants resident before this arrangement should vote for one of three settlements: the *status quo* under the League, union with France, or return to Germany. In case they voted for return to Germany, France was to give back the mines and to receive compensation from Germany.

The problem of reparation was not effectively solved by the Council of Four. Many English and U.S. advisers, thinking of Germany's exhaustion, the danger of making the German people desperate and the mistaken policy of asking that a blank check be signed and handed over for the Allies to fill in, urged that Germany be cleared of charges for reparation by payment at once of whatever amount it could produce. The debate ramified into the uncertainties of Germany's capacity to pay and the largest sum for which Germany might be held liable. The French view prevailed. It was agreed that Germany should be held liable to pay to the limit of its capacity. The demands of the British and French that pensions should be included in the reparations bill were at first opposed by Wilson, but he finally yielded. (*See* REPARATIONS.)

The deadlock over Danzig was broken by Lloyd George, who

sought and found a complicated compromise between Wilson's thirteenth point that Poland should have free and secure access to the sea and British fears that a *Germania irredenta* might be created. Danzig was to be a free city under the protection of the League of Nations, but Poland was to have access through Polish territory to the Baltic Sea and virtual control over Danzig's interests abroad. Within a week after President Wilson had threatened to leave the conference, these differences had been ironed out so well that the representatives of Germany were invited to appear at Versailles on April 25.

Claims of Italy, Belgium, Yugoslavia, and Japan.—But another crisis suddenly appeared. The Italians threatened to withdraw from the conference unless their claims to Austro-Hungarian territories were met before the Germans signed the treaty. These claims were grounded upon promises given by France and Great Britain in the secret treaty of London (April 26, 1915). Orlando went further, however, to claim the city and port of Fiume (*see* RIJEKA) which had not been allotted to Italy by the secret treaty. In this case he argued for the principle of self-determination, although he had opposed the application of that principle to the German population in the Tirol south of the Brenner Pass. Wilson gave way to Orlando's contention to the extent of agreeing that Italy's northern frontier should be extended to the Brenner. But he resisted the Italian pretensions on the eastern shore of the Adriatic because they were advanced at the expense of Yugoslavia and Albania. Fiume had a large Croat population and a purely Croat hinterland. It was the natural seaport of the Slavonic and Magyar regions to the east. Wilson rejected the suggestion that Fiume should be given to Italy in exchange for the Italian renunciation of claims upon Dalmatia under the treaty of London. On April 23 Wilson publicly declared his reasons for opposing Italian claims. Orlando and his foreign minister, Sonnino, left Paris for Rome, but returned when the conference determined to proceed with the German treaty. They reached Paris on May 7, a day too late for the sixth plenary session which approved the draft of the treaty, and only a few hours before it was handed to the Germans at Versailles. The Italians were back in the conference, but the question of the Adriatic was not settled.

Meanwhile the claims of Belgium, Yugoslavia, and Japan further complicated the situation for the Council of Four. Paul Hymans appeared on April 29 to demand that, since Belgium had been first to suffer in the war, it should be first to receive compensation for war costs. It had been promised as much in the Armistice. He asked that Belgium be given a prior lien upon $500,000,000 of the first cash receipts from Germany and complete settlement of the Belgian account within ten years.

Eventually the U.S. view prevailed—that Belgium's case was different from all others. Belgium was practically assured payment of its war costs by receiving a special issue of German bonds and priority on the cash receipts. Serbia immediately asked for $400,000,000, but the Council of Four dismissed that claim summarily.

The Japanese issue, however, could not be settled so easily as the Belgian or the Serbian claims. The Japanese representatives took exception to the suggestion that the German area in Shantung should be handed back directly to the Chinese. Japan claimed Shantung on several grounds, and a secret agreement in 1917 with the Allies had assured Japan that they would offer no objection to Japanese claims in Shantung, although the United States had never been a party to the agreement. Wilson resisted the Japanese claims, but finally accepted a compromise on April 30.

The Italian crisis was threatening to disrupt the conference, and an understanding with Japan was more than ever necessary. It was agreed that the Japanese would keep Kiaochow and its adjacent district, with rights also to exploit the mines and railways in the peninsula; but that Chinese sovereignty would be restored over the peninsula of Shantung "as soon as possible." The U.S. president expressed faith in the oral promise of the Japanese that Japan would eventually evacuate Shantung in favour of China and retain there only commercial concessions. The Chinese representatives at the peace conference had no such faith. They refused to sign the treaty with Germany, but they gained a place for China in the League of Nations by signing the subsequent treaty with Austria.

TREATY OF VERSAILLES

The draft of the treaty with Germany was handed to Germany's chief representative, Count Ulrich von Brockdorff-Rantzau, on May 7, 1919, at the Trianon. Without rising from his chair the German hurled sharp words at the representatives of the Allies for their dilatory methods. In the past six months, he declared, the blockade had caused the deaths of hundreds of thousands in Germany. "Think of that," he said, "when you speak of guilt and punishment." He and his countrymen would accept the liabilities to which they were committed by the Armistice, would share in restoring Belgium and the devastated areas of France. But they and their nation did not hope for a just peace. "We know," he said, "the power of the hatred that we encounter here."

German Objections.—The Germans protested that the Allied plan for reparations was too severe and that the treaty as a whole was inconsistent with the terms of the pre-Armistice agreement. The Allies rejected this imputation, and a movement for revision led by Lloyd George came to an end on June 13. The only consequence was that some concessions were made to Germany on minor points. The treaty was signed in the Hall of Mirrors at Versailles on June 28 (*see* VERSAILLES, TREATY OF).

The Treaty of Versailles was ratified on July 9 by Germany, and by October Great Britain, France, Italy, and Japan also had ratified. The exchange of ratifications was delayed for two reasons. First, it was hoped that the Senate of the United States would ratify at least with reservations. Second, Germany was required to make amends for the destruction of its fleet in violation of the Armistice.

On Nov. 19, 1919, the U.S. Senate failed to ratify; but on Jan. 10, 1920, Germany finally signed a protocol to give compensation for scuttling the fleet. Then the exchange of ratifications was made at Paris between the European Allies and Germany, and on Jan. 16, 1920, the League of Nations was formally inaugurated.

Other Treaties.—After the Germans had signed the Treaty of Versailles on June 28, 1919, the peace conference turned to the problems of Austria (*see* SAINT-GERMAIN, TREATY OF), Hungary (*see* TRIANON, TREATY OF), Bulgaria (*see* NEUILLY, TREATY OF) and Turkey (*see* SÈVRES, TREATY OF).

Mandates.—The acceptance of the principle of mandates was one of the most far-reaching decisions of the conference. It was a new venture in the government of backward peoples and was destined to play a large part in the affairs of many nations. It provided an excuse and a method for taking over the German colonies by the several countries interested. The German colonial empire vanished overnight. Its loss was one of the hardest blows which German pride suffered and was resented with passionate fervour.

Until the Paris conference there had been no attempt to reach a general understanding or fixed policy between the more powerful civilized nations regarding the control or betterment of such states or territories. However, the system hitherto practised was admittedly so bad that when the conference came to the disposition of the former German colonies there was general agreement that a more enlightened policy should be inaugurated. In furtherance of this desire art. 22 was incorporated in the covenant of the League of Nations and a commission was appointed to sit in London during the summer of 1919 to prepare the terms of the mandates. Upon this commission were Lord Milner, who had as his adviser Lord Robert Cecil; Henri Simon, French minister for the colonies; Viscount Chinda of Japan; Signor Marconi for Italy; and Colonel House for the United States, with George Louis Beer as adviser (*see* MANDATE). (E. M. H.; R. B. McC.)

SUMMARY

Few treaties of peace have been so severely criticized by both victor and vanquished as the Treaty of Versailles and the treaties subordinate to it. The first criticism is with regard to time and method. It has often been argued reasonably enough that the

conference should have begun earlier than the second half of January 1919 and that there should have been a preliminary peace which would have enabled Europe to begin the work of reconstruction. But this argument ignores the difficulties which the Allied Powers had in organizing their delegations and preparing to meet the intricate questions which the exhausting efforts of war work had caused them to delay. Moreover, President Wilson had to face the biennial mid-term elections in November and would have found it difficult to be in Paris sooner, and so great was his prestige at that time that the conference would have been useless without him. In Great Britain the prime minister judged it necessary to hold a general election, a step which has been much criticized, but this criticism overlooks the fact that the parliament in existence had exceeded its normal span by three years and had become in some respects unrepresentative.

It has also been said that not enough forethought had been given to the methods of working the conference and that more should have been left to the professional diplomats of the Allied countries who would have worked more skilfully and speedily if left to themselves. But the three dominant statesmen, Wilson, Lloyd George, and Clemenceau, were men of such outstanding personality and men with such a suspicion and contempt for conventional diplomatic methods that they naturally expected and were expected by their countries to be in the centre of the peacemaking from the first. Their political power outweighed the diplomatic skill of their most experienced advisers.

French opinion was not satisfied with the treaty, for it did not provide in a clear enough manner either the military security the French naturally desired or the material compensation for the destruction of so much of their country. The guarantee of security through the League of Nations covenant, incorporated in the treaty, was unconvincing to the French and smacked of misty Anglo-Saxon idealism. The pact which would have bound Great Britain and the United States to give military support to France foundered with the failure of the treaty to secure ratification in the U.S. Senate. On the other hand the French well understood that the Germans were unlikely to accept the treaty in spirit and were certain to resent its severe conditions. The judgment of Jacques Bainville that the treaty was "too harsh for its lenity" expressed very well French uneasiness.

In Great Britain and the United States opinion began rapidly to turn against the treaty. In the United States this was a double reaction of the isolationists who could not accept the League of Nations and of many liberals who felt that Wilson had renounced his higher idealism in being party to such a severe document. In Great Britain opinion at first was favourable; only two English members of parliament voted in the commons against its acceptance and the act of King George V in meeting Lloyd George personally at Victoria Station on his return from the conference was in tune with popular feeling. But already much Liberal and Labour opinion was anxious and indignant and had made itself felt.

Later in the year this opinion was stimulated by one of the most effective political pamphlets of modern times, J. M. Keynes's *The Economic Consequences of the Peace* (1919). This book, which enjoyed at once great celebrity, painted a picture of the conference and of the peace which came to be accepted by most Liberals and Radicals in Britain and the United States although it was widely denounced at the time in Conservative organs. Its main purpose was to demonstrate that the provisions of the treaty with regard to reparations were absurd and cruel but more generally it poured scorn on the principal actors at the conference, the conduct of the election in 1918, and the supposedly odious character of the new parliament.

In the course of time Conservative opinion began to turn against the settlement, less on humanitarian and economic grounds than because it was "unrealistic." Conservative opinion did not seriously accept the covenant of the League as a great boon. The passing of the old Austro-Hungarian Empire, now replaced by smaller and new states, was regretted without much reflection on the fact that the Austro-Hungarian Empire had disappeared by the time the hostilities had ceased in 1918.

By insisting on including the full cost of the war as a basis for reparations the British and French delegations had aroused expectations which were not fulfilled. The Reparations Commission, which was charged with arranging the amount and manner of the payments, was a source of much dispute between Britain and France in postwar years and the collapse of the German currency added to the difficulties. A more moderate demand for a fixed sum might have been more successful. In time Keynes's criticism of the economic consequences of the treaty came to be generally accepted although it was later challenged, notably by the work of Étienne Mantoux, *The Carthaginian Peace* (1946).

The attempt to base a European settlement on the principle of self-determination has also been vigorously assailed and many examples of unjust frontiers have been cited as revealing either folly or vindictiveness. In each instance a case can be made out for the frontier lines chosen. But the severe limitation of the frontiers of Hungary appeared unduly oppressive. The inclusion of the southern Tirol in Italy was a concession to the Italian claims of a strategic frontier and a defiance of national considerations. The frontiers of Poland in the west were vigorously assailed; the strip which gave access to the sea, the so-called Polish corridor, became especially notorious. Yet it was the violation of Poland's western frontier by Germany which was the occasion of the British and French declaration of war in 1939. The Turkish treaty was severely attacked and probably with most reason. The extension of the Greek kingdom into Thrace and into Asia Minor proved to be politically untenable and militarily indefensible and the reviving power of Turkey under Mustafa Kemal Ataturk enabled the Turks to return to Constantinople and to Smyrna. The British mandate for Palestine (which enabled the Jews to find a home in their ancient land) attracted little attention at the time but later produced the gravest difficulties; by Jews, however, it is remembered as the beginning of the new state of Israel. There is a certain irony in the reflection that while the principle of self-determination was essentially a Liberal principle, the Liberals in Great Britain and elsewhere, with a few exceptions, were unable to greet its practical applications with approval; they were much influenced by the fact that the treaty had been carried out by their political enemies and in an atmosphere of chauvinism and nationalistic excitement repugnant to their taste and conscience.

The view may be taken that the treaty was unsound in its general principles, that it injured Germany too severely without providing guarantees against its future aggression. On the other hand, it may be held that the treaty was the best obtainable in the circumstances and that the new frontiers of Europe, for all the difficulties which they presented, were more just to the various peoples of Europe than the previous state of affairs which left all Europe east of the Rhine under the control of three despotic empires—Germany, Austria, and Russia. What was defective was not the treaty itself but the will of the victors to enforce it. The Bolshevik Revolution and the outbreak of class warfare in all countries presented problems which drew attention away from national problems. The challenge of Marxist socialism produced a new form of counter-revolutionary demagogy which under the name of fascism or naziism threatened the peace of Europe in a way which no one in 1919 could possibly have predicted.

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PARIS, DECLARATION OF (1856) owes its origin to the diametrically opposing views of Great Britain and France on the carriage of property at sea at the time of the Crimean War. In 1854 France allowed enemy goods in neutral vessels to go free but confiscated neutral goods in enemy vessels. Great Britain confiscated enemy goods in neutral vessels but respected neutral goods in enemy vessels. The situation was an impossible one for neutrals. Accordingly, each power abandoned part of its own doctrines and accepted part of its ally's doctrines. This compromise was expressed in the Declaration of Paris, which stated four principles of international law:

(1) Privateering (*see* PRIVATEER) continues to be illegal. (2) The neutral flag covers enemy's goods, with the exception of contraband of war (*see* CONTRABAND). (3) Neutral goods, with the exception of contraband of war, are not liable to capture under the enemy's flag. (4) Blockades in order to be binding must be effective, *i.e.*, maintained by a force sufficient to prevent access to the coast of the enemy (*see* BLOCKADE).

The declaration was signed by Austria, France, Great Britain, Prussia, Russia, Sardinia, and Turkey, and was soon acceded to by all the powers except Bolivia, Spain, United States, Uruguay, and Venezuela. Spain acceded in 1908. The United States withheld formal adherence on the ground that, not possessing a large navy, it was obliged to rely upon privateers in time of war. The U.S. government would not agree to give up the right to commission privateers unless the principle of the immunity of private property at sea was generally accepted. At the beginning of the American Civil War and again in the Spanish-American War of 1898 the United States declared its adherence to the declaration for the duration of hostilities only. Spain in the latter war, while repudiating any obligation to the declaration, announced that it would take a similar course.

During World War I the British Prize Court declared that it would regard the declaration not only in the light of rules binding in the conduct of war but also as a recognized and acknowledged part of the law of nations. The provisions regarding enemy goods in neutral ships became almost wholly nullified by a series of developments: the disappearance of the "Free List" (a list of goods that could not be declared contraband); the extension of the term "contraband" to include all commodities of use, directly or indirectly, to the enemy in the conduct of the war; the presumption of hostile destination; and the application of the doctrine of continuous voyage. The provision for safeguarding neutral goods was also rendered almost wholly nugatory by the German submarine method of indiscriminate destruction. While the neutral owner of goods on board an enemy vessel was entitled to have them restored or paid for when brought in for adjudication, he took the risk of all necessary acts of war. It was held by the French and German Prize courts that in the case of lawful destruction of an enemy merchant vessel, compensation for loss of neutral goods on board could not be claimed. Sinking at sight, without putting passengers and crew in a place of safety, although forbidden by the London Naval Treaty of 1930 (Art. 22) and the London Protocol of 1936, was resorted to by the principal belligerents on both sides in World War II. (*See* Nürnberg judgments on Dönitz and Raeder, *International Military Tribunal*, pp. 304, 308 [1946].) The provision concerning blockades was repeated in the Declaration of London (1909) but "paper blockades"—those not made effective by ships of the blockading power—were complained of in World War I. Conditions of war against enemy commerce had so changed that the Declaration of Paris had little applicability during or after World War II. *See* also ECONOMIC WARFARE.

(H. H. L. B.; Q. W.)

PARIS, TREATIES OF. When this term is used without qualification it refers either to the treaties signed at Paris on May 30, 1814, and on Nov. 20, 1815, at the end of the Napoleonic Wars, or to the treaty of March 30, 1856, that ended the Crimean War.

Many other treaties and conventions have been signed at Paris. They are most readily identified by their dates and by the names of the wars they ended. The treaty of Paris signed by Great Britain and France on Feb. 10, 1763, for example, ended the Seven Years' War. Other notable examples are the treaty of alliance between France and the United States signed at Paris on Feb. 6, 1778; the treaty of Sept. 3, 1783, which ended the American Revolution; the treaty of Dec. 10, 1898, ending the Spanish-American War; and the treaties after World War II with Finland, Italy, Hungary, Rumania, and Bulgaria.

The treaties signed at various Parisian suburbs, such as Versailles, in 1919 and 1920 at the end of World War I are sometimes referred to collectively as the treaties of Paris (*see* PARIS, CONFERENCE OF).

Treaties of 1814–15.—The treaties of Paris signed on May 30, 1814, were between France on the one side and Austria, Great Britain, Portugal, Prussia, Russia and Sweden on the other. Spain made the same treaty with France on July 20. Napoleon had abdicated in April and the victors, even after nearly a quarter century of war, gave generous terms to France under the restored Bourbon dynasty. France was allowed to retain her boundaries of Jan. 1, 1792, keeping possession of the enclaves annexed in the early years of the revolution; the most substantial was the papal territory around Avignon. Outside this frontier, France kept some small territories of which the most important were the fortress of Landau and, in the southwest, Savoy. Most of the French colonies were given back to France, but Tobago and St. Lucia in the West Indies and the Ile-de-France (now Mauritius) and its dependencies in the Indian ocean were ceded to Great Britain; San Domingo went to Spain; and France recognized the British possession of Malta. France received most-favoured-nation trading rights in British India and her old fishing rights at Newfoundland and the Gulf of St. Lawrence.

The first treaties dealt only in general terms with the disposal of the European territories taken from the French empire and ended with the provision that all of the powers engaged on either side in the war should send plenipotentiaries to Vienna to complete the arrangements. In "additional, separate, and secret articles," however, France agreed to accept the principles to be determined at the Vienna conference by the allied powers, Austria, Great Britain, Prussia and Russia. The articles formed the basis for much of the subsequent treaty of Vienna. Other supplementary treaties dealt with the abolition of the slave trade, the expenses of prisoners of war and private claims against France.

The second treaty (Nov. 20, 1815) and its dependent instruments were signed in an altogether different spirit. Napoleon had returned from Elba and had met with no resistance and with much welcome from the French. War was resumed and continued until Napoleon was defeated at Waterloo. The preamble of the treaty stated that the allied powers had preserved France and Europe from the disturbances with which they had been menaced by Napoleon's last enterprise. They had decided, therefore, for the sake of future security to exact indemnities from France, partly in territory and partly in money. The French frontier was changed from that of 1792 to that of Jan. 1, 1790. The enclaves remained French but a number of bits of territory along the Belgian border, the fortress of Landau, and Savoy were taken away. France had to pay an indemnity of 700,000,000 fr. and to support an army of occupation of 150,000 men for not more than five years nor less than three years. In supplementary treaties, the provisions for the settlement of public and private claims were more detailed and more severe than in the treaty of 1814. The treaty abolishing the slave trade was renewed and strengthened.

On the same day, a treaty commonly known as the Quadruple Alliance was signed by Austria, Great Britain, Prussia, and Russia. The four powers declared their intention to enforce the treaties signed with France, to exclude the Bonaparte family from the throne and to continue their alliance after the military occupation of France was ended. The sixth article stated that in order to facilitate and to secure the execution of the present treaty, the sovereigns or their ministers would meet at fixed periods to consider measures that might be useful for the repose and prosperity of nations and the peace of Europe. In accordance with this last article the congresses of Aix-la-Chapelle (1818), Troppau (1820), Laibach (1821) and Verona (1822) were held (*qq.v.*).

Treaty of 1856.—The treaty of 1856 dealt with problems that had not been included in the settlement of 1814–15; the Near East

and the influence of Russia in the Ottoman empire. The terms of the treaty were worked out at a congress that met in Paris from Feb. 25 to April 30 on principles that had been agreed on under Austrian mediation. The congress convened to make peace between the belligerents of the Crimean War: Russia on the one side, France, Great Britain, Sardinia-Piedmont, and Turkey on the other. Austria, which had maintained formal neutrality during the war but had leaned toward the western powers, was represented throughout the congress; Prussia was invited to attend to help revise certain existing treaties.

As the principal occasion for the war against Russia had been the protection of Turkey, the treaty gave special attention to this problem. Turkey was for the first time formally admitted into the system of the public law of Europe and the other powers agreed to respect and to guarantee her independence and territorial integrity. In turn, the Sultan promised to improve the condition of his subjects without distinction of religion or race. The Black sea was neutralized: its ports and waters were opened to merchant ships of all nations but were closed to all warships, and its shores were to be forever without fortifications or naval bases. The Danube river was opened to free navigation and an international commission was created to regulate this and to keep the channel free of obstacles. Russia was removed from direct contact with the delta of the river by the cession of part of Bessarabia to Moldavia. The principalities of Moldavia and Walachia (later joined as Rumania) were reorganized as autonomous states under the suzerainty of the Sultan.

An additional convention reaffirmed the "ancient rule" that the Straits of the Bosporus and Dardanelles were closed to all foreign warships while Turkey was at peace. A declaration on the maritime law of war, which was generally accepted as international law, abolished privateering; declared that enemy goods, except contraband, were protected by a neutral flag; that neutral goods, except contraband, were not subject to capture even on enemy ships; and required that blockade, to be effective, must be maintained by a force sufficient really to prevent access to the enemy coast. *See* EASTERN QUESTION; PARIS, DECLARATION OF; *see* also references under "Paris, Treaties of" in the Index.

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PARIS, UNIVERSITY OF. The University of Paris had its beginnings in the 12th century. Like most other medieval universities, it was a kind of corporate company including both professors and students. Before it came into existence, the already famous Paris schools were divided into two categories: the École de Notre Dame, dependent on the chapter (*see* CATHEDRAL: *Development in the Middle Ages*) of the cathedral, which was administered by the chancellor of Notre Dame; and the abbey schools, which were organized in famous ecclesiastical institutions, of which the most celebrated were those of Sainte-Geneviève and Saint-Victor.

The chancellor of Notre Dame sought to control all education within his jurisdiction. Thus he alone bestowed the *licentia docendi; i.e.*, the right of teaching. Professors and students opposed this and tried to gain autonomy so as to organize education in their own way. Among other things, they wanted all who showed adequate intellectual ability to have the right to teach, and they therefore joined in a *conjuratio*, a community of professors and students, which was given the name of *universitas*, and sought the pope's protection. (*See* UNIVERSITIES for complementary accounts of origin and subsequent history.)

A precise date of birth cannot be assigned to the university. However, in 1200 King Philip II Augustus granted the university authorities certain privileges, and in 1208 Pope Innocent III permitted them to frame regulations; in 1215 the papal legate Robert de Courçon presented them with a statute. (The word *universitas* was used for the first time in 1219.) A bull of 1231 defined the relations between the university and the bishop, to the disadvantage of the latter.

Like the schools that preceded it in the 12th century, the university continued to attract the most celebrated professors in Europe, who were ecclesiastics as were the students themselves. Freedom from episcopal jurisdiction, with direct answerability to Rome, widened the scope of the curriculum and allowed greater papal control of its orthodoxy, which was further increased by the entry of the mendicant orders—Dominicans and Franciscans both began teaching during the 1220s. Their intrusion provoked discontent, for they claimed all the privileges of membership of the university but refused to acknowledge its authority, and the subsequent conflict, which also involved the controversies between the Averroists and the moderate Aristotelians, became acute in *c.* 1250. (*See* AVERROISM, LATIN.) As a result of the power acquired by the friars, secular theological students were virtually deprived of the chance of appointment as professors, and, after statutes passed by the secular masters against the mendicants and compelling all masters to take an oath of obedience had been disobeyed, the masters in 1254 addressed an open letter against the friars to the prelates of Christendom. Louis IX and the court, influenced by the king's confessor, himself a friar, supported the mendicants; Pope Innocent IV supported the secular masters, but on his death (1254), Alexander IV revoked the bull by which he had withdrawn the mendicants' privileges, and in April 1255 issued his bull *Quasi lignum vitae*, ordering the university to admit the friars to all privileges.

The secular masters dissolved the university, and the quarrel became involved with their simultaneous attempt to procure condemnation of the fanatical Franciscan writings of the Fraticelli, and especially of Gerard of Borgo San Donnino's *Introductorius ad evangelium eternum*, published in Paris in 1254, as an introduction to the works of Abbot Joachim (*q.v.*) of Floris. In retaliation, Guillaume de St. Amour (1202–72), a theologian and leader of the seculars, had written his *Des Périls des derniers temps* (1256), identifying the friars with "the ungodly men" who were to foretell the coming of Antichrist. The king was persuaded to submit Guillaume's book to the pope, but the university defied the subsequent papal excommunication and banishment of Guillaume by appointing him their proctor at the trial. In 1257 the papal court condemned the book but did not declare it heretical. Guillaume refused to accept its judgment and, although the king petitioned the pope for permission to recall him, he was banished to his estates in Franche-Comté, where he died. Meanwhile, the quarrel between the secular masters and the mendicants had been settled by the pope in favour of the mendicants, and the bull *Quasi lignum vitae* had been accepted by the secular masters (despite their protest that to them it was a *"lignum mortis"*); and the mendicant orders thenceforward taught without hindrance.

At the end of the 13th century and during the 14th century, the University of Paris was the most celebrated teaching centre of all Christendom, particularly in theological studies. Among the famous professors were the great schoolmen St. Bonaventura, St. Albert the Great (Albertus Magnus), and St. Thomas Aquinas. (*See* SCHOLASTICISM.) Students poured in from all countries and the international character of education, deeply Christian in inspiration, was never more in evidence than in those days. The masters had grouped themselves into four faculties: the faculty of arts where the trivium (grammar, rhetoric, and dialectics) and quadrivium (arithmetic, geometry, astronomy, and music) were taught together with scientific, literary, and general culture; the faculty of theology, the most famous of the faculties; the faculty of law (canon law); and the faculty of medicine. In each faculty students were divided into four "nations" according to their origin: French (for students of Latin race), Picard (including also Walloons), Norman (with Bretons), and English (including also Germans and Swedes and after 1436 called the German "nation"). A dean was elected as head of each faculty, and the dean of the faculty of arts was the nominal chief of the university with the title of rector. Many colleges were built to accommodate the students; one which was to be the best-known in later years was founded in the middle of the 13th century by the legate Robert de Sorbon and was called the Sorbonne (this has always been the name of a building only, but has been confused with the name of

the university itself, which is partly accommodated there). Mont-Sainte-Geneviève became the district of studies, the Latin Quarter.

The University of Paris spoke for orthodoxy and its pronouncements had great influence. During the Great Schism (1378–1417) it outlined the various solutions capable of bringing the church crisis to an end and generally upheld the conciliar theory (*see* COUNCIL: *Conciliar Theory*); its professors were Pierre d'Ailly and Jean de Gerson (*qq.v.*). The university also took part in politics; for example, during the quarrel between the Armagnacs and the Burgundians (at the beginning of the 15th century), it upheld the cause of the duke of Burgundy, John the Fearless. Such activities somewhat detracted from its prestige. In addition, education founded essentially on scholastic dialectic became rigidly fixed. As a result, the university made little contribution to the humanism of the Renaissance, in spite of the presence of as great a scholar as Jacques Lefèvre d'Étaples (*q.v.*). Finally, it was torn by the conflicts arising out of the Reformation.

The university's reluctance to accept advanced theories explained its critical situation at the end of the 16th century. Its resources had become impoverished after the wars of religion, its authority reduced and its discipline relaxed; and academic studies had been abandoned by a generation more attracted by martial glory. The kings therefore undertook reforms. In 1598 Henry IV promulgated new statutes which specified the functions of teachers, reinforced discipline, and established new programs. Cardinal Richelieu further clarified these rules and proceeded with the construction of colleges. The new Sorbonne was completed in 1627 on its present site and Richelieu wished to be buried in the chapel, the first stone of which he laid in 1635. The statutes of 1598 were in operation throughout the 17th and 18th centuries. They gave the university a solid foundation, and its members enjoyed high repute. They took part in the quarrels of the Quietists, Jansenists, and Gallicans (for the professors were opposed to the Jesuits whose teaching flourished in many colleges, particularly that of Clermont, founded in 1611). In 1762 the colleges of the Jesuits were taken over by the university.

The French Revolution aimed at sweeping away all institutions of the *ancien régime* (and of the Roman Catholic Church) and at reorganizing education; so the colleges and the four faculties of the university were abolished on Sept. 15, 1793. For 13 years they were replaced by institutions of learning specializing in different fields—the Polytechnic school, the École Normale, the school of medicine, and the museum. In 1806 Napoleon founded the University of France, an administrative structure within which all teaching units were regrouped and which was given the monopoly of teaching throughout the country. Organized according to a decree of March 17, 1808, it was subdivided into academies, each of which had a government-nominated rector at its head and contained a university consisting of the four classical faculties (law, science, letters, medicine) and of various specialized institutes. Thus, within the Academy of Paris was the reconstituted University of Paris. Among its several faculties were some which were to disappear in the future (for example, that of theology in 1886), while others were to be created, for example, those of science and pharmacy. It came to include great schools such as the École Normale Supérieure, the École des Chartes, and the Institut d'Études Politiques. Teaching was secular; *i.e.*, independent in regard to political or religious doctrine. Professors were co-opted. At mid-20th century (by which time the University of France, as a central organizing body, had given place to the Ministère de l'Instruction Publique) the University of Paris included mainly the faculties of law, medicine and pharmacy, science, and letters.

The University of Paris renewed its fame as a preeminent scientific and intellectual centre. The most distinguished professors lecture there, and there are more than 600 professorial chairs. Students in 1885 numbered nearly 12,000; in the 1960s they exceeded 100,000. Students of both sexes come from all parts of France, from the territories of French-speaking Africa, and from many foreign countries. The university curriculum underwent considerable changes. The faculties of letters, of the sciences, and of law, it is true, were in the second half of the 20th century still granting the same degrees and setting the same examinations as previously (for the *baccalauréat*, for the *licence*, and for the *doctorat*); but other faculties had an entirely different structure. A student of medicine, for instance, proceeded directly to his doctorate without any intervening change of status; students of pharmacy or at the various institutes took their own special diplomas; and the old examinations were being progressively superseded by competitions. These developments, however, were not restricted to the University of Paris. They reflected, rather, the tendency of higher education in France in calling for a radical reform that would affect the range of studies and the methods of instruction.

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(M. PAC.)

PARISH, from the Greek *paroikia*, is the technical word for the unit through which the Christian church does its pastoral work. It was first used in this sense in the 2nd century A.D. Today a parish is a subunit of a diocese. But in the early church the unit, called a parish, was the whole body of Christians in a city of the Roman Empire under the bishop. The bishop stood in the same relationship to the Christians of the whole city as does a parish priest today. Assisted by the other clergy he presided at all the services and did most of the preaching. *Paroikia* is used in the New Testament, where it means sojourning or temporary residence. The parish in the early church was a body of people temporarily resident in an earthly city. Heaven was their real home. Christians in villages near a city were treated as part of the city parish.

When in the 4th century Christianity in Western Europe spread to the countryside, Christians in important villages would be organized into a unit with their own priest under the jurisdiction of the bishop of the city from which they had received the gospel. The unit was called a parish. These first country parishes remained few in number till the 8th century. They served large areas and their boundaries were ill-defined.

In Anglo-Saxon England the first parish churches were founded in important administrative centres. They were called minsters, and subsequently old minsters, to distinguish them from the later village churches. In the Celtic church pastoral work was carried on from monasteries, whose clergy were both monks and parish priests; a monastery's parish meant the lesser monasteries under its control.

The existing parochial system in England and on the European continent was created between the 8th and 12th centuries. The payment of tithe, made obligatory on the European continent in the 8th and in England in the 10th century, had the result that a church's parish meant the geographical area from which it received its tithe rather than the people in the area. Continental cities remained one parish under their bishop till the 11th century. The first to be divided into separate parishes were Cologne and Worms. Until the 11th century "parish" was used for both the whole area, a diocese, under the bishop, and the area served by a town or village church, a parish in the modern sense. Subsequently parishes became the unit of local civil administration and in rural areas of England are still the lowest unit of local government. The increase in population during the 19th and 20th centuries necessitated the formation of many new parishes and the alteration of old boundaries.

Territorial parishes were created in North America in the 17th and 18th centuries. Maryland, where the Church of England was established, was divided by 1784 into 44 parishes, roughly four or five to a county.

See also BENEFICE; DIOCESE; TITHES. (G. W. O. A.)

PARISITE, a rare mineral, consisting of the cerium group of rare earths (cerium, lanthanum, didymium) and calcium fluocarbonate. For many years the only known occurrence of the mineral was in the famous emerald mine at Muzo in the eastern Andes in Colombia found by J. J. Paris, who rediscovered the mine. It has

been found in Norway, Italy and Madagascar, at Quincy, Mass., and in Montana. The composition of parisite is $(CeF)_2Ca(CO_3)_3$ in which La and Di may replace varying portions of Ce. It is found only as crystals, which belong to the hexagonal system and usually have the form of acute double pyramids terminated by the basal planes; parallel to the basal plane there is a perfect cleavage. The crystals are hair brown in colour and are translucent. Light which has traversed a crystal of parisite exhibits a characteristic absorption spectrum. (L. J. S.; X.)

PARITY, LAW OF CONSERVATION OF. The law of the conservation of parity states that in every physical process a certain characteristic of the physical system, called its parity, remains unchanged. The law belongs to the class of conservation laws (like that of energy) which are the most powerful principles of physics. The parity of a system, like its energy, is a relatively abstract property. Unlike energy, parity has no meaning in classical physics, and the law is thus not readily put into everyday language. But the basic concept of symmetry which underlies the law is old and familiar, and will be described in some detail below. (*See* also ENERGY: *Conservation of Energy.*)

The conservation of parity was explicitly formulated in the early days of quantum mechanics by E. P. Wigner (*q.v.*); it became an intrinsic part of the theory. In the summer of 1956, Tsung-Dao Lee and Chen Ning Yang (*qq.v.*) of Columbia University and the Institute for Advanced Study, Princeton, suggested that the law, however well-verified in other parts of physics, might fail in certain inherently slow decay processes of various fundamental particles. A worldwide attack on the problem by many experimenters led to a full confirmation of the proposal of Lee and Yang. In such decay processes it was found that parity indeed is not conserved. Lee and Yang were jointly awarded the 1957 Nobel Prize for physics.

Parity is the formal expression of the behaviour of the wave function of any system when the spatial coordinates describing the system are inverted through the point at the origin; that is, the coordinates x, y, and z, are sent into $-x$, $-y$, and $-z$. Such an analytical transformation may be visualized by thinking of the relation between a right and a left hand or by viewing not the object directly but its optical image in an ordinary plane mirror. Since the time of I. Kant, at least, this distinction between object and image has concerned natural philosophy. Such a mirroring produces a counterpart to any given physical system; the full content of the law of conservation of parity is simply that the mirrored system so produced is as fully physical as its original. The world of the looking glass is a possible real world—of course, it is an unfamiliar one. In Lewis Carroll's *Through the Looking-Glass*, Alice first thought the looking-glass book was in a strange language, but it was a *possible* language. Only a particular historical sequence led to the form of our letters and the direction in which we read them on the page. It is the same for all artifacts; there can be no real distinction between object and mirror image. For each of them, a mirrored artifact is possible. Even in biology the off-centred heartbeat and the coiling direction of snail shells are mere accidents of history. Mirrored organisms are perfectly possible, and indeed occur. The asymmetry of chemical molecules lies deeper, but is no different (*see* STEREOCHEMISTRY). For every optically active form, its mirror counterpart is possible, and identical in stability and function. The ubiquity, for example, of L-amino acids in nature is simply a historical fact; evolution might equally well have given us a living world made wholly with D-amino acids.

But the β-decay of radioactive nuclei, and related processes, such as the decay of π and μ mesons, can distinguish object from image. Experiment demonstrates that the emitted particles in such processes show a particular sense of spin direction around their directions of flight. The ordinary β-decay processes, emitting negative electrons, send out neutrinos all of which spin in the sense a left-handed screw would turn if advanced along the direction of flight of the neutrino. No stronger violation of the parity principle could be produced; the looking-glass β-decay process is reversed in neutrino spin sense, and unrealizable in our world. But such decay processes are intrinsically rare; in all specifically nuclear processes and in mechanical and electromagnetic processes, which span all of the physical and chemical changes of everyday life, the object and image are equally realizable in nature and parity is fully conserved. Only in the slow decays, caused by the so-called weak interactions, was the proposal of Lee and Yang found to describe the case (*see* FORCE).

It is probable that even the distinction between object and image allowed by the weak interactions would fail if the "mirror" were rather more broadly interpreted. If the mirrored system were not only spatially different, but if it were as well made of antimatter (substituting positron for electron, antinucleon for nucleon, and so on throughout) the antimatter mirrored system would become realizable. The looking-glass positron emission would yield spin directions just like the ones we can observe. It is possible that this more general mirroring in fact eliminates the apparent distinction, and that what we see as the fundamental distinction between our matter and antimatter is only an accidental feature of the grand evolution of matter in our cosmic neighbourhood. But Alice could never enter the looking-glass world of antimatter on pain of annihilation!

See also PARTICLES, ELEMENTARY; QUANTUM MECHANICS; ANTIMATTER.

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PARK, MUNGO (1771–1806?), Scottish explorer of the Niger, was born in Selkirkshire at Foulshiels on Sept. 10, 1771. He was apprenticed to a surgeon and through the good offices of Sir Joseph Banks became assistant surgeon on an East Indiaman. Returning from his first voyage in 1793, he contributed a description of eight new Sumatran fishes to the *Transactions* of the Linnean Society.

In 1794 Park offered his services to the African Association to explore the Niger. On June 21, 1795, he reached the Gambia and ascended that river 200 mi. to Pisania, a British trading station. On Dec. 2, he started for the unknown interior by crossing the upper Senegal Basin. The journey was full of difficulties. At Ludamar he was imprisoned by an Arab chief for four months; he escaped alone on July 1, 1796, with nothing but his horse and a pocket compass. On July 21 he reached the long-sought Niger at Ségou. He followed the river downstream 80 mi. to Silla, where he was obliged to turn back, being without means and utterly exhausted. On his return journey he took a route more to the south, keeping close to the Niger as far as Bamako. He reached Pisania again on June 10, 1797. A detailed narrative of his journey, *Travels in the Interior of Africa*, was published in 1799. It was extremely popular at the time and is still regarded as a classic.

In 1799 Park married and settled at Foulshiels. Two years later he moved to Peebles, where he practised medicine. In the autumn of 1803 he was invited by the government to lead another expedition to the Niger. Park accepted the offer, but the start of the expedition was delayed, so he went back to Foulshiels. He made the acquaintance of Sir Walter Scott, who was then living nearby at Ashestiel.

In September, Park was summoned to London to leave on the new expedition. He sailed from Portsmouth for the Gambia on Jan. 31, 1805, having been given a captain's commission as head of the government expedition. Alexander Anderson, his brother-in-law, was second in command. Having picked up reinforcements at Goree, Park began to ascend the Gambia with a company of 40 Europeans. Only 11 of them were alive when the expedition reached the Niger in August; the rest had succumbed to fever or dysentery. From Bamako the journey to Ségou was made by canoe. He received permission from the ruler of that town to proceed and at Sansanding, a little below Ségou, Park prepared for his journey down the still unknown part of the river. With eight companions he set sail on Nov. 19, 1805.

Park wrote to his wife stating his intention not to stop or land anywhere until he reached the coast, where he expected to arrive about the end of January 1806. No more was heard of the party

until reports of disaster reached the settlements on the Gambia. As a result of inquiries made on behalf of the British government it was established that Park and his company reached the rapids at Bussa, about 1,000 mi. below Sansanding. There they were attacked by hostile natives and Park was drowned.

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PARK, ROBERT EZRA (1864–1944), U.S. sociologist, an authority on race relations, was born in Luzerne County, Pa., Feb. 14, 1864, and graduated from the University of Michigan, Ann Arbor, in 1887. His experiences as a newspaper reporter and editor in Minneapolis, Minn., Chicago, Ill., and Detroit, Mich. (1887–98) led him to study the mechanisms of individual and social behaviour with William James and Josiah Royce at Harvard University and with Georg Simmel and Wilhelm Windelband at the University of Heidelberg, where he received his Ph.D. in 1904.

Park was assistant in philosophy at Harvard, 1904–05, and later, while secretary to Booker T. Washington, devoted himself to the study of the Negro. He was a member of the sociological staff of the University of Chicago, 1913–33, and after his retirement taught and conducted research at Fisk University, Nashville, Tenn., 1936–43.

Park conceived of sociology as a natural science of human behaviour. He defined its relations to other social sciences and developed its conceptual systems in terms of the processes of communication, conflict, accommodation and interaction. He made a clear distinction, which he believed to be fundamental, between the ecological community as an aggregate of individuals characterized by symbiosis, the division of labour, and competitive cooperation and society as an organization of persons through communication, socialization, and collective behaviour. These and other sociological concepts he regarded not as ends in themselves but as research instruments.

With E. W. Burgess he wrote *Introduction to the Science of Sociology* (1921) which was influential in promoting empirical research. Among his other writings are *The Immigrant Press and Its Control* (1922); *The City, Suggestions for the Study of the Urban Environment* (1925); *Race and Culture*, collected papers, volume 1 (1950); *Human Communities*, collected papers, volume 2 (1952); *Society*, collected papers, volume 3 (1955).

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(ET. W. B.)

PARK AND PLAYGROUND. The first parks were grants of the royal lands for the enjoyment of people; modern parks are gifts from the people to themselves. They are paid for by public funds and are planned in an organized and functional way for the use and recreation of taxpayers. In the course of this development there have been many changes, increasing in number each year.

In the parks of post-Renaissance times there were extensive woods, rectilinear *allées* stretching between one vantage point and another, raised galleries and, in many cases, elaborate aviaries and cages for wild beasts, attesting to the hunting proclivities of the lords. Later the concept of the public park was somewhat domesticated. An area devoted simply to green landscape, a salubrious and healthful breathing space as a relief from the densely populated and industrialized city of the mid-19th century, became of vital importance. Examples of this type park are Birkenhead park in England (1844) by Sir Joseph Paxton; Jean Charles Alphand's Bois de Boulogne; Central park in New York city by F. L. Olmsted and C. Vaux; Friedrich-Wilhelmsgarten in Germany; the Botanic gardens in Melbourne, Aust.; and Akashi park in Kōbe, Japan. The design was generally romantic in character. The primary purpose was to provide for passive recreation—walking and taking the air in agreeable and natural surroundings reminiscent of the unspoiled country.

What primarily differentiates modern parks is their accommodation for active recreation. Park areas differ greatly from country to country, and their designs reflect differences in climate, cultural attitudes, social habits and pastimes. In the gardens of the Generalife, a Spanish family may enjoy its holiday outing in a shaded *bosque* near a cool fountain. On an evening in Venice a procession with banners and torches may sweep into one of the little piazzas. In the Buttes-Chaumont in Paris little boys reach out from wooden horses on the merry-go-round to spear a brass ring. During the bright summer week-ends in Stockholm residents cultivate vegetables in allotment gardens leased to them by the park department. In Israel, Iran and Pakistan, basketball, soccer and kabadei (a game like rugby) are played in parks; in Japan, volleyball, tennis and sumō (wrestling). Almost universally, there is recognition of the creative possibilities of leisure and of community responsibility to provide space and facilities for recreation.

The facilities include outdoor theatres, zoos, concert shells, historical exhibits, concessions for dining and dancing, amusement areas, boating and areas for sports of all kinds such as fly-casting pools and skating rinks. There is always the danger that the original reason for creating the park, *i.e.*, to bring a part of nature within reach of the city dweller, will be sacrificed to its specific recreational functions. It is difficult to keep the balance—the tempo of urban life is mounting and with it the requirements for intensive use.

Another danger to the public park has been the automobile. With the tremendous growth in automobile traffic, and consequently increasing pressure from traffic authorities for more land, there has been hardly a major city that has not lost some sections of its parks to highways. There has been a growing awareness, particularly in Europe, that large-scale urban planning should be carried out in such a way that traffic functions are clearly separate and do not encroach on other spheres. In the United States also, there have been victories for the park user against the automobile; in San Francisco, the state freeway was halted at the city limits, and in New York, Washington square was closed to traffic altogether.

It is unfortunate that the word park has come to connote almost exclusively the "romantic" style park or English garden of the 19th century, examples of which have been noted above. In truth, there are other traditions whose influence has been equally vital. How different from the Parisian Buttes-Chaumont, for instance, are the Tuilleries across the river. These were laid out under the supervision of Marie de Medici in the style of the Boboli gardens in Florence. Versailles, the Belvedere park in Vienna, the Vatican gardens in Rome, Hellbrun in Salzburg, Blenheim in England, Drottningsholm in Sweden and Peterhof in the U.S.S.R.—all these parks arise originally from the Italian baroque tradition. They were not intended to be a foil or escape from the oppressive city, but rather to be its central dramatic focus—a display for the opulence of rulers, a piazza for the moving of great crowds, from the tournament and guild ceremonies of Florence in the 17th century to the formal pageantry of the court. It was in the baroque park that the handling, control and stimulation of crowds in the open air developed as one of the great arts of the urban designer.

A third park tradition which has had world-wide influence is that of Islam. In Teheran, Marrakesh, Seville, Lahore and Delhi, this tradition is the dominant one and, as with all parks, developed according to the climate, social custom and religious ethos. The original Muslim idea was to think of the garden as a paradise, a symbol of the afterlife as an oasis of beauty blooming in the earthly desert. Water and the cypress are the two main elements. Within the park then is water, the symbol of purity, in the four-way river of paradise, and trees (above all the cypress, symbolizing life), surrounded by high walls to keep out the dry wind. Everywhere, in keeping with Muslim belief, the design pattern is abstract rather than figurative. The fundamental idea creates its own specific technical skills; nowhere is there more artful use of irrigation for plants, of jets of water to cool the air, of orchards for shade, of colour to break up the sun's glare or of the use of masonry patterns than in these Islamic gardens.

The Taj Mahal in India dates from the 17th century, when by the testament of Shah Jahan this area of 20 ac. was to be maintained as a public grounds in perpetuity, where the poor could walk and pick fruit. In China and Japan, a similar opening of the royal

precinct for public enjoyment, as with the Winter palace or the Katsura Imperial Villa gardens in Kyōto, has been a more recent development. The great religious shrines, however, have always resembled western parks. The Horimonji temple in Tokyo, the Mimeguri shrine, the great Buddhist temple at Ise and the Inner (Shintō) shrine at Mieshima are examples of an age-old garden tradition in which man is but "one of a thousand things" and where nature is presented in an idealized and symbolic way as an object for contemplation and spiritual enjoyment. In their techniques of horticulture and in their use of stones, water and surface textures, the gardens of the far east are of a high level. This eastern tradition had its effect on European park design in the 18th century and again in the 20th century, as in the grounds for the UNESCO building in Paris, designed by Isamu Noguchi.

PLAYGROUNDS

The playground is perhaps the most typical facility of the new park's recreational function. There are active playground building programs in almost all countries. The acquisition of lands, the most difficult of all problems, is approached in various ways. In London, for instance, laws have been enacted to permit conversion of ancient burial grounds in the city core to recreational use. In New York playground areas have been acquired in conjunction with traffic planning; playgrounds are often built as adjuncts to highway developments.

There have been changes in the educational philosophy behind playgrounds and immense changes in their design and methods of construction. At the beginning of the century the originators of the playground movement in western Europe and the United States were preoccupied with problems of health and safety. Ample statistics demonstrated that higher rates of tuberculosis, traffic accidents and delinquency occurred in areas without playground facilities. The typical playground of that day was an outdoor gymnasium for body and character building through the development of athletic skills.

These goals have not changed but others have been added; new categories of childhood experience have been taken into consideration. There has been, for instance, much attention given by psychologists, child development specialists and educators generally to the preschool child. New attitudes toward play, developed first in nursery schools, have liberalized thinking toward all outdoor play areas and resulted in the design of highly distinctive equipment for public areas often called "tot-lots." The effects of this new spirit are seen in an awareness of the child's own scale, in an appreciation of materials that can be used by the active child emotionally and socially as well as physically. Much has been done with objects that stimulate the child's innate skills of improvisation. In addition to sand, water and simple building materials in abstract shapes, boats, trains, wagons and similar toys have been installed in playgrounds for children to use in dramatic play.

While playgrounds in the United States tend to have structural and mechanical equipment, European playgrounds, particularly those in the Scandinavian countries usually have more informal and natural materials; *e.g.*, the simple hardwood trees in Scandinavian playgrounds; the "junk playgrounds" in Denmark where children are encouraged to do their building out of odds and ends with their own tools. This is also a characteristic of the new state nurseries in the U.S.S.R., of the English "adventure" playgrounds and those of the "Pro Juvente" movement in Switzerland, one example of which is the famous Robinson Crusoe playground in Zurich. In the Netherlands there has been an attempt to adapt portions of residential streets for use as playgrounds.

Another influential development has been the amusement park or kiddie land, of which the most famous example is California's Disneyland where the old fairy tales and nursery rhymes are brought to life and animated mechanically. Though the child participates only as a spectator, and therefore passively, these storybook playgrounds are genuinely popular. They have introduced new materials, particularly plastics with their bright colours and resilient textures, to the construction of playground equipment and have brought new gaiety and liveliness into the design.

Indeed, design has become a major factor in the contemporary playground. Formerly the area was considered as an open space to be outfitted with standard equipment from the manufacturers; it has now become a challenge to the landscape architect, the industrial designer and the sculptor. Moller-Nielsen in Sweden and Seebacher-Konzut in Vienna are two of the foremost designers of this new play sculpture; in the U.S., the foremost landscape architects are Eckbo and Royston. Almost everywhere where there are new playgrounds, exciting and original work is being produced.

STANDARDS

Park and playground standards vary from one country to another not simply because parks and playgrounds are planned in relation to varying population densities and diverse physical and cultural patterns. The idea of standards of any kind is a fairly recent one and an outgrowth of the prior notion that cities themselves can be planned for the health and recreation of their citizens; that is, in a rational way by responsible agencies with certain definite technical means at their disposal.

In the layout of the new planned towns and cities, Chandigarh in India, Kitimat in Alaska, Valingby in Sweden and Brasília in Brazil, definite standards as to recreation space have been adhered to. In Chandigarh, communities of from 8,000 to 20,000 have been planned within a $\frac{1}{2}$-mi. radius of the local community centre or sports field, slightly less than a 15-min. walk. This agrees roughly with the standards of the other new towns.

In older cities, city planning must have been well established and effective over a relatively long period for standards to have any validity. In Zurich, there are playfields and social centres serving well-defined neighbourhoods within an average walking distance of $\frac{5}{8}$ mi. from each residence. This pattern is the result of careful planning and a social outlook which is less in evidence in cities where development is in the hands of the uncontrolled speculative builder.

Standards throughout the United States and Canada have been perhaps the most widely publicized. The National Recreation association (N.R.A.) recommends for neighbourhood playgrounds from 3.25 to 6 ac. to serve a population of 2,000–6,000 or about 1 ac. for each 800 persons. The area should be located within an average of $\frac{1}{4}$ mi. walking distance from each residence. Playfields with recreation building should be from 12 to 20 ac. to serve a population of 20,000 or about 1 ac. for each 800 persons; it should be located within $\frac{1}{2}$ to 1 mi. walking distance. Standards set by the California committee for recreation park areas and facilities (with particular reference to high-density areas in Los Angeles) call for one playground serving a neighbourhood of from 2,000 to 4,000 persons, at an average walking distance of $\frac{1}{2}$ mi. Standards recommended by the Canadian Federation of Mayors and Municipalities agree generally with those of the N.R.A. The figure often quoted as the standard for total recreation space in cities (which would include larger parks, conservation areas, zoos, botanical gardens and concert grounds) is 1 ac. to every 100 persons.

According to the N.R.A. actual figures at mid-20th century for several U.S. cities are as follows:

In Los Angeles, there is 1 ac. total park space for each 500 persons and 1 playground under year-round leadership (including public school playgrounds) for each 11,000 persons. In Philadelphia there is 1 ac. total park space for each 200 persons and 1 playground under active year-round leadership for each 50,000 persons. In Seattle, there is 1 ac. total park space for each 160 persons and 1 playground for each 23,000 persons.

New facilities constructed in the United States are generally of high standard, but there is still a long way to go before coverage is adequate for most urban populations. Perhaps the most encouraging trend, particularly in western U.S., is the increasing use of the public school playground and its facilities (such as auditorium, gym and club rooms) as a community and neighbourhood centre throughout the year.

It is significant that in statistics published for certain European cities, in contrast to those for U.S. cities, relatively little emphasis is placed on small neighbourhood playgrounds, not because they do not exist, but because they are provided by other than public

or governmental recreation agencies. In the newer urban sections particularly, the common building type is the large and openly landscaped housing estate, in which play spaces for the younger children are created as part of the original plan.

In France, where social patterns are again different, younger children's play is oriented more to the family group than to the wider peer group. Also, the quality of play depends less on motor activity and use of apparatus. There is consequently little provision for playgrounds of this type in the parks.

There are many other instances in which standards are almost inapplicable. In Spain, for instance, the private sports club, organized for football, soccer, rowing and other activities, performs a function provided elsewhere by the public authority; there is also the institution of the "Penas" or informal conversational club, in which the boulevard cafe becomes in a real sense a social centre.

In countries where the baroque design tradition predominates, particularly in the Mediterranean countries, there is more spontaneous and open social play and a sense of pageantry that makes use of public squares and boulevards in immeasurable ways.

After World War II, there was an almost world-wide dissemination of playgrounds and facilities of the western type. However, there has also been a growing appreciation of indigenous recreation forms such as folk music, gardening, wrestling or simply a quiet contemplation of nature as in the oriental gardens. Indeed there is implicit in the word playground a dissociation from both home and work that would be incomprehensible to certain cultures not overtaken by the march of industrialism. In part, the recreation movement has followed the industrial revolution, and has been in a sense an answer to certain problems and displacements which might not otherwise have been acute. *See* also CITY PLANNING; ZONING.

See Talbot Hamlin, *Forms and Functions of 20th Century Architecture*, vol. 4, ch. 48–49 (1952). (R. B. NI.)

PARKER, ALTON BROOKS (1852–1926), U.S. jurist and Democratic candidate for president in 1904, was born in Cortland, N.Y., May 14, 1852. He graduated from the Albany Law School in 1873 and began to practise law in Kingston, N.Y. After serving as surrogate of Ulster County for several years he was appointed justice of the State Supreme Court in 1885 to fill a vacancy and was regularly elected the next year. He was appointed to the New York Court of Appeals in 1889 and in 1897 was elected chief justice of the Court of Appeals by a large majority.

Following the defeat of William Jennings Bryan in 1896 and 1900, Democrats of the East, seeking a conservative candidate for president in 1904, turned to Parker. Before the national convention Parker held aloof from politics, for he did not want to compromise his position as a judge. At the St. Louis convention of the Democratic Party he was nominated on the first ballot. In the November election, however, he lost to the Republican candidate, Theodore Roosevelt, by a wider margin than Bryan had lost in the two preceding campaigns. Parker thereupon resumed the practice of law in New York City, representing organized labour in important cases and serving as counsel for the managers of the impeachment of Gov. William Sulzer of New York in 1913. He died in New York City on May 10, 1926. (H. F. Tt.)

PARKER, FRANCIS WAYLAND (1837–1902), U.S. educator, a founder of what is commonly called the progressive education movement, was born in Bedford, N.H., Oct. 9, 1837. He started to teach at age 16 and five years later (1858) became school principal in Carrolton, Ill. After service in the Union Army during the Civil War he resumed teaching until 1872 when he went to Germany to study the new educational practices pioneered by Pestalozzi, Herbart, and Froebel.

Parker's main work was accomplished as school superintendent in Quincy, Mass., and as head of the Cook County Normal School in Chicago, Ill. His pedagogy was essentially progressive, advocating self-expression, activity, and a humanized instruction that stressed the child's individuality and the teacher's artistry. (*See* also PROGRESSIVE EDUCATION.) Parker emphasized arts and crafts and urged the correlation of subjects around a common core. Much of this was basically European, but Parker was no mere borrower. In an era when principals were tsars in their schools, Parker favoured the democratic process. To encourage understanding and cooperation, he convened his teachers in weekly discussions and organized the first parent-teacher group in Chicago. The private progressive Francis W. Parker school in Chicago was named after him. Parker died on March 2, 1902.

For Parker's views *see* his *Talks on Teaching* (1896) and *Talks on Pedagogics* (1894).

See Adolphe E. Meyer, *An Educational History of the American People* (1957). (A. E. M.)

PARKER, SIR (HORATIO) GILBERT (1860–1932), Canadian-born politician and writer of popular adventure fiction and historical romance, was born at Camden East, Ont., Nov. 23, 1860. He was educated at local schools, Ottawa Normal School and Trinity College, Toronto. In 1885 he went to Australia and traveled extensively in the South Seas; in 1889 he moved to London and soon became known for his skill in weaving spirited stories out of energetic action, vivid characters, and rich local colour. In politics he became a prominent imperialist and was a member of Parliament for Gravesend from 1900 to 1918. Knighted in 1902, he was made a baronet in 1915 and a privy councilor in 1916. He died in London, Sept. 6, 1932, but was buried in Belleville, Ont.

Parker first made his mark as a writer with *Pierre and His People* (1892) and other dramatic tales of the Canadian northwest and of French Canada. The most widely read of his 33 volumes were *The Seats of the Mighty* (1896), a romance of the conquest of Quebec; *The Battle of the Strong* (1898), a historical tale of the Channel Islands during the Napoleonic Wars; *The Right of Way* (1901), a violent contemporary novel set in Quebec; and *The Weavers* (1907), a melodramatic story of imperialist intrigue in England and Egypt. His collected works were published in 23 volumes (1912–1923).

See C. F. Klinck and R. W. Watters, *Canadian Anthology* (1955). (G. H. Ro.)

PARKER, HORATIO WILLIAM (1863–1919), U.S. composer, conductor, and teacher who helped establish the character of U.S. music at the beginning of the 20th century, was born at Auburndale, Mass., on Sept. 15, 1863. He studied with G. W. Chadwick in Boston and with J. G. Rheinberger in Munich. On his return to the U.S. he taught counterpoint at the National Conservatory of Music, New York City, where he also came under the influence of its director, Antonin Dvorak. His reputation was established with his oratorio *Hora Novissima* (New York City, 1893), and in 1894 he was appointed professor of music at Yale, forming the New Haven Symphony Orchestra there. He conducted his works in England and was made an honorary doctor of music at Cambridge in 1902. His works include two operas, *Mona* (New York City, 1912) and *Fairyland* (Los Angeles, 1915); choral works, including the ode *Hymnos Andron*, written for the bicentenary of Yale University, and the morality *The Dream of Mary*, for soloists, chorus, and orchestra; and many organ works and songs. His book *Music and Public Entertainment* (1911) deals with social aspects of music. He died at Cedarhurst, L.I., N.Y., on Dec. 18, 1919.

See D. S. Smith, "A Study of Horatio Parker," *The Musical Quarterly* (April 1930).

PARKER, SIR HYDE, BART. (1739–1807), British admiral who commanded the fleet at the Battle of Copenhagen (1801) and was the author of the signal to which Nelson turned his blind eye (*see* NELSON, HORATIO NELSON, Viscount). The second son of Vice-Admiral Sir Hyde Parker (1714–82), he entered the Navy at an early age, and became lieutenant in 1758. Five years later he became a post captain, and from 1766 served in the West Indies and in North American waters, particularly distinguishing himself in breaking the defences of the North River (N.Y.) in 1776. His services on this occasion earned him a knighthood. In 1778 he was engaged in the Savannah expedition, and in 1780 his ship was wrecked on the hostile Cuban coast. His men, however, entrenched themselves, and were in the end brought off safely. Also in 1780 Parker served with his father at the Dogger Bank, and in the following year with Howe in the two actions in the Strait of Gibraltar. In 1793, having just become rear admiral, he served under Lord Hood at Toulon and in Corsica, and two years

later, as a vice-admiral, he took part, under Hotham, in the indecisive fleet actions of March 13 and July 13, 1795. From 1796 to 1800 he was in command at Jamaica. In 1801 he was appointed to command the fleet destined to break up the northern Armed Neutrality, with Nelson as his second-in-command. Copenhagen fell on April 2 to the fierce attack of Nelson's squadron, Parker with the heavier ships taking little part. Subsequently Parker hesitated to advance up the Baltic, a decision which was severely criticized. In May he was recalled and Nelson succeeded him. He died on March 16, 1807.

PARKER, MARTIN (*c.* 1600–*c.* 1652), English ballad writer whose best-known song "The King enjoyes his own again" (1645?) was a favourite with royalists and Jacobites in the 17th and 18th centuries. He may have been a London tavern keeper and apparently began publishing ballads about 1625. Many, with his signature or initials, are preserved in the British Museum, London.

Parker was acknowledged by his contemporaries as the "popular" poet laureate and by John Dryden as the best ballad writer of his time. His ballads were tuneful, topical, and often amusing: one, "Saylors for my Money," inspired Thomas Campbell's "Ye mariners of England." Parker died about 1652.

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PARKER, MATTHEW (1504–1575), archbishop of Canterbury whose modest statesmanship during his primacy did much to establish and strengthen the moderate character of the Elizabethan church settlement, was born at Norwich on Aug. 6, 1504. He went to Corpus Christi College, Cambridge, in September 1520 and became a fellow of the college on being ordained priest in 1527. He was in sympathy with the Cambridge Lutheran Reformers of the 1520s and went to Norwich to see Thomas Bilney of Trinity Hall burned for heresy in 1531. From 1535 to 1547 he was dean of a college of priests in Suffolk. In the reign of Henry VIII he was also chaplain to Anne Boleyn (1535), chaplain to the king (1538), and canon of Ely (1541). In 1544 he was elected master of Corpus, where he remained until his resignation, under Mary, in December 1553. He was the most notable master in the history of the college and helped to write statutes by which it was governed until 1861. He was vice-chancellor of the university in 1545 and again, under Edward VI, in 1549. He married in 1547; his wife, Margaret Harlestone, died in 1570. Parker's loyalty and generosity to Corpus and to Cambridge (especially after he became archbishop) are striking traits of his character. Under Edward VI he was also appointed dean of Lincoln (1552). Under Mary I, when many of his friends went into exile, he lived privately in England, working on such things as his English verse version of the Psalms (published *c.* 1567).

Parker was consecrated archbishop on Dec. 17, 1559, 13 months after Elizabeth I's accession and the death of Archbishop Reginald Pole. The validity of his consecration has been a point of controversy. Elizabeth's choice of Parker as archbishop was an indication of the moderation of her church settlement. Next in importance to that moderation, among Parker's contributions to the Church of England, was his appeal to history and sound learning. At Lambeth Palace he organized the collecting of manuscripts from the dissolved monastic libraries; some of these he gave to the Cambridge University Library, but most (more than 430 volumes, including 40 Saxon manuscripts and the so-called Canterbury Gospels) to Corpus. Under his auspices were printed texts of medieval English historians such as Matthew Paris; translations of Saxon sermons; and a Saxon version of the four Gospels (1571), to prove (wrote John Foxe in the preface) "how the religion presently taught in the church is no new reformation but rather a reduction of the church to the state of old conformity." With the same motive Parker compiled his own *De antiquitate Britannicae ecclesiae* (1572), "to note at what time Augustine my first predecessor came into this land, what religion he brought with him, and how it was continued." As an author, then, he indulged in scholarly propaganda, not theological controversy.

As archbishop, Parker supervised the revision of Cranmer's 42 doctrinal articles of 1553: the Thirty-Nine Articles were printed in 1563 and authorized in 1571. He also organized a new translation of the Bible, himself translating Genesis, Matthew, and some Pauline Epistles; this Bishops' Bible (1568) was official until the King James Version (1611). But the main theme of Parker's primacy was the increasing conflict with the extremer reformers in the Church of England (known from about 1565 as Precisians or Puritans). His rules for clerical conformity, called the "Advertisements," were printed in March 1566, being based on ordinances he had prepared a year earlier after a strong letter from Elizabeth (January 1565) about "unity, quietness and concord." But Parker got little support and won few victories; not until John Whitgift became archbishop in 1583 were the Puritans effectively dealt with. Parker died at Lambeth on May 17, 1575, at the age of 71, apprehensive about the future of his church. His motto expresses his consolation and his sense of life as pilgrimage: "The World Passes and the Desire of It."

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PARKER, THEODORE (1810–1860), U.S. theologian, preacher, and social reformer, influential in many phases of mid-19th-century American life, was born at Lexington, Mass., on Aug. 24, 1810, the grandson of Capt. John Parker, who had led the Lexington minutemen. He is believed to be the source of Lincoln's formula: "government of the people, by the people, for the people."

After studies at the district school and the Lexington Academy, Parker became a schoolmaster at 17. He passed entrance examinations to Harvard College in 1830 but did not reside at Cambridge until he began theological studies in 1834. Graduating in 1836, he was ordained pastor of the Unitarian Church in West Roxbury the following year. His journal from divinity-school days shows knowledge of 20 languages; despite his tendency to echo faculty opinions, he made independent use of German biblical scholarship and entertained doubts of some orthodox doctrines.

On graduating, Parker began translating Wilhelm M. L. De Wette's *Beiträge zur Einleitung in das Alte Testament* (published in 1843). His interest in "higher criticism" reflected his concern for a scientific methodology in religion which would make possible rational belief and bring about moral and ecclesiastical reforms. Though critical of popular religion, he appraised Christianity as the highest evolutionary development of universal and absolute religion. By 1841 he had formulated his rationalistic views and incorporated them in a famous sermon on "The Transient and Permanent in Christianity." The following winter he elaborated his position in lectures published as *A Discourse of Matters Pertaining to Religion.* Soon thereafter he resigned the West Roxbury pastorate and was installed as minister of the Twenty-Eighth Congregational Society of Boston. He continued to preach a Christianity reflecting an Enlightenment philosophy and to oppose orthodoxy as unenlightened and inhuman.

Parker's devotion to critical learning was linked with his estimate of America's historic task. He believed that popular ignorance and corrupt leadership required the advancement of intellectual, moral, and religious education. He took up major social questions—including temperance, prison reform, and education of women—and was fearless in his discussion of slavery. He actively assisted the cause of fugitive slaves and supported John Brown in the belief that this cause would precipitate the conflict which Parker saw as inevitable. His influence in political life, though modest, is evidenced by an immense correspondence, much of it with public leaders of his day.

He became ill in 1857 and a violent lung hemorrhage in early 1859 ended all public activity. He vainly sought relief in travel to Europe and died in Florence on May 10, 1860. A scholarly preacher, a critical theologian, and a social reformer, Parker was often numbered among the transcendentalists, but he maintained

a distance from romanticism through his rational, argumentative, and scientific interests.

His writings are collected in *Theodore Parker's Works*, 14 volumes (1863–70), edited by Frances P. Cobbe and published in London; also in the Centenary Edition, 15 volumes (1907–11), published by the American Unitarian Association. A German edition, *Theodor Parkers Sämmtliche Werke*, five volumes (1854–61), was prepared by Johannes Ziethen and published in Leipzig.

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PARKERSBURG, a city of West Virginia, U.S., and seat of Wood County, is located at the confluence of the Little Kanawha and Ohio rivers about midway between Pittsburgh and Cincinnati. Settled about 1785 as Neal's Station on a land tract originally purchased by Alexander Parker, it was first chartered by Virginia in 1820, and rechartered by West Virginia in 1863.

The city is the marketing centre for a large agricultural and industrial area in the mid-Ohio and Little Kanawha regions. Raw materials and natural resources include oil, natural gas, sand, gravel, clays, hardwoods, and brines. Around these a diversified industry developed including oil well equipment, glass and porcelain products, rayon, shovels, iron and steel, and chemicals.

Blennerhassett Island, once the property of Harman Blennerhassett, lies just below the city.

For comparative population figures *see* table in WEST VIRGINIA: *Population*. (S. R. Sm.)

PARKES, SIR HENRY (1815–1896), Australian statesman who was five times premier of New South Wales between 1872 and 1891 and was described as the father of Australian federation. Born on May 27, 1815, at Stoneleigh, Warwickshire, Eng., where his father was a small tenant farmer, Parkes had a hard upbringing and no formal education. He began work at the age of eight and later was apprenticed as an ivory turner at Birmingham, where he became an active member of the Political Union. After unsuccessfully starting in business on his own, Parkes decided to emigrate to Australia. He arrived in Sydney with his wife in 1839. At first he was employed as an agricultural labourer; later he opened a shop where he carried on his trade as an ivory turner. His political activity brought him into public notice; in 1848 he was appointed one of two secretaries for the electoral campaign of Robert Lowe (later Viscount Sherbrooke). In 1850 he launched the *Empire*, a newspaper which continued until 1858. He became a leader in the movement against the reintroduction of convict transportation and was in favour of fully representative government. He was elected to the Legislative Council of New South Wales as a member for Sydney in 1854. Although he resigned his seat eight times and often changed his constituency, Parkes was a member of every New South Wales Parliament between 1856 and 1895 and was a minister for 15 years.

In 1866 he introduced the Public Schools Act, which reflected his opposition to the control of education by religious organizations. It became the foundation of the New South Wales education system. He was always an advocate of free trade and in the series of ministries that he led between 1872 and 1887 he established New South Wales as a "free trade colony." In his fourth ministry (January 1887–January 1889) he was also associated with measures that placed public works and government railways on a sounder basis and restricted Chinese immigration.

Although his support for Australian federation was not always consistent or unqualified, Parkes gave the movement strong support. Having played a prominent part in the organization of the conference of state premiers in 1890, he presided over the subsequent Federal Convention at Sydney in 1891 and was largely responsible for the draft constitution that the convention accepted. During his last ministry he failed to retain the support of the new Labor Party, on which his ministry was dependent, and in October 1891 he resigned as premier and was ousted as leader of the New South Wales free trade group by his rival, George Reid. He died in Sydney on April 27, 1896.

Parkes, the most prominent figure in Australian politics of his time, consistently upheld radical and democratic principles and genuinely sought the welfare of Australia. He did not always press his views and aims with single-minded vigour, but the compromises he made were always realistic and can hardly be said to have diminished his reputation. He wrote several volumes of verse and an autobiography, *Fifty Years in the Making of Australian History* (two volumes, 1892).

See C. E. Lyne, *Life of Sir Henry Parkes* (1897). (J. F. C.)

PARK FOREST, a residential village in Cook County, 11 mi. S of Chicago, in northeastern Illinois, U.S. Developed after World War II, Park Forest attracted widespread interest because its planners assumed responsibilities for all phases of community development.

The builders designed the village primarily for middle-income families, to include rental and privately owned dwellings, as well as schools, churches, shopping centres, municipal services, and an industry park. Construction began in August 1947. From its incorporation in 1949, the community has retained a village organization with a trustee-manager form of municipal government. Commuters are served by railway and bus lines. For comparative population figures *see* table in ILLINOIS: *Population*. (AR. C. H.)

PARKINSONISM, also known as Parkinson's disease, shaking palsy, and paralysis agitans, is a relatively common chronic malady of the central nervous system that produces such striking symptoms that almost any observant person can recognize it at a glance. The stooped posture, the slowness of movement, the carriage of the arms in front of the body, the short-stepped festinating gait, the fixity of facial expression, and the tremor of the hands are the characteristic signs.

The onset of the disease usually occurs in late adult life but it may begin as early as the third decade. The course is slowly progressive over 10 to 20 or more years. The first symptom may be the scuffing of one foot in walking, a sense of heaviness of a limb, or a gentle tremor of one hand; the other symptoms follow in slow procession. The handwriting becomes small and this and other manual skills are gradually lost. Speech is poorly articulated and swallowing and chewing are laborious. Locomotion becomes increasingly difficult and ultimately the patient finds it an effort even to arise from bed or a chair or to walk; and there is a tendency to lose balance and to fall. In the advanced stages the patient is greatly handicapped in all voluntary movements though not as a rule paralyzed. An unexpected call for action may momentarily excite the patient to perform some movement with surprising facility. The senses and the intellect are not damaged.

The cause of the disease is unknown. There is a slight tendency for more than one member of a family to be affected. The nerve cells in certain of the basal ganglia of the brain (the substantia nigra, locus caeruleus, and the globus pallidus, and their afferent and efferent nerve connections) degenerate. The affected nerve cells often contain a cytoplasmic inclusion body (Lewy body). In a closely related disease with almost identical symptoms, *i.e.*, postencephalitic parkinsonism, a virus is believed to attack the same parts of the brain. There is no specific therapy but several drugs, particularly those of the belladonna family, partially alleviate the tremor and muscular rigidity. Several surgical operations on the brain have been proposed to reduce tremor and rigidity. (R. D. A.)

PARKMAN, FRANCIS (1823–1893), U.S. historian best known for his multivolume work *France and England in North America*, and sometimes called America's greatest historian, was born in Boston, Mass., on Sept. 16, 1823, of an old New England family with an illustrious Puritan heritage. Following his admission to Harvard College in 1840, he undertook an extensive reading program in literature and history under the guidance of the historian, Jared Sparks. Despite persistent illness, he entered law school after graduation from college and received his law degree

in 1846. As a historian, he showed a lawyer's persistence in sifting facts and judiciously appraising evidence.

In the spring of 1846 Parkman began a journey across the Great Plains that took him from Independence, Mo., westward along the Oregon Trail (*q.v.*). Pushing on beyond Ft. Laramie to the arid basin of the Medicine Bow River, he lived for a time with the Sioux; he returned to Independence by way of Bent's Fort and the Santa Fe Trail (*q.v.*). This journey, like his college expeditions through the woods of New England and Canada, left an indelible imprint on his historical writings. *The Oregon Trail* (1849), an account of his sojourn on the prairies, is a superb adventure story. His first historical work, *History of the Conspiracy of Pontiac* (1851), a descriptive narrative of the English conquest of Canada and the great Indian uprising of 1763–64, was in part the product of his ethnological observations on the plains.

While these books were being written, Parkman suffered a severe crisis in his health, a combination of partial blindness and violent head pains. His marriage in 1850 to Catherine Scollay Bigelow marked the beginning of a brief period of recovery, but after she died in 1858, leaving him with two daughters, the attacks became more virulent. He managed, however, to publish his *Pioneers of France in the New World* (1865), chronologically the first volume of his great *History*. In the next 27 years, despite frequent periods of illness, Parkman finished his elaborate series by writing six additional histories: *The Jesuits in North America* (1867), *La Salle and the Discovery of the Great West* (1869), *The Old Régime in Canada* (1874), *Count Frontenac and New France Under Louis XIV* (1877), *Montcalm and Wolfe* (1884), and *A Half-Century of Conflict* (1892). Besides an autobiographical novel, *Vassall Morton*, and a number of magazine articles, he also wrote an attractive book on the cultivation of roses. He died at Jamaica Plain, Mass., on Nov. 8, 1893.

The enduring fame of Parkman's *History* is rooted in his penetrating and accurate research, his literary skill, and his responsiveness to the beauties of nature and the variables of human nature. He had the financial means to employ copyists who combed foreign archives for documentary material and he visited the site of every significant episode in his narrative. He studied the primitive Sioux of the plains in order to write about the 17th-century Iroquois, thus pioneering in comparative ethnology.

Parkman brought remarkable sympathy and understanding to his study of New France. The great Jesuit martyrs and his other heroes—La Salle, Frontenac, and Montcalm—stride through his pages in the spirit of their age. Using the techniques of the novelist, he created a living image of the past, for he believed historical writing was a romantic art. Economic, institutional, and political history were all woven into a dramatic fabric. He demonstrated that authentic history could be made as fascinating as a great novel, and this was probably his greatest achievement as a historian.

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PARK RIDGE, a residential city in Cook County, 13 mi. NW of Chicago, in northeastern Illinois, U.S. The town site developed around a brickyard founded by George Penny and Robert Meachem in 1854. Known first as Pennyville, then Brickton, the village was organized as a residential community and renamed Park Ridge in 1873, following the exhaustion of its clay deposits. Proximity to Chicago and location on the Chicago and North Western railway brought a steady growth without industry. It was incorporated as a city in 1910. The family home of John Alden Carpenter (*q.v.*), the U.S. composer, later became the city hall. Rapid expansion occurred after the 1940s with the suburban movement of business and the nearby construction of Chicago-O'Hare International Airport. In 1950 the city adopted a council-manager form of government. For comparative population figures *see* table in ILLINOIS: *Population*. (AR. C. H.)

PARLEMENT, the "sovereign" or "superior" court of judicature under the *ancien régime* in France. The word is derived from the verb *parler*, "to speak"; and originally, in France and in England alike, it meant simply speech or dialogue, occurring in this sense in the *Chanson de Roland* of the early 12th century and being so used by Racine as late as the 17th. The latinized forms *parlamentum* and *pallamentum* date from the 13th century.

Origin.—It was an ancient tradition of the monarchy in France that the king should consult with his council for purposes of government; and the early Capetian kings periodically convened their principal vassals and the prelates of the kingdom to deliberate with them on feudal and political matters in the *curia regis*, or king's court. These gatherings took place at some great festival of the liturgical year and were held wherever the king might be residing. The king, however, was not only the political and military head of the kingdom, but also the fount of all justice, so that it was natural that the *curia* should be invited to take cognizance of the few legal cases submitted to him as sovereign judge. Though the king would always insist in principle on his general competence as judge, that competence was not formally defined, and it was not compulsory to submit cases to him for judgment; nor was there at first any system of appeal in the modern sense. On the other hand political problems in the Middle Ages were most often treated in the form of a judicial argument.

Throughout the 12th century and in the first decades of the 13th the *curia regis* grew in importance; and, besides the magnates participating in it, the records begin to mention *consiliarii* (Fr. *conseillers*, councilors or counselors), who were evidently members of the king's permanent entourage, retained by him as his professional advisers. By a slow process, meanwhile, the judicial sessions of the *curia regis* came to be differentiated from its meetings for other business; and by the middle of Louis IX's reign (1226–70) these judicial sessions were being described as *curia regis in parlamento*, or *parlement*. A system of appeal also grew up, with the *parlement* hearing appeals against the judgments of *baillis* or seneschals; and cases concerning the royal towns were likewise decided by the *parlement*. Furthermore, the expansion of the royal domain enlarged the competence of the *curia in parlamento*, which moreover could serve politically to strengthen the royal power by means of its *arrêts*, or final judgments, since these expressed the king's law with incontestable authority.

In the 13th century the peers of France (*see* PEERAGE) tried to claim that they alone should be judges in cases concerning a peer. The king never acknowledged this claim; and whenever a trial of this sort occurred the other members of the *curia* took part in it as well as the peers. On such occasions the court was described as *garnie de pairs*, and it was by virtue of this purely honorific privilege that the peers of France finally became *ex officio* members of the *parlement*, entitled, should they so wish, to deliberate and to vote on any matter.

Organization.—Louis IX had his *curia in parlamento* installed in a special *chambre aux plaids*, or pleading chamber, in his royal palace on the Île de la Cité in Paris (on the site of the modern Palais de Justice). This palace subsequently became the fixed seat of the *parlement*, though it was not formally declared so till Philip IV's reign. Sessions, which took place four times a year in Louis IX's time, were reduced to two a year by the end of the 13th century. In the 14th century a single session from Martinmas (Nov. 11) till the end of May became the rule. Later it was prolonged to the middle of August.

The first *Olim* books, or early registers of the *parlement*, the most ancient of which contains *arrêts* of 1258, show the names of the same councilors recurring from session to session, though their numbers vary. These men were professional jurists and are designated as *magistri* from 1268 onward. Later they were known as "councilors of the king in his court of *parlement*." Some of them were laymen (*conseillers lais*), some were ecclesiastics (*conseillers clercs*), the latter fewer and fewer as time went on.

The measure of specialization that had been achieved by evolving the *parlement* from the *curia regis* soon proved inadequate to the amount of work to be done. The *parlement* therefore subdivided itself into *chambres*. The first known reference to this subdivision occurs in the ordinance for the *parlement* of January 1278.

The *grand chambre*, as the *chambre aux plaids* grew to be called,

remained the core of the *parlement*. Judgment in cases such as those directly affecting the king's interest or the royal domain was reserved to it; and a peculiar procedure was followed in it. This procedure was known as oral, because originally parties and witnesses had been required to make their statements in person; but eventually the *grand chambre* admitted certain written documents. Even after the venality of offices in the *parlement* had become lawful, an order of seniority was maintained for the passing of councilors from the other chambers into the *grand chambre*.

The *chambre des enquêtes* was one of the earliest subdivisions. At first the *enquêteurs* (Lat. *magistri inquestarum*) or *auditeurs* had been an auxiliary staff of clerks whose function was to conduct the inquests ordered by the *parlement* itself. Later, when the system of appeal grew and when the *parlement* began to admit written evidence, the *appel par écrit* (appeal by writing) came into use beside the older procedure, and the *parlement* had to take cognizance of inquests made under the jurisdiction of other courts. The *enquêteurs* then had to make an abstract of the written documents and present a report on them. The next step was to allow the *rapporteurs*, who framed the reports, to judge the cases together with a number of councilors of the *parlement;* and from 1307 onward the *chambre des enquêtes* was in being. Even so, for a long time all cases brought before the *parlement* were still received in the first place by the *grand chambre*, which would then send some of them to the *chambre des enquêtes;* and the *grand chambre* debated questions arising from the reports of the *chambre des enquêtes* and gave effect to the latter's decisions, which moreover it might revise. Gradually all these restrictions lapsed, till by the 16th century they were quite forgotten. Additional *chambres des enquêtes* were created after the first one: from 1454 there were two such *chambres*, from 1568 there were five. In fact they did most of the work of the *parlement*. Their decisions were called *jugés*, as distinct from *arrêts*.

The *chambre des requêtes* had a very different function. In the early years of the 14th century some of the councilors were nominated to receive and judge the *requêtes* (petitions) on judicial questions which had been presented to the king. This practice duly led to the formation of a chamber proper; but members of this *chambre des requêtes du palais* must be distinguished from the *maîtres des requêtes de l'hôtel* (masters of petitions of the king's household). The latter were entitled to sit in the *grand chambre* and had a room of their own within the palace but belonged strictly to a separate body under the direct control of the chancellor. The business of the *requêtes* in the *parlement* came to be limited to the civil suits of those privileged persons or corporations to whom the king, by letters of *committimus*, had given the right of having their cases evoked from lesser jurisdictions. A second *chambre des requêtes* was created in 1580.

The *chambre de la Tournelle* (so named because it sat in a turret in the palace) was the criminal chamber. Though it was not formally instituted till 1515, it was in being much earlier. It had no fixed membership, lay councilors taking turns to serve in it (ecclesiastical councilors could not participate in judgments that might end in a death sentence). The *Tournelle civile*, a chamber introduced to deal with civil cases involving nothing worth more than 3,000 livres, functioned only from 1667 to 1691.

The *chambre de l'Édit* (so named from the edicts of Poitiers and of Nantes, which successively established it), comprising Catholic and Huguenot councilors for affairs of Huguenot interest, was in being from 1577 to 1585 and from 1598 to 1669.

The *chambre de la marée* was an administrative section, controlling the supply of fish to Paris for days of abstinence.

The presidents of the chambers were councilors entitled to conduct audiences and deliberations. Till the 1340s there were regularly at least two presidents of the *grand chambre*, one lay, one ecclesiastical, but from 1345 it was determined that there should be three presidents, so that the balance between lay and ecclesiastical had to lapse; and gradually the number was increased to eight. Of these presidents of the *grand chambre*, called *présidents à mortier* because of their distinguishing headdress, the chief was the premier president, who was second only to the chancellor in the judicial hierarchy.

Vacant seats in the *parlement* in the later Middle Ages were supposed to be filled by election or co-optation; but from the end of the 15th century they were in practice being sold, and in 1522 venality was formally recognized as regular by the institution of the Bureau des Parties Casuelles for dealing in offices. These sales were so profitable to the government that in 1554 the system of the *semestre* was introduced into the *parlement* of Paris, each office being granted to two holders, who sat by turns every six months; but this was dropped in 1558. Attempts to abolish venality (1560 and 1566) came to nothing; and in 1604 the "annual right" or *paulette* (devised by the financier Charles Paulet) was established, enabling officeholders to ensure the hereditability of their office by paying one-sixtieth of its purchase price every year. The office of premier president, however, could be acquired only by a nominee of the crown.

Provincial Parlements.—Originally there was only one *parlement*, that of Paris, but later others were created for the provinces of the kingdom. Sometimes it might be desired to preserve to a newly annexed territory the sovereign jurisdiction which it had had under foreign rule; sometimes, when a great fief of the kingdom was reunited to the French crown, a *parlement* was established to take the place of its superior jurisdiction, from which, before reunion, the crown would have sought to institute a right of appeal to the *parlement* of Paris. There might however be an interval during which delegates from Paris would hold assizes in the province before a separate *parlement* was created.

The first provincial *parlement* was that of Toulouse, for Languedoc (1443). The others were those of Grenoble, for Dauphiné (1453); of Bordeaux, for Guienne (1462); of Dijon, for Burgundy (1477); of Rouen, for Normandy (1499, when the seat of the Norman exchequer was fixed, though it was not named a *parlement* till 1515); of Aix, for Provence (1501–02); of Rennes, for Brittany (sessions alternating between Rennes and Nantes from 1554, fixed at Rennes from 1580); of Pau, for Navarre, that is to say for Béarn and Basse-Navarre (1620); of Metz, for the Three Bishoprics and adjacent territories (*see* LORRAINE; 1633); of Tournai, for Flanders (1670; transferred to Douai after the loss of Tournai by France in 1709); of Besançon, for Franche-Comté (1676); of Trévoux, for Dombes (1762; merged with the *parlement* of Dijon in 1771); and of Nancy, for ducal Lorraine (1775). In addition to these, there were organs exercising the same functions in other provinces, but designated as "sovereign councils" or "superior councils," not as *parlements*.

The provincial *parlements* were organized on lines similar to that of Paris and claimed to possess equal powers. But the *parlement* of Paris had jurisdiction over nearly half of the kingdom.

Powers and Pretensions.—The *parlements* had a practically legislative power insofar as they could promulgate *arrêt de règlement*, or decisions on previously uncertain points of law, which were of general application and of lasting validity as interpretations of custom or of the statutes. They also had certain administrative duties: the *parlement* of Paris, for example, was ultimately responsible for the town's highways and thoroughfares, for the control of building, for public decency, for sanitation, and for the food supply.

The political pretensions of the *parlements* were based on the usage of having the king's edicts and letters patent registered by them. This registration, introduced in the first half of the 14th century for practical convenience, became a routine for the promulgation of new measures; but from it there grew a right of remonstrance. Before registering a measure, the *parlements* "verified" it; *i.e.*, they examined it to see whether it conformed with the principles of law and justice and with the interests of king and kingdom; and if it did not, they withheld registration and addressed remonstrances to the king. Apart from its concern with secular matters, the *parlement* regarded itself as the custodian both of the Catholic faith and of the rights of the Gallican Church and so was usually prompt to remonstrate not only against measures of tolerance for heretics but also against papal bulls or concordats which the king might wish to accept but which the *parlement* regarded as encroachments on the Gallican liberties.

Remonstrance was in fact a way of performing that duty of

counsel which more than one ordinance had expressly enjoined on the *parlements*. But to the royal government it came to appear as obstruction. When the king wished to force a *parlement* to registration, he would either send a *lettre de jussion*, ordering it, or come in person, to hold a *lit de justice*, at which his actual presence suspended any delegation of authority to the magistrates.

The right of remonstrance, which was also enjoyed by other sovereign courts, such as the *chambre des comptes* and the *cour des aides*, enabled the *parlements*, in the latter centuries of the Middle Ages, to exert a counterbalancing influence in relation to the royal power, though this influence was restricted and negative insofar as the courts had no right of initiative in political matters. With the troubles of the 16th century and of the first half of the 17th a change came about. The *parlements* took up a course of systematic opposition, which reached a peak at the beginning of the Fronde (*q.v.*) in 1648. It was to prevent any more opposition that Louis XIV first set a time limit for remonstrances (ordinance of 1667), then prescribed that registration should always precede remonstrance (letters patent of 1673). No more remonstrances were made for the rest of the reign; but on Louis XIV's death (1715) the *parlement* recovered its old right, primarily because its connivance was required in order to inaugurate the regency of the duc d'Orléans for Louis XV. Thenceforward the *parlement* of Paris resumed its role of opposition, challenging the government over financial matters and, especially, over the application of the bull *Unigenitus* (which it had hesitated to register in 1714) against the Jansenists. From Paris opposition spread to the provinces; and in the 1760s the quarrel of the Breton *parlement* against the royal government provided a sensational example, with La Chalotais and the duc d'Aiguillon (*qq.v.*) as protagonists. Acting in solidarity with the Bretons, the *parlement* of Paris provoked the *coup d'état* of the chancellor de Maupeou (*q.v.*) in 1770–71; but Maupeou's work was undone on the accession of Louis XVI (1774).

The venality of offices had transformed the *parlements* into the reserve of a self-perpetuating caste. If an office was not passed from generation to generation of the same family, it was bought by some ambitious bourgeois who could thereby enter the *noblesse de robe*, or nobility of the judge's robe (red in the case of the *parlementaires*). The opposition of these men was motivated, to a large extent, by anxiety to maintain their own privileges; but it served to focus more general feelings of political and social discontent. This discontent broke out in the French Revolution (*q.v.*), which swept the *parlements* into oblivion even before the destruction of the monarchy: by the Constituent Assembly's decree of Nov. 3, 1789, they were suspended and by that of Sept. 7, 1790, they were abolished.

For the *parlements* of 19th- and 20th-century France, where the word is used in a sense like that of the English Parliament (*q.v.*), *see* FRANCE: *History* and *Administration and Social Conditions*.

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(MI. F.)

PARLEY, PETER: *see* GOODRICH, SAMUEL GRISWOLD.

PARLIAMENT, the name given originally to the legislature of England, which became successively the Parliament of Great Britain under the Union with Scotland Act (1707), the Parliament of the United Kingdom of Great Britain and Ireland under the Union with Ireland Act (1800) and the Parliament of the United Kingdom of Great Britain and Northern Ireland under the Royal and Parliamentary Titles Act (1927). The name was also applied to the legislatures of Scotland and Ireland, abolished in 1707 and 1800 respectively, and to that of Northern Ireland. It has been extended to the legislatures of other independent countries within the British Commonwealth which were once under British rule and is often used informally as the English equivalent of the local name for a foreign legislature.

In relation to the Parliament of the United Kingdom the word is often used loosely. In strict law the legislative authority is the king (or queen regnant) in Parliament, *i.e.*, the formal sitting of the sovereign with the Lords spiritual and temporal in their robes, and with the Commons standing at the bar. In practice the real work of legislation is the preparatory work, the consideration of the "bill" which, when assented to by the sovereign, becomes an "act of Parliament." This consideration is given separately in the House of Lords and the House of Commons. Hence when it is said that "Parliament is sitting" what is meant is that the House of Lords and the House of Commons are sitting. Because in the 19th century the House of Commons became predominant, it is possible to use "Parliament" to mean the House of Commons only. Thus, responsibility to "Parliament" means responsibility to the Commons. The term "member of Parliament" was originally a loose expression for a knight or a burgess elected to Parliament; strictly speaking he is a member of the House of Commons.

Moreover, the Parliament of England was not, and the Parliament of the United Kingdom is not, exclusively a legislative body. The king (or queen) in Parliament is also the highest legal tribunal for England and Wales, Scotland, and Northern Ireland, the "High Court of Parliament." This judicial work is, however, done by the House of Lords, or a committee thereof. Hence we commonly speak of an appeal to the House of Lords when we mean an appeal to the king (or queen) in Parliament.

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I. THE PARLIAMENT OF ENGLAND

1. Origins.—Modern parliaments arose through a fusion of the legislative and judicial functions and the voting of taxation or supply. In medieval times a *parlement* or *parliamentum* was usually a meeting of the king in council to which the judges were summoned for the consideration of pleas and petitions (or bills) to

the king to redress grievances. Under the Norman kings the functions were undifferentiated. At a sitting of the *curia regis* (king's court or council), petitions might be considered and disposed of by what would be called a judicial determination, or by an order to a sheriff to see that right was done, or by a general order which partook of the nature of legislation. The creation of separate courts for what would be called judicial business—the Court of Common Pleas, the Court of King's Bench, the Court of Exchequer, the courts of justices in eyre, and courts of justices assigned—left to the council in parliament (*concilium regis ad parliamenta sua* or *in parliamento*) the consideration of extralegal petitions, for instance, petitions that the law operated harshly, or that justice could not be obtained because of the influence of a powerful baron. Where the order was, to use modern language, legislative, its purpose was not to change the law but to improve it, since law was thought of not as legislation but as custom. Everybody knew what duties a tenant owed to his lord, or the lord owed to the king; but it might prove desirable formally to set out what rights lords of manors in general had to enclose the waste land of their manors.

On the other hand, the word *parliamentum* might be applied to what was more usually described as a *colloquium*, a meeting of the clergy, or the lords, or the representatives of counties or boroughs, or merchants, or any or all of them. Such a *colloquium* might be summoned, for instance, to discuss measures for dealing with raids by the Scots over the border, or the sending of an army to Gascony. More often the purpose was to obtain assent for the levying of an aid or customs duties. Usually the cause of the summons was not stated, except in general terms. For instance, knights and burgesses were summoned to the parliament of 1275 by Edward I *ad tractandum una cum magnatibus regni nostri de negotiis ejusdem regni* ("to discuss with the magnates the affairs of the kingdom"). At that Parliament, the Statute of Westminster I was enacted with the assent of the archbishops, bishops, abbots, priors, earls, barons, and the commonalty of the land; and the customs duties on wool, woolfells, and leather were granted to the king. The former document, which is in Norman-French, uses the word *parlement;* and the latter, which is in Latin, uses *parliamentum.* This was no innovation, for the statute says that it was Edward's "first parliament general after his coronation," showing that there had been previous "parliaments" of this kind.

This second sort of "parliament," or *colloquium*, to which clergy, lords and commons, or some of them, were summoned *ad tractandum* was usually also a meeting of the king's council in Parliament. Pleas and petitions could therefore be heard and orders given by authority of the king in council. If the meeting was merely a *colloquium* of the magnates, and there was not to be a meeting of the council in Parliament, the intention was clearly marked, at least under Edward II. The writ issued was *de tractatu habendo*, and not *de veniendo ad parliamentum*. If both functions were to be exercised, the "king's business," *i.e.*, the matters for which the magnates and commons had been summoned, was taken before the pleas and petitions of subjects; and the magnates or the commons, or both, might be dismissed before the hearing of pleas and petitions was completed, because the council was still *in parliamento.*

2. Composition of Early Parliaments.—This account of the development of Parliament shows that it is not possible to say when it began. It is, indeed, simply the *curia regis* of the Norman kings. The first known use of the word *parlement*, in relation to the council, comes from the later years of Henry II; but *parlement* is simply a parley, so that "parliament" could be used of any meeting and is still used of meetings of benchers of some of the Inns of Court. It was, as stated, used officially in the Statute of Westminster I of 1275. The writs *de veniendo ad parliamentum* began, so far as is known, under Edward I. The Parliament rolls and the statute rolls began in 1278. The Anglo-Saxon witan (*q.v.*) was basically a *colloquium* of magnates, and the *magnum concilium* of the Norman kings was much the same sort of assembly except that after the Conquest the majority of baronial councilors would be the king's tenants in chief, bound by feudal law to attend his court. The use of representation for counties, hundreds, boroughs, and vills is also a Norman device, much developed by Henry II. The summoning of representatives of counties and boroughs to treat with the magnates began under Henry III; and Edward I's Parliament of 1295 was a "model" only in the sense that the idea of summoning two knights from each shire and two burgesses from each borough, which later became the rule, was then accepted. Edward I, though not an innovator, may be regarded as the king who first made extensive use of councils in Parliament afforced by the magnates and the representatives of counties and boroughs (*see* EDWARD I; ENGLISH HISTORY, *The 13th Century*).

3. Separation of Council from Parliament.—The business of the council in parliament gradually diminished as remedies for wrongs or grievances became available elsewhere. The Court of Common Pleas may be said to have become distinct from the end (1216) of John's reign; the court *coram rege* (*see* QUEEN'S BENCH, COURT OF) was distinct from the end of Henry III's reign, though there was no formal separation from the council until the end of the 14th century; the Court of Exchequer was distinct from the end of the 13th century. Moreover, these courts dealt with an increasing range of wrongs, especially through the development of the writs of trespass and trespass on the case. A later development was the power of the chancellor to give a remedy for a wrong which could not be remedied at common law. At first this was done by reference from the council, but when petitioners discovered that the chancellor had such power they naturally petitioned him direct: in other words, if they thought the chancellor could remedy the grievances, they submitted a "bill in Chancery" instead of a "bill in Parliament." By the beginning of the 15th century he had a recognized jurisdiction over cases which would, in the 13th century, have gone to the council in parliament.

Even more important was the separation of the council from Parliament, which occurred during the 14th century. The council always was in every Parliament, and theoretically it is still there: but when parliaments were infrequent, the council, which might be a small body and need not be afforced by the lords and commons, necessarily dealt with minor grievances. The council became a definite body, and not merely a body summoned *ad hoc*, when during the minority of Richard II councilors were sworn. By the end of the reign of Henry V "council" and "parliament" were different bodies. The council ceased to exercise any considerable jurisdiction under Henry VI, but it was revived under Edward IV and became a most effective judicial or quasi-judicial body under the Tudors and Stuarts, especially in the branch of the council known as the Court of Star Chamber.

4. Growth of Legislative Functions.—This development involved a gradual diminution of the jurisdiction of the High Court of Parliament as a court, and there was a corresponding increase in the importance of its work as a legislature. This, too, was a gradual development, arising out of the fact that petitions were laid before the council in parliament. A petition always ends with a prayer for redress; the particular redress sought may be set out in detail; and if it requires a change or "improvement" in the law it may set out the actual text of the provision sought. This was known as "a bill in the form of an act"; and that is what a bill in Parliament still is, except that in most cases the bill is not a petition with a proposed law annexed but merely a proposed law.

In the 13th century there was no rule that proposed laws should be referred to the lords and commons. Most of the laws from that century in the printed collections of statutes were never so referred. On the other hand, a change in the law, even an "improvement," was a serious matter because it affected customary and feudal rights. Hence, though the law could be made by the council, the bill might be referred to the lords and commons afforcing the council in parliament. The petition might come from a private person, but as other means were found for redressing private grievances, petitions tended to come from bodies of persons or corporations, possibly persons representing or claiming to represent a county, or the clergy, or the merchants. As Parliament became a more important body in the 14th century a distinction grew up between ordinances (laws assented to by the king in council) and statutes (laws based on petitions assented to by the king in Parliament). Since the latter were entered on the

statute roll they enjoyed a high degree of authority. Moreover, Parliament became critical of legislation by ordinance and began to claim a right to be consulted.

The most representative body in the country was, however, the Parliament itself. Petitions by the commons, or by the lords, or both, became common in the 14th century. In that century, and in the early years of the 15th century, the law was framed and enacted by the king in council; but later in the 15th century this was found inconvenient, and the petition, or bill in the form of an act, became common. If this was assented to by the king, with or without amendment, it became an act of Parliament. Complaints that changes were made by the council were common, and Henry V had to agree that nothing would be added to a commons petition. The commons insisted that they be assenters as well as petitioners. Under Henry VI it became regular practice for petitions or bills to be in the form of acts, whether they were initiated by private persons, or by the king in council, or by the lords or commons, and the assent of the lords and commons was required for the actual text. The bill was enacted by the king, by and with the advice and consent of the lords and commons, "and by the authority of the same." The bill no longer needed to take the form of a petition, except when it came from a private person, in which case it was a "private bill"; and a "private bill" is initiated by petition even today. A "public bill" is not; it is simply introduced by a member.

5. Development of the Two Houses of Parliament.—The discussion of bills and grants by the lords and commons necessarily implied debate outside the formal sittings at which the king was present; and, though the groups of clergy, barons, knights, and burgesses sometimes sat separately, the practice developed of the archbishops, bishops, abbots, earls, and barons sitting in one chamber or "house" and the knights and burgesses sitting in another chamber or "house." Strictly speaking there were and still are three "houses": the king and his council, including the judges; the Lords spiritual and temporal; and the Commons or knights and burgesses. Under the Lancastrian kings, however, the king was forced to take most if not all of his councilors from among the Lords; and under the Tudors it became the practice to find seats in the House of Commons for privy councilors who were not lords.

Hence, when the king had explained to the Lords and Commons in Parliament assembled the reasons for their having been summoned (the "king's speech"), the king, the judges, and such councilors as were not lords left the chamber, the Commons went off to some more or less private place (in the 14th century first the refectory and then the chapter house of Westminster Abbey), and the Lords settled down to business in the Palace of Westminster. The business of both Lords and Commons was to consider the matters referred to them by the king, to put into bills any petitions which any member laid before the House, to consider their common grievances, if any, and to draft bills designed to remedy those grievances.

In the House of Lords the chancellor presided as the king's deputy, though he was not allowed to speak unless he was a prelate or a temporal lord. The clerk of the parliaments helped with the drafting and kept whatever records were needed. In the House of Commons a speaker was elected to speak for the Commons when the king returned to Parliament and wanted answers to his questions; he, and he alone, had the right to speak. How and when the speaker became the chairman of the House of Commons is not known. He was presiding when the Commons' journals began in 1547, but there had been speakers at least since 1377 and some of them probably presided; but until the Commons had established themselves under the Tudors they left no records. Until 1547 there were only the records of the clerks of parliaments on the Parliament rolls, and they tell only what happened in the Lords' chamber. The Commons had a clerk (at least from 1363), the second clerk of the parliaments, and in due course he became the clerk of the House of Commons, but he kept no record until 1547.

6. Increased Importance Under the Tudors.—The fact that the Lords' journals began in 1509 and the Commons' journals in 1547 is significant. It shows the increasing importance of Parliament under the Tudors, and especially under Henry VIII. All the great changes effected by Henry VIII were carried out by acts of Parliament. It was still possible to make law by proclamation or ordinance, but the Tudors were too wise to make frequent use of this method, and too popular and conciliatory not to get from their parliaments most of what they wanted. James I was neither wise nor conciliatory, but Chief Justice Coke solved the problem by declaring, contrary to all the facts of history, that legislation by proclamation was and always had been unlawful.

Another innovation of Henry VIII was to keep parliaments in being for years but to interrupt their proceedings and send them home until they were recalled. In other words, instead of declaring a Parliament to be "dissolved," so that new elections for knights and burgesses had to be held when he again needed a Parliament, he merely prorogued it, so that the same knights and burgesses were recalled for a new session of the same Parliament. From the king's point of view this had the advantage that he knew the members and could rely on their support; but it also had the result that members became experienced in parliamentary business and that the House of Commons developed both a formal procedure and an *esprit de corps*.

There was another reason for this developing *esprit de corps*. In the 13th and 14th centuries it was a burden for a county or a borough to send members to Parliament. Their expenses (for traveling, and a daily wage for subsistence) had to be met by the county or borough. In the 15th century it became a privilege to sit in Parliament because it was becoming an important body. Scions of great houses and ambitious men welcomed the chance of being sent to Westminster and were often prepared to waive the expenses. There was consequently a tendency for the same persons to be returned to successive parliaments. When to this practice was added that of keeping a Parliament in being for several sessions, there developed a class of almost professional parliamentarians. Some would be used by the king to secure assent to his measures; others would disagree with some of those measures and encourage the House to reject them, though the idea of a "formed opposition" did not develop until the 18th century and the phrase "his majesty's opposition" comes from the early years of the 19th century (so far as is known the phrase was first used by John Cam Hobhouse, later Lord Broughton, as a joke, in 1826).

7. The Party System.—In a sense, parties began in the reigns of James I and Charles I, in opposition to the king. The distinction between "Whig" and "Tory" (*see* WHIG AND TORY) began, however, over the agitation to exclude James, duke of York, from the throne because he was a papist. After the Revolution of 1688 the Whigs were those who supported the Protestant succession, toleration for Dissenters, and popular liberties. Neither they nor the independent country gentlemen, generally called Tories, were organized in parties. A prominent Whig peer, active in politics, had his "connection," whose members tended to vote the same way, but the modern party system really began to develop after 1783, when the younger Pitt led the Tories and Charles James Fox the Whigs. Effective power was passing from the king to his cabinet; peers and members of the House of Commons began to use the party label; and from 1830, when the Whigs took office under Earl Grey, the two-party system became stricter. *See* also ENGLISH HISTORY.

II. THE PARLIAMENT OF SCOTLAND

1. Origin and Powers.—English institutions were copied in Scotland through the settlement of Anglo-Norman barons in the Lowlands, particularly under David I (1124–53), but the development from *curia regis* to Parliament was slower and diverged from that in England. The term "parliament" first appears in the records in 1293; and, as in England, it was a meeting of the king in council, which was also a *colloquium*. On the other hand, though like the Parliament of England it was a court of law, powers of legislation, taxation, and the making of treaties were also exercised, until the end of the 17th century, by the general council, consisting of prelates, earls, and barons. On occasions, however, burgesses also were summoned. From about 1531 the term "convention" was generally used for a general council. The difference

between a Parliament and a general council or convention appears to be that the latter was a less formal body, summoned more easily and more fluctuating in its personnel. It was in fact an enlarged privy council. From the 16th century, however, there was a closer approximation between a convention and a parliament; the former became in the 17th century a less formal parliament.

The legislation passed by a convention was temporary, since legislative authority was vested in Parliament. The power to levy taxation which the convention possessed is, to an English lawyer, surprising. On the other hand, the kings of Scotland to a greater extent than the kings of England could "live of their own"; the Scottish Parliament, unlike the English Parliament, was under royal control and never became a centre of conflict between prerogative and private rights, though there were instances of the refusal of grants; above all, the Scots had not the large and potentially powerful "middle class" which Tudor prosperity had created in England and which dominated the English parliaments of James I and Charles I. It should be noted, however, that the business of a convention was strictly limited to the matters specified in the royal letters of summons. It had no power of initiation.

2. Composition.—The Parliament of Scotland consisted of the three estates of the realm (a formula adopted not from England but from France), namely the clergy, the tenants in chief of the crown, and the burgesses of the royal burghs. The clergy were the bishops, the abbots and priors, and the inferior clergy. After the Reformation in Scotland (1560), titular bishops sat in Parliament until the restoration of the hierarchy by James VI in 1610; they were not present between 1639 and 1661, or after 1689. The abbots and priors sat as landowners and many were laymen; accordingly they did not disappear at the Reformation. But the "commendators" (laymen who held *in commendam*) disappeared in 1640. The inferior clergy had disappeared by the 16th century, except for those who were royal officers.

Tenants in chief of the crown of Scotland, like those of the crown of England, owed suit of court, but only the more important were summoned personally. Generally, it seems, those so summoned were earls and barons—in Scottish terminology, the "barons" being those tenants in chief who had the right to hold a court. In 1426 legislation of James I, however, resulted in the appointment of "lords of Parliament" who received individual writs and were therefore distinguished from other barons and lairds. The lords of Parliament became hereditary, though the title generally passed with the land. The other barons and lairds were, by an act of 1428, to be represented by commissioners of shires, elected by the tenants in chief in the head court of each shire; but this act never took effect, and some barons and lairds attended Parliament throughout the 15th century. In the 16th century the practice disappeared, and in 1587 the act of 1428 was revived; though the act did not specifically enact that the electors should be 40*s.* freeholders, that rule was in fact adopted from England. They had, however, to be tenants in chief, and the valuation of 40*s.* was determined by what was known as the "old extent," a valuation made only on land held direct from the crown and which increased as the coinage depreciated. Accordingly, changes in the value of money did not, as it did in England, confer and thus widen the franchise. An annual election was contemplated, but after the Restoration in 1660 (and in some cases before) the English practice of having an election only for a new Parliament was followed.

There is no evidence that, up to 1366, any royal burghs were represented in Parliament, though there were instances of their being represented in general council. In that year there is no doubt that commissioners for the royal burghs were in Parliament, apparently because (for the first time) the grant of supply was considered in Parliament. Scotland thus had its "third estate"; and the phrase "three estates" soon became common. The three estates were not, as in England from the 15th century, the king, the lords, and the commons, but the clergy, the lords and lairds, and the burgesses. There was, however, a separate body representing the burghs, the convention of royal burghs (dating from the 14th century), and the commissioners from burghs were in fact also representatives of the convention, which, in respect of parliamentary functions, acted as a sort of "pressure group."

3. The Lords of the Articles.—The parliaments of Scotland were unicameral and the officers of state were always present. The separation into Privy Council, House of Lords, and House of Commons (which implied that active privy councilors were peers or elected members of the House of Commons) did not happen in Scotland. Moreover, the Scottish Parliament did much of its work by delegation to commissioners, who often functioned after the other members had gone home. One result of this process of delegation was that most of the judicial work went to the Court of Session, later to become (1535) the College of Justice. Another result was that much of the other work went to a commission or committee called the Lords of the Articles. In the 17th century it was under royal control and obtained the sole power of initiating business. The only function of Parliament was to receive and approve the report of the Lords of the Articles. This procedure was abolished in 1690.

The parliaments of Scotland were much less representative than the parliaments of England. The most truly representative body after the Reformation was the General Assembly of the Church of Scotland. Parliament was in competition with other bodies, the general councils and the conventions of the royal burghs. The great constitutional disputes of Scotland were, generally, outside Parliament. Parliament itself was virtually controlled, from the time of James III (d. 1488) if not from that of James I (d. 1437), by the Lords of the Articles. Though in the later period of its history it began to look more like the Parliament of England, it never played the part in Scottish life which the English Parliament played in English life. Its abolition in 1707 was not so unpopular as to be impracticable, provided that Scotland obtained, as it did, other advantages from the Act of Union. *See* also SCOTLAND: *History*.

III. THE PARLIAMENT OF IRELAND

The Anglo-Norman settlement of the east and southeast of Ireland enabled Edward I to begin the process of summoning parliaments on the English model, the first known Parliament of Ireland being that of 1297. The archbishops, bishops, abbots, priors, earls and barons, "and other chief persons of this land" were summoned severally; each of the sheriffs of the counties of Dublin, Louth, Kildare, Waterford, Tipperary, Cork, Limerick, Kerry, Connaught, and Roscommon, and the seneschals of the liberties of Meath, Wexford, Carlow, Kilkenny, and Ulster were directed to hold elections in his county court or liberty court and elect two honest and discreet knights. Burgesses were added in later parliaments.

As a result of Poynings' Laws (1494–95) the prior consent of the king in council was henceforward needed for legislation, and all acts required the assent of the king in council (*see* POYNINGS, SIR EDWARD). The Parliament of Ireland had, however, no jurisdiction over the "wild Irishry," *i.e.*, the parts of Ireland that were not under British rule but were governed by tribal law. Thus only after the Cromwellian settlements was the Parliament of "Ireland" really the Parliament of all Ireland. Irishmen were not excluded; but initially the parliaments of Ireland were almost exclusively English because most of the landowners were English who not only elected Englishmen in the county courts but also dominated the boroughs. This also implied that, after the Reformation, the parliaments of Ireland tended to be Protestant, since most of the landowners conformed with the (Protestant) Church of Ireland, while most of the rest of the population, except in Ulster (where Presbyterianism was strong through Scottish immigration) remained Catholic.

Since the Roman Catholics had supported James II until his defeat at the Battle of the Boyne in 1690, the English Parliament in 1691 required every member of the Irish Parliament to make a declaration against transubstantiation, which in effect excluded Catholics from membership, though they still had the franchise until an act of the Irish Parliament in 1727 took it away.

In the 17th century, the right of the English Parliament to legislate for Ireland was challenged. In 1719 the Parliament of Great Britain passed an act declaring that the kingdom of Ireland was subordinate to the kingdom of Great Britain and that the Parlia-

ment of Great Britain "had, hath, and of right ought to have full power and authority to make laws and statutes of sufficient force and validity to bind the kingdom and the people of Ireland." The Anglo-Irish were, however, becoming more Irish than English, particularly because of the economic disabilities under which the Irish suffered. The American Revolution increased the economic difficulties and secured much sympathy in Ireland. The situation became so serious that the British Parliament removed the economic restrictions and, in 1782–83, repealed the act of 1719. An act of the Irish Parliament in 1782 virtually repealed Poynings' Laws. Thus Ireland obtained an independent Parliament, though the government of Ireland was still responsible to the government of Great Britain.

Economic conditions in Ireland did not improve much, and the French Revolution of 1789 strengthened revolutionary movements. Most of the disabilities of Roman Catholics had been removed in 1778 and 1782, and from 1793 they had the vote in theory, though it was not much use to them because of the narrowness of the unreformed franchise and because they could not sit in Parliament. By 1796 rebellion had broken out and there was grave danger of a French invasion. Pitt's solution to the Irish problem was the union of Great Britain and Ireland (1800), which was carried in the Irish Parliament by bribery. Pitt intended to provide for Roman Catholic representation also, but owing to George III's opposition this could not be carried until 1829. *See* also IRELAND: *History.*

IV. THE PARLIAMENT OF NORTHERN IRELAND

The agitation for the repeal of the Act of Union, which Daniel O'Connell began soon after he was elected to Parliament in 1828–29, ended in the rebellions of 1916 and 1919. The Government of Ireland Act (1920) was passed in the hope that it would settle the matter. Under it two parliaments were to be established, one for the six counties of Ulster, the Parliament of Northern Ireland, and the other for the rest of Ireland, the Parliament of Southern Ireland. The Sinn Fein Party, the party in rebellion, fought the election (1921), won every territorial seat, and then boycotted the Parliament of Southern Ireland, which accordingly never met. In December 1921 Southern Ireland became the Irish Free State, and in 1949 it became the Republic of Ireland.

The Parliament of Northern Ireland, on the other hand, is a flourishing institution, a replica of the Parliament of the United Kingdom, in which Northern Ireland is also represented by 12 members. Legally speaking, the Parliament of the United Kingdom has full legislative power in Northern Ireland, but it does not exercise it within the limits of the powers delegated to the Parliament of Northern Ireland, except in agreement with the government of Northern Ireland, *e.g.*, where it is considered that the Government of Ireland Act needs amendment, or where common legislation is enacted so as to avoid a conflict of jurisdiction. *See* also IRELAND, NORTHERN.

V. THE PARLIAMENT OF THE UNITED KINGDOM

A. General Characteristics

1. Composition.—The persons summoned or elected to the Parliament of the United Kingdom are: (1) the archbishops of Canterbury and York, the bishops of London, Durham, and Winchester, and 21 other bishops holding sees in England, in order of seniority as bishops; (2) all the dukes, marquesses, earls, viscounts, and barons in the peerages of England, Scotland, and the United Kingdom, including those men and women who hold life peerages; (3) the judges of the Supreme Court of Judicature (*i.e.*, the judges of the Court of Appeal and the High Court), the attorney general, and the solicitor general; and (4) the members elected for the several constituencies in the United Kingdom. The Lords spiritual and temporal, *i.e.*, groups (1) and (2), are the members of the House of Lords. The judges and law officers in group (3) sit in Parliament when the sovereign is present, but do not otherwise sit unless their attendance is required by the House of Lords for the purpose of advising that House on a matter of law. The members in group (4) are the members of the House of Commons. The lord chancellor, if present, presides over the House of Lords whether or not he is a lord spiritual or a lord temporal, but cannot speak unless he is. The sovereign, when present in person, is attended by his principal officers of state; but, apart from the lord chancellor, they do not sit in either House of Parliament unless entitled as lords spiritual or temporal or as members of the House of Commons. In practice they are in fact so entitled, though there are occasional and temporary exceptions; the British system of responsible government depends for its operation on the presence in Parliament of the members of the government.

Women may be elected to the House of Commons; and they may sit in the House of Lords if they hold hereditary or life peerages in their own right. Peers of England, Scotland, or the United Kingdom may not be elected to the House of Commons, but Irish peers may. The minimum age for membership of both Houses is 21.

2. Meetings of Parliament.—A Parliament is summoned by a proclamation issued by the sovereign. Thereupon writs of summons are issued to the Lords spiritual and temporal. Writs are also issued to the returning officers of constituencies directing that elections be held for members of the House of Commons.

A Parliament is not constituted unless the three estates of the realm, *i.e.*, the sovereign, the Lords spiritual and temporal, and the Commons, are all present. Hence the "great councils" consisting of king and lords, sometimes summoned in medieval England, are now deemed not to have been parliaments—an important matter for those who claim "baronies by writ" on the ground that their ancestors were summoned to and sat in Parliament. Similarly, the "parliaments" summoned between the outbreak of the Civil War in 1642 and the restoration of Charles II in 1660 were not parliaments. The sovereign may, however, appoint lords commissioners to act on his behalf in Parliament, and this is usually done, except that the "speech from the throne" at the beginning of each session is often read by the sovereign in person. Moreover the rule that a Parliament must consist of the three estates does not mean that the House of Lords and the House of Commons may not sit separately in their respective chambers. This is indeed the normal practice, though they may not do business until the business of the session has been put before them in Parliament; nor may legislation be enacted save in Parliament. Parliament consists of the sovereign on the throne, the Lords spiritual and temporal on the benches, and the Commons at the bar: it does not consist of the sovereign, the House of Lords and the House of Commons, sitting separately.

On the day appointed, the members of the two Houses meet in their respective chambers. The lords commissioners appointed by the crown command the gentleman usher of the black rod to let the Commons know that the lords commissioners desire their immediate attendance. The Commons attending at the bar, the letters patent are read and the lord chancellor indicates the sovereign's pleasure that a speaker be elected. The Commons withdraw and proceed to elect a speaker, while the Lords take the oath. Next day the lords commissioners again send for the Commons, and the speaker-elect informs the lords commissioners of his election. The lord chancellor having expressed the sovereign's approval, the speaker claims for the Commons their ancient and undoubted rights and privileges, which are confirmed by the lord chancellor. The speaker leads the Commons back to their chamber, where they take the oath.

On the next day both houses meet again, this time with the judges in the Lords. The sovereign (or the lords commissioners) being present and seated, the Commons are again sent for and the speech from the throne is read. Both Lords and Commons may now proceed to the business of considering the matters in the speech; but, in order to show that grievances may be considered before those matters, each House formally "reads" a bill for the first time.

3. Business in Parliament.—Parliament, strictly so called, does not meet again until either there are bills to be presented for the royal assent or the sovereign desires to prorogue or dissolve Parliament. The real work of Parliament is of course done by the House of Lords and the House of Commons, sitting separately—the considering of bills, the voting of supplies, the appropriation

of the moneys voted, the questioning of ministers, the debate of issues of public policy, and so forth. But only in the loose, popular sense is this "Parliament." When bills are ready for the royal assent, however, lords commissioners are again appointed, empowered by the commission to assent to the bills named, and they take their seats in the Lords. The Commons having been sent for, the commission is read and the title of each bill is read by the clerk of the crown. The clerk of the parliaments then announces the sovereign's assent in the appropriate form, as follows: (1) Bill voting supplies: *La Reyne* [*Le Roi*] *remercie ses bons sujets, accepte leur bénévolence, et ainsi le veult;* (2) Any other public bill or a local bill: *La Reyne* [*Le Roi*] *le veult;* (3) Personal bill: *Soit fait comme il est désiré.* In the unlikely event of the sovereign wishing to refuse assent (it has not happened since Queen Anne refused her assent to a Scottish bill in 1707), the formula would be: *La Reyne* [*Le Roi*] *s'avisera.*

This system of granting or refusing assent in Parliament is apparently unique, and certainly is so among Commonwealth countries. It arises from the historical fact that a bill is a petition to the sovereign presented in Parliament by the Commons with the assent of the Lords, or by the Lords with the assent of the Commons. The petition is in the form of an act, and when the sovereign consents to that act, it is enacted "by the queen's [or king's] most excellent majesty, by and with the advice and consent of the Lords spiritual and temporal, and Commons [not the House of Lords and the House of Commons], in this present Parliament assembled, and by the authority of the same." In Canada, on the other hand, the sovereign legislates "by and with the advice and consent of the Senate and the House of Commons"; the formula is similar in other Commonwealth countries.

But even in the United Kingdom, the Canadian formula better expresses the political reality, as distinct from the constitutional form. The legislation enacted by the sovereign in Parliament has in fact been assented to by the House of Lords and the House of Commons. Since 1886, however, when the Liberal Party was split by Gladstone's Home Rule proposals for Ireland, the House of Lords has been predominantly Conservative. Hence since that date Conservative legislation passed by the House of Commons has never been rejected by the House of Lords, whereas the Conservative Party had a veto on legislation proposed by a Liberal majority in the House of Commons; and, on occasions, it did not hesitate to exercise it (*e.g.*, against Gladstone's Home Rule Bill of 1893 and Lloyd George's Finance Bill of 1909). The only remedy of a Liberal government was to threaten to create enough Liberal peers to give the Liberals a majority in the House of Lords. The precedent for such action had been set in 1712, when Queen Anne created 12 Tory peers, but the threat was used to pass the Reform Bill of 1832, and it was used again in 1911 to pass the Parliament Act which deprived the Conservative Lords of their absolute veto. The procedure contemplated by this act was used to pass the Parliament Act (1949) which amended the 1911 act and further curtailed the Lords' powers.

Effect of the Acts of 1911 and 1949.—The Parliament acts of 1911 and 1949 apply to all public bills except a bill containing a provision to extend the maximum duration of Parliament. Different provisions apply, however, to money bills and to other public bills. "Money bill" has a precise definition which has been applied with great strictness by successive speakers. In fact, it is clear that Lloyd George's Finance Bill of 1909 would not have been certified as a "money bill" if the act of 1911 had been in force.

If a money bill, having been passed by the House of Commons, and sent up to the House of Lords at least one month before the end of the session, is not passed by the House of Lords without amendment within one month after it is so sent up to that House, the bill shall, unless the House of Commons direct to the contrary, be presented to the sovereign and become an act of Parliament on the royal assent being signified, notwithstanding that the House of Lords have not consented to the bill.

In respect of a public bill other than a money bill the act of 1911 was amended by the act of 1949. In effect the act of 1911 enabled the majority of the House of Commons to override the majority of the House of Lords in two years. Under that provision the Government of Ireland Act and the Welsh Church Disestablishment Act, both in 1914, and the Parliament Act in 1949, were passed into law. The act of 1949 reduced the period to one year, though the provisions of the act were not used by the Labour House of Commons' majority of 1949–51, since the Conservative majority in the House of Lords refrained from pushing its opposition so far that it had to be overridden.

One effect of the acts of 1911 and 1949 is the statutory recognition of the "informal" procedure whereby each bill is read three times in the House of Commons and (except under the acts) three times in the House of Lords before being presented to the sovereign in Parliament. Indeed, the procedure of the acts cannot be used unless there is a certificate from the speaker either that the bill is a money bill or that the provisions of the acts relating to public bills other than money bills have been complied with. The speaker's certificate is conclusive for all purposes and cannot be questioned in any court of law.

The Legal Unchallengeability of Acts of Parliament.—An act assented to by the sovereign in Parliament becomes a matter of public record. That record is conclusive as to what it says because Parliament is still "the High Court of Parliament," the highest court in the United Kingdom. Hence unless the act contains an error on its face, *i.e.*, shows that it did not receive the appropriate assents in Parliament, its validity cannot be challenged. All modern statutes contain an appropriate enacting formula, indicating that the act in question has been enacted by the sovereign with the assent of Lords and Commons (or, where passed under the Parliament acts, of the Commons alone in accordance with those acts); and this is sufficient to make the acts unchallengeable. Some early statutes give no indication of the assent of Lords and Commons, but are presumed to have received that assent. Where, however, a statute refers to the assent of the Lords alone, it is not an act of Parliament; similarly, the "acts" of the Long Parliament or of the subsequent "parliaments" of the Interregnum, not bearing on their face the assertion that they were enacted by Charles I or Charles II, are invalid even if enrolled.

This rule, that an act of Parliament which does not show an error on its face cannot be challenged, has given rise to the theory of the "sovereignty of Parliament." If this is only a formula for the rule stated in the previous paragraph, it is at worst a misuse of language. If, however, it means that because Parliament is "sovereign" it cannot bind itself, it may be misleading. It has yet to be decided that the rule in question, being a rule of the law and custom of Parliament, cannot like other rules be amended by act of Parliament. (*See* also STATUTE LAW.)

4. Duration of Parliament.—When Parliament has been constituted in accordance with a royal proclamation it remains in being until it is dissolved. Formerly it could be dissolved only by another royal proclamation, or by the death of the sovereign who had summoned it. The famous Long Parliament of 1640 enacted in 1641, however, that that Parliament should not be dissolved except by act of Parliament. But neither its "dissolution" by a declaration of Oliver Cromwell and the council in 1653, nor its dissolution by its own act in March 1660 had any legal effect, since even the "act" was invalid, lacking the royal assent. The "Convention" Parliament (April–December 1660), which invited Charles II to return as king, finally enacted the dissolution of the Long Parliament, though the Convention Parliament itself was not a lawful Parliament because it had not been summoned by the king. Its legality was sought to be assured by the passage of an act declaring it a legal Parliament; its proceedings were, moreover, confirmed by its successor, a Parliament summoned (1661) by the king's writs. There was again legal difficulty in 1688 because when James II "abdicated" there was no Parliament in being.

By the Triennial Act (1694) the length of a Parliament was limited to three years from the date on which it was directed to meet by the writs of summons. This did not prevent a Parliament from prolonging its own life by act of Parliament, which was in fact done in 1716 by the Septennial Act. That act was passed during the troubles caused by James the Old Pretender and it provided that the existing Parliament and all future parliaments

should last seven years unless sooner dissolved. The rule so enacted remained in operation until 1911, when the maximum period was reduced by the Parliament Act to five years. The parliaments that were elected in 1910 and 1935 prolonged their lives by temporary acts, for one year at a time, until 1918 and 1945, respectively.

The death of the sovereign does not now dissolve Parliament. In 1707 it was enacted that the Parliament in existence on the death of the sovereign should continue for six months, unless sooner dissolved. The limitation to six months was, however, removed by the Representation of the People Act (1867). Thus, every Parliament now remains in being for five years unless sooner dissolved. In fact, it is always specifically dissolved by proclamation. After the Septennial Act it became the practice to dissolve after six years, so as to hold a general election at a period convenient to the government; and on occasions there were earlier dissolutions, to enable the government in office to use the royal and "treasury" influence to strengthen itself. In the 19th century dissolutions were due sometimes to government defeats and sometimes to the anxiety of the party in power to "cash in" on a temporary popularity.

Prorogation and Adjournment.—The fact that a Parliament is kept in being for some four years does not imply, however, that it is in session for the whole of that period. It can be prorogued by a commission, preceded by a proclamation, or by a proclamation alone. The prorogation discharges the Lords and Commons from service for the time being, but they may be summoned to meet again on a day fixed either by that proclamation or by a subsequent proclamation. Parliament used to be in session from January or February to July or August. Because of the press of business, however, it became more usual to summon Parliament to meet in October or November; and, because of the danger in the international situation during the 1930s the practice developed of avoiding a prorogation over the summer. Hence Parliament is now summoned in November and prorogued in the following October or November when, after a very short interval, it is again summoned.

Since neither House can sit during a prorogation, all business in both Houses is terminated. A bill must, for instance, start again in the next session. Either House can, however, provide for its own adjournment; and, though the periods of adjournment used to be short, the summer recess is now provided for not by prorogation but by adjournment, power being given to the lord chancellor and the speaker to summon their respective Houses if they are satisfied of the desirability of so doing.

As has been said above, prorogation is effected either by a proclamation, *i.e.*, without having a meeting of Parliament; or by commission and proclamation. The sovereign could prorogue in person, though this has not been done since 1854. Usually a commission is appointed, the speech from the throne being read by the lord chancellor, the Commons having been summoned from their chamber. When, in accordance with the proclamation, Parliament meets again, the procedure is the same as at the opening of a new Parliament, save that there is not an election of a speaker nor is it necessary for Lords and Commons to take the oath.

A dissolution is usually preceded by a prorogation, though this is not legally necessary and in any case the House of Commons is usually informed, before the prorogation, that it is the sovereign's intention to dissolve Parliament.

5. Frequency of Parliaments.—Because of the "eleven years' tyranny," (1629–40) when Charles I ruled without a Parliament, the Long Parliament passed an act in 1641 providing that if a parliament was not summoned by Sept. 10 in the third year next after the last sitting of a Parliament, a Parliament should be summoned in accordance with the act. That is, if the Parliament had been prorogued or adjourned, it should be dissolved and writs should be issued by the lord chancellor without direction from the king; and if there was no Parliament, writs should similarly be issued for a new Parliament. The whole matter was regulated in great detail so as to make certain that, whatever happened, there should always be a meeting of Parliament after an interval of not more than three years. This act was repealed by the Triennial Act (1664) as being "in derogation of his Majesty's just rights and prerogative inherent to the imperial crown of this realm." Instead, it was merely provided that the sitting or holding of parliaments should not be intermitted or discontinued above three years at the most. The Triennial Act (1694) which provided for a dissolution every three years, also provided that there should not be an intermission of more than three years; and in this respect the act is still in force. It is, however, no longer necessary. Since the parliaments immediately after the Revolution of 1688 wanted to abolish the standing army, they enacted the Mutiny Bill (now called the Army and Air Force Bill) for one year at a time only—though there were years in which no Mutiny Bill was passed. Since in fact a standing army always has been necessary, this practice has thus required an annual meeting of Parliament—though the modern practice is to produce an Army and Air Force Act only once in five years and to continue the Army and Air Force by annual resolutions in between. Moreover, part of the taxation (generally the income tax) is continued only from year to year, and expenditure has to be authorized and appropriated every year.

In any case, political considerations now require frequent and regular sittings. In effect, therefore, Parliament is almost continuously in session, and both Houses of Parliament meet for several days in each week, save for short adjournments at Christmas, Easter, and Whitsuntide and for a longer adjournment from August to October, subject to political exigencies.

6. The Two Houses of Parliament.—The High Court of Parliament, like every court established in the Middle Ages, has its own system of law, generally known as the law and custom of Parliament. It is, in the main, a system of case law recorded in the Lords' journals and the Commons' journals, though there are also decisions of the speakers (*e.g.*, in relation to the refusal of motions and questions) recorded in volumes of precedents which are not published but to which the speaker and the clerks-at-the-table have access. A few acts of Parliament also regulate the two Houses and their relations with each other. Each House, too, has standing orders which continue, subject to alteration, from session to session and from Parliament to Parliament, and sessional orders which are adopted at the beginning of each session. The whole of this considerable body of law is summarized in Sir Thomas Erskine May's *Treatise on the Law, Privileges, Proceedings and Usage of Parliament* (1st ed., 1844; 16th ed. by Sir Edward Fellowes and T. G. B. Cocks, 1957).

Speaking generally, there is no conflict between the law and custom of Parliament, on the one hand, and the common law, on the other. There is conflict, however, in a few matters of parliamentary privilege: and where there is such conflict neither law prevails over the other. The Court of King's (Queen's) Bench had no power to keep either House of Parliament within its jurisdiction; and neither House of Parliament has power to override the common law by resolution. The Houses of Parliament and the courts of common law are, of course, bound by acts of Parliament.

The judicial functions of the High Court of Parliament are performed by the House of Lords. These relate to (1) appeals from all courts in the United Kingdom except ecclesiastical courts, prize courts, and the House of Commons, but subject to limitations laid down by acts of Parliament; (2) impeachments at the suit of the House of Commons; (3) until 1948 it also had power to try peers accused of treason, felony, or misprision of either. If, however, Parliament was not in session, the House of Lords sat as the Court of the Lord High Steward, and the peers were judges only of fact.

The two Houses are courts of record and have power to try and punish persons for breaches of their own privileges. These privileges are designed to maintain the authority, independence, and dignity of the two Houses and began to develop in the 14th century. The House of Lords relies upon its inherent authority; but since 1515 the speaker, after being confirmed in office by the sovereign at the beginning of a Parliament, has laid claim for the Commons "to their ancient and undoubted rights and privileges," which are thereupon confirmed.

The privileges are: (1) right of access to the sovereign, claimed

by every peer individually, and by the Commons through the speaker or such of their members as are privy councilors—in consequence of this privilege the speaker has a right of way down the Mall (leading to Buckingham Palace, London) when attending a royal levée; (2) freedom of peers and members from civil arrest for a period from 40 days before to 40 days after a meeting of Parliament; (3) freedom of speech in Parliament (confirmed by the Bill of Rights, 1689); (4) the right to exclude strangers and to forbid the publication of reports of debates (the latter now exercised only in respect of "secret sessions" in wartime); (5) absolute privilege in respect of papers published by order of either House (confirmed by the Parliamentary Papers Act, 1840, after a dispute between the House of Commons and the Court of Queen's Bench in the case of *Stockdale* v. *Hansard*); (6) right of the Commons to order the issue of writs for the filling of vacancies, to enforce disqualifications for sitting in Parliament and (until 1868) to determine disputed elections; and the corresponding right of the House of Lords to determine the right of persons to sit in that House; (7) right to the exclusive cognizance of matters arising within the House; and (8) power to punish any person for breach of privilege.

In respect of the last of these, conflicts sometimes arise between the House of Commons and the courts of common law. The House has always claimed power to determine the limits of its own privileges. The courts, while recognizing all the above privileges, hold that their limits are cognizable at common law. Accordingly, if the House commits a person to the clock tower for the breach of a privilege specified in the order of the House, the High Court will order his release by habeas corpus if that court considers that there is no such privilege. Such conflicts are avoided, however, if the person is committed for contempt of the House, without the order specifying what the contempt was: for the courts recognize the right of the House to commit for contempt of itself.

In the above respects the two Houses are courts of record. In the reign of Elizabeth I it was possible for Sir Thomas Smith, whose *De republica Anglorum* (1583) is one of the earliest monographs on constitutional law, to give equal weight to the judicial and the legislative functions. Today the legislative functions are much more important, and they include the functions of voting supplies, imposing taxation, and regulating the national expenditure. These are, however, part only of the general function of debating, criticizing, and approving the actions of the government for the time being. The authority of that government rests upon its party majority in the House of Commons: but party majorities are usually stable from one general election to another, and so the parliamentary system enables the government to secure the support of the majority of the House of Commons, but subject to possible criticism from its own party and regular criticism from the parties in opposition. What is more, the government has the means for defending itself, since most of its leading members are in the House of Commons and the rest in the House of Lords.

B. The House of Commons

1. Representation.—The Commons is singular: in the Norman French of the Middle Ages it was *commune* or *communauté*. It was the body of subjects, excluding those who were summoned to Parliament by individual writs. It could attend Parliament only by representation, and representation was based on the units of local government, the shires and the boroughs. Each was represented by two persons, irrespective of population, because population as such was not represented. There was equal representation of each "community" in order to secure an adequate representation of the whole community or commons.

In 1509, when Henry VIII came to the throne, 37 counties and 111 boroughs were represented. The counties were the ancient counties of England, less the counties palatine of Chester and Durham and the county of Monmouth. Under Henry VIII the counties of Chester and Monmouth were given two seats each by act of Parliament, and each of the Welsh counties was given one seat. Under Charles II the county of Durham was given two seats. So far as England and Wales were concerned, there was no further alteration until the Reform Act of 1832, save that in 1821 the borough of Grampound was disfranchised and the two seats thus released given to Yorkshire, which thus had four seats. By the Act of Union with Scotland in 1707, however, 30 county members were brought in for Scotland. Since there were then 34 Scottish counties (Ross and Cromarty were not joined until 1889), 8 counties had to be combined in pairs. By the Act of Union with Ireland in 1800, 64 county members were elected.

The ancient boroughs were, for the most part, seaports, county towns, and fortified places that had received franchises or liberties by royal charter conferring special privileges. Since representation was an onerous and expensive duty, however, many chartered boroughs had ceased to be parliamentary boroughs. The majority of those represented in the parliaments of Henry VIII were in the south, west, and east of England, where most of the thriving towns were to be found, though a borough continued to be represented even if, as a town, it had virtually disappeared (*e.g.*, Old Sarum). Since representation depended on a royal charter, however, it was possible for the king to increase the number of boroughs so represented. Moreover the House of Commons claimed the right to decide whether a borough was entitled to representation; and since the 15th century representation was becoming less and less of an onerous duty and more and more of a privilege. This arose because the nobility, especially the new nobility of the Tudors, gained prestige by being able to nominate their relatives, friends, and retainers to Parliament and the persons so nominated were usually willing to relieve the boroughs of all expense. Accordingly, under the Tudors there was a rapid increase in borough representation. Of this increase of 148 borough members, 15 were due to legislation under Henry VIII bringing in Chester, Monmouth, and the Welsh boroughs: all the rest were due to royal charters. Under the Stuarts the recalcitrant Commons became critical of this exercise of the royal prerogative, and though James I created 11 new seats, only 2 were afterward created by charter, under Charles II. The city of Durham was given 2 seats by act of Parliament under Charles II, and under James I and Charles I 32 seats were created by the restoration of ancient privileges by the House of Commons. No borough seats were created between 1688 and 1832, except by act of Parliament, and then only to give representation to Scotland and Ireland—though, as mentioned above, Grampound lost its 2 seats for corruption. Hence the membership of the House of Commons grew, as shown in Table I.

Table I.—*House of Commons Membership, 1509–1830*

Year	Counties	Boroughs	Total
Death of Henry VII (1509)	74	222	296
Death of Henry VIII (1547)	90	251	341
Death of Edward VI (1553)	90	285	375
Death of Mary I (1558)	90	308	398
Death of Elizabeth I (1603)	90	370	460
Death of Charles II (1685)	92	417	509
Death of Anne (1714)	122	432	554
Death of George IV (1830)	188	465	653

To these must be added the universities of Cambridge and Oxford, enfranchised by royal charter under James I, and Trinity College, Dublin, enfranchised by the Act of Union with Ireland. Consequently the unreformed Parliament contained 658 members.

The Reform Acts of 1832 did not change the total, but only the distribution. Wales was given 29 seats instead of 24, Scotland 53 seats instead of 45, and Ireland 105 seats instead of 100. The great changes were made in England, where 56 boroughs were disfranchised and the representation of 31 reduced from two to one (four to two in the case of the combined boroughs of Weymouth and Melcombe Regis). Forty-two English towns became new boroughs and 34 English counties received additional members. These changes were not intended to be revolutionary. What was sought was a better balance. The small boroughs were wholly or partially disfranchised on a population basis, though many small boroughs had their boundaries extended in order to continue their representation. Populous places like Birmingham, Leeds, Manchester, and Sheffield were enfranchised. This decreased the number of boroughs under aristocratic control and increased the representation of the "manufacturing interest"; but this was balanced by the increase in the number of county seats that benefited the

"landed interest." The principle of equality of representation for communities or areas was not given up because, though small boroughs had only one seat, no borough except London had more than two seats. Moreover the counties which had four seats (and Yorkshire which had six) were divided into two-member constituencies.

The changes made in 1867–68 were few, and the great change was made in 1884–85, when the principle of representation according to population was accepted. Moreover the principle of the single-chamber constituency was accepted everywhere, except in the universities and in those boroughs which had two members both before and after 1884. There were redistributions, on the same principles, in 1918, 1945, 1949, and 1954, and there is now permanent provision for redistribution at intervals of 12–15 years, by commissions presided over by the speaker of the House of Commons.

2. The Franchise.—Meanwhile the franchise had been changing. In the 14th century the knights of the shire were elected in the county court; and, since nobody particularly wanted to undertake the duty, it was unnecessary to lay down qualifications for voting. Early in the 15th century, however, the convention developed that it was an honour to be a knight of the shire, and accordingly it was enacted in 1430 that the right to vote should be vested in all persons who held freehold land of the clear annual value of 40*s*. This was, until 1832, the sole qualification for county elections, and it remained the basic qualification until 1918. Meanwhile the value of land, in terms of money, had risen enormously; but the ordinary villager or townsman was not thereby enfranchised because he usually held by copyhold or leasehold.

In respect of the boroughs there was no legislation until 1832, and the franchise was regulated by local custom. In some boroughs, like Preston and Westminster, it was very wide, and extended to all inhabitant householders who had separate kitchens ("potwallopers," who boiled their own pots) or who paid local taxes ("scot and lot") or even, in Preston, all persons without restriction. In other boroughs only the freemen had the vote. Where the local guilds remained strong and provision was made for journeymen's apprentices to become freemen, this franchise might be widespread, as in Liverpool. Elsewhere, as in Cambridge, the creation of freemen was left to the corporation, whose members tended to keep the franchise close in order to control elections. In yet other boroughs the election was in the hands of the members of the corporation themselves. Finally, there were boroughs in which the franchise was vested in the owners of land held on burgage tenure. The notorious borough of Old Sarum, which had ceased to exist but continued to return two members, was in this category. It was bought by the Pitt family (*i.e.*, they bought the burgage lands) and mortgaged to the treasury. It should be mentioned, however, that in those boroughs that were cities or boroughs of counties, like Bristol and Norwich, the 40*s*. freeholders had the vote.

It should be emphasized that, until 1884, contested elections were the exception. This was very largely due to the expense involved. Where there was anything like a popular franchise (*i.e.*, in all the counties and about half the boroughs) the whole cost of the election, *i.e.*, the fees of the officials concerned, the erection of the hustings, the cost of the polling booths, had to be met by the candidates. To this had to be added the cost of bringing electors to the poll, which in the case of a county meant bringing them to the county town, and feeding and perhaps lodging them. Further, many electors were nonresident and had to be transported from their homes, perhaps in London (in the 19th century the party organizations bought railway tickets and charged the cost to the candidates). It was usual to employ bands, to distribute ribbons and other favours and to open the inns and taverns to the free and independent electors. Nor were other methods, such as bribery, abduction, or impersonation, always avoided. Charles Dickens' famous election scene in *Pickwick Papers* was based on fact: and indeed "Eatanswill" may have been the notoriously corrupt borough of Sudbury, which Dickens reported on at the general election of 1835. The cost of a hotly contested election could be anything from £10,000 to £100,000.

On the other hand, there was usually no contested election in a corporation borough, or in a freeman borough with few freemen, or in a burgage borough where one person owned most of the burgages. Moreover, the modern idea of voting for party had not developed, at least before 1800. Most people would vote, if there were a contest, for the squire's candidate, because that was the proper thing to do. In the 19th century the reformers said that tenants voted for landlords, shopkeepers for their wealthy customers, employees for their employers, etc., because of fear of victimization: but this was to put the cart before the horse. It was just as disloyal to vote against the squire as it would be for a Yorkshireman to cheer for Lancashire in a cricket match or for a trade unionist to be a "blackleg."

The result in a county election was that, for instance, Sir James Lowther (created earl of Lonsdale in 1784) could nominate the members for Westmorland because the squires always supported his candidates and the freeholders supported their squires. Only where the great landowners contested for the "influence" (*e.g.* the Percys and the Greys in Northumberland) was there a contested election; and usually it was agreed to divide the seats, the Percys having one and the Greys the other.

Most of the boroughs were similarly under "influence," *e.g.*, no decent person would dare to oppose the Churchill (or the friend of the Churchills) nominated by the duke of Marlborough for Woodstock. Hence some boroughs were "owned" by great landowners and many were "influenced" by them. Only in the "open" boroughs, where potwallopers, scot and lot electors or freemen were numerous, could there be a contested election, and then a good deal of money was required. Electorates were generally small even after 1832; and in Cambridge, for instance, Sam Long's paid cohort of 200 electors could win any election for the candidate who did a deal with Sam.

In 1832 the £10 copyholder, the £10 leaseholder for 60 years or of £50 for 20 years, and the tenant at will who paid £50 a year rent, were enfranchised in the county and the £10 occupier in the borough. The householder was enfranchised in the borough in 1867 and in the county in 1884. In 1832, too, the ancient franchises were extinguished forthwith in the case of nonresidents, and after existing lives in other cases. (This meant that in some "open" boroughs like Liverpool working class electors were disfranchised.) In 1918 only two qualifications were recognized, residence and the occupation of business premises of £10 a year. In 1948 the business premises qualification was abolished, and so were the 12 university seats (2 each for Oxford and Cambridge and the "English universities," one each for London, the University of Wales, the Queen's University of Belfast, 3 for the "Scottish universities"; all but Oxford and Cambridge had received representation between 1867 and 1928). Meanwhile women aged 30 or more were enfranchised in 1918 and women aged 21 or more were enfranchised in 1928. Moreover, the secret ballot had been introduced in 1872 and a really effective Corrupt and Illegal Practices Act passed in 1883.

The successive changes in the franchise have produced the result shown in Table II. There was, however, much duplication before 1918 and some duplication between 1918 and 1948.

TABLE II.—*Growth of the Electorate of Great Britain*

Year	Total electorate	Population aged 20 and over*	Electorate as percentage of population aged 20 and over
1831 . . .	438,000	10,207,000	4.4%
1832 . . .	720,784	10,207,000	7.1
1864 . . .	1,130,372	13,051,816	9.0
1868 . . .	2,231,030	13,625,658	16.4
1883 . . .	2,955,190	16,426,233	18.0
1886 . . .	4,965,618	17,394,014	28.5
1914 . . .	7,483,165	24,969,241	30.0
1921 . . .	19,984,037	26,846,785	74.0
1927 . . .	21,895,347	29,654,721	74.0
1931 . . .	29,175,608	30,096,135	96.9
1946 . . .	34,320,351	34,566,000	99.3
1949 . . .	33,545,221	34,981,000	95.9

*Persons under 21 have no vote, but separate population figures for the 20–21 group are not available.

3. Procedure in the House of Commons.—The procedure of the House of Commons is based on the principle that it is the business of the government to govern and of the opposition to op-

pose. The government must therefore be able, by using its majority, to secure the enactment by Parliament of the legislation which it considers necessary; but it must not be able, except where the opposition consents (as it does for emergency legislation at the outbreak of war), to get that legislation through without debating and justifying its policy, both legislative and executive, and listening to all the criticism that members of Parliament may choose to make.

Question Time.—The House of Commons now meets at 2:30 P.M. After prayers and private (now entirely formal) business, the House then comes to question time (2:45–3:30 P.M.). Replies may be asked for orally or in writing. Most questions are "starred" (marked with an asterisk) to indicate that an oral answer is requested: but so numerous are the questions, in spite of the rule which limits every member to three questions, that many starred questions are not reached. On the answer given by the minister supplementary questions may be asked by any member, and on a controversial matter many supplementary questions may be asked. At the end of questions, any member may move the adjournment of the House "for the purpose of discussing a definite matter of urgent public importance." Interpretations of the phrase by successive speakers have limited its value: but there is no doubt that if any urgent question of outstanding importance were raised—even if it related only to a serious injustice to a private citizen—the speaker would allow a debate which would interrupt other business later the same evening.

Orders of the Day.—Next comes more formal business, and then the "orders of the day," *i.e.*, the main items of agenda. In the procedure of the 18th and early 19th century—which is still fundamentally the procedure of the House of Lords—any member could put down any motion or amendment and have it debated, and any member could speak at any length on any motion or amendment. This system broke down in the 1880s because the Irish members began to obstruct all business which was not Irish, and to obstruct nearly all Irish business because it was, in their opinion, bad. In other words, they used the rules of debate to try to force the Parliament of the United Kingdom to send the Irish members back to Dublin, where they would be happy to enliven an Irish Parliament. The system would have broken down, however, even if there had been no Irish obstruction, for three reasons. First, until 1885 most members of Parliament did not depend on popular election. The Reform Acts of 1832 abolished the "nomination boroughs," *i.e.*, those in which a landed proprietor or a corporation had only to nominate candidates to secure their election: but they did not abolish "influence." Outside the industrial areas most county and borough seats depended on "influence," and most were uncontested. The fierce popular elections which began in Middlesex and Westminster under George III gradually became more frequent, but not until after 1884 did they become the rule. Hence most members did not have to make a show of activity to secure reelection or, in other words, to become professional politicians. There were professional politicians like Peel, Palmerston, Russell and Gladstone; but it was because they were so few, that they could spend so much time on the floor of the House. Many other members attended only rarely and spoke even more rarely.

The second reason for the breakdown is akin to the first; it was the growing fierceness of the party conflict. The modern practice of "fighting sham battles with wooden swords" dates from the combats of Gladstone and Disraeli: but even Disraeli did not have a party meeting once a week to organize the combats for next week. He might send out a few letters from Hughenden, his house in Buckinghamshire, to suggest that perhaps in the next session they might challenge Gladstone on Egypt or discuss the plight of British agriculture; but the notion that parliamentary opposition must work the five-day week is quite modern.

The third reason is the size and complexity of modern legislation. Where there was such legislation before 1906, like the public health legislation of 1872–75, it was regarded as mainly technical and therefore requiring only a few general remarks about the health of the nation that Disraeli, for instance, was so good at making. But even in the 1880s, when Joseph Chamberlain began the process of making people happy by passing laws, the government departments did not have to "fight for time" before the Future Legislation Committee of the Cabinet—indeed there was no need for such a committee because there was ample time for anybody who wanted it. The process of planning the parliamentary timetable by cabinet committee began in 1918; but the process of filling up the timetable with a succession of large bills began in 1906.

Private Member's Bills.—The result has been not only a considerable extension of the parliamentary session, which in effect (though not in form) extends almost continuously from the beginning of October to the beginning of August, but also a series of reforms, proposed by select committees on procedure, designed to put quarts into pint pots. The reforms have taken several forms. Government business was at first given precedence on two days a week and now has precedence on four days a week up to about Easter, and on five days a week thereafter. A private member can still put down any motion he pleases or introduce any bill he pleases, but he cannot get his motion debated unless he is successful in the ballot for priority on alternate Fridays; and he cannot get his bill passed unless either not a single member objects (in which case it is read a second time as an unopposed bill) or he is successful in the ballot for priority on the other Fridays.

He can, however, "raise the matter on the adjournment," if he is lucky. This arises because of the next reform, the automatic termination of a debate at a fixed hour unless "exempted business" is under discussion. If the debate ends at the fixed hour, the House rises half an hour later; and in that half hour a short debate on a subject raised by a private member takes place, though there can be no division. Until World War II any member could start any subject on the motion that the House do adjourn; but now the half hours have to be rationed by the speaker or by ballot. More important is the fact that the day's debate is limited (by the "ten o'clock rule") to seven hours, most of which will be taken up by at least four front bench speakers.

The Closure.—Further, a debate can now be brought to an end by a closure motion (that "the question be now put"). This was always theoretically possible, but a closure motion, like every other motion, could be debated, and was therefore useless. Nowadays a closure motion must, if the speaker thinks it is not an abuse of the process of the House, be put without debate; and, if it is moved by a government spokesman and the whips are put on, it is invariably carried. The closure is not in fact used very often because, knowing that it can always closure a debate, the government can usually make reasonable agreements with the opposition for bringing debate to an end. Sometimes these arrangements break down and then, if "exempted business" is under discussion or the ten o'clock rule has been suspended, the House has to go through the ordeal of an all-night sitting punctuated by closure motions from the government side and adjournment motions from the opposition side. This happens only when the opposition thinks that the government is trying to crowd in too much business, but the exception proves the rule that business is usually arranged by the whips to suit the convenience of the party leaders, whether or not it suits the convenience of backbenchers.

Other Restrictions.—Debate on financial business has been rigorously cut down. Formerly debate could take place on the motion to go into committee. Now, except on specified occasions, the motion is put without debate. In committee the number of "supply days" has been fixed (at 26 before Aug. 5), so that on the last two days a substantial part of the time has to be spent in voting on estimates which have not been discussed. Also, on any motion, whether in the House or in committee, the speaker or chairman has power to select amendments. On ordinary motions, including motions in supply, he usually selects the amendment moved from the opposition front bench; but on bills he often selects back bench amendments.

The Three Readings of a Bill.—Most bills are now sent to standing committees "upstairs," though finance bills and other bills of major importance are taken on the floor of the House. Most bills are government bills, and indeed private members may in-

troduce opposed bills only on alternate Fridays, and then only if they have been successful in the ballot. The first reading of a bill is purely formal, except that private members sometimes introduce bills under the "ten minutes rule," which enables the proposer and one opposer to make short statements. The second reading is the occasion for debate on the principle involved. The bill then goes into committee, where it is examined clause by clause and even line by line. The chairman can usually keep debate down by accepting closure motions and selecting amendments. Very often, indeed, there is an informal agreement between the parties whereby a timetable is laid down. If, however, the bill is both complicated and hotly contested, it is necessary for the government to introduce into the House a "guillotine motion," which in effect imposes a timetable on the committee. This motion can be debated, and so the procedure is used only when agreement cannot be reached informally. After the committee stage comes the report stage, when further amendments may be moved, though a clause is not debated unless an amendment is moved to it. Finally, the bill is read a third time after another debate on its principle. Usually, however, the third reading follows immediately upon the report stage.

Financial Measures.—If, however, the bill contains any financial clauses, and government bills usually do, there has to be a financial resolution in committee of ways and means (*i.e.,* on the floor of the House), followed by the report of the resolution to the House. The purpose of this procedure is to require the House to debate the financial implications of legislative proposals, though more often it results in another second-reading debate. Where the bill is mainly financial, the financial resolution is taken before the second reading. The so-called "budget statement," made by the chancellor of the exchequer annually in April, is in fact a speech on a series of financial resolutions, in committee of ways and means, intended to precede the second reading of the finance bill. Where the financial provisions are merely incidental (*e.g.,* an education bill that contains a clause authorizing grants to local education authorities), the financial resolution follows the second reading. In either case the financial resolution controls the committee stage, so that amendments cannot be moved contrary to the financial resolution, which is often narrowly drawn.

A financial resolution can be moved only on the recommendation of the crown. This is the effect of the oldest standing order still in operation, dating from Queen Anne. The crown is in fact the government; and the purpose of the rule is to prevent private members from distributing largesse to constituents—in the American idiom, "distributing the pork barrel." There is nothing to stop the government from purchasing (or trying to purchase) votes by increasing social services or otherwise: but the government must raise the money as well as spend it, whereas private members can vote for expenditure and against taxation. *See* also SPEAKER.

C. The House of Lords

These complications do not concern the House of Lords. Few peers attend the normal debates and even an attendance of 200 is exceptional. The party controversy is much less fierce in the Lords than in the Commons. Above all there are no financial resolutions, estimates, supplementary estimates, or committee work on financial measures. Financial bills and financial clauses of general bills are considered to be matters within the exclusive cognizance of the House of Commons. This means that they may be debated but not amended by the House of Lords. In the case of a "money bill," as defined by the Parliament Act of 1911, rejection by the House of Lords can be overruled. It follows that, though the procedure of the House of Lords is fundamentally the same as that of the House of Commons, it is free from restrictions introduced into the latter since 1800. The House of Lords usually sits for only three hours a day, three days a week.

VI. OTHER PARLIAMENTS OF BRITISH ORIGIN

The word "parliament" is usually restricted to the legislatures of independent countries and self-governing colonies within the Commonwealth of Nations, and to that of the Republic of South Africa, no longer a member of the Commonwealth. Other British colonies usually have a legislative council or a legislative assembly or both, though other names, like "state council," are sometimes employed. The legislatures of the Australian states are called "parliaments" because the constitutions of those states were not affected by the creation of the Commonwealth of Australia in 1900. In Canada, however, the provincial legislatures are known as "legislatures"; and this precedent was followed for the state legislatures of India, the provincial legislatures of Pakistan (constitution of 1956, abrogated in 1958), and the state legislatures of the Federation of Malaya (since 1963 extended to become the Federation of Malaysia).

The fundamental difference between the Parliament of the United Kingdom and other parliaments is that the latter are regulated by written constitutions. The degree of regulation depends upon the amount of detail put into the constitution and the ease or difficulty with which that constitution can be amended. In every case the outline of the composition is in the constitution, and in every case there is some departure from the United Kingdom model. As we have seen, the Parliament of the United Kingdom consists in legal form of the king (or queen regnant), the Lords spiritual and temporal, and the Commons, in Parliament assembled. The Parliament of Canada consists of the sovereign, the Senate, and the House of Commons; the Commonwealth Parliament of Australia consists of the sovereign, the Senate, and the House of Representatives; the Parliament of New Zealand consists of the governor general and the House of Representatives (this form survives from colonial practice); the Parliament of the Republic of South Africa consists of the state president, the Senate, and the House of Assembly; the Parliament of India consists of the president, the Council of States, and the House of the People; the parliaments of Pakistan and of Ghana consist of the president and the National Assembly; the Parliament of Ceylon consists of the sovereign (represented by the governor general), the Senate, and the House of Representatives; the Parliament of the Federation of Malaya consisted, and that of the Federation of Malaysia consists, of the *yang di-pertuan agong* (the supreme head of the federation), the Senate, and the House of Representatives. It will be seen that, allowing for the variations in the head of the state and in respect of a second chamber, the formulas are identical in principle and differ from the United Kingdom formula. The difference is not one of form only, since it may affect the validity of legislation. Legislation has in fact been declared invalid in South Africa, Pakistan (1947 constitution), and Ceylon, because of defects of form.

The "lower" house in the bicameral legislatures and the house in the unicameral legislatures are invariably based on direct election on adult franchise. However, the principle of "one person, one vote, one value" is not universally accepted. In Canada and Australia it was considered necessary to provide a minimum representation for the smaller provinces and states and there is provision for multimember constituencies in Ceylon. Also in Ceylon the governor general is empowered to appoint six members, again for the purpose of representing minorities.

The greatest disparity, however, is in respect of the second chamber. New Zealand had one but abolished it by constitutional amendment in 1950 (taking effect on Jan. 1, 1951). Pakistan in its 1956 and 1962 constitutions decided not to have one. Canada has a Senate whose members are nominated for life by the government, while Australia, South Africa, and India have elected second chambers. In Ceylon the Senate is half nominated by the governor general and half elected by the lower house, while in Malaysia 28 members of the upper house are elected by the states and 22 nominated by the *yang di-pertuan agong.* This is a matter almost of taste. In a federation there is some case for making the second chamber the body representing the states or provinces, as in the United States, and there are traces of this American influence in the constitutions of Australia, India, and Malaysia. In a unitary constitution, on the other hand, there is something to be said for indirect election and also something to be said for securing by nomination the services of persons who would not be willing to stand for election.

Other provisions inserted in all the constitutions relate to the

qualifications and disqualifications of members of one or both houses. The details relating to franchise and election are usually to be found in separate laws, capable of being amended by Parliament. In some cases, however, following the precedent set by India in 1950, provision is made for the appointment of an independent election commission charged with responsibility for the conduct of elections. It is usual, too, to provide for the delimitation of constituencies by another independent commission.

1. Legislative Powers.—Great diversity exists in respect of legislative powers. In those countries still under the queen all such powers come directly or indirectly from the crown or from the Parliament of the United Kingdom. In Ceylon they came from the crown, because Ceylon was partly a conquered and partly a ceded colony. Hence the constitution of Ceylon is in orders in council, but the legislative power was enlarged by the Independence Act of 1947. In Malaysia the authority behind the constitution is complicated. On the establishment of the Federation of Malaya an act of Parliament giving approval to an agreement between the crown and the Malayan rulers, the agreement itself, ordinances enacted by the federal legislature and the nine state legislatures, and an order in council in respect of Penang and Malacca all contributed to the constitution. In India and in Pakistan (1956 constitution) the constitutions were enacted by constituent assemblies set up under the authority of the Indian Independence Act (1947). In Canada, Australia, New Zealand, and South Africa the constitutions were acts of Parliament, but have been amended locally.

Only in New Zealand and Ghana are the powers so conferred on Parliament unlimited—and the Ghana Parliament has obtained such powers by constitutional amendment. In South Africa there was no limitation except in respect of the "entrenched matters," which required a two-thirds majority at a joint sitting of the two houses (*see* SOUTH AFRICA, REPUBLIC OF: *Constitution*). In Ceylon there is not only a special requirement in respect of constitutional amendments, but also a provision intended to give protection to religious and communal minorities (though it has not proved very effective owing to what may be a faulty interpretation). In Canada the powers of constitutional amendment are limited (other amendments have still to be made by the Parliament of the United Kingdom), and in Australia, India, Pakistan (1962), and Malaysia a special procedure has been prescribed.

There are, too, limitations in Canada, Australia, India, Pakistan, and Malaysia because of the federal structure of their constitutions. In Canada there are two legislative lists, federal and provincial, with the residue vested in the Canadian Parliament. In Australia there is a short list of powers vested exclusively in the Commonwealth and a longer list of powers exercised concurrently by the Commonwealth and state parliaments, Commonwealth laws prevailing where there is any conflict. In Pakistan there is an exclusive list of federal powers and the residue is in the provinces. India and Malaysia (though with greater variation in the case of Malaysia) follow the principle adopted in the Government of India Act (1935), whereby there are detailed federal, state (or provincial), and concurrent lists. Also, India and Malaysia have provisions setting out "fundamental liberties" that operate as limitations on the legislative powers of their parliaments. The result is that in all the countries mentioned except New Zealand and Ghana, the courts have power to declare legislation invalid, although the limitations are small in South Africa and not very considerable in Ceylon. Canada, Australia, and India have a vast constitutional case law.

2. Procedure.—In other respects, the parliaments of countries belonging to, or once belonging to, the Commonwealth follow the mother of parliaments with considerable fidelity, which is cemented by frequent meetings of speakers and by the Society of Clerks-at-the-Table. The rules of procedure are founded on those at Westminster, though sometimes at second remove. Those in operation in India and Pakistan, for instance, derive from the rules in operation under the Government of India Act (1935) which in turn derived from Westminster. Moreover, the rules often apply differently. Thus in Ceylon the "question hour" hardly exists, while in Australia questions are "shot at" ministers without notice. In Australia and in New Zealand parliamentary proceedings are broadcast.

The privileges of Parliament are normally limited to those possessed by the British House of Commons but, subject to that limitation, are determined by legislation. In some cases, however, breaches of privileges, in so far as they affect persons outside the House, are dealt with by the courts of law.

See also the articles on the various countries mentioned in this section. (W. I. J.)

VII. CONTINENTAL EUROPE

A. HISTORICAL DEVELOPMENT

In contrast to the long and unbroken history of the British Parliament, those of other European countries have had in modern times—with but few exceptions—a comparatively short and much more uncertain existence. Although parliamentary institutions have flourished in a number of smaller countries of the continent—in Scandinavia, the Netherlands, and Belgium, for instance—in larger countries such as Germany, France, and Italy they have faced severe problems. In these three countries parliaments have at various times given way before pressure for more autocratic forms of government; and, even since the reestablishment of parliamentary institutions at the end of World War II, renewed difficulties led in the Fifth French Republic (1958) to a reduction of Parliament's powers and in Italy to a succession of weak and unstable governments.

1. The Origins of Modern Parliaments.—Many of the difficulties encountered on the continent can be traced back to the long tradition of authoritarian government that prevailed under the absolute monarchies of the 16th, 17th, and 18th centuries. Under them medieval representative institutions (*see* ESTATES-GENERAL) either disappeared or grew effete and political power became concentrated in a narrow circle of hereditary monarchs. The Swedish *riksdag* was a solitary exception, and even it was temporarily eclipsed from 1660 to 1718 under Charles XI and Charles XII and from 1772 to 1809 under Gustavus III and Gustavus IV.

The decisive initial impulse toward modern forms of representative government was given by the French Revolution and the Napoleonic Wars that followed it. It was then that the doctrine of popular sovereignty, formally proclaimed in the French constitution of 1791, first became an effective revolutionary watchword as a justification both for revolt against established monarchical rule and for aspirations toward national independence. In the century between 1815 and 1914 these ideas gradually won a wide measure of general acceptance and the establishment of national parliaments came to be regarded as a natural and essential corollary of national unity and independence. Most continental parliaments thus found themselves faced by the problem (in the new nation states) of governing what were essentially new political units. The difficulties which they encountered, exacerbated by the demands of militant nationalist movements, often proved too severe for countries unaccustomed to government by discussion and majority decision rather than by force and authoritarian decree.

Even in France, where national independence was not in question, the passions generated by the Revolution proved too great for those who sought in its early days to devise constitutions giving sovereign power to an elected national assembly. Although their ideals were to exercise a lasting influence on the course of events throughout the 19th century, and their initial constitutional experiments gave parts of the Italian peninsula, the Netherlands, and Switzerland a first brief taste of modern forms of representative institutions, it was perhaps the Napoleonic Wars, rather than the Revolution, that contributed most toward the creation of national parliaments. During those wars the *ancien régime* in many parts of the continent received a shock from which it never fully recovered. Hopes of national independence were stimulated, and the way was paved for their eventual fulfillment.

Although the majority of the rulers restored after 1815 rapidly reestablished absolute forms of government, it was significant that in France the restoration was accompanied by the granting of a constitutional charter. This assured equality before the law, and other basic freedoms, and created a bicameral Parliament con-

sisting of a Chamber of Peers (modeled on the British House of Lords) together with an elective Chamber of Deputies. The franchise was a narrow one—not more than about 100,000 persons received the vote—and the king retained an exclusive right to initiate legislation. The responsibility for legislative acts was, however, shared between the monarch and Parliament. In other words, the right of a partially elected parliamentary body to some participation in the processes of government was conceded. In comparison with the objectives of the early revolutionaries this was a meagre advance: nevertheless, as events were to show, constitutional government on these lines was to open new perspectives for popular participation.

2. The Establishment of Constitutional Rule.—Already in 1809 the new Swedish monarch Charles XIII had been forced to accept a constitution which, while resting heavily on past experience, had borrowed from Montesquieu the principle of the separation of powers. A few years later, in the newly created Kingdom of the Netherlands, the Fundamental Law of 1815 established a bicameral Parliament (the States-General) with an indirectly elected lower house and an upper house nominated by the king. Such limited experiments in constitutional rule established a framework within which, as the century progressed, political rights could be granted to an increasing number of people. The upper and property-owning middle classes were the first to benefit: it was pressure upon these essentially conservative ranks by newly enriched professional and business groups that provided the mainspring of constitutional advance in western European countries in the period up to World War I. The 1830 Revolution in France was a characteristic example of this process. It was then that the *bourgeoisie* successfully revolted against the restored Bourbon monarchy, installed the Orleanist Louis Philippe, and obtained the abolition of the hereditary peerage and an enlargement of the franchise. Their success led to agitation for similar liberal developments within a number of Swiss cantons (which resulted eventually in the revision of the federal constitution in 1848), and to the revolt of the Belgians (since 1815 linked with the Dutch in the Kingdom of the Netherlands) who set up an independent state with a constitutional monarch and a bicameral Parliament.

At the next major revolutionary outbreak in 1848 the hasty resort to the granting of constitutions by monarchs suddenly threatened by insurrection was further evidence of their growing —if still reluctant—acceptance of the need for some widening of the circle of political power. The *statuto* granted by Charles Albert of Piedmont (dated in February but promulgated in March 1848) proved of particular importance. In the hands of Cavour it survived the stresses of the years in which Italian unity was forged to become the constitution of the new state. Within this framework the Parliament of the united kingdom became not only a symbol of national independence but also the most important single institution of its political life.

Germany's experience on the other hand was significantly different. Unification in this case was achieved under the aegis of an autocrat, Bismarck, to whom representative institutions were little more than a necessary piece of window dressing. In appearance the *Reichstag* of the German Empire (established in 1871) was a highly democratic body elected by universal male suffrage; in practice, however, its powers were slight and the emperor William II made no secret of his scorn for its members whom he termed "a bunch of fools." Within the constituent states of the German Empire the various princes also continued to exercise a large degree of personal power after having conceded the establishment of parliamentary bodies. The promulgation in 1867 by Francis Joseph, the Habsburg emperor, of a series of fundamental laws for the dual monarchy (Austria-Hungary) similarly allowed him in fact a degree of power much greater than that exercised by either of the parliamentary bodies in Austria or Hungary.

3. The Growth of Parliamentary Government.—In the German and Austrian empires constitutional rule did not lead to parliamentary government. Power continued to rest above all in the hands of the hereditary monarch or the person of his choice. Parliament was allowed to take part in the legislative process, to criticize, and to suggest—but not to have the decisive say in government. The situation was quite different in France under the Third Republic, in Italy, and increasingly in a number of the smaller states in the western part of the continent. There it was Parliament—and specifically the elected chamber—which came to exercise a dominant role. To continue in power cabinets were dependent on being able to secure a majority in the lower chamber, and the head of state exercised only occasionally a decisive influence on the conduct of government. In the case of France parliamentary government in this sense was written into the constitution, one of the constitutional acts of 1875 declaring that ministers were responsible to Parliament. This was also true of Spain under the 1876 constitution. Italy and the Netherlands on the other hand were examples of states in which government by a cabinet responsible to Parliament rested on an evolving tradition rather than formal written guarantees.

The pace of this development toward parliamentary supremacy, and the factors which promoted it, differed a good deal from country to country. In France, for instance, it was the strength of the revolutionary tradition and the military defeat of Napoleon III in 1870 that proved decisive, while in Italy the fact that the Savoy monarchs needed the support of the liberals in the face of the Vatican's hostility to the new state, and were willing to place their confidence in Cavour's successors was of the greatest importance. Underlying both these developments—and the resistance to them in the German and Austro-Hungarian empires—were, however, more fundamental factors arising from the economic and social composition of the new states of continental Europe and the attitude of the upper layers of society to the exercise of power.

In both types of regime the contours of political life gradually changed toward the end of the 19th century as a result of an enlarged electorate. In some cases, as in France (1848) and in Germany (1871; 1867 in the North German Federation), adult manhood suffrage was achieved overnight. Elsewhere it came in stages, at a rapidly increasing pace in the latter years of the 19th and in the first decade of the 20th century. In Belgium, for instance, the vote was given to all males over 25 in 1893 and was first exercised in 1894: in Italy in 1912 adult manhood suffrage (with some reservations for those under 30) was admitted, the electorate being increased as a consequence from about 2,900,000 to about 8,400,000. In 1919 a further electoral reform brought the figure to more than 10,000,000. With the growth of a mass electorate, which admitted to active political life illiterate peasants as well as the industrial working classes, socialist party members began to make their appearance in parliaments; liberal parties found their predominance challenged and the intensity of party organization increased. No longer the preserve of the wealthy and educated, the parliamentary game had now to take into account the desires of the representatives of new social groups and reconcile a wider cross section of often strongly divergent interests.

In 1905 even the tsar, Nicholas II, who had hitherto resisted liberal pressure for a constitution and dismissed the idea of summoning a national assembly as "foolish dreams," reluctantly agreed, under extreme pressure from liberal and revolutionary groups, to the calling of a Duma (*q.v.*). His aversion to any expression of criticism of his regime prevented its development, however, and the Revolution of 1917 engulfed not only the Romanov dynasty but also hopes that a new regime might be modeled on Western constitutional and parliamentary experience.

In the West itself, on the other hand, World War I marked the apogee of belief in parliamentary institutions. As a result of the postwar settlement, parliamentary regimes were introduced into Austria, Poland, Czechoslovakia, and the Baltic states. In Germany the Weimar Republic came into being equipped with a constitution promulgated in August 1919 which was hailed at the time as the most liberal and egalitarian of all constitutions. In other countries—Italy (1919), Denmark (1915), Sweden (1919), for instance, there were substantial further extensions of the suffrage, mainly by the enfranchisement of women. For a short time it seemed that the war had made continental Europe safe for parliamentary democracy.

4. 20th-Century Problems.—Such hopes for the future of parliamentary institutions soon proved ill-founded. The economic

chaos which followed the end of World War I generated in both Italy and Germany bitter social and political conflicts which weak governments resting on unstable parliamentary support were unable to contain. In these two countries, in Spain, and in a number of east European countries parliamentary rule proved vulnerable to the challenge of single-party dictatorship backed by armed force. In Italy, Mussolini came to power in 1922 and rapidly replaced effective parliamentary rule by a Fascist regime; in 1933 Hitler followed in Germany and established an even more thorough dictatorship through the Nazi Party. Their example gave rise, in a number of other countries including France, to movements that sought the replacement of parliamentary rule by dictatorial forms of government.

World War II, which was fought by the Western powers to defend political freedom, had one major—and unforeseen—consequence. Those parliamentary regimes of eastern Europe which had survived the stresses of the interwar years were now engulfed by the Soviet Army under whose aegis Communist regimes were speedily established. In the West, on the other hand, the war did lead to a restoration of genuine parliamentary control in France, in the Federal Republic of Germany, and in Italy—though Spain and Portugal retained autocratic regimes. In France the Constitutional Act of October 1946 inaugurated the Fourth Republic with a bicameral Parliament designed to remedy the defects of its predecessor which had collapsed in July 1940 under the weight of military defeat. In Italy a majority in a referendum held in 1946 opted for a republic. As in France, a constituent assembly drew up a new constitution, which was promulgated in December 1947 and came into force in January 1948. In West Germany the three occupying powers (France, Britain, and the United States) themselves took the initial steps toward a revival of representative institutions, which led eventually to the establishment in September 1949 of the Federal Republic of Germany in which parliamentary institutions were set up under the terms of the Basic Law of May of the same year.

In France, however, the restored parliamentary regime soon ran into difficulties. Challenged by a large Communist Party, and by a series of severe problems both at home and in its threatened colonial possessions in Asia, the centre parties found it increasingly difficult to sustain cabinets strong and stable enough to govern effectively. Finally, faced since 1954 by the challenge of the Algerian revolt and the threat of a military coup, the Fourth Republic collapsed in May 1958. With the return to power of General de Gaulle (June 1) and the establishment of the Fifth Republic, the role of Parliament was substantially reduced. In Italy there were also difficulties, though of a less dramatic kind. There the largest party, the Christian Democrats, lost their absolute majority in Parliament in the elections of 1953 and were subsequently deserted by their centre party allies. The formation in 1963 of a new governmental majority with the participation of the Nenni Socialists was strongly resisted by right-wing elements in the party, and the resulting governmental weakness provoked new criticisms of the parliamentary regime itself, though its opponents lacked a leader capable of proving a rallying point for opposition. In Belgium and the Netherlands government continued to be delicately posed on parliamentary coalitions, but in these countries as in Scandinavia the underlying strength of parliamentary institutions was sufficient to sustain even prolonged cabinet crises without serious difficulty.

B. Characteristics of Continental Parliamentary Institutions

1. Structural Features.—In view of the wide variety of conditions in which parliaments on the European continent have worked, it is not surprising that they have assumed a wide variety of forms. They have been introduced into both monarchical and republican regimes, and into confederal, federal, and unitary states. Moreover, parliaments have been devised with single chamber, bicameral, and multicameral characteristics. Examples of the first type were to be found in the mid-20th century in Denmark, Finland, and—in a modified form—in Norway where the *storting* was elected as one body of 150 members, but divided itself into two component bodies, the *odelsting* (112 members) and the *lagting* (38 members). Bicameral parliaments predominated, however; experiments during the 19th century with more than two chambers (as under the First and Second French empires) did not prove a success.

The composition and powers of second chambers was a perennial source of debate. Originally most of them were conceived under 19th century constitutional regimes as essentially conservative bodies and for this reason were composed of hereditary or life peers, royal princes, great officers of state, and similar persons. The trend toward full parliamentary government made such bodies more and more of an anachronism, and it remained extremely difficult to arrive at a definition of their role that could be fully reconciled with current doctrines of popular sovereignty. Unless second chambers were to be exact replicas of the lower chambers, some arbitrary selection had to be made of particular interests within the state for special representation. No satisfactory solution of this dilemma was reached but the practical need for a revisionary chamber brushed theoretical niceties aside. A number of countries—including France, Italy, Belgium, the Netherlands, and Sweden—converted their upper houses into forums in which representatives of local government units had a preponderant part, though with varying practical results. In France under both the Fourth and Fifth republics agricultural interests tended to predominate, while in Italy the Senate—largely because of the failure to create the regions which its members were intended under the constitution to represent—became merely a slightly paler, and older (senators had to be 40, deputies 25 years old), version of the lower chamber. In that country discussion soon began again about its reform.

In all cases the upper houses continued to be smaller than the lower chambers—the Italian Senate having 315 members, the French Senate 274, the Belgian Senate 183, the Swedish First Chamber 151, and that of the Netherlands 75. Major political power rapidly came to be exercised by the lower houses, though the Swedish system retained a formal equality between the two—all bills, for instance, being considered by joint committees of the two houses. Direct elections by universal suffrage came to be universally accepted for the lower chambers, with the single exception of the exclusion of women from Swiss federal elections. Most countries adopted 21 as the qualifying age for electors. In general the size of the lower chambers reflected the comparative size of the countries concerned: Luxembourg's Chamber of Deputies had 52 members, the Netherlands' Second Chamber 150, while in the Federal Republic of Germany and Italy the lower houses each had more than 500 members, as did France until Algerian representation was ended in 1962. The duration of the various legislatures varied between four years (Federal Republic of Germany, Belgium, the Netherlands, and the Scandinavian countries) and five years (France and Italy).

2. Electoral Factors.—The gradual and orderly assimilation of a mass electorate to the political life of the nation state was in many countries one of the major achievements of parliamentary government. In the closing years of the 19th century the extension of the suffrage led to the election of an increasing number of socialists who in most countries were gradually converted to an acceptance of the rules of the parliamentary game. Their participation secured for representative institutions the support of large sections of the industrial working class, and at the end of World War II socialist parties were playing an important part in many governmental coalitions.

The widening of the suffrage did not always, however, contribute to the strengthening of parliamentary institutions. In France, where universal suffrage was suddenly achieved in 1848, it proved disastrous for the fortunes of the republicans who introduced it (*see* France: *History*), and in Italy the two sudden enlargements of the electorate in 1912 and 1919 radically altered the balance of political power in the country and contributed to a fatal weakening of the parliamentary system. In the mid-20th century the existence of powerful Communist parties in these two countries was also a factor of weakness within their parliamentary systems. Their presence sharpened political conflict, increased the strength

of extreme right-wing forces, frequently delayed parliamentary business, and narrowed the area of choice for the formation of a parliamentary majority. Various attempts were made in both cases to restrict the number of Communists elected to Parliament, but with only limited success.

The existence of strong organized parties fundamentally hostile to existing parliamentary institutions in a number of continental countries was one factor which distinguished their political life from that of Great Britain. So, too, did the much greater political fragmentation which continued to be a major characteristic of many of these countries. This arose partly out of a more doctrinaire attitude to politics, and partly from the existence of deep-seated economic, social, and religious cleavages in society. One reflection of this diversity of interests that had to be reconciled within Parliament was the wide use on the European continent of forms of proportional representation—moderated in some cases by devices tending to favour the larger parties. Various countries tried at different times to counter the difficulties that such systems tended to create in the way of the formation of strong and stable governments by resort to electoral systems that allocated seats to that party or individual that obtained a majority of the votes cast in an electoral college or constituency. Under the Fifth Republic, for instance, France returned to single-member constituencies in which members were elected if they received an absolute majority of votes cast at the first ballot, or a relative majority at the second ballot. In the Federal Republic half the *Bundestag* was elected by a relative majority in single-member constituencies, the remaining seats being allocated by d'Hondt's system among party lists put forward for each *Land*. The inherent difficulties of devising systems satisfactory to all parties led elsewhere—as in Italy—to frequent changes in the electoral laws, and no single system emerged as universally acceptable.

3. Internal Organization.—The greater complexity of parliamentary politics on the continent was symbolized by the semicircular arrangements of their lower chambers adopted by all parliaments with the exception of that of the Netherlands. In most cases members sat by party groups ranged from left to right, though in Norway and Sweden members continued to sit in constituency groups.

Some traces of the influence of the doctrine of separation of powers were found in the exclusion of ministers from membership of Parliament in the Netherlands and Norway. In other countries they were not obliged (as were ministers in Great Britain) to be members of one or other house, although in practice the great majority were. Similarly, in the legislative process itself, committees on the continent tended to assume a more important political role than in Britain. In Italy

TABLE III.—*Details of Commonwealth and of Some Other Parliaments*

Country	Name of Upper House Number of Members How Elected Duration	Name of Lower House Number of Members How Elected Duration	Relation to Executive
Great Britain	House of Lords c. 910 Hereditary and life peers; not elected Up to 5 years	House of Commons 630 Elected by majority vote in each constituency by all over 21 years old Up to 5 years	Government is responsible to Parliament: ministers must have a seat in one or other House, and cannot enter the house of which they are not members
Northern Ireland	Senate 26 (2 *ex officio*) 12 elected every 4 years on proportional representation by House of Commons	House of Commons 52 Elected by majority vote in each constituency by all over 21 years old Up to 5 years	Government is responsible to Parliament: ministers must be members of one House, can appear in either but only vote in their own
Republic of Ireland	*Seanad éireann* (Senate) 60 Part nominated, part elected, to represent various interests, by an electoral college of *c.* 900 Up to 5 years	*Dáil éireann* (House of Representatives) 144 Elected by those over 21 by proportional representation Up to 5 years	Government responsible to the *dáil*. All but 2 (and these not the most important) ministers must be members of the *dáil;* the 2 may be members of the *seanad*
Canada	Senate 102 Nominated for life by governor-general: represent various provinces	House of Commons 265 Elected on majority vote by all over 21 years Up to 5 years	Government responsible to House of Commons. Ministers must be members of it although one may be a member of the Senate
Australia	Senate 60 30 elected every 3 years Senators elected by universal suffrage, to represent the various states	House of Representatives 124 Elected by all British subjects over 21 years, on population basis Up to 3 years	Government responsible to Parliament: ministers must be members of one or other House
New Zealand	House of Representatives 80 Elected on universal suffrage 3 years		Government responsible to Parliament: ministers must be members of the House
Ceylon	Senate 30 15 nominated by Governor General, 15 elected by single transferable vote by the House of Representatives One-third elected every 2 years	House of Representatives 157 6 appointed by governor-general to represent minority interests: 151 elected by all over 18 years old Up to 5 years	Government responsible to Parliament: most ministers are members of the House of Representatives; not less than 2 of them must be in Senate
India	*Rajya Sabha* (Council of States) Not more than 250 12 nominated by president, others elected (indirectly) by assemblies of the various states One-third of number retire every 2 years	*Lok Sabha* (House of the People) Not more than 500 Elected by all citizens of India over 21 years Up to 5 years	Council of ministers responsible to the *Lok Sabha*. Ministers can speak in either House but vote only in the one of which they are members
Pakistan	National Assembly 156 (75 from East and 75 from West Pakistan, 6 seats for women) Elected indirectly by all over 21 Duration not fixed		Ministers are responsible to the president; they need not be members of the National Assembly
Malaysia	*Dewan Negara* (Senate) 50 22 appointed by the *yang di-pertuan agong* (head of state), 28 elected by state legislatures Up to 5 years or as decided	*Dewan Ra'ayat* (House of Representatives) 159 Elected by universal adult suffrage Up to 5 years or as decided	Government responsible to Parliament: ministers can speak in either House but only vote in that of which they are members
Federation of Nigeria	Senate 44 Nominated from all the regions 5 years	House of Representatives 312 Elected by full adult suffrage in eastern and western Nigeria, by adult male suffrage in northern Nigeria 5 years	Government responsible to Parliament: ministers must sit in one or other House, normally the lower
Sierra Leone	House of Representatives 74 Elected by universal adult suffrage Up to 5 years		Government responsible to the House: ministers must be members of it
Ghana	National Assembly 114 (10 seats reserved for representatives of women) 104 elected by adult suffrage, the 10 women's representatives elected by members of the Assembly Up to 5 years		Ministers responsible to Parliament: they sit in the National Assembly
Republic of South Africa	Senate 54 11 nominated by state president in council, 43 elected by provinces. (1 of these elected by Cape Coloured voters on a property and literacy qualification.) White voters over 18 years Up to 5 years	House of Assembly 160 Elected by white voters over 18 years, 4 members elected by Cape Coloured voters (as for Senate) Up to 5 years	Ministers must command the confidence of the House of Assembly and are appointed by the president from members or prospective members of Parliament

TABLE III. — *Details of Commonwealth and of Some Other Parliaments (continued)*

Country	Name of Upper House Number of Members How Elected Duration	Name of Lower House Number of Members How Elected Duration	Relation to Executive
France	*Sénat* (Senate) 274 Elected indirectly by an electoral college of members of the Assembly and local officials Elected for 9 years, one-third retiring every 3 years	*Assemblée nationale* (National Assembly) 482 Elected by all over 21 years 5 years	Ministers responsible to Parliament. They may not sit in either House
Federal Republic of Germany	*Bundesrat* (Federal Council) 41 (+ 4 from West Berlin) They are members of the governments of the various *Länder* Changes when *Länder* governments change	*Bundestag* (Federal Diet) 499 (+ 22 nonvoting for West Berlin) Elected by direct adult suffrage 4 years	Government responsible to Parliament. Ministers are usually members of the *Bundestag* and in any case can be summoned to answer questions
Italy	*Senato* (Senate) 315 Elected by all over 25 years 6 years	*Camera dei deputati* (Chamber of Deputies) 630 Elected by all over 21 years 5 years	Ministers responsible to both Houses. They may, but need not, be members of one or other House. They can speak in either and can be summoned to do so
Spain	*Cortes* 441 Comprises ministers and officials and representatives of various interests 3 years		Government not responsible to *Cortes*
Portugal	(Corporative Chamber) Numbers vary Represents 12 sectional interests	*Assembleia nacional* (National Assembly) 130 Elected by direct vote 4 years	Government responsible only to president
Belgium	*Sénat* (Senate) 106 directly elected, 46 provincial members and 23 co-opted 4 years	*Chambre des représentants* (Chamber of Representatives) 212 Elected by all over 21 years 4 years	Ministers responsible to both Houses. May, but need not, be members of one or other House. Can appear but not vote unless a member
The Netherlands	*Eerste Kamer* (First Chamber) 75 Elected by the provincial diets ½ every 3 years	*Tweede Kamer* (Second Chamber) 150 Elected by all over 23 years Up to 4 years	Government responsible to Parliament: ministers must not be members of the States-General but can appear in either Chamber
Luxembourg	*Conseil d'état* (Council of State) 21 Chosen for life by the sovereign	*Chambre des députés* (Chamber of Deputies) 56 Elected by all over 21 years 5 years	Government responsible to Chamber but ministers need not be members. They have a right and duty to appear in the Chamber
Denmark	*Folketing* 179 Elected by all over 21 years, by proportional representation, 175 seats allocated to metropolitan Denmark, 2 to Faeroe Islands, 2 to Greenland Up to 4 years		Government responsible to the *folketing*: ministers are usually, but not necessarily, members of it
Norway	*Lagting* (Upper Chamber) 38 The *storting* (150 members) is elected by all over 21 by proportional representation. It then divides itself by election into the *lagting* and *odelsting* 4 years	*Odelsting* (Lower Chamber) 112	Government responsible to the *storting*. Ministers may attend its meetings but may not vote
Sweden	*Första kammaren* (First Chamber) 151 Indirectly elected: ⅛ annually, by provincial *Landstings*	*Andra kammaren* (Second Chamber) 232 Elected by all over 21 years, by proportional representation 4 years	Government responsible to *riksdag*. Ministers are usually members of one or other House and can appear in either but not vote unless they are members
Finland	(Parliament) 200 Elected by all over 21 years, by proportional representation 4 years		Government responsible to Parliament. Ministers may, but need not, be members of Parliament
Iceland	*Elfrideild* (Upper House) 20 The *althing* (60 members elected by proportional representation) divides itself by electing 20 of its members to belong to the Upper House. The remainder comprise the Lower 4 years	*Nedrideild* (Lower House) 40	Ministers are responsible to Parliament. They are usually, but not necessarily, members of Parliament

devised ways of exercising a *post factum* power of ratifying or rejecting such legislative orders though the degree of such control varied considerably from country to country. Methods of control over government expenditure also varied in detail, but the principle of parliamentary approval of an annual budget remained of cardinal importance.

4. Political Role.—The effectiveness of parliamentary institutions, however, depended much less on the technical perfection of their rule of procedure than on their ability on the one hand to rally the mass of the population to the support of the political methods necessary for the survival of Parliament, and on the other to create and sustain stable government. It is in these two respects that the experience of many continental countries diverged so markedly from that of Great Britain.

The closest parallels with British forms were to be found in the smaller states of the European northwest seaboard. The similarity of their institutional development may well have owed a great deal to the fact that these countries, like Britain, were predominantly Protestant and mercantile in character. Their size may also have contributed to the strength of Parliament both on account of the relatively homogeneous nature of their several societies, and also because they were not tempted in recent times to seek territorial expansion. Essentially pacific in their relations with their neighbours, they were spared many of the internal tensions that beset larger powers.

There can be little doubt that in the rest of the continent the exacerbated nationalism of the late 19th and early 20th centuries generated political forces which were often inimical to parliamentary forms of government. This was particularly true in France, Germany, and Italy where nationalist parties added a further source of division to societies already characterized by deep-rooted economic, social, and religious tensions. In this way they increased the difficulty of reaching sufficient agreement in Parliament to sustain stable government. In such cases Parliament tended to be a mirror of unresolved conflict rather than a source of strong and effective rule. Coalition ministries, delicately balanced on the thin edge of uneasy compromise, necessarily meant that the power of the executive was much weaker than in Great Britain—and that of Parliament correspondingly greater. Rule by the assembly, rather than cabinet government in the British sense, was therefore a major characteristic of parliamentary practice on the continent.

In such circumstances, one result was that permanent civil servants tended to play a much more important role in government than in Britain. They were the real guardians of continuity in

under the post-World War II republican regime the entire legislative process including final approval for certain types of bills was allowed to take place in committee. This method reduced pressure of business on plenary sessions. Specialized standing committees also were important in many countries, several of which followed French practice in sending bills for initial consideration to these bodies, the subsequent debate in the full house being based on the report drawn up by the *rapporteur* (the committee's nominee who explained its findings to the house). Such committees tended to supersede the older system originally favoured by the Benelux countries by which each draft bill was given a preliminary scrutiny by all the members of Parliament grouped for the purpose in a number of *bureaux* (or sections) chosen by lot.

All parliaments were faced in the 20th century by a substantial growth in the body of new laws, and by the executive's frequent use of various forms of delegated legislation. Most parliaments

policy, especially in the highly centralized French system of government. Another result was that the activity of government, particularly in home affairs, was much more closely circumscribed than in Britain. Where an executive rested on a coalition of divergent political interests it was bound to be more cautious in its policies than a single-party government sure of its parliamentary majority. In some countries measures of reform were, for this reason, much more difficult to achieve than in Great Britain, and parliamentary politicians did not always avoid the reproach of being unduly sensitive to entrenched interests whose influence had been exerted backstage rather than in public. Suspicion that real power remained outside the effective control of elected parliamentarians certainly contributed to the support given to the Communist Party in France and Italy by those who were persuaded that only a change of regime could bring a substantial improvement in their own material conditions.

Nevertheless, and in spite of its many deficiencies, representative government based on Parliament remained the ideal of most nations of western Europe. No other system had been devised that offered the same guarantees of responsible government and freedom of political life, and after the disastrous experience of 20th-century dictatorship, even critics of parliamentary rule accepted its major premises.

5. A Parliament of Europe.—While efforts to improve the functioning of national parliaments continued, a new type of parliamentary activity developed in western Europe in the mid-20th century. This aimed at inserting parliamentary control in the new dimension of government that developed after World War II. It arose out of the increasingly close co-operation between states, and the number of intergovernmental and supranational organizations that were set up with this purpose. Many of the decisions taken by governments in the field of military and economic policy were now reached in concert with their neighbours, and beyond the effective control of national parliaments. This was particularly true in the case of the three European Communities (European Coal and Steel Community, European Atomic Energy Community, and European Economic Community) in which the six member states surrendered some degree of national power to independent Community institutions. To reassert some degree of parliamentary criticism and control over such bodies a series of international assemblies was created. The first was the Consultative Assembly of the Council of Europe (1949), which was followed by smaller regional consultative assemblies—notably the Nordic Council (1953), the Assembly of Western European Union (1954), and the Benelux Consultative Interparliamentary Council (1957). The latest—an enlarged version of the original Common Assembly (1952) of the European Coal and Steel Community—was the European Parliamentary Assembly (1958), now called the European Parliament. This was given a measure of supervision over the independent executives of the three Communities and a consultative role in legislation. Provision was made for its eventual election by direct suffrage, but the failure of member governments to agree about this in 1960 led to a concentration on efforts designed first to increase its powers. It may well be that the major test for parliamentary institutions in western Europe lies in this new sphere of government, as the states in that part of the world move toward economic integration and a real degree of political unity.

See articles on the countries mentioned in this section; *see* also references under "Parliament" in the Index. (R. Pr.)

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PARLIAMENTARY LAW: *see* Rules of Order.

PARMA, chief town of the province of the same name in the region of Emilia-Romagna, northern Italy, and the seat of a bishopric, lies 91 km. (57 mi.) NW of Bologna by road. Pop. (1961) 143,155 (commune). The town is crossed by the Via Emilia and by the Parma River, which separates the old part on the left bank from the new on the right. In the new part there are the remains of a Roman theatre and amphitheatre. The imposing Romanesque Cathedral, rebuilt after an earthquake in the 12th century, has a transept, choir with apses, and a cupola; the front has three rows of arches and a porch supported by two huge marble lions (the work of Giovanni Bona, 1281). Works of art in the interior include La Deposizione (The Descent from the Cross), a relief by Benedetto Antelami (1178), and Correggio's magnificent Assunzióne (Assumption) (1526–30). There are sculptures by Antelami and others of his school in the baptistery (1196–1260) nearby. Noteworthy also are the church of S. Giovanni Evangelista (Bernardino Zaccagni, 1494–1510), with facade and campanile of the early 17th century and a cupola with frescoes by Correggio and arabesques by Michelangelo Anselmi; Sta. Maria della Steccata (16th century), in the form of a Greek cross with a cupola with frescoes by Parmigianino (it was the burial place of the Farnese family); the Gothic churches of S. Francesco del Prato (1298–1462) and of the Carmine (1313–1460); the 16th-century monastery of S. Paolo, with the Camera della Badessa (Room of the Abbess) with frescoes by Correggio; the Old Hospital (15th century), containing the state archives; the church of the Annunziata begun by Giovanni Fornovo in 1566, and that of S. Antonio (Ferdinando Bibiena, 1714).

The Palazzo della Pilotta, residence of the Farnese (begun by Giovanni Boscoli in 1583), was heavily damaged by an air raid on May 13, 1944. In it is the Pinacoteca, containing some of the most famous of Correggio's works and works by other world-famous artists. The Teatro Farnese (G. B. Aleotti, 1618) was restored after war damage; the Biblioteca Palatina has important manuscripts; and the Teatro Regio, built to the order of Marie Louise, is sumptuously decorated. The ducal park, adorned with statues, contains the partly ruined Palazzo Ducale. The Università degli

Studi was founded in the 11th century and reorganized in 1601 by Ranuccio I Farnese. Famous people born at Parma include Benedetto Antelami, Correggio (Antonio Allegri), Parmigianino (Francesco Mazzola), and the conductor, Arturo Toscanini. The printer and type-face designer Giambattista Bodoni worked and died there.

Parma is an important rail and road junction on the main routes from Milan to Bologna. Its economy is mainly agricultural, its industries being largely associated with food products; Parmesan cheese is world famous. Alcohol, fertilizers, and glass are made; also perfumes, including the well-known Parma violet scent.

Founded by the Romans along the Via Emilia in 183 B.C., Parma was important as a road junction; its economy flourished and it obtained Roman citizenship. Made an episcopal see in the 4th century, it was destroyed by Theodoric, king of the Ostrogoths, revived in the Middle Ages and was the seat of the public treasury, hence its appellation Chrysopolis ("golden city"). After being involved in the struggles between empire and papacy, Parma enjoyed some decades of communal liberty, but then passed under a series of local lordships, such as the Da Correggio, and outsiders like the Scaligeri, the Estensi, and the Visconti, under whom its economy progressed. Created a duchy, it passed to the Farnese, and then to the Austrians, from whom it was taken by Napoleon. After the Congress of Vienna it was given to his wife, Marie Louise of Austria. In 1831 it took part in the liberal risings; in 1861, after a plebiscite, it became part of united Italy. From 1875 the diocese was declared subject to the Holy See. During World War II, in April–May 1944, it was extensively damaged by Allied bombardment. (*See* also PARMA AND PIACENZA, DUCHIES OF.)

PARMA PROVINCE has a population (1961) of 381,624 and an area of 1,332 sq.mi. It includes the valleys of the Taro, the Parma, and the Enza. Agriculture and cattle breeding are well developed; there are thermal waters and deposits of methane and petroleum. Notable centres are Busseto (near which is Le Roncole, Giuseppe Verdi's birthplace), Salsomaggiore (saline waters), Colorno (Palazzo Farnese), and Fidenza (Romanesque cathedral, 13th century). (M. T. A. N.)

PARMA, a city of Cuyahoga County, Ohio, U.S., immediately south of Cleveland (*q.v.*). Pop. (1960) 82,845. It has grown rapidly in the post-World War II period (for comparative population figures *see* table in OHIO: *Population*). Although primarily a residential community, Parma also has a large manufacture of automobile and truck components, several tool and die plants, and numerous retail establishments.

Originally named Greenbriar, Parma received township status in 1826. Its early residents of New England stock, as well as later immigrants, were content to remain a predominantly agricultural community until 1912, when a small section seceded to form Parma Heights. In 1924 the remainder of the township incorporated as the village of Parma. The village electorate defeated a proposal of annexation to Cleveland in 1931, choosing instead to become a city on Jan. 1, 1932. (W. G. K.)

PARMA AND PIACENZA, DUCHIES OF. Parma and Piacenza (*qq.v.*), with their dependent territories, were detached from the Papal State by Pope Paul III on Aug. 19, 1545, and erected into duchies for his son, Pier Luigi Farnese (d. 1547). Traversed from the southwest by the Taro River, the new state at its foundation was bounded northwest and north by Milanese territory; northeast by Gonzaga possessions; east by the duchy of Modena; south by the upper Lunigiana (Pontremoli, etc.); and southwest by possessions of the Genoese Republic. For Pier Luigi Farnese and his successors in the male line down to Antonio (d. 1731), *see* FARNESE.

Since Antonio left no legitimate issue, the two duchies passed on his death to the eldest son of his niece Elizabetta Farnese (*see* ISABELLA, consort of Philip V of Spain), namely to the Spanish Bourbon infante Don Carlos (later Charles III of Spain); but when Don Carlos had made himself king of Naples, during the War of the Polish Succession, the duchies were transferred to the Austrian Habsburgs by the preliminaries and Peace of Vienna (1735 and 1738). After the War of the Austrian Succession, however, the Treaty of Aix-la-Chapelle (1748) assigned Parma and Piacenza to Don Carlos' younger brother Philip, who then also received the outlying duchy of Guastalla, a former Gonzaga possession.

For the house of Bourbon-Parma *see* BOURBON: *Table VI.* Philip's son Ferdinand succeeded to the three duchies in 1765, but Napoleon in 1801 prescribed that Ferdinand's son Louis should become king of Etruria instead of waiting to inherit them. Thus a French "administrator" ruled the duchies from Ferdinand's death (1802) till 1808, when they were formally annexed to the French Empire and organized as the Taro *département*.

The Congress of Vienna in 1814 gave Parma, Piacenza, and Guastalla to Napoleon's consort, the Austrian archduchess Marie Louise (*q.v.*). Then the Treaty of Paris (1817) excluded Marie Louise's son, the duke of Reichstadt, from the succession and stipulated that on her death the three duchies should revert to the House of Bourbon-Parma, which was to hold Lucca meanwhile but was to cede Lucca to Tuscany on recovering the three duchies. In 1844, by the secret Treaty of Florence, anticipating the reversion, the future Charles II of Parma (Charles Louis of Lucca) promised Guastalla and Parma's territory east of the Enza River to Modena, in exchange for less valuable territory in northern Lunigiana to be ceded to him by Modena and by Tuscany.

Marie Louise died in December 1847. The Bourbon dynasty was then restored to Parma and Piacenza; but Charles II went into exile during the Revolution of 1848 (Parma and Piacenza then voted for annexation to Sardinia-Piedmont) and abdicated in favour of his son Charles III in March 1849. Assassinated in March 1854, Charles III left the duchies to his infant son Robert, under the regency of his widow Louise of Bourbon-Berry. During the Franco-Sardinian War against Austria the regent transferred her powers on June 9, 1859, to a provisional government, which paved the way for the annexation of Parma and Piacenza to Sardinia-Piedmont in March 1860.

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(E. FA.)

PARMENIDES, of Elea (Velia) in Italy, Greek philosopher, whose application of logical analysis to metaphysical problems was a profoundly original contribution to philosophy, is said by Diogenes Laërtius to have been "in his prime" between 504 and 500 B.C. and would thus seem to have been born *c.* 539. Plato indeed (*Parmenides*, 127 B) makes Socrates hear Parmenides when the latter was about 65 years of age, in which case he cannot have been born before 519; but in the absence of further evidence this may be regarded as one of Plato's anachronisms. At all events Parmenides was a contemporary of Heraclitus. Parmenides attached himself for a time to the aristocratic brotherhood which Pythagoras established at Crotona; and this is in keeping with the mystical tone of his writing. The theological speculations of Xenophanes, who described God as one and unchanging, may well have suggested Parmenides' doctrine about reality in general.

The Poem.—Parmenides embodied his tenets in a short poem called *Nature*, of which about 160 lines have been preserved in the writings of Sextus Empiricus, Simplicius and others. It is traditionally divided into three parts—the "Proem," "Truth" (the way of truth) and "Opinion" (the way of belief).

The "Proem."—In the "Proem" the poet describes his journey from darkness to light. Borne in a chariot, attended by the daughters of the sun, he reaches a temple sacred to an unnamed goddess (variously identified by the commentators with Nature, Wisdom, or Themis) by whom the rest of the poem is spoken. He must learn all things, she tells him, both truth, which is certain, and human opinions; for, though in human opinions there can be no "true faith," they must be studied for what they are worth.

"Truth."—There are three ways of research, and three ways only. Of these, one asserts *"It is not*, and there must be not-being." This is utterly forbidden: what is not cannot even be thought of. A second way to that of mortals without wisdom, who say of what is that "it is and is not," "is the same and not the same." In contrast to them the way of truth starts from the proposition *"It is*, and not-being is impossible."

What is is uncreated, for it cannot be derived either from

being or from not-being; it is imperishable, for it cannot pass into not-being; it is whole, indivisible, continuous (for nothing exists to break its continuity), homogeneous and unchangeable (for nothing *else* can exist or come into existence; it is perfect, for there is nothing which it can want; it never was, nor will be, but only is; it is evenly extended in every direction and therefore a sphere, exactly balanced; it is identical with the thought that recognizes it—thought means thinking "It is," and there is nothing apart from what is.

As then what is is one, invariable and immutable, all plurality, variety and mutation belong to what is not. Whence it follows that all things which men suppose to be real, generation and destruction, being and not-being, change of place, alteration of quality are no more than empty words.

"*Opinion.*"—It remains in "Opinion" to describe the plurality of things, not as they are, for they are not, but as they appear. In the phenomenal world there are, it has been thought (and Parmenides accepts the theory, which appears to be of Pythagorean origin), two primary elements—namely, fire, which is gentle, thin, homogeneous, and night, which is dark, thick, heavy. These elements are separate or different from each other, but self-identical and on an equal footing; all things are composed of them. The foundation for a cosmology thus being laid in dualism, the poem describes the generation of "earth and sun, and moon and air that is common to all, and the milky way, and farthest Olympus, and the glowing stars"; but the scanty fragments which have survived only show that Parmenides regarded the universe as a series of concentric bands composed of the two primary elements and of mixtures of them, the whole system being directed by an unnamed goddess established at its centre. Next came a theory of animal development, followed by a psychology, according to which like is known by like. For thought is identical (?) with the constitution of the elements (not "limbs") in a man's body; and if Parmenides is referring here to sensation, whose objects were mere appearances, knowledge of the one reality was probably identical with a plenum of light (*fr.* 16). "Thus according to opinion," Parmenides concludes, "were the things of our world generated, and are now, and shall hereafter grow and come to an end."

The Meaning of the Poem.—The understanding of the whole poem is beset with difficulties. The most important points are: (1) the meaning of the *It is* of the way of truth; (2) the meaning of the identity between thought and its object; and (3) the relation of opinion to truth.

1. The Ionian philosophers who preceded Parmenides had put the question "What is nature, or reality?" in physical terms. They had looked for some single stuff, such as water or air or something indeterminate, which underlay the plurality and change that we observe. This was what really is, rather than comes to be as a mere process. Parmenides answered the same question by considering, as a matter of purely abstract analysis, what it is for anything to "be." He therefore unfolds a chain of implications involved in the assertion "It is." The subject of the proposition is primarily impersonal (as in "It is freezing"), but it will also be reality itself or "being", just as "reality" means for us ambiguously both "what it is to be real" and "that which is real." The implications appear in the form of properties which must be possessed by reality in the concrete. The method depends on treating anything *besides* "being" as *not* "being" and therefore sheer nothing. Thus reality is "complete," for there *is* nothing *else* which it could be; and, because complete, it is "unchanging," for change implies coming to possess a property which it does not yet have.

2. By stressing the abstract or logical nature of the method, it is possible to reach the identity of thought and reality. Logical "being" is that which is found in thought, or (as the copula) in judgments; and this is the only universal kind of being, hence what really is. But while the translation of the relevant passages is doubtful, they all appear to be associated with the denial of not-being. So it may be that Parmenides means only that thought of reality cannot be anything over and above reality: "thinking" means "thought *is*" or "there is a thought." The psychology of "Opinion" would be an attempt to explain this. Simply to say that Parmenides is a mystic and a kind of pantheist, who believes that nature is conscious, is not to the point. For his position has to be a deduction from the way of truth.

3. The cosmology is said to be deceptive and concerned only with appearances, but at the same time to be "unsurpassable by mortal judgment." Its dogmatic tone makes it quite improbable that Parmenides meant it ironically or was describing a system which was not his own. It is not truth, because it concedes two realities. All qualities are somehow aspects of these: for instance, heat, life and knowledge are fire or light; cold, death and ignorance are night or darkness. But where it differs from Ionian physics is in substituting mixture of the elements for transmutation. For neither element can ever *not be* what it is. So much is conceded to the way of truth. How unity and reality can ever give rise to appearance and plurality is a problem which Parmenides does not finally answer.

Influence.—His departure from the method of the Ionian physical philosophers made Parmenides the father of metaphysics. Before there was a technical name for metaphysics, Aristotle spoke of "the science of truth as it was introduced by the school of Anaxagoras and Parmenides" (*Protrepticus*, no. 5b in R. R. Walzer's ed. of the *Fragments*). But just because the new analysis of "reality" was so abstract, it could be used by widely differing thinkers. It suggested the properties of the atom to Leucippus and to Democritus. In his *Parmenides* and in his *Sophist* Plato developed it dialectically so as to account for the formal characteristics of his own "Ideas." The denial of "not-being" was used by the sophists to deny the logical possibility both of contradiction and of falsehood (since this is "saying the thing that is not"). The denial of motion led to Zeno's paradoxes and to the theoretical problem of the continuum.

See ELEATIC SCHOOL; *see* also references under "Parmenides" in the Index.

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PARMENIO (*c.* 400–330 B.C.), son of Philotas, Macedonian general in the service of Philip II and Alexander the Great. During the reign of Philip he obtained a great victory over the Illyrians (356); he was one of the Macedonian delegates appointed to conclude peace with Athens (346), and was sent with an army to uphold Macedonian influence in Euboea (342). In 336 he was sent with Amyntas and Attalus, his son-in-law, to Asia Minor to make preparations for the conquest of Asia. In the confusion that followed Philip's murder he declared for Alexander and helped to murder Attalus. In 335 Alexander recalled him. Parmenio was his second-in-command throughout the conquest of Persia, and commanded the left wing at the battles of Granicus, Issus, and Gaugamela, at which last he was outmaneuvered by Mazaeus and had to send to Alexander for help. When Alexander went on eastward to Drangiana he left Parmenio behind in Media to guard his communications; on the campaign Philotas, Parmenio's son, was charged with conspiracy, tried by the army and put to death. The guilt of Philotas or his father is uncertain; but Alexander sent orders to Parmenio's subordinates to murder him at Ecbatana (autumn 330).

PARMIGIANINO (PARMIGIANO; GIROLAMO FRANCESCO MARIA MAZZOLA or MAZZUOLI) (1503–1540), Italian painter, who was one of the first artists to react against Renaissance classicism, was born in Parma on Jan. 11, 1503. He was brought up by his two uncles who made him learn to draw "under the instruction of excellent masters" (G. Vasari). He was probably never a pupil of Correggio, but there is no doubt that Correggio's was

the strongest single influence on his early development. This is apparent, for example, in his first important work, the "Mystic Marriage of St. Catherine" (*c.* 1521, Canonica di Bardi, near Parma), though that work already contains an element of asymmetry in its composition which foreshadows the later development of his personal style. About 1522–23 he executed two series of frescoes: one in the first two side chapels on the left in S. Giovanni Evangelista, Parma, contemporaneously with Correggio's great work on the dome and pendentives of that church; and the other, representing the "Legend of Diana and Actaeon," on the ceiling of a room in the castle of Fontanellato just outside the city. The scheme of the latter decoration, with its children playing among an imitation pergola which is open to the sky and which forms lunettes below, recalls Correggio's work in the Camera di San Paolo in Parma itself.

In 1524 Parmigianino moved to Rome, taking with him three specimens of his work to impress the pope, including the famous portrait which he had painted of himself reflected in a convex mirror on a convex panel (Kunsthistorisches museum, Vienna). His chief painting done in Rome, the large "Vision of St. Jerome" (National gallery, London), shows the influence of Michelangelo, but it was rather, in Vasari's words, "the spirit of Raphael which passed into the body of Francesco" and which remained with him all his life; it was Raphael's ideal beauty of form and feature, rather than Raphaelesque motives or compositions, which he found sympathetic. While at work on the "Vision of St. Jerome" in 1527, he was interrupted by soldiers of the imperial army taking part in the sack of Rome, and he left for Bologna. There he painted one of his masterpieces, the "Madonna With St. Margaret and Other Saints" (Bologna gallery), which shows a new fluency of linear rhythm and a new technical virtuosity of handling. In 1531 he returned to Parma, where he remained for the rest of his life, the principal works of this last period being the "Madonna dal Collo Lungo" (Uffizi gallery, Florence) and the frescoes on the vault preceding the apse of Sta. Maria della Steccata, Parma. The latter were to have been only part of a much larger scheme of decoration in the church, but Parmigianino was extremely dilatory over their execution and he was eventually imprisoned for breaking his contract. He died on Aug. 24, 1540, at Casalmaggiore, Cremona.

BY COURTESY OF THE TRUSTEES OF THE NATIONAL GALLERY, LONDON

"VISION OF ST. JEROME" BY PARMIGIANINO, 1527, IN THE NATIONAL GALLERY, LONDON

The style which he developed was the first and perhaps the most brilliant exposition of one of the two major aspects within the style known as mannerism, that which might loosely be called its "decorative" aspect (the other, the "expressionist," having been developed in Florence chiefly by Jacopo da Pontormo). This involved a reaction against many of the principles of High Renaissance art, especially its dependence on nature and its basis in stability and clarity of design.

Parmigianino's works are distinguished by ambiguity of space composition, by distortion and elongation of the human figure and by the pursuit of what Vasari called "grace," that is to say, a rhythmical, sensuous beauty beyond the beauty of nature. This last quality is evident not only in Parmigianino's paintings, but also in his numerous and sensitive drawings, which range from elaborate studies for compositions to slight sketches of genre subjects.

He was perhaps the first Italian artist to practise etching (*q.v.*), and he was one of the most remarkable portrait painters of the century outside Venice. Some of his best portraits are in the Naples gallery, including the "Gian Galeazzo Sanvitale" (1524) and the so-called "Portrait of the Courtesan, Antea" (*c.* 1535–37).

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PARMOOR, CHARLES ALFRED CRIPPS, 1st BARON (1852–1941), English lawyer and statesman, a strenuous supporter of international cooperation for peace and a member of the first two Labour governments, was born at West Ilsley, Berkshire, on Oct. 3, 1852. Educated at Winchester and New College, Oxford, he was called to the bar by the Middle Temple in 1877 and became a queen's counsel in 1890. He became a bencher of his Inn in 1893 and its treasurer in 1917. The basis of his successful legal practice was ecclesiastical. He was appointed attorney general to the prince of Wales in 1895 and was reappointed in 1901 and 1912. He sat in the House of Commons as a Conservative between 1895 and 1914. A strong high churchman, he was made vicar-general to the province of York in 1900 and was vicar-general of Canterbury, 1902–24. In 1914 he was specially appointed a judicial member of the privy council and was raised to the peerage. After World War I Parmoor's interest in international order led him toward the Labour Party; and in the Labour governments of 1924 and 1929–31 he was lord president of the council. In 1924 he represented Great Britain at the assembly of the League of Nations. He died at Henley-on-Thames on June 30, 1941. His youngest son was Sir Stafford Cripps (*q.v.*). (R. J.)

PARNAÍBA, a port in the state of Piauí, Braz., on the right bank of the Parnaíba River, 9 mi. upstream from the Atlantic Ocean. Pop. (1960) 39,951. Founded in 1761, the town has served as the most important commercial centre for the river valley. The chief products shipped from Piauí through Parnaíba and its outport, Luis Correia, are carnauba wax, cotton, babassu oil, sugar, cattle, and hides. (P. E. J.)

PARNASSIANS, a group of French poets, headed by Leconte de Lisle, and for a time by Théodore de Banville, who looked for impersonality, technical perfection, and pictorial qualities, and who derived their name from the anthology to which they contributed; *Le Parnasse contemporain*, edited by Xavier de Ricard and Catulle Mendès and published by Alphonse Lemerre (1866, 1871, and 1876). They had become conscious of a common aim in *La Revue fantaisiste* (1861), likewise founded by Mendès, and some of their ideas had already been formulated by Leconte de Lisle in the preface to his *Poèmes antiques* (1852). The principal disciples were Joseph Albert Glatigny, François Coppée, Léon Dierx, and José-Maria de Heredia. Others, like Sully Prudhomme, adhered only to certain tenets. The Parnassians were opposed to the lyrical effusions and loose versification of romantics like Alphonse de Lamartine and Alfred de Musset. They admired Victor Hugo's *Les Orientales* (1829) for its colourfulness and virtuosity, and they considered that Théophile Gautier's preface to *Mademoiselle de Maupin* (1835), which expounded the theory of art for art's sake, and his book of verse, *Émaux et Camées* (1852), pointed to a new conception of poetry. They extolled craftsmanship and were suspicious of inspiration. Much experimentation with metres and verse forms was carried on, particularly by Banville in *Poésies complètes* (1857) and *Petit Traité de poésie française* (1872). The sonnet, neglected by the romantics, again enjoyed a remarkable vogue.

Political disillusionment after the 1848 Revolution and the *coup d'état* of 1851 led the Parnassians to turn away from contemporary society toward exotic lands and past civilizations, notably to ancient Greece (here they recognized André Chénier as a precursor) and to India. Comparative mythology and the history of religions, epics, and sagas furnished erudite themes for poets imbued with the scientific spirit of the age; *e.g.*, Leconte de Lisle's *Poèmes barbares* (1862). The visual arts were "transposed" into poetry, and in this respect Heredia's *Les Trophées* (1893) was a typical Parnassian work. But it marked the end of the movement,

for a new generation of poets, the Symbolists, were following Stéphane Mallarmé and Paul Verlaine, themselves Parnassians in their youth, who had broken away from precise description in search of an art of nuance and musical suggestion.

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(E. M. So.)

PARNASSUS (Gr. PARNASSÓS), a mountain in Greece, 8,061 ft., in the south of Phocis (Fokís), rising north of Delphi. Parnassus was in ancient times a holy mountain, sacred to Dionysus and the Corycian nymphs, later also to Apollo. Its chief peaks were Tithorea and Lycorea (modern Liákoura). Two projecting cliffs, named the Phaedriades ("shining rocks"), frame the gorge in which the Castalian Spring flows out, and to the west of this, on a projecting shelf, is the site of the sanctuary of Apollo at Delphi. The Corycian Cave, a large two-chambered stalactite cave sacred in ancient times to the Nymphs and Pan, is on the plateau between Delphi (*q.v.*) and the summit. Roman poets began the process by which Parnassus has usurped the place of Mt. Helicon as home of the Muses, and the Castalian Spring has come to be represented as a source of poetic inspiration. Parnassus, a barren limestone mass, is usually ascended either from Delphi or from the village of Arákhova at its southern foot.

PARNASSUS PLAYS, a series of three scholastic entertainments performed at St. John's college, Cambridge, between 1597 and 1603. They are satirical in character and aim at setting forth the wretched state of scholars and the small respect paid to learning by the world at large, as exemplified in the adventures of two university men, Philomusus and Studioso. The first part, *The Pilgrimage to Parnassus,* describes allegorically their four years' journey to Parnassus; *i.e.,* their progress through the university course. The sequel *The Returne From Parnassus,* which deals with the adventures of the two students after the completion of their studies at the university, shows them discovering by bitter experience of how little pecuniary value their learning is. A further sequel, *The Second Part of the Returne From Parnassus, or the Scourge of Simony,* is a more ambitious, and from every point of view more interesting, production than the two earlier pieces. In it on pretense of discussing a recently published collection of extracts from contemporary poetry, John Bodenham's *Bel-vedere* (1600), one of the characters sums up a number of writers of the day, among them being Spenser, Henry Constable, Michael Drayton, John Davies, Marlowe, Jonson, Shakespeare and Thomas Nashe.

Their author is unknown, but the plays have generally been regarded as the work of a single writer—possibly John Day or one William Dodd (for a full discussion *see* A. W. Ward, *A History of English Dramatic Literature to the Death of Queen Anne,* ii, p. 640, note 2 [1875]). The three pieces were evidently performed at Christmas of different years, and allusions to contemporary affairs show that the first cannot have been earlier than 1598 nor the last later than 1602.

BIBLIOGRAPHY.—The only part of the trilogy which was in print at an early date was *2 Return,* called simply *The Returne From Parnassus: Or The Scourge of Simony* (1606), two editions bearing the same date. This has been reprinted several times, the best separate edition being that of E. Arber (1880). Manuscript copies of all three plays were found among T. Hearne's papers in the Bodleian library, Oxford, by W. D. Macray and were printed by him in 1886 (the last from one of the editions of 1606, collated with the manuscript). G. C. Moore Smith, "The Parnassus Plays," *Modern Language Review,* x (1915), gives a number of corrections of Macray's text. *See* also *The Three Parnassus Plays, 1598–1601,* ed. by J. B. Leishman (1949), and W. Lühr, *Die drei Cambridger Spiele vom Parnass* (1900).

(R. B. McK.)

PARNELL, CHARLES STEWART (1846–1891), ardent Irish nationalist and first president of the Home Rule party, was born at Avondale, County Wicklow, on June 27, 1846. The Parnell family were Protestant landowners of Cheshire origin, settled in Ireland since the late 17th century. Charles Stewart's great-grandfather, Sir John Parnell, chancellor of the Irish exchequer in Henry Grattan's parliament (1782–1800), was an uncorrupted opponent of the Act of Union (1800). His mother was a daughter of Commodore Charles Stewart of the United States navy, a hero of the War of 1812 whose parents had emigrated from Belfast before the American Revolution. The traditions and atmosphere of the home in which Parnell grew up were thus significantly different from those of the majority of the landowning class. They did not, however, prevent Parnell's parents from giving their son an education normal for his class. He went to three English boarding schools, where he seems to have been unhappy, and to Magdalene college, Cambridge, where in 1869, after an undistinguished career, he was rusticated for a relatively minor breach of discipline, and decided not to return.

BY COURTESY OF THE NATIONAL GALLERY OF IRELAND

CHARLES STEWART PARNELL, FROM A PAINTING DONE IN 1892 BY SYDNEY PRIOR HALL

The Home Rule League and the Land League.—The Ireland to which Parnell returned was in ferment (*see* IRELAND: *History*). The execution of three Fenians, the "Manchester martyrs," in Nov. 1867, had aroused intense indignation, and the amnesty movement for Fenian prisoners was supported not only by the revolutionary Irish Republican brotherhood (Fenians) but also by moderate "constitutional" nationalists, and gave the impetus for the launching in 1870 of a new political group, the Home Rule league. In the general election of 1874, 56 candidates pledged to the league—to autonomy for Ireland in purely local affairs—were successful. They formed, nominally, a Home Rule party in parliament and were led, also nominally, by Isaac Butt (*q.v.*). They were socially conservative, deferential to the opinions of the Catholic hierarchy and, in most cases, to the English Liberal whips. All appealed in some degree to the national sentiments of the electorate.

Parnell, an eminently suitable Home Rule candidate, was elected as member for Meath in April 1875. Within two years he distinguished himself by his indifference to the opinion of the house of commons and his sensitivity to Irish nationalist opinion. He embraced the policy of obstructing English legislation to draw attention to Ireland's needs, and his handsome presence and commanding personality gave him a powerful appeal. Butt disavowed these activities, thereby losing the support of Irish nationalist opinion, which now looked to Parnell as a rising leader. In Sept. 1877 the Home Rule Confederation of Great Britain, largely controlled by Fenians, elected Parnell its president in place of Butt, who fell ill and died soon afterward. Parnell had become, at the age of 31, the most conspicuous figure in Irish politics.

The year 1878 saw the beginning of a major agricultural crisis in Ireland, which seemed to threaten a repetition of the terrible famine and mass evictions of the 1840s. To resist eviction and make Irish landlordism unworkable, the Irish Land league was founded in 1879 by Michael Davitt, a Fenian recently released from Dartmoor prison. The majority of the Home Rule party condemned the league, as did the Catholic bishops. Parnell identified himself with it and became its first president, thus becoming the centre of the great "new departure" national movement in which revolutionary devotion was combined with agrarian agitation, and was supported by the obstructionist tactics of the "active section" in parliament. Soon after the general election of 1880, Parnell was elected chairman of the Home Rule group in the new parliament. After the rejection by the house of lords of a moderate measure for Irish land reform, Parnell organized a massive land agitation, for which he then won the support of the clergy and of "moderate" opinion. It was combined with parliamentary obstruction on so large a scale that ultimately 36 Irish members were suspended. At this time Parnell rejected a policy of secession from parliament, put forward by the Land league.

The passage in 1881 of Gladstone's Land act, which conceded the principle that fair rents could be judicially determined, pre-

sented Parnell with a serious test of statesmanship. Its passage was unquestionably a great achievement for the Land league, but the most active Land leaguers were not content and a split in the movement seemed likely. This Parnell avoided by pursuing a policy moderate in substance—testing the act by bringing selected cases before the land commission—but making speeches couched in violent language. As a result, probably in accordance with his wish, he was, on Oct. 13, 1881, lodged in Kilmainham jail, Dublin. This assured his continued popularity and absolved him of responsibility for subsequent events.

Parnell's arrest was followed by the suppression of the Land league, and a winter of sporadic local terror. "Captain Moonlight" (the signature usually appended to written threats made against landlords and obnoxious tenants) had taken his place. In the spring of 1882, when Irish opinion had become exasperated, Parnell began negotiations for his release, conducted in the main through Capt. William O'Shea, a "moderate" Home Rule member, whose wife had been Parnell's mistress since 1880 (*see* O'SHEA, WILLIAM HENRY and KATHARINE). The settlement reached, the "Kilmainham treaty," was not inconsistent with Parnell's previous political action. The tenants were to obtain substantial concessions and Parnell was to use all his influence to decrease further agitation.

The murders, in Phoenix park, Dublin, of the chief secretary and the permanent undersecretary, which occurred within a few days of Parnell's release (May 2, 1882), caused a general revulsion against terrorism and Parnell had little difficulty in bringing the nationalist movement again under firm discipline, subordinating the Irish National league (the successor to the Land league) to the Home Rule party in parliament. The Fenians lost much influence and agitation was brought under control.

Parliamentary Maneuvers.—The "Kilmainham treaty" ended the revolutionary phase of the "new departure." The results of by-elections showed that Parnell's leadership was unquestioned, except in eastern Ulster, and, after the franchise reform of 1884, it became apparent that Parnell was likely in the next parliament to lead a party of between 80 and 90 members. With this potential strength, which would give control of the balance of power, Parnell became a force to be reckoned with. Two powerful groups set themselves to seek an arrangement with him. The first of these, the Radicals, led by Joseph Chamberlain and Sir Charles Dilke, failed, mainly because Parnell saw the opportunity of an arrangement with the Tories, more profitable, he believed, than anything offered by a mere section of the Liberal party. His contemptuous rejection of their overtures left a legacy of resentment.

The Tory advances led very quickly to a combination in which Tories and Irish voted together to defeat the Liberal government (June 1885). In the period of Tory minority administration the possibilities of legislation to satisfy the Home Rule demand were discussed, inconclusively. In the election campaign that followed (Nov.–Dec. 1885), Parnell, having failed to get a satisfactory Home Rule statement from Gladstone, issued the so-called "vote-Tory manifesto." Parnell's "pro-Tory" policy has been criticized as one founded on the illusion of Tory benevolence. Parnell, however, was bearing in mind two important facts: the strategic fact that the Tories, with their influence in the house of lords, were in a better position to make their policies law, and the tactical fact that, as the Liberals were the party most likely to win, it was in the Irish interest to keep down their margin of victory. The results showed, however, that although the Irish could put the Liberals out, they could not keep the Tories in. In these circumstances, the Tories immediately broke with them and announced the intention of reintroducing coercion in Ireland. Parnellites and Liberals voted together to bring down the government and Gladstone took office on Feb. 1, 1886. For his continuation in office he depended on Irish support.

There followed the curious and ominous episode of the Galway election. Parnell, under pressure from the O'Sheas and Joseph Chamberlain, put forward Captain O'Shea as Home Rule candidate, although he had refused to take the pledge "to sit and vote with the party." The evidence suggests that Chamberlain was attempting to undermine Parnell's authority and split his party. If so, he failed. A mutiny of a small faction was quelled and O'Shea was elected.

Although Gladstone's Home Rule proposals—involving a wide measure of autonomy—fell short of nationalist aspirations, Parnell accepted them as a basis of settlement and enlisted public opinion in their support. The introduction of the bill, though it was later rejected by the commons on the second reading (June 1886), was regarded as his personal triumph. When the Conservative Lord Salisbury succeeded Gladstone as prime minister, Parnell withdrew to some extent from active political life. This was partly due to ill-health, but also to political reasons. With the Irish party firmly allied to the opposition, there was now no room for parliamentary obstruction. Parnell would neither challenge Gladstone's leadership nor appear as his henchman. He also held aloof in Ireland from the ingenious rent-withholding combination known as the "plan of campaign," devised by William O'Brien.

Despite his relative inactivity, however, Parnell's name was kept before the public through the misdirected efforts of his enemies. On April 18, 1887, *The Times* published a facsimile of a letter purporting to be written by Parnell condoning the murder of the undersecretary (Thomas Henry Burke) in Phoenix park in May 1882. Parnell immediately denounced it as a forgery. Nearly two years later the forger, a journalist named Richard Pigott, collapsed under cross-examination before the commission established to investigate the charges. Pigott's suicide in Madrid soon afterward riveted public attention on Parnell. His already towering prestige in Ireland, recently increased by his firm and subtle handling of a potential crisis caused by a Holy office rescript (1888) condemning the "plan of campaign," could receive only additional lustre from these events, while in the eyes of the English liberals he was transformed from a dubious ally into a hero and martyr. This brief period was the peak of Parnell's career.

Parnell's Fall.—On Dec. 24, 1889, Captain O'Shea filed his petition for divorce, naming Parnell as corespondent. Although the relations between Parnell and Katharine O'Shea had been known to some members of the Irish party, nationalist Ireland in general took it that the proceedings represented another Unionist attempt to wreck Home Rule. This was given colour by the fact that O'Shea had given evidence in the Pigott case and was a follower of Joseph Chamberlain. The theory that there were political motives behind the divorce proceedings is not necessarily false. The suit being undefended, the court returned a verdict against Parnell and Mrs. O'Shea on Nov. 17, 1890.

The initial reaction of the Irish public was to uphold Parnell. In England, however, nonconformist opinion was so hostile that Gladstone wrote to John Morley that Parnell's continuance as leader of the Irish party would render his own leadership "almost a nullity." The Irish parliamentary party found itself in an agonizing dilemma. Parnell was determined to hold the leadership and defy Gladstone. If the party upheld Parnell they would be destroying the Liberal alliance, and with it the hopes of Home Rule in their generation. If they rejected Parnell, they would be turning against him at the bidding of an Englishman. After a long and emotional debate, during which Parnell used his powers as chairman in a resolutely partisan fashion, the majority rejected his leadership. A sizable minority remained with him.

There followed a series of bitter electoral campaigns. The Catholic hierarchy, although slow to pronounce, now declared Parnell morally unfit for leadership. His marriage to Mrs. O'Shea in June 1891 exacerbated Catholic opposition. He himself displayed feverish energy and increasing recklessness, directing his appeal more and more to the revolutionary elements. This appeal left a deep impression on the young but was rejected by the majority of the electors in three by-elections fought between Dec. 1890 and July 1891. When his principal ally, the nationalist *Freeman's Journal*, fell to his enemies shortly after his marriage, his cause was clearly lost. He died at his wife's home in Brighton on Oct. 6, 1891, and was buried in Glasnevin cemetery, Dublin. The city, Parnellite to the end, gave him a magnificent funeral.

Parnell's achievement was that he took the question of self-government for Ireland out of the academic domain into that of practical politics. After the Cromwellian land settlement had been

disrupted by the "new departure," and after one of the two great English parties had been brought to accept the principle of Home Rule, English authority in Ireland never again rested on so solid a foundation. His image in defeat had a powerful effect on the next generation. Both Sinn Fein and the Irish literary revivalists regarded him as a hero and precursor.

See IRELAND: *History; see* also references under "Parnell, Charles Stewart" in the Index.

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PARNELL, THOMAS (1679–1718), Anglo-Irish poet, who alone among Alexander Pope's associates could, like him, combine wit with lyrical pathos, was born in Dublin in 1679. In 1706 he became archdeacon of Clogher and in 1716 vicar of Finglass. He contributed to the *Spectator* and the *Guardian* and was a member of the Scriblerus Club (*see* LITERATURE, SOCIETIES OF). In 1717 he published *Homer's Battle of the Frogs and Mice. With the Remarks of Zoilus. To which Is prefixed, the Life of the Said Zoilus.* His *Poems on Several Occasions* were published by Pope in 1722, after Parnell's death at Chester in 1718. He was buried at Chester on Oct. 24, 1718.

Though his best-known poem is "The Hermit," which was very popular in his own century, better than it are "A Fairy Tale in the Ancient English Style," a piece of medievalism which begins as mockery but becomes something more; "A Nightpiece on Death," which Oliver Goldsmith thought superior to Gray's *Elegy Written in a Country Churchyard,* and "An Elegy to an Old Beauty," which includes the lines:

> While with'ring seasons in succession, here,
> Strip the gay gardens, and deform the year.

His love songs and anacreontics show the grace and gaiety—what Pope esteemed as the "ease"—of the aristocratic lyrists of the previous century. In general Parnell wrote a highly artificial though imaginative language, but he could be colloquial, as in much of "An Elegy to an Old Beauty."

See *Poetical Works,* ed. by G. Aitken (1894); *Minor Poets of the Eighteenth Century,* ed. by H. l'A. Fausset (1930), contains all Parnell's poems. (D. A. DE.)

PARNU (PYARNU; Ger. PERNAU), the second seaport of Estonia (since 1940 the Estonian Soviet Socialist Republic, U.S.S.R.), lies on the left bank of the Parnu river, ½ mi. above its entrance into Parnu bay, the northern arm of the Gulf of Riga. Parnu is about 120 km. (75 mi.) S. of Tallinn by road. Pop. (1959) 36,100. The town has fish, timber, textile and motor industries. Parnu is Estonia's most popular seaside resort, noted for its mud baths. Founded on the right bank of the river in 1251 by the bishop of Saaremaa (Swedish Ösel), Parnu was occupied in succession by the Swedes, the Poles and the Teutonic Knights in the 16th century. After 1599 the Poles transferred the town to the left bank and in 1642 the Swedes, who had been in possession since 1617, strengthened it with fortifications. In 1699–1710 the Swedish university, evacuated from Tartu on the advance of the Russians, was established there. In 1710 Parnu was taken by the Russians, who called it Pernov, and in 1918 it was included in independent Estonia. Soviet forces occupied it in 1940 and the Germans from 1941 to 1944, after which it again became part of the Soviet Union. (AL. K.)

PAROCHIAL EDUCATION, U.S. Many church parishes and other religious bodies in the United States maintain elementary and secondary schools that provide education based on sectarian principles and are separate from the public, or common, school system. Such schools for the children of members of a parish or congregation are supported principally by the voluntary offerings of the parishioners, augmented occasionally by modest fees; they are distinguished from public schools operated under the direction of school boards made up of local citizens and supported by public taxes, and from private schools maintained by private individuals or groups and supported principally by tuition fees.

The first schools in North America were established by religious groups. As early as 1606 Spanish Roman Catholic missionaries opened a school in Saint Augustine, Fla. Subsequently the missionaries who accompanied other expeditions established schools to educate the children of their comrades as well as the natives. Later various Protestant religious groups seeking freedom of worship emigrated to North America and established their own schools.

Through the 17th century church and state were closely allied, in the American colonies as in Europe. With the increase in the 18th century of nonconformist groups opposed to the control of education by the established churches, the colonies began to permit different religious groups to conduct their own schools. The chief function of such schools was to educate the child in the basic skills of reading, writing, number work, the practical arts, and the religious principles of the particular denomination sponsoring the school.

The development of the U.S. public school began in the 18th century, although in 1850, according to the census of that year, many "public" schools still were supported largely by tuition and other fees. The church-conducted school was still common and in many places it was supported in part by public funds. In some states, certain types of public support continued into the 20th century. A general policy developed through a series of state and federal supreme court decisions prohibited direct aid to church-controlled schools as unconstitutional, but permitted auxiliary aid, as for transportation, safety, health and welfare. Some states provide such auxiliary aid. (For fuller discussion of the historical development of public and parochial schools in relation to the separation of church and state in the United States *see* EDUCATION, HISTORY OF: *National Systems: United States,* especially the sections *Control of Education in Colonial America* and *Public Education in the Early National Period.*)

Parochial, or denominational, schools, classified as independent schools, also developed in Australia and New Zealand after support from public funds was withdrawn when the state school systems were established in the 1870s and 1880s. In some countries that have denominational as well as undenominational schools, both types are principally supported by public funds, as in England and Canada.

Opponents of parochial education generally maintain that it serves to promote divisive elements in society. Further, while admitting that individual schools have provided excellent educational programs, they point out that many parochial institutions have operated at standards well below those of the public schools with poorly trained teachers and inadequate buildings, facilities and programs. Some, too, have been critical of textbooks and other teaching materials that seem to present a biased point of view.

In the second half of the 20th century about 14% of all U.S. children or about 6,500,000 attended private and parochial schools. Approximately 90% of these children attended schools sponsored by the Roman Catholic Church.

Roman Catholic Parochial Schools.—These schools are organized on a diocesan basis and are financed by the parish. In some areas, these schools serve the children of several parishes or a district defined by the bishop. Such schools are called diocesan schools and are financed by the several parishes involved and sometimes by diocesan funds. To educate children having particular problems or handicaps, many dioceses establish and maintain special schools for orphans, the deaf, the blind, the speech defective, the emotionally disturbed or the mentally retarded.

The administration of the schools of a diocese is the direct responsibility of the bishop. This work is usually delegated to a priest, appointed by the bishop, who is given the title of superintendent of schools or secretary for education. His functions closely parallel those of the chief school officer in the public school system. He is responsible for the organization and supervision of the schools of the diocese; selection of textbooks; preparation of courses of study; policies and practices of all the schools; and enforcement of diocesan and state regulations. His office and authority are defined by the bishop.

Most dioceses have a school board made up of members ap-

pointed by the bishop. Usually this board has no administrative power but acts in an advisory capacity to the bishop and his chief school officer.

The Roman Catholic schools teach the same subjects as the public schools, but two important differences should be noted. In the Catholic school, a course in Christian doctrine is included which presents the truths of faith and morals which are the teachings of the Roman Catholic Church. Furthermore, all subjects in the school program are based ultimately on religious truths. The entire program is designed to help the child develop into the likeness of Christ.

Both religious and laymen teach in the Catholic schools. The religious teachers belong to one of the many religious communities and usually reside in a convent located near the school to which they are assigned. A modest salary is paid to the religious community for the support of each teacher. Lay teachers receive regular salaries, generally less than their colleagues in private or public education. All teachers must be prepared for this work and must meet standards established by the diocese and in some instances by the state.

Oftentimes diocesan systems organize on a state-wide or regional basis in order to share certain educational advantages and to exchange ideas and programs for the betterment of their teachers and schools. All diocesan systems are members of the National Catholic Educational association, a nation-wide organization established for the mutual benefit of all schools and teachers. The common interests of the Catholic bishops of the United States in education are represented by the department of education in the National Catholic Welfare conference. (J. B. McD.)

Protestant Parochial Schools.—Wherever the Protestant Reformation spread, Lutherans, Calvinists and other Protestant groups founded schools to teach the principles of Christian faith and life. While these schools offered a general education, they were founded and maintained because of religious convictions that a complete education must include religion and must develop a Christian world view.

With the development of the public-school system in the United States in the 18th century many Protestant groups felt that the public schools were adequately serving the purpose of general education and discontinued their schools. They decided that specifically Christian education could be provided by the Christian home and by such church schools as the Sunday school (*q.v.*), vacation Bible school, weekday classes and the Saturday school.

Despite the development of public education, some parents and some church bodies continued to believe that the most effective educational agency available for the Christian education of children and youth was the parochial school. While supporting the public school as the community effort in general education, such groups have founded, supported and patronized parochial schools because of deep convictions as to the desirability of providing a thorough Christian education.

Among Protestant groups that maintain parochial school systems, the Lutheran bodies are by far the most active, with around 190,000 children in Lutheran schools. Smaller school systems are sponsored by the Seventh-day Adventists, the National Union of Christian Schools, the Protestant Episcopal Church, the National Association of Christian Schools (evangelical), and the Quakers, Mennonites, Baptists, Methodists and Presbyterians.

The administration of most Protestant schools is in the hands of a board of education elected by the sponsoring group—either individual congregation, association of congregations, or association of individuals. This board selects a principal and in cooperation with him develops the policies that control the school program. The clergy of the sponsoring groups have been active participants in all aspects of such school programs.

The teachers in Protestant schools are drawn both from denominational teachers colleges and liberal arts colleges. In addition to meeting the general requirements set for teachers at the elementary and secondary levels, teachers in Protestant schools need training in Bible and doctrine to achieve the objectives of Christian education.

Protestant elementary and secondary schools strive to meet or exceed the educational requirements of the several states. While the course of study for each grade is substantially the same as given in the public schools, Christianity is made the unifying and integrating factor in the educational program. (A. L. Mi.)

Jewish Parochial Schools.—The Jewish Day school or "complete" school (*i.e.*, the Jewish parochial school) is an educational institution in which a combined program of Jewish and general studies is offered. There are four types of institutions that provide intensive Jewish religious education as well as a complete course of study in general subject matter. These are the talmudic day school, the modern day school, the integrated day school and the Hebrew-English private school.

The talmudic day school makes provision for the study of the Hebrew texts of the Pentateuch, major portions of the Prophets and Scriptures, including the Masoretic commentaries, and places great stress on teaching of the Talmud. The secular studies meet the requirements of the city and state authorities. The school day ranges from eight to ten hours. The Hebrew studies are given in the morning hours and the English in the afternoon.

The modern day school stresses the study of Hebrew language, the Bible, Jewish history, prayers and selected portions from the Talmud. All instruction is in the Hebrew language. The secular subjects are given equal attention and equal time. The school day begins at nine and ends at four o'clock.

The integrated day school aims to achieve a blending of instruction in Judaism and secular subjects. To attain this end "both curricula are offered departmentally throughout the school day." The pupil may begin the school day with the study of the Bible, go next to a lesson in arithmetic, then proceed to the reading of a Hebrew text, then to geography, and so on.

The Hebrew-English private school emphasizes the study of general subjects and provides opportunities for Jewish learning for only five hours a week. It is a modern and progressive school which satisfies those parents who seek private instruction of a high calibre and who are eager to solve the problem of a two-school system. A number of day schools are also sponsored by Yiddish-culture groups. The program of these schools differs from the modern day school in that Yiddish language and literature are included as basic subjects of instruction.

The majority of day schools (85%) are sponsored by Orthodox groups. Some that fall in the category of modern day schools are conducted by Conservative and other groups.

In 1935 there were 17 day schools with an enrollment of 4,600; by the 1960s enrollment in the United States and Canada had increased to more than 50,000 pupils in about 300 schools, almost one-half of which were in New York city. The number of children in the day school constituted 8.5% of the total Jewish religious school enrollment. The overwhelming majority of Jewish children attend the public schools and to these children Jewish education is supplementary to their general education. Most day schools conduct classes on the elementary level; only a few operate high school departments. Torah Umesorah (National Society for Hebrew Day Schools) and the National Council for Torah Education help to establish day schools, place teachers and administrators, conduct seminars and workshops for educational personnel and publish Hebrew text materials.

See also EDUCATION, HISTORY OF; SCHOOL ADMINISTRATION; ROMAN CATHOLIC CHURCH: *The Church in The Americas: North America: Education;* and *Education* sections of articles on various countries. (Ju. P.)

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PARODY, the comic imitation of a serious manner, was in its Greek origins "a song sung alongside another" (*parodia*). It has, however, by extension come to cover other forms of art and even of social behaviour. Aristotle attributes the invention of parody to Hegemon of Thasos, whose imitation of *The Battle of the Giants* refers to the defeat of the Athenian expeditionary force in Sicily. But the mock-Homeric *Batrachomyomachia* or *Battle of the Frogs and Mice,* once attributed to Homer himself, is certainly much earlier. The greatest of Greek parodists was undoubtedly Aristophanes, who imitated Aeschylus and Euripides. His attack on Euripides in *The Acharnians* remains one of the most penetrating and venomous criticisms by parody ever practised by one great man on another.

Parody, which flourished with all forms of light drama and entertainment from Aristophanes to the modern revue, is distinguished from burlesque hy the depth of its technical penetration. True parody mercilessly takes off all the tricks both of manner and thought of its victim, yet cannot be written without an almost loving appreciation of the work which it is ridiculing. At its best, it is always an oblique form of criticism.

In England Shakespeare mimicked Christopher Marlowe's high dramatic style in the players' scene in *Hamlet,* and was himself parodied by John Marston, who wrote a travesty of *Venus and Adonis* entitled *The Metamorphosis of Pigmalion's Image.* John Philips, in *The Splendid Shilling,* which attained great popularity on its publication in 1705, caught all the superficial epic mannerisms of Milton's *Paradise Lost,* particularly in his warning to debtors not to go abroad by day:

> Beware, ye Debtors! when ye walk, beware,
> Be circumspect; oft with insidious ken
> The caitiff eyes your steps aloof, and oft
> Lies perdue in a nook or gloomy cave.

Alexander Pope wrote an excellent and indelicate parody of Chaucer, and Isaac Hawkins Browne (1705–60) made splendid fun of Pope, Swift, and others. The first collection of parodies to score a wide success was *The Rejected Addresses* (1812) of Horace and James Smith, which took the form of dedicatory odes in the manner of various contemporary poets, on the reopening of the Drury Lane Theatre in 1812. Scott, Byron, Southey, Wordsworth, and Coleridge were among the brothers' victims, of whom none came off worse than Coleridge, whose alleged musings began:

> My pensive public, wherefore look you sad?
> I had a grandmother, she kept a donkey
> To carry to the mart her crockery ware,
> And when that donkey look'd me in the face,
> His face was sad! and you are sad, my Public!

The Ingoldsby Legends (1840–47) by R. H. Barham contain some straightforward parodies, but are more successful in travestying the exaggerations of the Gothic convention in slapdash punning colloquialism than in catching the details of its style. Their author, like his contemporary Thomas Hood, seems to have been by temperament a foiled Romantic poet who expressed his latent yearning by means of mockery. Psychological ambivalence of this type perhaps goes to the making of every good parodist.

While neither Hood nor Barham parodied particular poems, the leading Victorian practitioners were generally more exact in their targets. The joint authors of the *Bon Gaultier Ballads* (1845), Sir Theodore Martin and W. E. Aytoun, parodied the great poets of their day, as did C. S. Calverley and J. K. Stephen, whose favourite victims were Robert Browning and the Pre-Raphaelites. Stephen's "Sincere Flattery of R. B." is almost mistakable for original Browning, so closely does it observe his mannerisms, even to his peculiarities of punctuation:

> Birthdays? yes in a general way;
> For the most if not for the best of men:
> You were born (I suppose) on a certain day:
> So was I: or perhaps in the night: what then?

Calverley's gibe at Browning's *The Ring and the Book* is, by contrast, only a surface imitation. Calverley has not the patience of the true parodist. He too often forsakes oblique criticism for direct. By the third verse of his Pre-Raphaelite "Ballad," indeed, he has already begun to speak in the first person:

> The farmer he strode through the square farmyard
> (*Butter and eggs and a pound of cheese*)
> His last brew of ale was a trifle hard—
> The connexion of which with the plot one sees.

Unique among Victorian parodists, Lewis Carroll preserved in the amber of his mockery flies that would otherwise have perished long ago. Robert Southey's "Old Man's Comforts" (the excuse for "You Are Old, Father William") and those verses of Isaac Watts that gave rise to "How Doth the Little Crocodile" and " 'Tis the Voice of the Lobster," are unknown to all but a small fraction of those who know the parodies by heart.

The art of parody has been encouraged in the 20th century by such periodicals as *Punch,* which has numbered two expert parodists, Sir Owen Seaman and E. V. Knox, among its editors, and by other journals that have offered prizes for parodies on their competition pages. The scope of parody has also been widened to take in the far more difficult task of parodying prose. At this Sir Max Beerbohm and Sir John Squire have been most successful. Sir John Squire was also one of the finest verse parodists in the years between World Wars I and II; and his invention of the double-parody, whereby the sense of one poet is rendered in the manner of another, has been the greatest modern innovation in the art. An example is his "If Gray had had to write his Elegy in the Cemetery of Spoon River instead of in that of Stoke Poges," one model for which was the *Spoon River Anthology* (1915) of Edgar Lee Masters. Outstanding too among modern parodists have been Sir Arthur Quiller-Couch, H. D. Traill, and G. H. Vallins, whose exercises in Milton's and Tennyson's style were at times unfortunately marred by references to the minor discomforts of the wartime world in which he wrote.

Parody flourishes also in the United States and in Russia, where some contemporary poets enjoy mimicking each others' styles. American poets of the 19th century presented sitting targets to a little school of American parodists, the chief of whom was the poet and translator Bayard Taylor. Poe, Whittier, and the English Pre-Raphaelites were his chief victims. Bret Harte wrote a good parody of Whittier, and himself provided models for his fellow parodists. The versions of "Home Sweet Home" by Henry Cuyler Bunner, in a variety of styles, also deserve to be remembered. Owing to the variety of accents of 19th-century immigrants, however, the individual characteristic of American parody is the play on dialect. C. G. Leland parodied Heine and Uhland in his *Hans Breitmann's Ballads* in German-American, and in his *Pidgin English Sing-Song* he wrote a potted "Excelsior" in the chopped syllables of a Chinese laundryman. Among more modern and scientific parodists Samuel Hoffenstein is outstanding for his carefully damaging versions of A. E. Housman and the Georgians. *The New Yorker* (founded 1925) is noted for its parody, especially of prose. *See* also biographies of writers of parody mentioned.

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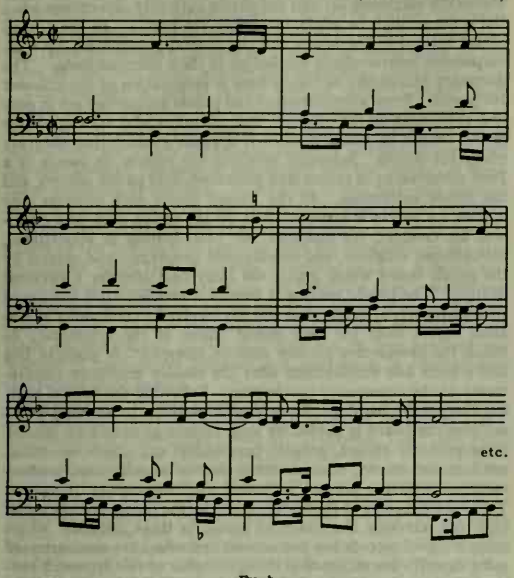
PARODY (IN MUSIC), a term used to describe a Renaissance technique in which several voices of a preexistent composition are creatively reworked to form a new composition, as in the parody Mass (*missa parodia*). This technique is not to be confused with (1) *cantus firmus* (*q.v.*), where a single line only of the original (*e.g.,* the tenor of a chanson) is employed, or (2) *contrafactum,* where the original music is merely provided with a substitute text (*e.g.,* the secular song "Innsbruck ich muss dich lassen" of the early 16th century, later sung to a religious text "O Welt, ich muss dich lassen").

In the 15th and 16th centuries chansons, madrigals, and motets were used as the basis for parody Masses. The parody Mass, usually known by the name of the model from which it derived (*e.g.,* example a), is characterized by the reorganization of material from several voices of the original composition, introduced either successively or, as in example b, simultaneously.

Parody in the more familiar sense of the word, *i.e.,* as a form of humour, has, in music, a restricted field of expression. This is

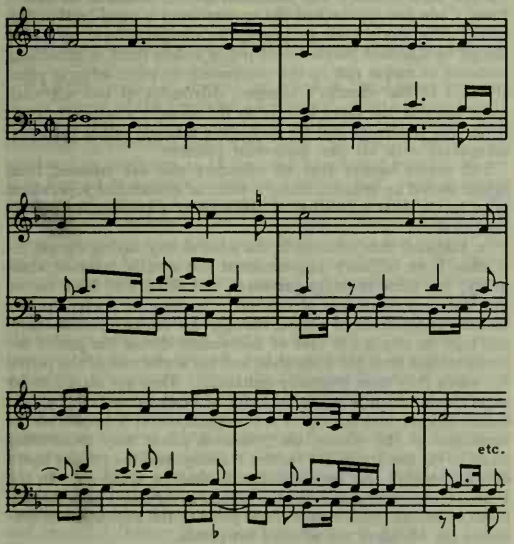
Ex. a

Chanson "Rosa playsant" — Philippe Caron (late 15th century)



Ex. b

Pleni from *Missa Rosa playsant* — Jakob Obrecht (1452-1505)



because, unless the composer is concerned with a broad form of humour, it is difficult to differentiate between the style of the parody and the object parodied. Parody is thus often indistinguishable from pastiche, as the oversubtle parody of 18th-century opera in Stravinsky's *Mavra*. More successful examples of musical parody are *Ein musikalischer Spass* of Mozart, concluding with glaringly wrong notes; and the absurd repetitions in quick tempo of the word "Amen" by the chorus in Berlioz's *L'Enfance du Christ*.

PAROLE is a form of supervised conditional liberty from prison granted prior to the expiration of sentence. The term was derived from the French *parole d'honneur*, "word of honour," and came to mean especially the pledge by a prisoner of war, in return for partial or conditional freedom, not to try to escape and not to bear arms against his captors. As a form of correctional treatment parole is designed to enhance the protection of the community through the supervision and rehabilitation of selected offenders following their release from prison. Parole conditions define minimum standards of conduct, delimit freedom of movement, and require the parolee to report regularly to a parole officer. Violation of the conditions of parole may constitute grounds for parole revocation and reincarceration.

The modern use of parole as a correctional method stems from a change in penal philosophy from emphasis upon retribution and punishment to efforts at reform and rehabilitation. Parole in relation to the treatment and rehabilitation of juvenile offenders is dealt with under BORSTAL SYSTEM and REFORMATORY. (*See* also JUVENILE DELINQUENCY.)

History.—In 1840 a form of parole was introduced by Alexander Maconochie at the famous British penal colony of Norfolk Island, east of Australia, and in 1853 Sir Walter Crofton initiated in Ireland an indeterminate sentence under which prisoners could earn conditional liberty (*see* PRISON). Under Maconochie's plan tickets of leave (documents that could be issued to prisoners enabling them to work for wages and choose their own employers) were awarded on the basis of a system of marks earned for good conduct, instead of on the basis of time served.

A series of statutes enacted by New York in the United States and culminating in the opening of Elmira Reformatory in 1876 marked the earliest significant development of an established parole system embodying indefinite sentences and parole with parole supervision and a return to custody for violation of parole rules. Almost immediately other U.S. states began enacting parole laws, and by 1900 such statutes were in effect in nearly half the states. By 1922 the U.S. federal government and all but four states had enacted such laws, and by the second half of the 20th century parole had become an integral part of the penal and correctional code of every state. Administration of these systems, in general, is by appointive parole boards with quasi-judicial functions including power to convene hearings and grant or deny parole, power to revoke parole and recommit offenders, and administrative functions relating to the establishment of parole conditions and the activities of field parole agents.

Various forms of parole or conditional release from prison were adopted in the majority of European and in many other countries of the world. As noted above, England can perhaps claim the longest history of such services though not until the 20th century did conditional release become general in Great Britain. Law reforms in 1908 introduced rehabilitation concepts and the Criminal Justice Act of 1948 brought into being modern principles of release under supervision and aftercare. The system is complex, but is under general surveillance of the secretary of state of the British Home Office. A central council coordinates the work of private prisoner aid and aftercare associations. There has been increased use of probation officers as supervisors and a gradual diminution in the use of the traditional voluntary social services for assistance to and supervision of those leaving penal institutions.

Forms of parole were introduced in France in 1885 and in the Netherlands in 1886. Since 1946 the Ministry of Justice in France has established committees in each *département* to administer parole. Private social agencies assist in the supervision of parolees. In the Netherlands parole has perhaps reached a higher level and is more extensively used than in most other continental countries. Although the Ministry of Justice maintains general administrative supervision, the strong tradition of private social work dominates the scene and parole supervision is largely administered by private rehabilitation agencies.

In 1953 the Federal Republic of Germany through a series of criminal law amendments introduced parole. Administration is under the Ministry of Justice.

In Denmark parole is widely used though the indeterminate sen-

tence is not known. Offenders are eligible for parole at the expiration of two-thirds of their sentence and supervision is conducted by private social agencies.

Variations of parole and conditional release exist in Belgium, Portugal, Switzerland, Sweden, Australia, South Africa, Punjab (Pakistan), Argentina, Chile, Canada, and Mexico. Administration is usually lodged with the Ministry of Justice, although in Mexico and South Africa the program is administered by the Ministry of Welfare. In a few countries parole is a function of the judiciary.

Eligibility varies but in most countries what are termed common offenders are eligible for parole at the expiration of from one-half to two-thirds of the original sentence. Parole supervision ranges from little more than a periodic police check to intensive supervision by trained personnel.

Administration of Parole.—As indicated in the examples cited above parole systems are administered by a designated official, as a prison or other government official; by a government ministry or agency; or by a special government agency, as a parole board. An effective parole system requires (1) public support reflected in sentencing and parole laws and (2) the cooperative functioning of the parole authority and the authority that administers penal and correctional institutions, in systems in which these authorities are separate.

Parole Boards.—Parole boards range from part-time nonpaid members to full-time paid officials. In the United States about 20 states have full-time parole boards of three or more members usually appointed by the governor. The U.S. Board of Parole is comprised of eight full-time members appointed by the president.

The responsibilities of a parole board are comparable to those of a court. Since parole selection involves the evaluation of emotional, psychological, and social traits of offenders, board members need to have professional knowledge from such fields as social work, psychology, sociology, law, criminology, education, and corrections.

Parole Staff.—The parole authorities are served first of all by prison or correctional institution personnel who aid in the classification and selection of prisoners for parole; *i.e.*, inform the board as to prisoners' eligibility (*see* below). This function is especially important in those systems that are based on indeterminate or flexible sentences. Whether conditional release is based upon a fixed proportion of sentence served or upon the decision of the parole authority within the limits of indeterminate sentences, parole authorities also are served by field parole agents who supervise parolees in accordance with policies laid down by the parole authority. These parole agents, or parole officers, may be employees of the parole authority or, more generally in the United States, of a state department of corrections or state department of public welfare. As previously indicated, in Great Britain there has been increasing use of probation officers; the general pattern in other countries is for field supervision of parolees to be provided by private social or rehabilitation agencies.

Parole Eligibility.—Eligibility for parole is governed by statutes that provide either definite or indefinite sentences and define offenses for which parole may be used. In some jurisdictions eligibility for parole is prohibited by statute for offenders convicted of such serious crimes as narcotics peddling, armed robbery, kidnapping, rape, or murder. Under the theory of individualized justice such statutes are often opposed on grounds that parole should not be arbitrarily denied any rehabilitated prisoner whose release would constitute no threat to the community.

Statutes that provide definite prison terms for specific crimes make provision for parole eligibility upon completion of a specified fraction of the full term. Under the system of conditional release practised in England, for example, discharge is fixed by the earning of "remission"; no board or other authority can alter the earliest date of discharge, and that date will be effective unless the prisoner by bad conduct loses periods of his remission. The normal release is after two-thirds of the sentence has been served. In a very few cases, where a life sentence has been passed, there is consideration periodically of the prisoner's readiness for release, the decision being with the secretary of state.

Selection Under Indeterminate Sentence.—Under an indeterminate sentence the term of imprisonment remains indefinite within the maximum set and the parole authority determines when the prisoner shall be eligible to apply for parole. In the United States a third of the states and the federal government have incorporated indeterminate sentencing in their criminal codes. The dominant philosophy of this system is preparation of the prisoner for parole. Penal administrators and parole authorities are in general agreement on the principle that offenders who are eligible for parole should be released when it appears evident that they are ready for parole. Scientific selection for release on parole is a joint undertaking of prison staff personnel, field parole officers, and the parole authorities. In the United States each offender who applies for parole is screened, first by the prison staff who evaluates his conduct, his attitudes, his participation in educational, recreational, religious, and employment programs; and second by the parole board which grants the individual offender a personal hearing. The parole hearing is usually scheduled after the board reviews reports of prison staff and has received a community evaluation report from the field parole officer of the community to which the prospective parolee may be returned. A place to live and a bona fide employment offer are usually minimum requirements of the community parole plan. Following the formal hearing the parole board grants or denies parole. In arriving at its decision the board is guided by such factors as nature of offense, prior criminal record, general personality and character traits, employment record, marital status, family attachments, confinement adjustment, present attitudes, and community prospects. Thorough screening of this nature provides the parole board a sound basis for reserving the award of parole to those offenders whose prior criminal records are less serious and who have demonstrated some capacity for responsible living. Critics of this approach contend that too much stress is placed upon the background of the offender.

Other Approaches.—The American Law Institute in its Model Penal Code has approached the matter from a quasi-legal standpoint. The model code proposes that routine release on parole should be standard parole board policy unless there is immediate evidence of undue risk to the community or other adverse effect attached to the offender's release. Advocates of this approach point out that the focus here is on the offender's response to institutional treatment and his immediate attitude rather than preoccupation with his past behaviour patterns.

Still others believe that all offenders who are released from prison should be released under a form of conditional supervision prior to the final expiration of sentence as a community protection measure.

In England, men released in the normal way having earned remission from ordinary imprisonment are usually released absolutely; but some ordinary prisoners, and those who have served life sentences, sentences of corrective training or preventive detention, or sentences of borstal training, are released conditionally and may be recalled in case of misconduct during the period between release from the institution and the actual end of the period for which they were originally sentenced. They are placed under supervision, which is in the majority of cases carried out by probation officers, and in case of noncooperation, or a breach of the conditions of the release, the probation officer may recommend recall to the institution for further training; and the prisons board decides whether this recommendation shall be acted on. In the United States some states and the federal government have mandatory conditional release procedures prior to full expiration of sentences for offenders not selected for parole.

Parole Supervision.—Parole supervision is based on the concept that the individual parolee has the capacity to accept help and to change his behaviour. But the parolee may need counseling on such matters as continued vocational training, employment placement, and adjustment to unexpected marital, economic, or other personal or family problems. The skills of the parole officer when applied through counseling and casework or groupwork services can contribute much to the continuing rehabilitation of offenders. Parole supervision varies in quality from little more than

perfunctory monthly reporting to skilled individual casework treatment. Standard-setting organizations recommend that parole officers be college graduates with professional graduate training in social work. Officers serving the U.S. Board of Parole, for example, are required to have completed an A.B. or B.S. degree plus two years of graduate training in a school of social work or two years of full time social welfare or correctional experience.

The privilege of parole carries with it obligations that must be met by the parolee. The obligations commonly referred to as conditions of parole and almost universally specified by parole authorities vary widely but usually relate to restrictions surrounding the parolee's freedom of movement and the setting of minimum standards of conduct. A frequent if not universal requirement is the avoidance of association with other former convicts.

These conditions are not ends in themselves but serve both as guides to the parolee and controls over his behaviour in the free community while he is on parole. Parolees tend to respond well to such concrete obligations when the latter are clearly stated and consistently interpreted. Given adequate administration and sufficient budgets to command competent staff with reasonable case loads, experience has shown that four out of five parolees will respond to constructive guidance and supervision by satisfactorily completing their paroles.

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PAROS (mod. Gr. PÁROS), an island in the Aegean Sea, one of the largest of the Cyclades (Kikládhes), with a population in 1961 of 7,830. It lies to the west of Naxos, from which it is separated by a channel about 4 mi. wide. Its greatest length from northeast to southwest is 13 mi., and its greatest breadth 10 mi. It is formed of a single mountain 2,460 ft. high, sloping evenly down on all sides to a maritime plain, which is broadest on the northeast and southwest sides. The island is composed of marble, though gneiss and mica schist are to be found in a few places. The capital Paros (Parikía), on a bay on the northwest of the island, occupies the site of the ancient capital. Its harbour admits small vessels, but the entrance is dangerous. By the sea is a medieval castle built almost entirely of ancient remains, notably of a late 6th-century Ionic temple. North of the town is the Delion sanctuary of Apollo and Artemis, and to the south is a precinct of Asclepius. Outside the town is the church of Panayia Katapoliani or Hekatontapiliani (Our Lady of the Hundred Doors). On the north side of the island is the Bay of Náoussa (Órmos Naoúsis), a safe roomy harbour. Another good harbour is that of Dhríos on the southeast. Immediately to the southwest is the satellite island of Antiparos (Andiparos; ancient Oliaros), 8 mi. long and 3 mi. wide, which is known for its stalactite caves.

Parian marble, white and semitransparent, with coarse grain and beautiful texture, was the chief source of wealth to Paros. The quarries lie on the northern side of Mt. Marpessa (Mt. Elias or Profítis Ilías). It was this marble, exported from the 6th century B.C. onward, that was favoured for sculpture. It came from subterranean quarries driven horizontally or descending into the rock. Several of these tunnels can still be seen. At the entrance to one of them is a bas-relief dedicated to Pan and the Nymphs. Attempts to work the marble have been made in modern times. The local economy depends on the production of wine, olive oil, figs, and tobacco.

History.—Paros shared the Early Bronze Age culture of the Cyclades (*see* AEGEAN CIVILIZATION). Traditionally it was colonized first by Arcadians, then Ionians. In the 7th century B.C. Parian colonies were sent to Thasos and to Parium on the Propontis (Sea of Marmara). Shortly before the Greco-Persian Wars Paros seems to have been a dependency of Naxos. In 490 Paros joined the Persians and sent a trireme to Marathon. In retaliation, its capital was unsuccessfully besieged by an Athenian fleet under Miltiades (*q.v.*). Paros also sided with Xerxes, but after the Battle of Artemisium its contingent remained in Kythnos (Kíthnos). In the Delian League Paros paid the highest tribute of all the islands—18 talents, raised to 30 in 425–424. In 385 the Parians, in association with Dionysius the Elder of Syracuse, founded a colony on the Adriatic island of Pharos (modern Hvar Island, Yugos.). Paros joined the Athenian Confederacy of 378 B.C. Later the island lost political importance, passing with other Cycladic islands to the Ptolemies of Egypt, and thence to Roman rule. After the Latin conquest of Constantinople (1204), Paros became subject to Venice, becoming a duchy independent of the dukes of Naxos in 1389. In 1537 it was conquered by the Turks, and after the War of Greek Independence was annexed to Greece. Among the most interesting discoveries made in the island is the Parian Chronicle (*q.v.*).

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PARR, CATHERINE: *see* CATHERINE (Catherine Parr).

PARR, THOMAS (d. 1635), a celebrated English centenarian known as "Old Parr," is reputed to have been born in 1483, at Winnington, Shropshire. He is said to have threshed corn when 130 years old. In 1635 his fame reached Thomas Howard, 14th earl of Arundel, a noted art and curiosity collector, who conveyed him to London where he was presented to Charles I and exhibited in the Queen's Head Tavern in the Strand. The change of air and diet soon affected him and he died in Arundel's house in London on Nov. 14, 1635. He was buried in the south transept of Westminster Abbey, where the inscription reads: "Tho. Parr of ye County of Sallop. Borne in Ao 1483. He lived in ye reignes of Ten princes viz: K. Edw. 4. K. Ed. 5. K. Rich. 3. K. Hen. 7. K. Hen. 8. K. Edw. 6. Q. Ma. Q. Eliz. K. Ja. and K. Charles. Aged 152 yeares and was Buryed here novemb. 15. 1635."

PARRAMATTA, a city of New South Wales, Austr., lies 14 mi. W of Sydney by rail, at the head of the Parramatta River. Pop. (1961) 104,061. The oldest settlement in Australia excepting Sydney, of which it is now virtually a suburb, Parramatta is a thriving commercial and industrial centre with a number of attractive residential areas. Buildings of historical interest include Experiment Cottage, on the site of the original home of James Ruse (*see* below), and Elizabeth Farm House, built by John Macarthur, a pioneer of Merino sheep farming. The city has more than 1,000 ac. of parks, the chief being Parramatta National Park (245 ac.) containing swimming facilities. Industries include engineering, automobile assembly, flour milling, and textile manufacturing.

The site was discovered in 1788 by Arthur Phillip, the colony's first governor, who founded the town in 1790 and set up his residence there. Two years later he made the first land grant in Australia to James Ruse, a former convict whom he had settled there as an experiment. Parramatta was incorporated as a municipality in 1861 and proclaimed a city in 1938, its boundaries being extended in 1948 to include Granville, Dundas, and Ermington-Rydalmere. (E. S. J.)

PARRATT, SIR WALTER (1841–1924), English organist and composer, was born at Huddersfield on Feb. 10, 1841. Taught by his father, Thomas Parratt, he became organist of Magdalen College, Oxford, in 1872 and in 1882 organist of St. George's Chapel, Windsor. From 1908 to 1918 he was professor of music at Oxford University. As teacher of the organ at the Royal College of Music, London, from 1883 to 1923, he exerted a great influence by his understanding of the works of J. S. Bach. By

insisting on accuracy of phrasing and simple registration Parratt helped restore the original style to the works of Bach. He was knighted in 1892. He died at Windsor on March 27, 1924.

See D. F. Tovey and G. Parratt, *Walter Parratt: Master of the Music* (1941). (H. Ru.)

PARRHASIUS (fl. 4th century B.C.), of Ephesus, one of the greatest painters of Greece. He settled in Athens and may be ranked among the Attic artists. He was certainly distinguished as a painter before 399 B.C. He is said to have been interested in the study of proportion. Many of his drawings on wood and parchment were preserved and highly valued by later painters for purposes of study. His picture of Theseus adorned the Capitol in Rome. His other works are chiefly mythological groups. A picture of the Demos, the personified People of Athens, is famous.

PARRINGTON, VERNON LOUIS (1871–1929), U.S. literary historian and teacher, who greatly influenced U.S. historical and literary thought, was born on Aug. 3, 1871, in Aurora, Ill., grew up in Emporia, Kan., and was educated at the College of Emporia and Harvard University. He taught English and modern languages at the College of Emporia (1893–97), at the University of Oklahoma (1897–1908) and at the University of Washington, Seattle (1908–29). He died suddenly on June 16, 1929, at Winchcombe, Gloucestershire, while on a visit to England.

Influenced by Morris and Ruskin, by the critical principles of Taine and the political program of the Populists, Parrington reappraised U.S. literary history in *Main Currents in American Thought,* two volumes (1927), which won the Pulitzer Prize for history in 1928. A third volume with the subtitle *Critical Realism in America,* incomplete at his death, was published in 1930. Parrington, a Jeffersonian liberal, objected to aestheticism and pedantry, emphasized economic influences and defined literature as any writing successfully presenting important ideas or experiences. His work, notwithstanding objections to his political liberalism, his economic determinism and his summary literary judgments of such writers as Poe and Henry James, remains an important landmark in U.S. literary history. He also wrote *The Connecticut Wits* (1926) and *Sinclair Lewis, Our Own Diogenes* (1927).

(E. H. E.)

PARROT, a name applied generally to a large group of gaudy, raucous birds whose more than 300 species are placed in the family Psittacidae, order Psittaciformes. Parrots include the popular small pets, parakeets, lovebirds and budgerigars, as well as the larger macaws, Amazon parrots, lories, cockatoos and others. Known from ancient times, parrots have always been popular as cage birds because they are amusing, often affectionate, easy to keep and astonishingly imitative of many sounds, including human speech. Since the chief interest in them still lies in these traits, parrots as pets will be dealt with later at some length. Numerous flocking species of parrots feeding on fruit and grain can become a serious economic threat to agriculture and fruit raising, as has happened in Australia and New Zealand. On the other hand, they destroy many weed seeds. The export of parrots for cage birds is an important industry.

Description and Natural History.—Parrots stand apart as a group and are well known to the ordinary observer by the following outstanding features. They have large heads and powerful bills, hawklike in the overhang of the upper mandible. The nostril is set in a fleshy cere at the base of the upper mandible, where the latter is hinged to the skull. This hinge, or its equivalent, present in all birds to permit the raising of the upper bill, is nowhere so easily seen in operation as when a parrot uses its bill as a third foot in climbing. The sharp angle of attack of the jaw muscles on the bony elements closing the bill combine to produce one of the most powerful crushing mechanisms in nature. A tiny budgie can inflict a painful bite; a macaw can take off a finger. The parrot tongue is fleshy and cylindrical. The first and fourth toes are directed backward, a tree-climbing adaptation that permits these birds to grasp food, as if "by hand," and carry it to the mouth, a somewhat amusing trait not found in other birds.

Most species nest in tree holes, a few in ground holes. They usually mate for life and lay from 1 to 12 usually white eggs. The eggs are incubated by one or both parents from 16 to 19 days in small species—nearly 30 in large species—following which the young emerge, usually blind and naked. The period of nest care is from two to three months, and the young are fed by regurgitation. This long period of parental care may be related to the large brain size, which requires a longer period of development before the young bird acquires motor patterns enabling it to care for itself. This large brain is certainly associated with the parrots' remarkable ability to learn a complex sequence of tricks or an astonishing vocabulary with the same ease. Many parrots live extraordinarily long lives, often longer than 50 years. (Unauthenticated reports of upwards of 80 years have been made for some species of large parrots.) On the other hand smaller cage birds such as parakeets and budgerigars are "old-timers" at five years (though some may of course live longer).

Most species of parrots are confined to the equatorial belt of the old and new world continents, the greatest variety occurring in the Australian region. This near confinement to the equator poses a problem for some zoogeographers. Those who subscribe to the Wegnerian hypothesis of continental drift have no difficulty, since they believe the present continents were once a single land mass; but those who believe in the permanence of continents and oceans must assume that there was once a warm climate connection across the northern part of the old and new worlds, probably at Bering strait. The finding of fossil parrots and tropical vegetation in Europe and even the Arctic supports this possibility but not more recently than 60,000,000 to 100,000,000 years ago.

On the other hand a few modern species have temperate ranges. The parakeet, *Platycercus erythrotis,* lives in the Macquarie Islands (lat. 55° S.) and the now extinct Carolina parakeet, *Conuropsis carolinensis,* ranged as far north as Ontario (lat. 45° N.).

New World Parrots.—The early explorers of the new world, beginning with Columbus, brought back to Europe astonishing tales of the bird life, particularly of the parrots, and before long living examples followed.

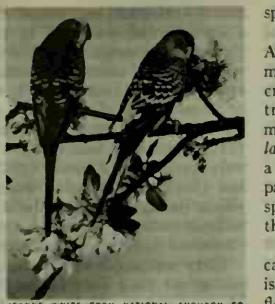
Macaws.—The three-foot-long scarlet macaw (*Ara macao*) and somewhat smaller red and green macaw (*A. chloroptera*), crushing with enormous bills the palm nuts man must crack with a hammer, still excite wonder. Together with the blue and yellow macaw (*A. ararauna*) and the green macaw (*A. militaris*), these huge parrots range from the Isthmus of Panama to the great interior rain forests of South America. *A. militaris* and *A. macao* even reach tropical Mexico. The hyacinthine macaw (*Anodorhynchus hyacinthinus*) is confined to swampy forests in interior Brazil, where it lays its two eggs in a hole in a bank. Species now extinct once lived on Cuba, Jamaica, Isle of Pines, Guadeloupe and Martinique. Macaws are popular in zoos, where they are often exhibited outside of cages on stands, to which tame individuals need not be chained. The macaws share with the next group an ear-splitting shriek, which may make them difficult pets.

ROBERT C. HERMES FROM NATIONAL AUDUBON SOCIETY

HYACINTHINE MACAW (ANODORHYNCHUS HYACINTHINUS)

Amazon Parrots.—The stocky Amazon parrots (*Amazona*) are about the size of a large pigeon, predominantly grass green and yellow, but with added patterns of red, blue and black. These are the best known parrots of the American tropics—the familiar talking birds. Some individuals become affectionate pets and ecstatically enjoy having their heads scratched by a trusted human friend. This is the bird frequently caricatured as having acquired from an original sailor owner a vocabulary too salty for

polite society. There are about 50 species and subspecies ranging through tropical Central and South America and the Caribbean islands. Familiar species in captivity include the yellow-headed and yellow-naped amazons (*Amazona ochrocephala*), blue-fronted amazons (*A. aestiva*) and green-cheeked amazons (*A. viridigena*).



JEANNE WHITE FROM NATIONAL AUDUBON SOCIETY

BUDGERIGARS (MELOPSITTACUS UNDULATUS)

Conures.—A group of smaller relatives of the Amazons, with about 45 species and subspecies, includes the sharp-tailed conures (*Aratinga*), which combine red, green, yellow and blue in numerous patterns. The Jendaya conure (*A. jendaya*) of Brazil has the head and neck yellow, breast and rump vermilion and back, wings and tail bluish green. It is 12 in. long.

The Carolina parakeet (*Conuropsis carolinensis*), now extinct, was a yellow-headed green conure, which was a real hazard to the fruit crop of early settlers in the forests of eastern United States. Still smaller are the five-inch American parrotlets (*Forpus*) of which there are about 19 greenish forms. These are not to be confused with dwarf parrots of which the orange-chinned, deep green Tovi (*Brotogerys jugularis*) is an example. This six-inch Mexican bird once glutted the American market as a spurious "lovebird" (see *True Lovebirds*, below).

African and Asian Parrots.—The first parrots known to civilization were apparently Indian parrots brought alive to Aristotle about 328 B.C. by his pupil Alexander the Great. African parrots were presented to Emperor Nero in A.D. 54 by an expedition sent to find the source of the Nile.

African Gray Parrots.—No doubt the African gray parrot (*Psittacus erithacus*), which surpasses all other parrots in mimetic and tonal quality, was considered an amusing pet by the Romans and was imported in great numbers, the surplus becoming a table delicacy. Both sexes are ash gray with a red tail; there are a number of similar related forms in Africa and Madagascar. They are forest birds, feeding in flocks on fruits and nuts. Their two to four white eggs are laid in tree holes.

Afro-Asian Parakeets.—A great many species of parakeets occur in huge flocks in the African and Malaysian areas. Very striking is the blossom-headed parakeet (*Psittacula cyanocephala*) of India and Ceylon, with red-violet head and shoulders, a black collar and a blue-and-yellow tail. In the Indo-Malaysian region a peculiar group of very small, mainly green parakeets—the hanging parakeets (*Loriculus*)—sleep suspended like bats and resemble clusters of leaves.

True Lovebirds.—The true lovebirds (*Agapornis*) are confined to Africa and Madagascar, about 14 species and subspecies. They are very small and green with a subterminal black bar on the rounded tail. Their common name derives from the mutual affection that mated pairs display.

Australian Region Parrots.—Taking this region to include New Guinea, Celebes, the Lesser Sundas east of Bali, New Zealand, New Caledonia and the Solomons as well as Australia itself, it is here that the parrots reach their greatest diversity. There are 86 subspecies in New Guinea and 46 in Australia.

Lories and Lorikeets.—A large group of species belong to the brush-tongued lories, pointed-tailed nectar feeders in which the tongue is covered with soft papillae or bristles, helpful in lapping up nectar or fruit juice. One of the most extensive in range is the rainbow lory (*Trichoglossus haematodus*) with a purple head, red under parts and green back. Lories are generally a little larger than starlings, but the brush-tongued lorikeets (*Vini*) are much smaller. One lorikeet, *V. margarethae*, is green above and scarlet below; the members of a flock feeding on tropical red tree blossoms in the Solomons appear as blossoms themselves. There are about 15 genera of lories and lorikeets. New Zealand has two species of large, brush-tongued lories.

Australian Parakeets, Budgerigars, etc.—A large group of small Australian parrots with blunt tongues (an aid in extracting the meat from a cracked nut) includes the rosellas (*Platycercus*) and crested parakeets (*Cyanoramphus*). The former occurs in Australia and New Zealand, the latter in New Zealand and in the mountains of New Caledonia. The cockateel (*Nymphicus hollandicus*) is a long-tailed, small Australian species, ash-gray with a yellow head and crest, often seen in pet shops. The smallest parrot in the world is the pygmy parrot (*Micropsitta*), with six species ranging from the Solomons to New Guinea; it is smaller than a canary and has a spiny tail like a woodpecker.

The Australian budgerigar (*Melopsittacus undulatus*), also called shell, grass and zebra parakeet and (erroneously) lovebird, is one of the long-tailed grassland parakeets that travel in large flocks and feed on grain. The wild budgie is grass green with a yellow forehead, much barred with black and yellow above, and a blue tail; breeders have been successful in bringing out basic colours of blue and mauve. Budgerigars are popular pets because they are small, inexpensive and companionable, and develop extraordinary vocabularies. They are raised in great numbers by breeders.

A peculiar little ground parrot (*Pezoporus*) of Australia nests on the ground and flushes in coveys like quail.

Owl Parrots, Keas, etc.—New Zealand, long separated from all other land, has produced some unusual species. The nearly extinct, large owl parrot or kakapo (*Strigops habroptilus*) is completely flightless and lives in burrows, feeding on roots.

The raven-sized kea (*Nestor notabilis*) is a nectar feeder in summer, but sometimes a sheep killer in winter, when it goes down into the valleys from its summer nesting grounds among the rock crevices in the snow country at 6,000 feet. Taken to feeding on discarded sheep carcasses, some keas alight on and peck open the backs of living sheep to get at the soft fat about the kidneys. A related species, the kaka (*N. meridionalis*), feeds on fruit, nectar and insects in the lowlands, and is prized as a pet. It travels in flocks except during the nesting season, when its four white eggs are laid in tree holes. The kea is dull green with an orange-red rump and underwing, the kaka olive brown. Species of keas formerly found on Norfolk and Phillip islands are extinct.

R. VAN NOSTRAND FROM NATIONAL AUDUBON SOCIETY

BLACK COCKATOO (CALYPTORHYNCHUS MAGNIFICUS)

Cockatoos.—The spectacular parrots of the Australian region are the cockatoos (*Cacatua*). They are large-billed species mainly white, square-tailed, and with long, erectile crests. Leadbeater's cockatoo (*C. leadbeateri*) is pink with a red, yellow and white crest. Other species are the rose-crested, sulfur-crested and bare-eyed cockatoos and the galah, found in various parts of the Australian region.

The cockatoo's nest is usually in a high tree hole in the tropical forest; the two white eggs are laid on wood chips. The young, which hatch naked and blind, are fed by the adults by regurgitation of partially digested food for about three months. Cockatoos often travel in immense flocks numbering many thousands. They make good pets and are found in all zoos. The giant black cockatoo (*Calyptorhynchus magnificus*) has naked cheeks that blush red under excitement. It spends its life in the New Guinea rain forests cracking hard candlenuts with its massive bill, then extracting the meat with its wormlike tongue.

Parrots as Pets.—*Talking.*—The best talkers are the African grays, but the Amazons are good, though inclined to be too harsh and noisy. Budgies may acquire amazing vocabularies, but their

voices are too tiny to carry the quality of the human voice. Teaching a parrot to talk requires perseverance. It is also essential that the parrot accept its owner as a companion; this association is encouraged if parrots are kept apart. Training should begin with one- or two-word phrases; these should be repeated frequently after the parrot has mastered them and passed on to other lessons. Unlike mammals, which learn by association entirely, parrots do not relate reward or punishment to the learning of a new phrase, so it is useless to offer a tidbit for each word learned.

Care and Breeding.—Karl Plath, former curator of birds at Brookfield zoo, near Chicago, gives the following advice on parrot care. A stainless steel cage is best. Sand or grit placed on the floor is swallowed by the birds to help in grinding food. Soft wood should be provided for chewing—a spool is ideal. If the cage is too small or the pet is lonely, the bird may pluck out its tail feathers or even its body feathers.

The following seed mixture works well for almost all larger parrots, cockatoos and macaws: one part each of sunflower, hemp and millet seeds; two parts canary seed; one part peanuts. Fruit, nuts, greens and fresh water should be supplied regularly. Brush-tongued lories should be fed Mellin's food (evaporated milk and honey, a teaspoonful of each in a half cup of cold water) and also sweet fruit. Some lories will also take canary seed and sunflower seed. Baby parrots are fed a mixture of pablum, clear sugar sirup and a little mashed banana by a narrow wooden spoon three times daily, even when the parents feed them by regurgitation.

The same diet as given for the larger parrots may be used for the smaller ones and for parakeets and budgerigars, except that peanuts should be replaced with whole oats and more millet seed.

Captive budgies breed readily if provided with a box 6 × 6 in. wide and 8 in. deep; a macaw may nest in a wooden barrel or even a dog kennel.

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PARROT FISH (Parrot Wrasse), any of the marine fishes of the family Scaridae, in which the teeth of the jaws are fused together, forming a sharp-edged beak similar to that of a parrot. The principal genera are *Scarus, Pseudoscarus, Odan,* and *Sparisama.* They have large scales; nine spines and ten rays in the dorsal fin and two spines with eight rays in the anal fin.

The dentition is remarkable. Using the sharp and hard beak, parrot fishes can bite off pieces of coral that contain fleshy polyps or cut off branches of rockweed. The process of pulverizing the food is performed by the pharyngeal, or throat, teeth, which are also fused, forming plates with broad masticatory surfaces.

Nearly 100 species of parrot fishes are known from the tropical and subtropical parts of the Indo-Pacific and Atlantic oceans; like other coral-feeding fishes, they are scarce on the tropical west coasts of America and Africa. Beautiful colours, subject to great variations in the same species (and creating nomenclatorial confusion), prevail in this group. An unusual habit is found among certain parrot fishes: at night a mucous envelope is secreted in which the fish apparently resides till daybreak. The majority of parrot fishes are edible. Many attain a length of three feet.

PARRY, SIR (CHARLES) HUBERT HASTINGS (1848–1918), English composer, writer, and teacher who helped to revive the creative spirit in English music at the end of the 19th century. Born at Bournemouth on Feb. 27, 1848, he studied at Eton, where he also took lessons in composition from Sir George Elvey. He obtained the degree of bachelor of music at Oxford University in 1867, before going into residence there. In the same year he spent the summer studying at Stuttgart, Ger., with Henry Hugo Pierson, an English composer who had settled in Germany. Later he studied with Sterndale Bennett and G. A. Macfarren. It was, however, under the influence of the pianist Edward Dannreuther that Parry's gifts developed, particularly as a composer of chamber music. Later he established his reputation as a composer of choral music. Here he showed a gift for spacious choral writing and for massive effects that nevertheless maintained a strong lyrical element. In 1880 his *Scenes from Prometheus Unbound* was produced at the Gloucester Festival, the first of a series of choral works that became characteristic of English music of the following generation. It was followed by the ode *Blest Pair of Sirens* (1887), for chorus and orchestra, which became one of his best-known works, and the oratorios *Judith* (1888), *Job* (1892), and *King Saul* (1894). Other successful works of Parry were his *Songs of Farewell* (1916–18) and his unison song *Jerusalem* (1916), a setting of words from William Blake's *Milton,* which, during and after World War I, became almost a second national anthem. He also wrote five symphonies, *Symphonic Variations* (1897), chorale preludes for organ, and many songs.

Parry was appointed choragus of Oxford University in 1883 and in the same year joined the staff of the Royal College of Music, London. He became director of the Royal College of Music in 1894 and professor of music at Oxford in 1900. His writings on music, which had much influence in their day, include *Studies of Great Composers* (1886), *The Evolution of the Art of Music* (1896), *Johann Sebastian Bach* (1909), and *Style in Musical Art* (1911). He was knighted in 1898 and created a baronet in 1903. He died at Rustington, Sussex, on Oct. 7, 1918.

See C. L. Graves, *Hubert Parry,* 2 vol. (1926). (H. Ru.)

PARRY, SIR WILLIAM EDWARD (1790–1855), English rear admiral and Arctic explorer who attempted to discover the Northwest Passage, was born in Bath on Dec. 19, 1790. At the age of 13 he entered the Royal Navy and in 1810 became lieutenant in the "Alexandria" which was employed for three years in protecting the Spitsbergen whale fishery. He made many astronomical observations in northern latitudes and published the results of his studies as *Nautical Astronomy by Night* (1816). From 1813 to 1817 he served on the North American Station. In 1818 he commanded the "Alexander" during the Arctic expedition under Captain (afterward Sir) John Ross. This expedition returned without success, but the following year Parry obtained the chief command of a new Arctic expedition, consisting of the "Griper" and "Hecla." This expedition returned to England in November 1820 after a successful voyage (*see* Arctic, The), having accomplished more than half the journey from Greenland to Bering Strait. Parry's *Journal of a Voyage to Discover a North-west Passage* appeared in 1821. In May 1821 Parry sailed with the "Fury" and "Hecla" on a second expedition to discover a Northwest Passage, but was compelled to return in October 1823 without achieving his purpose. Meanwhile he had in November 1821 been promoted to post rank, and shortly after his return he was appointed acting hydrographer to the Navy. His *Journal of a Second Voyage, etc.,* appeared in 1824.

With the same ships he undertook a third expedition on the same quest in 1824, but was again unsuccessful, and the "Fury" being wrecked, he returned home in October 1825 with a double ship's company. Of this voyage he published an account in 1826. In 1827 the admiralty sanctioned an attempt on the North Pole from the northern shores of Spitsbergen, and Parry reached 82°45′ N latitude. His *Narrative of the Attempt to Reach the North Pole, etc.,* appeared in 1827. He was knighted in 1829. He became controller of the new department of steam machinery of the Navy, retiring in 1846, when he was appointed captain superintendent of Haslar Hospital. He became a rear admiral in 1852, and in 1853 a governor of Greenwich Hospital.

Parry died on July 8, 1855.

See *Memoirs of Rear-Admiral Sir W. E. Parry* . . . by Rev. Edward Parry, 3rd ed. (1857). (A. M. Ss.)

PARSEC, the unit in which distances of stars are measured, officially adopted by the International Astronomical Union in 1922. A parallax of one second of arc corresponds to a distance of one parsec. It is approximately 19 million million (1.9×10^{13}) miles, or 3.26 light-years. *See* also Parallax: *Stellar Parallax.*

PARSEES (Parsis), the followers in India of the prophet Zoroaster are descendants of Persian Zoroastrians who emigrated to India to avoid religious persecution by the Muslims. Their name means "Persians." They number a little over 130,000 (including 5,000 in Pakistan) living chiefly in Bombay (India) and

a few towns and villages mostly to the north of Bombay, but also at Karachi (Pakistan) and Bangalore (Mysore, India). Although they are not, strictly speaking, a caste, since they are not Hindus, they form a well-defined community. They rarely marry outside their community and neither proselytize nor modify their religion under the influence of Hinduism, Islam, or Christianity.

History.—*Establishment in India.*—The exact date of the Parsees' migration is unknown. The sole historical document is the *Qissa i Sanjan*, a verse history written in Persian in A.D. 1600. According to the tradition embodied there, the Parsees initially settled at Hormuz on the Persian Gulf, but finding themselves still persecuted they set sail for India, arriving in the 8th century. The migration may in fact have taken place as late as the 10th century, or in both. They settled first at Diu in Kathiawar but soon moved to Gujarat, where they remained for about 800 years as a small agricultural community.

With the establishment of British trading posts at Surat and elsewhere in the early 17th century, the Parsees' circumstances altered radically, for they were in some ways more receptive of European influence than the Hindus or Muslims and they developed a flair for commerce. Bombay came under the control of the East India Company in 1668 and, since complete religious toleration was decreed soon afterward, the Parsees from Gujarat began to settle there. The expansion of the city in the 18th century was largely due to their industry and ability as merchants. (*See* BOMBAY: *History.*) By the 19th century they were manifestly a wealthy community, and from about 1850 onward they had considerable success in heavy industries, particularly those connected with railways and shipbuilding.

Relations with the Gabars.—Contact of the Parsees with their fellow countrymen appears to have been almost completely severed until the end of the 15th century, when, in 1477, they sent an official mission to the remaining Zoroastrians in Iran, a small sect called Gabars by the Muslim overlords. Until 1768 letters were exchanged on matters of ritual and law; 17 of these letters (*Rivayats*) have survived. As a result of these deliberations, in which the Parsee traditions were in conflict with the purer traditions of the Gabars, the Parsees, in the 18th century, split into two sects on questions of ritual and calendar (see *Sects*, below). Since about the middle of the 19th century the Parsees have given the Gabars much material and moral support and have helped to win them a more favourable social status from the Iranian government. (*See* also GABAR.)

20th Century.—In the 20th century the Parsee community has lost much of its vitality, although in 1948 they still had the highest rate of literacy in India (80%) and their mortality rate was about half that of the rest of the country. Their birth rate fell by 5% in the first half of the century, whereas for India as a whole it remained the same. (In practising birth control they disobey one of the major tenets of their religion.) They were formerly a beggarless community, but from about 1900, although there were many families with large fortunes, their overall prosperity was stationary or tended to decline.

The Parsees have always been distinguished for their beneficence as well as for their wealth. They have founded and maintained hospitals, schools, and other institutions, their liberality extending to others as well as to their own people.

What factors have promoted their commercial success and their many excellent qualities? Perhaps partly the fact that only the strongest or ablest families survived the many centuries of hardship under Hindu and then Muslim domination, and also that their practice of always marrying within their own community reinforced this process of natural selection. Furthermore, their religion did not dissuade them from enjoying worldly goods. Another important factor is that Zoroastrianism fosters a feeling of social solidarity by virtue of its fundamental command to help the good and fight the wicked. At all times the Parsee feels that he and his community are engaged in a vast enterprise which is concerned with both the greatest forces in the universe and the humblest labours of daily life and which is under the guardianship of a good and just god.

Parsee dress is not distinctive except for the dark brown or maroon turban, or a cap of stiff material, something like the European hat without any rim, which slopes backward from the top of the forehead. It is disrespectful to uncover in presence of an equal, much less of a superior. The priests wear a white turban and are wholly dressed in white. Men and women wear the sacred shirt, *sudrah*, and the girdle, *kusti*. Parsee women are not secluded.

Literature.—Parsee texts are discussed in ZOROASTRIAN LITERATURE and AVESTA. The *Desatir* (Arabic, pl. of *dastur*, "high priest") is also worth mentioning; this is a fraudulent document, probably of the 16th century, which purports to establish a certain Indo-Persian mysticism at the origin of Zoroastrianism. It is the only extant book among 23 works quoted in a 17th-century compilation called the *Dabistan*, made by the Sufi Muhsan-i-Fani, who incorporated elements of Islamic and Hindu universalism.

Zoroastrianism attracted the attention of European scholars in the 18th century. When A. H. Anquetil-Duperron visited the Parsees at Surat they expounded the Avesta to him according to the tradition maintained by the Gabars. Afterward he translated the work and it appeared for the first time in a European language in 1771, under the title *Zend-Avesta, Ouvrage de Zoroastre*. European scholars, in clarifying the original form of the religion and in tracing its developments, have helped the Parsees to reestablish the foundations of their ancient faith. In particular, by stressing the fundamental monotheism of Zoroaster's teaching, they have made it possible to refute the charge of dualism often made by Christian missionaries.

Priesthood.—Priesthood is hereditary, but every candidate must also undergo one or two ceremonies of investiture, according to the grade he wishes to attain. After the first ceremony (the *navar*) he becomes a *herbad* (or *ervad*) who may perform benedictions, investitures of children and marriages but may play only a minor part in other ceremonies. The second investiture (the *martab*) confers the degree of *mobad*, which allows the priest to conduct the more important ceremonies, such as sacrifices and initiations. Above the *herbads* and *mobads* are the *dasturs*, high priests or "bishops."

Sects.—The Parsee community split into two sects in the 18th century on a matter of calendar. The Qadimis ("Ancients") adopted the computation of the Gabars, as well as their practice of bringing the sacred fires once a year to the main temple, a ceremony since abandoned. The other Parsees call themselves Shahanshahees ("Imperials"). The two sects now coexist peacefully and intermarry. A third and smaller sect is the Fasalis.

Ritual.—Every Parsee child is initiated, at the age of seven, in a ceremony at which he is invested with the *sudrah* and the *kusti*. Five times a day (at sunrise, midday, in the afternoon, at dusk, and at midnight) a Parsee should recite set prayers in Avestan, Pahlavi, and Gujarati. Moreover he should pray (and untie and retie his *kusti*) on rising, when washing, eating, and relieving himself, and in numerous particular circumstances.

The most sacred ceremony of the Parsee ritual is the *yasna*, or sacrifice, essentially a recitation of a sacred text accompanied by an offering of *haoma* (sacred liquor) before the sacred fire, which is kept burning perpetually and held in great reverence. In the course of the ceremony all the Gathas are recited. The sacrifice is performed for the benefit of persons dead or alive.

Funerary ceremonies include a recitation of the *patet*, or confession, in the name of the dead man; washing him with *gomez* (bull's urine), which, as in many other ancient religions, is thought to have purifying qualities; and isolating him by drawing circles around him in the presence of a dog, whose gaze is thought to expel the *druj* Nasu (corpse-demon), *druj* of defilement. By the fourth morning the soul is supposed to have departed and the corpse is taken to a *dakhma*, or "tower of silence," where, in the ancient fashion of the Medes, it is exposed to birds of prey. The bones are later swept into a central pit. The purpose of this practice is to avoid defiling earth, fire, or water; nowadays it tends to be discontinued.

Zoroastrians set great store in avoiding contact with dead matter and all unclean objects. There are three ceremonies of purification. The *padyab*, which consists of washing one's face, hands,

and feet (if they are bare), is performed at sunrise, at meals, and after relieving oneself. The *nahn* is a ritual bath which is performed with a priest on important occasions such as investiture of the *kusti*, marriage, purification after childbirth, and in the last ten days of the year in honour of the dead. It includes rubbing the body with and drinking *gomez*. The *bareshnum*, reserved for corpse-bearers and candidates to priesthood, takes place on a specially prepared ground with holes or marked spots for carrying away the impurity. The candidate is washed several times with water, sand, and *gomez*, under the gaze of a dog, and then seeks isolation for nine nights.

Festivals.—The main dates of the Parsee year are the six seasonal feasts, or *gahanbars*, the last of which is known as Fravartigan, the days of the dead. Each *gahanbar* lasts five days, the last of which is the principal one. Benedictions and offerings are given, and the *yasna* may be performed. The consumption of the offerings is an essential feature of these celebrations, in which all the faithful are supposed to take part. Fravartigan falls on the last ten days of the year, which include the five intercalary days. Each family honours its dead with fires, frankincense, offerings and recitations of the Gathas.

The first month of the year, Farvardin (March–April), is also named after the dead and consecrated to them. Each of the other months is similarly devoted to deities, to whom moreover a particular day in the month is consecrated. The four most important are those in honour of Tir (Sirius), Mihr (Mithra), Spandarmad (the Earth) and Aban (the Waters).

Ethics.—The precepts of Zoroastrian ethics, "good thoughts, good words, and good deeds," have a twofold application. First, life must be maintained, an injunction to cultivate the land and to procreate; second, evil must be fought by combating the demons and whatever men or animals belong to them. Formerly consanguineous marriage, which probably developed from social reasons, was regarded as meritorious, but it has been abandoned. It is thought that after death the soul meets its conscience in the shape of a damsel or a hag, depending on the balance of good and evil thoughts, words, and deeds throughout his earthly life; and theoretically one's destiny in the hereafter is determined by this balance. However some faults may be canceled out by confession, with contrition and penance, or by the transfer of supererogatory merits; this constitutes a justification for the prayers and ceremonies for the dead, which are deemed efficacious of themselves, regardless of the merits of those who perform or sponsor them. *See* also ZOROASTRIANISM; ZOROASTER.

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PARSLEY (*Petroselinum crispum*), a hardy, biennial herb of the carrot family (Umbelliferae), native to Mediterranean lands. One form is grown only for its cluster of dark-green, tender, curled, deeply cut or highly frilled leaves that develops the first season of growth. A second form called turnip-rooted, or Hamburg, parsley is grown for its large, white, parsniplike root. Both forms in the second season put up seed stalks two to six feet high, topped by compound umbels of small greenish-yellow flowers. The seeds are similar to those of carrot, but without spines. Parsley leaves were used by the ancient Greeks and Romans as a flavouring and garnish for foods, as they are used in Europe and America in modern times.

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PARSLEY (PETROSELINUM CRISPUM)

Turnip-rooted parsley is popular in Europe but little grown in America. Parsley seedlings are small and weak; they emerge with difficulty from heavy, crusty soils. (V. R. B.)

PARSNIP (*Pastinaca sativa*), a member of the carrot family (Umbelliferae), cultivated since Roman times for its large, tapering, fleshy, white root, which has a distinctive flavour. The plant is a native of Europe; a wild form with a tough pungent root is found in roadsides and waste places in England and throughout Europe and temperate Asia. It was introduced on the American continent early in the 17th century and has become extensively naturalized in North America, especially in the Eastern states and Canada and on the Pacific Coast, sometimes becoming a troublesome weed.

The parsnip seed is sown in the spring, thinly in rows about one and a half feet apart, and the plants thinned to stand two to three inches apart in the row. At the end of summer the solids of the root consist largely of starch, but after the roots are exposed to temperature near freezing for a few weeks much of the starch changes to sugar, improving its eating quality. The root is quite hardy when left in the garden, being undamaged by hard freezing of the soil. (V. R. B.)

PARSONS, SIR CHARLES ALGERNON (1854–1931), British engineer, best known for the invention of a steam turbine bearing his name, was born in London, June 13, 1854, fourth son of the 3rd Earl of Rosse. Educated privately and at St. John's College, Cambridge, he entered the Armstrong Works at Elswick in 1877. In 1884, having served for a year on the experimental staff of Messrs. Kitson, of Leeds, he entered into partnership with Messrs. Clarke, Chapman and Co., of Gateshead. On the dissolution of the partnership in 1889, Parsons, whose invention of the Parsons steam turbine was bringing him into considerable prominence, established his own works at Heaton, Newcastle upon Tyne, for the manufacture of steam turbines, dynamos, and other electrical apparatus. Besides the chairmanship of C. A. Parsons and Co., he occupied important positions on the directorate of various electrical supply and engineering companies. He was made a fellow of the Royal Society in 1898, was awarded the Royal Society's Rumford Medal in 1902, was president of the Institute of Marine Engineers, 1905–06 and of the British Association, 1919–20. He was created knight commander of the Bath in 1911 and given the Order of Merit in 1927.

A collection of his own scientific papers and addresses was published posthumously in 1934. He died Feb. 11, 1931, at Kingston, Jamaica, on board the "Duchess of Richmond."

See R. Appleyard, *Charles Parsons, His Life and Work* (1933).

PARSONS, ELSIE WORTHINGTON CLEWS (pseudonym JOHN MAIN) (1875–1941), U.S. sociologist and anthropologist, best known for her studies of the Indians of the southwest, was born of a socially prominent family in New York City, Nov. 27, 1875. She received a bachelor's degree from Barnard College in 1896 and then studied at Columbia University under Franklin Giddings, receiving her master of arts in sociology in 1897 and her Ph.D. in 1899. She taught sociology from 1899 to 1905 at Barnard. Her early works, such as *The Family* (1906), *The Old Fashioned Woman* (1913), and *Fear and Conventionality* (1914), reflect concern over restrictions imposed upon women in many cultures and periods. In 1900 she married Herbert Parsons, attorney and U.S. congressman; six children were born of the marriage.

In 1915, as a result of a trip to the southwest where she met the anthropologists Franz Boas and P. E. Goddard, she turned to American Indian research and entered upon 25 years of field study and writing that established her as an authority on the Pueblo tribes. Outstanding among her Pueblo writings were the two-volume work, *Pueblo Indian Religion* (1939), and "The House-Clan Complex of the Pueblos," in *Essays in Anthropology in Honor of A. L. Kroeber* (1936). Her interest in all possible influences upon the Pueblo peoples led her to investigations among the Plains Indians, and in Mexico, Peru, Ecuador, and the Caribbean. *Mitla: Town of the Souls* (1936) is one of the best-known products of her extensive Mexican researches. She also published widely in the field of folklore, including Negro folklore.

She served as president of the American Ethnological Society (1923–25), and was president of the American Anthropological Association at the time of her death on Dec. 19, 1941, in New York City.

See Franz Boas, "Elsie Clews Parsons," in *Science* (Jan. 23, 1942).

(M. E. O.)

PARSONS (Persons), **ROBERT** (1546–1610), English Jesuit who with Cardinal William Allen organized Catholic resistance to the Elizabethan Protestant regime, was born at Nether Stowey, Somerset, on June 24, 1546, of yeoman family. He was educated at Taunton School and St. Mary Hall, Oxford. In 1568 he became a fellow of Balliol College, but in February 1574 was forced to resign because of his ill-concealed Catholic sympathies. He later defended himself in his *Apologie in Defence of the Ecclesiastical Hierarchy* (1602). On leaving Balliol, Parsons went to Louvain, where he became a Catholic, and in July 1575 entered the Society of Jesus in Rome.

In 1580 Parsons was sent with Edmund Campion (*q.v.*) to England, arriving on June 12, 1580. The instructions given to him in Rome and his own conduct in England show that his mission was nonpolitical. In little over a year he did much to organize the Catholic resistance, preached, wrote books and pamphlets, challenged Protestant clergy to debate, and set up a secret printing press, which was eventually seized.

After Campion's arrest (July 17, 1581) Parsons crossed to the continent to see William Allen and set up a printing press in Rouen. He was given the task of directing the Jesuit mission from abroad. In 1588 he was sent to Spain, where he spent nearly nine years and founded seminaries for the training of English priests at Valladolid, Seville, and Madrid.

While Parsons favoured armed intervention as a means of restoring Catholicism in England, the cardinal point of his policy was to wait, and, on the death of Queen Elizabeth, to press the claims of a Catholic successor.. Parsons was author of many controversial works written with much incisiveness and vigour. His *A Christian Directorie* (1585) established itself as a devotional classic among both Catholics and Protestants. He died at the English College, Rome, on April 15, 1610.

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(P. Cn.)

PARSONS, ROBERT (?–1570), one of the most distinguished English composers of church music of the mid-16th century. Probably born at Exeter, he was appointed gentleman of the Chapel Royal in 1563. He died by drowning in the River Trent at Newark in 1570.

Parson's contrapuntal writing often has very considerable strength and shows a virile and sometimes quite original treatment of dissonance. His best-known composition, "Pandolpho," a song with viol accompaniment, is remarkable not only for its expressive power but also for its intense motivic organization.

(Da. C. B.)

PARTHENIUS of Nicaea (Apamea) (fl. 1st century B.C.), Greek poet and grammarian, has justly been described as the "last of the Alexandrians." Captured in the third Mithridatic War and carried off to Italy, he became Virgil's teacher in Greek. His collection of 36 love stories made for the poet Cornelius Gallus has survived, and fragments from two funeral poems, one on his wife Arete, have come to light in papyri. He also wrote an encomium of the same lady in three books. His poems were favourite reading of the emperors Tiberius and Hadrian.

See S. Gaselee, *Parthenius,* with Eng. trans., "Loeb Series" (1916).

(E. A. B.)

PARTHENOCISSUS, a genus of the grape family (Vitaceae), including the Boston ivy and the Virginia creeper (*q.v.*).

PARTHENOGENESIS, an alternative to sexual reproduction in which the female (in rare cases the male) alone produces young. Throughout the animal and plant kingdoms sexual reproduction is common; a ripe egg borne by one organism (called variously female cell, ovum, macro- or megagamete, female gamete) is usually stimulated to develop into a new organism after fertilization (*q.v.*) by a sperm (called also male cell, spermatozoon, microgamete, male gamete) (*see* Reproduction). Parthenogenesis, or virgin birth, in the vast majority of cases involves the egg but not the sperm. In certain algae the male of the species is able to give rise to offspring without the female. Female parthenogenesis occurs naturally in many animals and plants and may be induced artificially or experimentally by man.

NATURAL PARTHENOGENESIS

Natural parthenogenesis is the exclusive method of reproduction in some plant lice (aphids, *q.v.*), parasitic wasps and thrips in which males are unknown; it is an occasional method in some members of all the major groups of animals except vertebrates and echinoderms (starfish, etc.). In still other groups of plant lice, and in rotifers and water fleas (crustacean order Cladocera) parthenogenesis alternates with sexual reproduction. In honeybees (and other members of the order Hymenoptera), white flies (order Hemiptera) and some thrips (order Thysanoptera) any egg is capable of developing parthenogenetically or after fertilization, the fertilized eggs are capable of producing females, the unfertilized eggs males.

True parthenogenesis is frequent among certain algae and fungi but is rare among seed plants and has been demonstrated in only a few including dandelion (*Taraxacum*) and cat's foot (*Antennaria*). There occur, however, various types of asexual reproduction that superficially resemble parthenogenesis; these are generally grouped under the term apogamy or apomixis, and include the production of adventitious embryos from tissue outside the egg. The process is very much like the production of plant bulblets externally.

Reproductive Cycles.—In most rotifers, aphids and water fleas the fertilized eggs develop into females whose eggs in turn are parthenogenetic. In the rotifers any successive generation may include both parthenogenetic and sexual females. The parthenogenetic female produces large eggs, which remain unfertilized and yield either parthenogenetic or sexual females. The sexual female produces small eggs, which may develop without fertilization and yield males, or be fertilized, grow larger and yield females.

In typical aphids several parthenogenetic generations follow the fertilized egg, which hatches in spring; during spring and summer wingless or winged females or both are produced. As autumn approaches, sexual forms appear—males and egg-laying females—and mating takes place. (When the parthenogenetic females produce sexual forms, sexual females are born mostly of winged mothers, males mostly of wingless mothers.) The fertilized eggs hatch the following spring and the cycle repeats.

The water flea cycle is more flexible. In certain species any female may produce either female or male offspring by parthenogenesis, or eggs that require fertilization and yield females. In all these cycles environment influences the time or frequency of appearance of the sexual forms.

Number of Chromosomes.—Important differences in parthenogenesis are related to the number of chromosomes in the developing egg. In most higher animals, whose body (somatic) cells contain what is known as the diploid or normal number of chromosomes (*e.g.*, in man 46 chromosomes, 23 like pairs) the reproductive cells undergo two maturation divisions in one of which the like or homologous chromosomes (after pairing) separate without division. As a consequence of this reduction division the mature germ cells have half the somatic number of chromosomes. This number is termed haploid (*e.g.*, in man 23 chromosomes, one of each of the like pairs). Some haploid eggs may develop parthenogenetically. More commonly, however, parthenogenetic eggs omit the reducing one of the two maturation divisions, and therefore are diploid. In the bee the fertilized eggs are diploid, as are also the females (queens or workers), which develop from them; but the mature unfertilized eggs are haploid. If they remain unfertilized they develop parthenogenetically to yield males (drones), which are haploid. When the drones produce spermatozoa, there is no further reduction of the chromosome number in these germ cells because only one set of chromosomes is present; at what

would be the reduction division all the chromosomes pass to one cell, and it is only from such cells that spermatozoa are derived. These males cells, like the eggs, are therefore haploid.

In aphids both parthenogenetic and sexual females are diploid. Eggs of sexual females result from two maturation divisions, and are haploid; but in parthenogenetic females the reducing division is suppressed, and the eggs are diploid. These eggs produce females, which are also diploid. The parthenogenetic eggs that develop into males eliminate only one whole chromosome in the maturation division, leaving the males with one less than the diploid number of chromosomes. In maturation of male germ cells there is an unequal division in which one cell receives the full haploid chromosome group, the other cell one less. Only the former cell produces a spermatozoon, so that male germ cells are haploid.

In water fleas, females and males are strictly diploid. Parthenogenetic eggs mature by one division and are diploid; sexual eggs and spermatozoa result from two divisions and are haploid.

Restoration of Diploid Chromosome Number.—In animals, even after a reduction division, the normal or diploid number of chromosomes may be restored in parthenogenesis by duplicating the chromosomes at the end of the reduction division; by fusion of the egg nucleus with the nucleus of the second polar body, the very small one of the two cells produced by the second division; or by fusion of two cleavage cells. In plants other ways of restoring or maintaining diploidy are available because of the long haploid phase of the cycle.

In animals the haploid phase is practically limited to the mature germ cells, but in the lower plants such as fungi, algae, ferns, etc., a conspicuous haploid generation is evident. Even in many flowering plants the embryo sac, which functions in development of the embryo and seed, consists normally of eight haploid cells. Sometimes the embryo sac develops from an unreduced spore, and thus is diploid. The eggs in diploid embryo sacs are ordinarily parthenogenetic, since fertilizing them would increase the chromosome number in the next generation. Diploid embryo sacs may also arise not from spores but from some kind of somatic cell, a process known as apospory. The eggs in such embryo sacs need some way to avoid doubling their already double chromosome number, and omitting fertilization is the remedy. Sometimes the embryo is produced not from the egg but from some other embryo sac cell. This process, called apogamy, is like parthenogenesis in not involving fertilization, and prevents the doubling of chromosome numbers.

Relation to Hybridization and Evolution.—Often some of the offspring of a cross between species reproduce by parthenogenesis. In such species hybrids the chromosomes must usually be to some degree unmatched. This inequality interferes with their pairing in maturation. While failure of chromosome pairing can hardly be the cause of parthenogenesis, diploid parthenogenesis clearly furnishes a correction of the defect. Species crosses in plants have often been followed by a prompt doubling of the chromosomes, after which pairing can take place because like chromosomes have been provided by the doubling. Many new species have arisen in this way, possessing the number of chromosomes of the two parent species combined. Doubling of chromosomes also occurs independently of species crosses. As a result there are many species that are polyploid, *i.e.*, possessed of a chromosome number higher than the diploid and a multiple of the basic haploid number present in some primitive species. Parthenogenesis occurs so much more frequently in polyploid species that there must be some causal relation between the two phenomena.

In organisms that reproduce by parthenogenesis, evolution is restricted because, in the absence of chromosome pairing, recombination of characters does not occur. Ineffectiveness of selection within parthenogenetic lines of descent indicates that changes are rare, though if crossing over (exchange of fragments between homologous chromosomes) ever occurs, recombination of characters is still possible, permitting a slow evolution. In species reproducing alternately by the parthenogenetic and sexual methods, parthenogenesis may be an evolutionary asset. When recombination in the sexual period produces an individual that fits some special niche in the environment, that individual need not stand alone in holding its place. By parthenogenesis it may produce hundreds of individuals having the same genetic constitution, some of which, even after high accidental losses, may well survive.

(A. F. Sl.; X.)

ARTIFICIAL PARTHENOGENESIS

Unfertilized eggs, under ordinary conditions, die within a relatively short time (one to several days, depending on the species) after having been shed from the ovary. However, it has been found that in a great many species of animals unfertilized eggs may be incited to develop by means of treatment with certain simple chemical or physical agents. This was initially discovered in 1886 by A. Tichomiroff, working with eggs of the silkworm moth. His results, however, attracted very little attention, presumably because the occurrence of natural parthenogenesis in the same species obscured the special significance of his work. In 1896–1900 T. H. Morgan and A. D. Mead showed that development could be initiated in unfertilized eggs of marine animals (sea urchins and worms) by treatment with certain salt solutions or hypertonic (concentrated) sea water, and Jacques Loeb in 1900 first demonstrated that normal larvae could be obtained by such means. Later, extensive investigations by many workers showed that in practically all the main groups of animals normal development can be obtained by artificial activation of the unfertilized eggs, although methods of treatment may vary considerably from one species to another. From this it may be concluded that the eggs of all species of animals are capable of development by artificial parthenogenesis.

Among plants artificial parthenogenesis has not received the same attention as it has among animals. However, eggs of the marine rockweed (*Fucus*) have been induced to develop into new plants by subjecting them to treatment with certain organic acids. Parthenocarpy or the "setting" of fruit without the usual development of seed, *i.e.*, without fertilization, should not be confused with parthenogenesis, for in the former only the seedless fruit results and not an embryo or a new organism (*see* Fruit; Plants and Plant Science: *Plant Physiology: Growth*).

Methods of Artificial Activation.—Marine invertebrate animals, particularly echinoderms, mollusks and worms, have been most extensively used in experiments on artificial parthenogenesis because they generally produce large quantities of eggs that are (1) easily obtained, since they are shed directly into the sea water or are readily removable from the animal, and (2) easily handled and cultured during their early development simply in sea water. However, many experiments have also been performed on eggs of insects, fish, frogs, and mammals. One of the most interesting features of the experiments is the great variety of methods of treatment that have been found to be effective. Even in a single species the eggs may be activated by any one of a number of diverse agents. Thus, in the sea urchin *Arbacia*, activation has been obtained by exposure of the eggs to increased acidity, increased alkalinity, neutral salt solutions (certain constituents of sea water), hypertonic (concentrated) or hypotonic (dilute) sea water, certain alkaloids, fat solvents, puncture with a fine needle, heat, cold, ultraviolet radiation and radium emanations. While not all these agents have been found to be equally effective, several of them have given practically similar results, and differences may reflect in part the failure of the investigator to find the best exposure to employ with a particular agent. The eggs of different species of animals generally differ in the kinds of agents to which they will best respond. Certain agents, such as heat and weak acids, have been found to be effective in a number of different species of animals, although with different optimum times of exposure.

Loeb's original method of treatment of sea urchin eggs consisted in exposure to a hypertonic solution. He later discovered a double treatment that proved very effective in giving a high percentage of normal development. This consisted in exposure for 1–3 min. to a dilute solution of butyric acid in sea water followed after 15 min. by exposure to a solution of sodium chloride in sea water for about ½ hr. E. E. Just subsequently showed that a single treatment

with a somewhat stronger solution of sodium chloride for 10 min. or less gives equally good results. (Details of methods used with eggs of various species of animals may be found in the references listed in the bibliography.)

Production of Normal Embryos and Adult Animals.—With appropriate artificial treatment the percentage of eggs that develop normally may be quite as high as that obtained by fertilization. This high degree of effectiveness has been obtained with eggs of several species of animals, particularly among the echinoderms and annelid worms, which have been extensively studied. Generally, the eggs have been reared only to the larval stage; however, parthenogenetic sea urchins and starfish have been reared to the adult condition. It is clear that when perfectly normal larvae are produced, the problem of obtaining the adults is principally a matter of finding proper culture methods.

In several species of higher animals, adults have been obtained by artificial parthenogenesis. Sexually mature adult moths as well as caterpillars have been obtained in large numbers from eggs of the silkworm moth after activation by heat and by acid. It has been reported that young carp can be obtained by activation of the eggs with male human saliva. Another report cites the rearing of shad to a practically full-grown condition after activation of the eggs, on an industrial scale, by means of a weak electric current. In frogs several dozen adults have been obtained by various investigators using the method of puncturing the egg with a fine (about 0.005-millimetre diameter) glass or platinum needle. In mammals, Gregory Pincus (1939–40) reported the production of seven parthenogenetic rabbits. Six of these were obtained by exposing the eggs to heat or hypertonicity after they were taken from the mother's body and then implanting them in the uterus of another prepared female rabbit. One rabbit was parthenogenetically produced by cold treatment of the eggs while they remained in the oviducts in the animal. This was accomplished by surgically exposing and cooling the oviduct, and its contained recently ovulated eggs, by means of cold water.

Number of Chromosomes.—The egg nucleus after the reduction divisions contains a haploid (single) set of chromosomes, as does also the nucleus of the spermatozoon. Union of the egg nucleus with the sperm nucleus in normal fertilization restores the diploid (double) chromosome number characteristic of all cells of the animal except the germ cells. (*See* CYTOLOGY; FERTILIZATION.) In artificial parthenogenesis, since the haploid set of chromosomes ordinarily contributed by the spermatozoon is absent, one would expect only haploid individuals to develop. However, cytological investigations have shown that, besides haploids, diploid embryos also occur. In fact, the only individuals that have been reared to or near the adult condition have turned out to be diploid. The haploid individuals generally die in an embryonic stage.

Several investigators have examined the fascinating problem of the manner in which artificially activated eggs spontaneously restore the chromosome number to diploid. This has been studied principally in eggs of the frog, the silkworm and the marine echiurid worm *Urechis*, and a number of methods of regulation have been revealed. Much is found to depend upon the stage of meiosis (reduction divisions) attained by the egg at the time it is ready for activation. In some animals, such as the sea urchins, the eggs are not ready for activation (either fertilization or artificial parthenogenesis) until they have extruded both polar bodies, thus completing the meiotic divisions. In fact they are not shed from the ovaries until they have attained that stage. Eggs of other animals, such as *Urechis*, are ready for activation at a stage considerably earlier than the first polar division. In *Urechis*, after activation by brief treatment with hypotonic sea water or with dilute ammonia, many of the eggs fail to extrude the polar bodies and the presumptive first polar spindle becomes the first cleavage spindle. The two cells resulting from this first division each have the diploid chromosome number. Successive divisions occur mitotically, thus retaining the diploid number in all of the cells of the embryo.

Another type of behaviour is exhibited by eggs of *Urechis* that have been given a somewhat prolonged treatment with dilute ammonia. In these, the first or both the first and second meiotic divisions occur submerged within the egg, and the corresponding polar bodies fail to be extruded. The egg nucleus then unites with one, two or three polar-body nuclei, depending upon how many have been left within the egg. Fusion with one polar-body nucleus provides a diploid nucleus for the first cleavage, which divides the egg into two cells, and the succeeding ordinary mitotic divisions would maintain the diploid condition.

Another type of regulation to diploidy has been discovered in the frog. In this species the eggs have completed only the first meiotic division when they are ready for fertilization or artificial activation. Upon artificial activation by means of the puncture method, the great majority of the eggs complete their second meiotic division normally, and about 1% of them undergo cleavage and early development. Most of these cleave at the regular time and develop as haploids, but some exhibit a delay in cleavage and develop as diploids. The delay generally occurs at the first cleavage, and during this time an extra division of the chromosomes (without cytoplasmic division) occurs, thus providing the diploid number of chromosomes for the cells of the embryo and adult.

A few diploids have also been obtained from eggs that exhibited no delay in cleavage but have evidently been regulated by means of one of the mechanisms described above for *Urechis*. In the silkworm moth it has been found that regulation to diploidy can occur by doubling of the chromosomes at the first cleavage or at a later division stage, or by elimination of the reduction division, depending upon the method of artificial activation employed.

Sex.—The sex of individuals obtained by artificial activation will depend upon the behaviour of the chromosomes, since they carry the primary sex-determining factors. Maleness or femaleness is determined by the ratio of the number of sex chromosomes to the number of sets of autosomes. Most species of animals, including man, belong to the so-called male-digametic type, in which the somatic cells of the males of the species have a single sex chromosome (X) and a diploid set of autosomes (2A) and the females have 2X + 2A. Birds, butterflies and moths and some fish belong to the female-digametic type, in which the somatic cells of the females have a single sex chromosome (termed Z in this type), the chromosome constitution being Z + 2A for the female and 2Z + 2A for the male.

Animals of the male-digametic type produce only one kind of egg, and these have the haploid chromosome constitution X + A. Upon artificial activation and regulation to diploidy the constitution would be 2X + 2A, which is that of the female. In animals of this type, then, it is to be expected that only females would be obtained from eggs that have been activated artificially. In accord with this, all the rabbits and most of the frogs raised to the stage at which their sex could be identified have been found to be female. The new male frogs were obtained presumably as a result of overripeness of the eggs or because of sex-chromosome elimination.

Animals of the female-digametic type produce two kinds of eggs, one with and one without the Z chromosome. The former, upon regulation to diploidy by doubling of the chromosome number, would give a male (2Z + 2A) and the latter would give a "hyperfemale" (0 + 2A), which is a type that does not ordinarily develop very far. If the regulation to diploidy is accomplished by fusion of the egg nucleus with a polar-body nucleus, females as well as males would be expected, depending upon the constitution of the nuclei involved. Extensive investigations have been made with eggs of the silkworm moth (which belongs to the female-digametic type) and these have shown the occurrence of both males and females, the results depending upon the method of activation employed and consequent method of regulation to diploidy.

Thus, it may be seen that, in most species of animals, artificial parthenogenesis would produce only females, while in a relatively few species both sexes would be obtained.

General Significance.—The experiments on artificial parthenogenesis have removed one mystical element from the problem of the initiation of development of the egg by showing that, in many cases, relatively simple chemical or physical agents can be employed in place of the complex living spermatozoon. Stimulation of the egg cell is thus analogous to the stimulation of nerve,

muscle or gland cells, which are known to respond to a variety of nonspecific agents. Various theories have been advanced to explain cell stimulation in general as well as artificial activation of eggs. One theory emphasized the role of calcium ions, the presence of which is shown to be important to obtain activation by various agents.

Special interest centres around the origin of the spindle and amphiaster, which comprise the essential mechanism for cell division (*see* CYTOLOGY). In fertilization the amphiaster for the first cleavage arises from the sperm aster, which forms around the central body (centriole or centrosome) brought in by the middle piece of the spermatozoon. In artificial parthenogenesis it has been found that the original central body of the egg takes over this function in some species of animals, while in other species new central bodies (and asters) are brought into existence as a result of the treatment. The latter has been shown especially in experiments on parthenogenetic merogony. Since the central bodies are known to be of the same nature as chromosomal material, these experiments have indicated the possibility of a *de novo* formation of self-producing bodies, perhaps genes, from cytoplasmic materials in the absence of a nucleus.

See also references under "Parthenogenesis" in the Index.

(A. TY.; X.)

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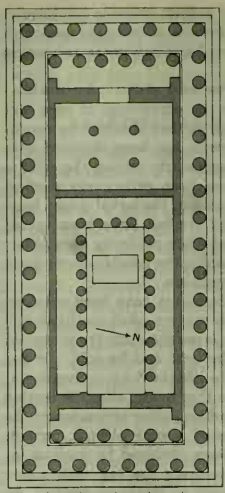
PARTHENON, the name generally given, since the 4th century B.C., to the chief temple of Athena on the Acropolis at Athens. The name is applied in the official inventories of the 5th and early 4th centuries to one compartment of the temple, and this was probably its original meaning. It is certainly to be associated with the cult of Athena Parthenos, "the Virgin."

History.—The most convenient position for a temple upon the rock platform of the Acropolis was occupied by the early temple of Athena. When, after Marathon, it was decided to supersede this by a more magnificent temple, it was necessary to provide a new site by means of a great substructure, which on its south side reaches down 40 ft. to the rock. The extant example is the chief among the buildings with which Pericles adorned the Acropolis. Ictinus and Callicrates were architects under the general supervision of the sculptor Phidias. Work began in 447 B.C., though the decision to build was made ten years earlier. The building itself was completed by 438 B.C., when the gold and ivory statue of Athena was dedicated; work on the carvings and decoration continued to 432 B.C.

Except for repairs to the roof and interior after a fire in the 2nd century A.D., the Parthenon remained essentially intact until the 5th century, when the colossal statue was removed and the temple transformed into a church dedicated to Hagia Sophia (the Holy Wisdom).

In A.D. 662 it was dedicated to the Virgin Mother of God. The adaptation of the building as a church involved the alteration of the inner columns and the roof, the construction of an apse at the east end, the opening of doors between the cella and the chamber to the west and the cutting of windows in the upper part of the cella wall. The Turks, after the capture of Athens in 1458, transformed the Parthenon into a mosque without material change save for carrying up a campanile, built in the southwest angle to form a minaret. In this state it was described by Spon and Wheler in 1676 and the sculpture drawn by the artist Carrey, for the marquis de Nointel, in 1674. In the same year the building was visited by Francis Vernon, who left valuable, unpublished notes. A powder magazine located in the building blew up in the bombardment of the Acropolis (1687) by the Venetian general, Morosini, and the middle of the temple was ruined. Further damage was done to the sculptures by Morosini's attempt to remove the horses of Athena from the west pediment.



FROM W. B. DINSMOOR, "THE ARCHITECTURE OF ANCIENT GREECE," 1950

PLAN OF THE PARTHENON

A small mosque was built in the ruins, but nothing further of interest is recorded until the visit of James Stuart (1751–53) and Nicholas Revett (1751–54, 1765–66), to whom we owe the best drawings of the sculptures that remained. They were removed in 1801–03 by Lord Elgin, on the authority of a firman, and subsequently sold in 1816 to the British museum. Certain other sculptures from the Parthenon are in the Louvre, in Copenhagen and elsewhere; many are still in Athens.

Description.—The temple designed by Ictinus measured 101.34 by 228.14 ft. on the stylobate (thus about 15 ft. shorter and about 6 ft. wider than its incompleted predecessor), and had a peripteron of 8 by 17 columns. The cella, known as the hecatompedon naos, a name inherited from the archaic Hecatompedon, was divided into three aisles by two-story Doric colonnades, returned at the west end just behind the great cult statue. The only light came through the east doorway, and possibly filtered through marble tiles in the roof and ceiling. Behind the cella, but not connected with it, was a square chamber, officially called the Parthenon, entered from the west. The prodomos (*i.e.*, the space before the entrance of the cella) and opisthodomos (*i.e.*, the room at the rear of the cella), each faced by a portico of six columns, were enclosed by bronze gratings fixed between the columns, and were thus adapted to contain valuable offerings and other treasures. There are inventories on marble of the contents of these four compartments of the temple. The opisthodomos, especially, would seem to have served as a treasury.

The Parthenon, which represents the peak of the Greek Doric order, embodies an extraordinary number of refinements which combine to give a plastic, sculptural appearance to the building. Among these may be mentioned: the upward curvature of the stylobate along the ends and sides and repeated in the entablature; the inward inclination of the axes of the columns, with their delicate, curving entasis as they diminish in diameter toward the top; the thickening of the angle columns to counteract the effect of being seen at certain angles against the sky; and the fact that

FEDERICO ARBORIO MELLA

PARTHENON (447–432 B.C.) AS SEEN FROM THE NORTHWEST. DESIGNED BY THE ARCHITECTS ICTINUS AND CALLICRATES. IT REPRESENTS THE PEAK OF THE DORIC ORDER IN GREEK ARCHITECTURE

scarcely a surface of the building is truly vertical, but sets in or out to give definition under simultaneous lighting conditions.

The perfection and detail have led many modern critics to propose various and often fantastic geometrical or mathematical systems of related sizes that could thus furnish an infallible rule of beauty. That so many different ones have been found to apply within relatively narrow limits is sufficient criticism of each. (*See* also ERECHTHEUM; GREEK ARCHITECTURE; ORDER; TEMPLE ARCHITECTURE.)

Sculpture.—Over the outer colonnade the metopes, carved in high relief, represented: on the east, the battle of gods and giants; on the south, Greeks and centaurs; on the west, probably Greeks and Amazons. Those on the north are almost lost. The continuous frieze around the top of the cella wall and above the hexastyle porticoes is one of several features that show the popularity of Ionic motifs in 5th-century Athens. It represents, in low relief, the Panathenaic procession, culminating on the east side, where two groups of seated gods flank a central panel in which appear the priest and priestess of Athena with three young attendants, to one of whom the priest confides a folded peplos. In the procession are, successively, the horsemen, chariot groups, citizens and offering bearers, the sacrificial sheep and cows and, lastly, the maidens of Athens, who appear in either flank of the eastern part of the frieze. The pediment groups, carved in the round, show, on the east, the birth of Athena, and on the west, her contest with Poseidon for the land of Attica. The entire work is a marvel of composition and clarity, which was further enhanced by colour and bronze accessories. Traces of colour are recorded in the frieze, and many details were added in bronze. The gold and ivory Athena, in the interior of the cella, was a masterpiece of Phidias. The goddess stood fully armed, with a Victory held in her right hand. Pausanias, a Roman traveler of the 2nd century A.D., has left us a very full description, and the general aspect of the statue is known through several small-scale, inferior Roman copies. On the pedestal of the image was a representation of the birth of Pandora.

The original was removed, possibly to Constantinople, in the 5th century A.D., when the Parthenon was made into a church. *See* also GREEK ART; and references under "Parthenon" in the Index. (R. St.)

PARTHIA, an ancient land corresponding roughly to the modern province of Khurasan in Iran. Although the exact boundaries of Parthia are not known, the greater part of the land was divided by the eastern Elburz Mountain Range. To the north of the mountains the present Iranian district of Gorgan and southern Turkmen S.S.R. were part of ancient Parthia, as well as the area south of the mountains to the central desert of Iran.

The first certain occurrence of the name is as *Parthava* in the Bisitun inscription (*c.* 520 B.C.) of Darius I. The etymology of the word is uncertain, but it may be a tribal name. It has been suggested that *Parthava* is only a dialectal variation of the name *Parsa* ("Persian"). Unfortunately, nothing is known of the history of Parthia as part of a satrapy (the 16th satrapy of Herodotus) of the Achaemenid Empire. It was one of the "lands" which revolted against Darius at the beginning of his reign. The father of Darius, Hystaspes, who was in Parthia, presumably as governor, suppressed the revolt. Parthia was joined to Hyrcania (present Gorgan) in the time of Alexander the Great and the two remained together as a province of the Seleucid Empire. The capital of the satrapy was at Zadracarta (near the modern town of Gorgan, formerly Asterabad), according to Arrian (*Anabasis,* iii, 25) and Quintus Curtius Rufus (*Historiae Alexandri Magni,* vi, 5, 22).

During the reigns of Seleucus I (*c.* 312–281 B.C.) and Antiochus I Soter (*c.* 280–262) the (A)parni nomads probably moved from central Asia into Parthia. The Parni were said to have been a tribe of the nomadic confederation known to the Greeks as Dahae (Strabo, *Geographica,* 508 and 515). The newcomers seem to have adopted the speech of the Parthians and were absorbed into the settled population.

There is a tradition that the first ruler of the Parthians, Arsaces I, was a governor under Diodotus, king of the Bactrian Greeks, who revolted and fled westward from Bactria to establish his own rule. This cannot be verified, but it would seem that the Seleucid governor of Parthia, Andragoras, revolted about 250 B.C. and struck his own coins. He was defeated by Arsaces sometime later (Justin, *Epitoma Historiarum Philippicarum,* xli, 4, 7) and thus the kingdom of the Parthians was launched. The Arsacid dynasty traced their genealogy back to the Achaemenid Artaxerxes II (Arrian, *Parthica,* 1; George Syncellus, *Chronographia,* Bonn Corpus, p. 539).

Arsaces I was succeeded by his brother Tiridates (*c.* 248–*c.* 211 B.C.). The succession to the throne of a brother, followed by the brother's son, seems to have been not abnormal among the early Parthians, perhaps a tradition of their nomadic background. The expansion of the Parthian realm was slow and there were several setbacks. One occurred when Seleucus II marched against the Parthians *c.* 228 B.C. Tiridates retreated before him and Seleucus returned to Antioch because of troubles in Syria. Tiridates was followed by Artabanus I (also known as Arsaces, which became a generic name used by most Parthian kings). In his reign Antiochus III invaded Iran *c.* 209 B.C. Antiochus fought a number of battles with the Parthians, after which the latter probably recognized Seleucid suzerainty. It is not known how long this dependence lasted, but possibly until the defeat of Antiochus by the Romans at Magnesia (190/189 B.C.). (For the later history of the Parthians and table of Parthian kings *see* PERSIAN HISTORY: *Parthian Empire.*)

The earliest capital of the Parthians was probably at Dara, founded by Arsaces (Justin, *Epitoma,* xli, 5), the site of which, near Abivard, has been identified by Soviet archaeologists. The town of Nisa, or Parthaunisa as Isidore of Charax calls it, was the necropolis of the early Parthian kings. It is possible that Nisa was the home town of Arsaces I. The sites of old and new Nisa have been excavated by archaeologists since World War II, and many ostraca with Parthian inscriptions, ivory rhytons and statues have been found. A later capital was Hecatompylos, probably near modern Damghan.

With the expansion of the Parthians the original homeland of Parthyene, as it is called by Isidore of Charax, recedes into the background as the term "Parthia" comes to mean the Parthian Empire for the Romans. With the rise of the Sasanians the name "Parthia" for the province disappears.

See also references under "Parthia" in the Index.

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PARTICLES, ELEMENTARY. Elementary particles are the fundamental constituents of matter and energy. As might be expected from this definition, the notion of an elementary particle has changed considerably with the growth of knowledge. Before the discoveries of the late 19th and early 20th centuries, atoms could be and sometimes were regarded as elementary particles, but the discovery of the electron and the structure of atoms led to a complete transformation of this view. In the half century following Ernest Rutherford's discovery (1911) of the existence of atomic nuclei, ideas about elementary particles changed even more radically. Good evidence was found for the existence of more than 90 distinct elementary particles, and the quantum theory suggested new ways of describing them quantitatively. The significance of current ideas (in the 1960s) is best appreciated in the light of the historical development which this article reviews. *See* the articles ATOM; ELECTRON; NUCLEUS; QUANTUM MECHANICS; and SPECTROSCOPY for detailed accounts of the structure of atoms and nuclei, matters which will only be mentioned here.

Negative Electrons, Photons and Protons.—By the early 1920s the following account of the structure of matter was current: matter is made of atoms. An atom consists of a positively charged nucleus with a cloud of negative electrons around it. The electron cloud is capable of existing in various states, and transitions between these states are accompanied by the emission or absorption of photons (γ), the elementary quanta of electromagnetic

radiation. The nucleus consists of protons (p) and neutrons (n) held together by powerful forces. This physical picture was not supported by a systematic quantitative theory, but the behaviour of the electron clouds could be semiquantitatively described by a combination of the classical theory of electricity and magnetism with the quantization rules of Albert Einstein and Niels Bohr.

A far-reaching improvement in the theoretical situation resulted from discovery of the true quantum mechanics in 1926. Once the quantum mechanics of the electromagnetic field had been worked out (Paul Dirac, 1927) a quantitative theory of photon emission and absorption could be given, and it agreed very well with experiment. The first application of quantum mechanics to the atomic nucleus, the theory of α radioactivity (G. Gamow, R. Gurney and E. Condon, 1928), was also quite successful (*see* RADIOACTIVITY). These gratifying results were not inconsistent with the idea that electrons and protons could not be created or destroyed but could be bound together by electrical forces, as in atoms, or by some other forces, as in the nucleus. However, there were at least three indications that such a picture is incomplete, and each of these led to a decisive advance in understanding.

First of all, there was the problem of N^{14}, the nitrogen isotope of mass number 14. According to the ideas of nuclear structure already described, this nucleus should contain 14 protons and 7 electrons, an odd number of particles. R. Kronig (1928) predicted from this a set of states for the nitrogen molecule which turned out to be in disagreement with experiment; an even number of particles in the nucleus seemed to be required. Second, there was a puzzling phenomenon in β radioactivity. Experiments showed that when an α particle is emitted from a radioactive nucleus, it has an energy which is the difference between the energies of the final and initial states of the nucleus. On the other hand, when β particles are emitted, they may have any energy less than the energy difference between the initial and final states of the nucleus. Apparently, energy is not conserved. The third indication was a theoretical paradox. The first quantum-mechanical theory of the electron was nonrelativistic and did not take into account effects of the finite propagation velocity of light. In 1928 Dirac introduced a relativistic theory of the electron which was successful in accounting for the spin of the electron and for the fine structure of the energy levels of hydrogen. Unfortunately, this theory also predicted the existence of states whose properties did not make sense, the so-called negative energy states. All attempts to amputate these negative energy states from the theory proved unsatisfactory.

Neutrons, Neutrinos and Positrons.—The difficulty concerning N^{14} vanished with J. Chadwick's discovery (1932) of the neutron (n). A new picture of nuclear structure developed in which a nucleus of mass number A is conceived of as a system of A nucleons, nucleon being a generic term used to describe neutrons and protons. In particular, N^{14} contains seven neutrons and seven protons, in agreement with the analysis of the light emitted by N^{14} molecules. (*See* MOLECULAR SPECTRA; NEUTRON.)

To explain the apparent disappearance of energy in the β decay of nuclei, W. Pauli proposed (1931) the hypothesis that a neutral particle of small mass (usually taken to be zero) is emitted which carries off the missing energy. This particle, later named the neutrino (ν), is quite difficult to detect because its interaction with matter is so weak. For a long time the main evidence for the existence of the neutrino was indirect. (Enrico Fermi's successful theory of β radioactivity [1934] is a quantitative formulation of the neutrino hypothesis. In it, a neutron can transform into a proton while emitting an electron and a neutrino.) Experiments showed that the missing energy E was accompanied by a missing momentum p. To within experimental error these quantities satisfied the equation $E = cp$, where c is the velocity of light. This is the relation expected according to the theory of relativity for a particle of rest mass zero. The first experiment in which a neutrino beam produced an observable effect was reported by F. Reines and C. Cowan in 1956.

The third difficulty, that of the superfluous negative energy states in the Dirac theory, had a more involved history. In 1930 Dirac made a bold proposal to put the negative energy states to good use to explain the existence of the proton. He noted that the Pauli exclusion principle (*see* QUANTUM MECHANICS: *Electron Spin*) forbids two electrons from occupying the same state. He then made the hypothesis that *in vacuo* all the negative energy states predicted by his theory are occupied by electrons but that the resulting charge distribution is unobservable. Thus a positive-energy electron (e^-) moving in the vacuum cannot jump into a negative-energy state with the emission of a photon because there is no negative-energy state which is not occupied. Furthermore, the removal of an electron from a negative-energy state would result in an observable "hole." Dirac showed that a hole would behave like a normal positive-energy particle of opposite charge (e^+). However, his initial proposal to interpret the proton as this hole turned out to be unsatisfactory for two reasons. First, it was found that a hole in the sea of negative-energy electrons would have to have the same mass as an ordinary electron, in disagreement with the observation that protons are 1,836 times heavier than electrons. Second, the hydrogen atom formed of an electron and a hole would annihilate itself in a small fraction of a second, leaving nothing but photons. In 1931 Dirac concluded that if holes existed, they would describe a new positive particle.

About a year later the positive electron was discovered by C. D. Anderson and was named the positron. (A later proposal of using the word "electron" as a generic term for positive and negative electrons and "negaton" and "positon" for the individual particles has not gained wide acceptance among physicists; therefore, the standard ambiguous usage in which electron is sometimes the generic term and sometimes means the negative electron is followed in this article.) Dirac's prediction was certainly one of the most spectacular achievements of theoretical physics, being comparable with Hideki Yukawa's prediction of the existence of the meson, which is described later.

Quantum Field Theory.—It was later shown that Dirac's hole theory is essentially equivalent to a theory in which electrons and positrons appear symmetrically with positive energies only, so that there is no unobservable sea of negative-energy electron states. The natural language for such a description was that of the quantum theory of fields. Indeed, the same remark applies to Fermi's theory of β disintegration, which described the interaction of nucleons, electrons and neutrinos also in terms of fields.

The notion of particle has such a different status in the relativistic quantum theory of fields and in the nonrelativistic theory of particles that it deserves an explicit discussion, even though it must be somewhat oversimplified. The main idea of field theory is that all particles of the theory appear as the quanta of some field. For example, photons are the particles associated with the electromagnetic field, while electrons and positrons are the quanta of a Dirac field. This appears to be a perfectly innocent requirement devoid of physical consequences, and indeed it is, until the additional requirement that the theory be relativistically invariant according to the special theory of relativity is introduced. Then the remarkable result is found that if the particles are to interact at all it must also be possible for them to be created and annihilated. Thus, if electrons and photons are to be described by a relativistic field theory and interact at all, electron-pair creation and annihilation must be possible. The fact that particle creation and annihilation necessarily takes place in such a theory makes the definition of an elementary particle essentially more difficult. Even if in a given physical situation no actual particle creation is possible without violation of the laws of conservation of energy and momentum, nevertheless the interaction responsible for pair creation and annihilation has indirect effects, the so-called "virtual" creation and annihilation processes. For example, in such a theory a single electron moving through the vacuum polarizes it, and thus the electron may be thought of as surrounded by a cloud of virtual photons and pairs. Under such circumstances there are at least two possible ways (and actually many more) to define an electron: with its cloud (the dressed electron) or without (the bare electron). The situation is even more complicated in Fermi's theory of β decay, where a proton has to be considered as sometimes existing as a neutron plus a positron plus a neutrino.

Antineutrinos of Nuclear β Decay.—Another feature of Fermi's theory also deserves mention, viz., the antineutrino ($\bar{\nu}$). Fermi developed his theory in strict analogy with electrodynamics so that he had neutrinos as particles, and antineutrinos as antiparticles, just as in electrodynamics there are electrons as particles, and positrons as antiparticles. E. Majorana in 1937 showed that this was not necessary and that a theory of β decay could be made in which the neutrino was identical with its own antiparticle, as is the photon in electrodynamics. Although at first sight it might seem difficult to distinguish between these two theories, a distinction is (in principle) possible as follows: In the theory involving antineutrinos the existence of the decay $n \rightarrow p + e^- + \nu$ implies that $\bar{\nu} + n \rightarrow p + e^-$ is possible, but not necessarily that $\nu + n \rightarrow p + e^-$ is possible, while in the Majorana theory the first decay implies the second *and* third since ν is the same as $\bar{\nu}$ in the Majorana theory.

Experimental and theoretical developments in the late 1950s led to great progress in understanding the neutrino and the antineutrino. (There were certain changes in notation as well. It had become standard practice to call the particle emitted in neutron decay an antineutrino: $n \rightarrow p + e^- + \bar{\nu}$. This is a matter of convention.) R. Davis showed that the antineutrinos produced in nuclear reactors do not cause radioactivity in Cl^{37}. This was interpreted to mean that there is indeed a neutrino as well as an antineutrino. Furthermore, it turned out that antineutrinos always have their spins directed along their direction of motion, whereas the neutrino's spin is always opposite to its direction of motion (M. Goldhaber and co-workers and others). To describe this latter fact, a new theory, the so-called two-component theory, was devised (T.-D. Lee and C. N. Yang, A. Salam and L. Landau). (*See* also NUCLEAR MOMENTS.)

Breakdown of Electrodynamics; Mesons.—In the preceding account of the properties of the quantum theory of fields, an important fact was ignored which had a strong influence on later developments, viz., the divergences. This refers to the infinite or ambiguous answers to some simple physical questions which can be obtained from the equations of the theory. In quantum electrodynamics, these difficulties were almost universally attributed to the physical assumption underlying the theory, viz., that the electrons are point particles. It was well known that in the classical theory of electrons difficulties of a similar type occur and are overcome by attributing a spatial extension to the electron. In the classical theory, this spatial extension leads to modifications not only of the divergent quantities of the theory but also of the quantities for which the point-electron theory predicts finite answers. Similar effects were expected in the quantum theory. Thus, for example, a breakdown in the theory was expected in the description of the process in which an electron loses energy by the emission of photons in a collision with a nucleus. When, in the period between 1933 and 1936, preliminary evidence appeared of particles in cosmic rays, with anomalously high penetrating power, it was tempting to explain them as electrons whose energy was sufficiently high that the predictions of quantum electrodynamics break down. This explanation was short-lived because more detailed experiments showed that there were two groups of particles, one of which lost energy by radiation (as they should, according to the predictions of the quantum electrodynamics worked out by H. Bethe and W. Heitler in 1934), while particles in the other group were far more penetrating. By 1937, the conclusion was inescapable. S. Neddermeyer, Anderson, J. Street and E. Stevenson announced the discovery of a new particle, first called a mesotron but later known as the meson, of mass several hundred times that of the electron. The laws of electrodynamics had not broken down in the anticipated way at all but rather in a different way: they did not predict the existence and production of mesons.

Unanticipated in electrodynamics, the discovery of the meson appeared to be a remarkable verification of ideas which Yukawa had put forward nearly three years before in an attempt to understand the origin of nuclear forces. (The term "nuclear forces" refers to those forces other than electrical forces which act between two nucleons [*see* NUCLEUS: *Nuclear Structure and Nuclear Forces*].) Yukawa's ideas were based on an instructive analogy with the theory of electrical forces which will now be explained. Coulomb's law of electrostatics states that the force which two charges e_1 and e_2 exert on one another when they are separated by a distance r_{12} is given by e_1e_2/r_{12}^2. There is an equally accurate, if somewhat less familiar, description of this force which attributes it to the exchange of photons between the two charges. The factor e_1e_2 in Coulomb's law then comes about because the ability of the first charge to emit and absorb photons is proportional to e_1 and that of the second charge is proportional to e_2. The value $1/r_{12}^2$ proves to be a simple geometrical factor. Yukawa pointed out that if two particles, instead of emitting and absorbing massless photons, emitted and absorbed mesons of mass $m \neq 0$, then the only essential change in the results is the replacement of e_1, e_2 by g_1, g_2, two numbers which are measures of the ability of the particles to emit and absorb mesons, and the appearance of a factor $\exp -r_{12}/(h/mc)$ in the force law, where $h = 1.06 \times 10^{-27}$ erg sec. is Planck's constant divided by 2π, and $c = 3.0 \times 10^{10}$ cm./sec. is the velocity of light. This latter factor is important because it makes the force fall off much faster with increasing r_{12}. Stated briefly, the forces which would arise from the exchange of mesons of mass m have a range which is approximately h/mc, a length which is called the Compton wave length of the meson. For m of the order of magnitude of a few hundred electron masses, h/mc is of the order of magnitude of 10^{-13} cm., which is that observed for nuclear forces. Although it was difficult to build Yukawa's ideas into a quantitative theory of nuclear forces, the ideas were accepted almost universally as giving a qualitative account of these forces.

Yukawa also remarked that nuclear β radioactivity could be accounted for if the meson were unstable against decay into an electron and a neutrino. The β decay of the neutron is then a two-step process. The neutron first emits a negative meson and becomes a proton. Then, the negative meson decays into an electron and a neutrino. It was therefore a second success of the theory when in the late 1930s it was shown that mesons reaching sea level were less intense when they arrived at large angles with the vertical, even if the stopping effect of the atmosphere was taken into account. The phenomenon was interpreted as being a result of meson decay in flight from the region 50,000–100,000 ft. above sea level, where the mesons were presumably produced. The value of the half life of a meson derived from this experiment was a few millionths of a second.

The mesons introduced by Yukawa were positively or negatively charged and of spin zero. (According to quantum mechanics, an elementary particle can have an intrinsic angular momentum or spin which is in magnitude some integer or half-odd integer measured in units of h. Reference has been made to the spin of the electron, which is $\frac{1}{2}$. Neutrons and protons also have spin $\frac{1}{2}$, while photons have spin 1.) A theory which described the interaction of spin-zero particles with the electromagnetic field had already been published by Pauli and V. F. Weisskopf in 1934. The years between 1935 and World War II saw a turbulent development of meson theory for charged and neutral mesons of spin 1 and spin 0. Probably one of the most significant developments of the period was the development by N. Kemmer of the charge symmetrical theory. In this theory, the interaction of nucleons with charged mesons is so related to their interaction with neutral mesons that the resulting nuclear forces are the same between proton and proton, proton and neutron, and neutron and neutron. Such nuclear forces are referred to as charge independent, and subsequent developments confirmed the idea that charge independence is a basic symmetry property in nature.

The basic divergence difficulties referred to previously in connection with electrodynamics turned out to be even more acute in meson theory because the dimensionless number g^2/hc, which measures the strength of the meson-nucleon interaction, is much larger than the corresponding one in electrodynamics, e^2/hc, which is approximately $\frac{1}{137}$. (The constant g is called the coupling constant; it has the dimensions of electric charge and plays an important role in meson physics.) The simple approximation methods based on the smallness of e^2/hc could scarcely be expected

to work in meson dynamics. Practically none of the quantitative calculations in meson theory undertaken during this period are of more than historical interest, since they were carried out in strict analogy to calculations in electrodynamics. On the other hand, the success of the electrodynamical calculations of the period deepened confidence in the essential validity of the theory. For example, J. Carlson and J. R. Oppenheimer and H. Bhabha and W. Heitler (1934) independently demonstrated how the cascade phenomenon of photons and electrons in cosmic rays could be interpreted as a chain of events in which high-energy photons make pairs and the electrons of the pairs make photons in colliding with nuclei.

The developments of this period illustrate a point which has not been emphasized in this summary account—the immensely fruitful connection between the theory of elementary particles and the study of cosmic-ray phenomena. In the mid-1950s there were only eight elementary particles known which had not been identified first in cosmic radiation (*see* COSMIC RAYS: *Particles Discovered in Secondary Rays*). However, it also became clear about that time that the giant particle accelerator would eventually replace the cosmic-ray beam except for studies of very high-energy events. Of course, the cosmic rays retain their astrophysical and cosmological interest.

Postwar Developments; π and μ Mesons.—At the end of World War II physicists returned with renewed vigour to the problems which had been left unsolved before the war. One of the first significant developments (an apparently stunning blow to the Yukawa theory of mesons) was the experiment of M. Conversi, E. Pancini and O. Piccioni on meson absorption (1947). According to Yukawa's theory, negative mesons stopped in ordinary solid materials would be absorbed very rapidly by nuclei long before they could decay. The Conversi–Pancini–Piccioni experiment showed that for a nucleus with about ten protons, decay and absorption were equally probable, a result disagreeing with the absorption rate calculated from Yukawa's theory by a factor of 10^{12}. Numerous suggestions of varying plausibility were made to save the theory. The one which proved to be correct was the two-meson hypothesis of R. E. Marshak (1947): the mesons observed at sea level were not Yukawa mesons but were weakly interacting decay products of the true Yukawa particle, which is produced copiously in nucleon-nucleon collisions high in the atmosphere. Shortly thereafter C. Lattes and co-workers turned a plausible explanation into an important discovery by publishing pictures of positive particles (π^+ mesons) which decayed into one positive particle (μ^+ meson) and one neutral particle (ν) according to the scheme $\pi^+ \rightarrow \mu + \nu$. Later cloud-chamber experiments by a number of workers (*see* CLOUD CHAMBERS) showed that the μ^+ decays into an e^+ and two light neutral particles: $\mu^+ \rightarrow e^+ + \nu + \bar{\nu}$.

The discovery of the π^+ meson was made using a specially prepared photographic emulsion sensitive to the passage of charged particles. These so-called nuclear emulsions proved to be one of the most powerful tools of that period in the search for elementary particles. Their use became a highly refined art (*see* COSMIC RAYS: *Methods of Detection*). Two important later innovations were electron-sensitive emulsions and stripped emulsions. Electron-sensitive emulsions are so sensitive that they record the tracks of all charged particles, even those of minimum ionization. The phrase "stripped emulsions" refers to a technique for exposing emulsion in a more or less solid block and then putting it in layers on glass backing for processing and study. The discovery of the π^+ and the μ^+ mesons was followed shortly by systematic studies of their negative counterparts, π^- and μ^-, by means of the nuclear disruptions or "stars" which they cause when absorbed in photographic emulsions.

In the decays of π and μ mesons (often called pions and muons), neutrinos have been indicated as the neutral reaction products. All that actually was proved experimentally was that they are of small (but not necessarily zero) mass, zero charge and half-odd integer spin. Only in the 1960s was it shown that two different kinds of neutrino exist. The next few paragraphs follow the history of the period in which the two kinds were not distinguished.

The decay of the μ meson into three particles naturally suggests a comparison with the neutron decay. A number of physicists explored the possibility that a theory analogous to Fermi's theory of β decay could describe μ-meson decay quantitatively. They obtained the remarkable result that the basic rate constant (Fermi constant) is of the same order of magnitude as in nuclear β decay. The discussion of the reaction $\mu^- + p \rightarrow n + \nu$, which accounts for the absorption of μ^- mesons by nuclei, led to a similar conclusion. The equality of these three Fermi constants led to speculations about the possibility of a universal Fermi interaction between spin-$\frac{1}{2}$ particles. Ten years later (1956–58), after a series of spectacular experiments on μ-meson decay and β decay, it became possible to single out a specific type of universal Fermi interaction which has continued to pass every experimental test (R. Marshak and E. C. G. Sudarshan, R. Feynman and M. Gell-Mann).

The successful operation of the synchro-cyclotron at Berkeley, Calif., in 1948 and of a number of other particle accelerators at other places in subsequent years made possible a variety of experiments with momentum-analyzed high-intensity beams of π mesons, of which only a few will be mentioned.

An analysis of the γ radiation from a cyclotron target led K. Björklund and collaborators in 1950 to the discovery of the π^0 meson. The γ radiation was interpreted as resulting from the decay $\pi^0 \rightarrow \gamma + \gamma$. The existence of such a process had been strongly indicated previously by cloud-chamber studies of cosmic rays.

Experiments on the absorption of π^- mesons in hydrogen led to a great deal of information about π^- and π^0 mesons. W. Panofsky and collaborators (1951) observed the reactions:

$$\pi^- + p \rightarrow n + \gamma$$
$$\pi^- + p \rightarrow n + \pi^0$$
$$\pi^- + d \rightarrow 2n$$
$$\pi^- + d \rightarrow 2n + \gamma$$

The second reaction gave a value of 10 electron masses for the π^-, π^0 mass difference. The third reaction showed that if the π^- meson has spin zero it is pseudoscalar. (In explanation of this last term: there are two kinds of spin-zero mesons, which differ in their transformation properties under inversion of all space co-ordinates. For one kind, the scalar, the third reaction is impossible for π^- mesons in the lowest orbit around a deuteron [d]. For the other kind, the pseudoscalar, the third reaction is possible.)

The spin of the π^+ meson was measured as zero by observing the rates of the inverse reactions $\pi^+ d \rightleftarrows p + p$ in experiments by D. Clark and co-workers and by R. Durbin and collaborators (1951).

Systematic measurements on the scattering of π mesons by nucleons were initiated by Fermi and associates, whose study of the angular distributions and total cross sections of the reactions

$$\pi^+ + p \rightarrow \pi^+ + p \text{ (scattering)}$$
$$\pi^- + p \rightarrow \pi^- + p \text{ (scattering)}$$
$$\pi^- + p \rightarrow \pi^0 + n \text{ (charge-exchange scattering)}$$

showed that there was a remarkable resonance in the positive-meson scattering and a lesser one in the negative-meson scattering.

The availability of data of this kind together with similar information on the reactions $\gamma + p \rightarrow n + \pi^+$ and $\gamma + p \rightarrow p + \pi^0$ furnished by workers at the California and Massachusetts institutes of technology, the University of Illinois and Cornell university led to a new era in meson theory. Heroic efforts were made to extract well-defined and physically sensible answers either from the relativistic theory or from models which embodied some essential features of the relativistic theory. The result was progress but not spectacular success. Part of the trouble could certainly be blamed on lack of progress in understanding the structure of the quantum field theory as later described. Possibly the most important result of the analysis was the support which it gave for the charge-symmetrical theory already mentioned in connection with the charge independence of nuclear forces.

K Mesons, Hyperons and Antiprotons.—Even before the

ANTILEPTONS

Symbol	μ^+
Spin	1/2
Mass	106
Charge	+1
Decay	$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$
Mean life	2.2×10^{-6} sec.

Symbol	e^+
Spin	1/2
Mass	0.51
Charge	+1

Symbol	$\bar{\nu}_\mu$
Spin	1/2
Helicity	+1
Mass	0
Charge	0

LEPTONS

Symbol	μ^-
Spin	1/2
Mass	106
Charge	−1
Decay	$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$
Mean life	2.2×10^{-6} sec.

Symbol	e^-
Spin	1/2
Mass	0.51
Charge	−1

Symbol	ν_μ
Spin	1/2
Helicity	−1
Mass	0
Charge	0

PHOTON

Symbol	$\bar{\nu}_e$
Spin	1/2
Helicity	+1
Mass	0
Charge	0

Symbol	γ
Spin	1
Helicity	±1
Mass	0

Symbol	ν_e
Spin	1/2
Helicity	−1
Mass	0
Charge	0

CHART 1.—THE LIGHT PARTICLES

Masses are given in units $Mev/c^2 = 1.8 \times 10^{-27}$ g. Charges are in units of the electron charge: $e = 4.80 \times 10^{-10}$ electrostatic units. Spins are in units of Planck's constant divided by 2π: $h = 1.06 \times 10^{-27}$ erg sec. Masses and mean lives have been rounded off

discovery of the π meson, isolated cloud-chamber photographs had been made which were best interpreted as showing particles distinct from those discussed so far. Two extremely clear events of this kind were found by G. Rochester and C. Butler in 1947. The pictured events were interpreted as the decays of two new particles, one neutral and one charged, which came to be known as V particles because of the characteristic appearance of their decays in a cloud chamber. Over a period of years further detailed studies, using both cloud chambers and photographic emulsions as particle detectors, showed that a number of different decay modes were involved. In some cases these modes were naturally ascribed to a single particle, in others they were not.

The new particles were divisible into two classes: the K mesons, whose mass is between that of the π meson and the proton; and the hyperons, whose mass is larger than that of the proton. In the first category are particles that undergo these decays:

$$K^0 \text{ (or } \bar{K}^0) \rightarrow \pi^+ + \pi^-$$
$$\rightarrow \pi^0 + \pi^0$$
$$\rightarrow \pi^+ + \pi^- + \pi^0$$
$$\rightarrow \pi^0 + \pi^0 + \pi^0$$
$$\rightarrow e^\pm + \nu + \pi^\mp$$
$$\rightarrow \mu^\pm + \nu + \pi^\mp$$

$$K^\pm \rightarrow \pi^\pm + \pi^0 + \pi^0$$
$$\rightarrow \pi^\pm + \pi^+ + \pi^-$$
$$\rightarrow \pi^\pm + \pi^0$$
$$\rightarrow \mu^\pm + \nu$$
$$\rightarrow \mu^\pm + \pi^0 + \nu$$
$$\rightarrow e^\pm + \pi^0 + \nu$$

In the second category are the Λ^0, the $\Sigma^\pm$ and Σ^0, and the Ξ^- (the so-called "cascade" particle) and Ξ^0 hyperons, which decay as follows:

$$\Lambda^0 \rightarrow p + \pi^-$$
$$\Lambda^0 \rightarrow n + \pi^0$$
$$\Sigma^+ \rightarrow p + \pi^0$$
$$\Sigma^+ \rightarrow n + \pi^+$$

$$\Sigma^- \rightarrow n + \pi^-$$
$$\Sigma^0 \rightarrow \Lambda^0 + \gamma$$
$$\Xi^- \rightarrow \Lambda^0 + \pi^-$$
$$\Xi^0 \rightarrow \Lambda^0 + \pi^0$$

An interesting and informative phenomenon connected with hyperons was discovered by M. Danysz and J. Pniewski (1953)—the hyperfragments. These objects are nuclei formed of nucleons together with a Λ^0 hyperon. The study of hyperfragments gives information not only on the spin of the Λ^0 hyperon and its interaction with nucleons but also on the structure of nuclei.

The mean lives of the K mesons and hyperons described above range from about 10^{-8} sec. to 10^{-11} sec. Although these are very short times by the standards of everyday life they are exceedingly long by nuclear standards; for example, the compound system $\pi^+ + p$ which gives the resonance in the scattering of π^+ mesons by protons lasts about 10^{-23} sec. This relative stability of the K mesons and of the hyperons is one of the basic facts which any theory of elementary particles has to explain.

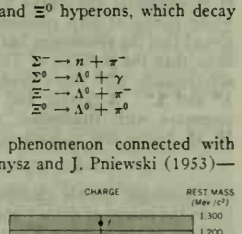

CHART 2.—MESONS, THE STRONGLY INTERACTING PARTICLES OF MASS NUMBER A = 0

The question of how many different K particles there are remained unanswered for a number of years. An analysis by R. Dalitz of the energy distribution of the π mesons appearing in the reaction $K^\pm \rightarrow \pi^\pm + \pi^+ + \pi^-$ indicated that a spin-zero pseudoscalar K gave the best fit. Experiments on neutral K decay showed that the reaction $K^\pm \rightarrow \pi^\pm + \pi^0$ occurs, which indicates that $K^\pm$ is not pseudoscalar. Nevertheless, the masses of the particles undergoing the decays seemed very close to the same. (This was referred to as the τ-θ puzzle, the three-pion mode of decay being denoted by τ and the two-pion mode being denoted by θ.) The solution to the difficulty was suggested by Lee and Yang (1956). It had been assumed in the analysis of the decays that all the usual conservation laws of physics hold. Lee and Yang proposed that parity, the quantum number arising from the symmetry of the laws of nature under reflections, is not conserved in the reactions. They further suggested that similar failures in the law of parity conservation might take place in other weak interactions, such as nuclear β decay. Their proposal for a test of this idea in nuclear β decay was triumphantly verified by C. S. Wu and co-workers (1957). Other experiments (R. Garwin and co-workers, and J. Friedman and V. Telegdi) showed that parity is not conserved in μ-meson decay, and that the failure of the law of parity conservation is an essential feature of the weak interactions (*see* Table II). (*See* PARITY, LAW OF CONSERVATION OF.)

The study of K mesons and hyperons was greatly aided by two research tools: accelerators capable of producing protons of energies in the range of billions of electron volts; and the bubble chamber (*see* ACCELERATORS, PARTICLE; BUBBLE CHAMBER).

Accelerators made available intense beams of the particles to be studied. In addition, the 6-Bev bevatron at the University of California at Berkeley made possible the discovery of the antiproton (*see* PROTON). In 1955 Emilio Segrè, Owen Chamberlain and co-workers published convincing evidence of the existence of that long-awaited elementary particle. The existence of the antiproton requires the existence of the antineutron and a whole tribe of antihyperons. It opened an entire new field for experiment.

The bubble chamber was invented by D. Glaser in 1952. It is a liquid-filled vessel which can be expanded periodically to the point where the liquid starts to boil. If a charged particle happens to pass through the liquid just as the boiling is about to begin, the bubbles form along the track of the particle. An advantage of the bubble chamber compared to the cloud chamber is that it contains much more matter for the same volume, therefore giving a much larger number of nuclear events per photograph.

Renormalization; Dispersion Theory.—As has been mentioned in connection with the discovery of mesons, divergences can appear in the answers given by electrodynamics to very simple physical questions. In the late 1940s great progress in overcoming these difficulties was made by S. Tomonaga, J. Schwinger, R. Feynman, F. Dyson and others. Their contribution was twofold. First, they reworked the formalism of electrodynamics, using methods which made calculation and insight much easier. Second, they showed that the divergences appearing in physical quantities were all direct or indirect consequences of two fundamental divergences, those in the corrections to the mass and charge of the electron arising from its interaction with photons. If the corrected mass and charge were set equal to the observed mass and charge of the electron (a process called mass and charge renormalization), all answers to physical questions become finite.

Actually, much of this advance in theory was stimulated by two fundamental experimental discoveries: the anomalous gyromagnetic ratio of the electron and the Lamb shift. In experiments carried out in 1947, P. Kusch and H. Foley showed that the value of the electron's spin magnetic moment was not $eh/2mc$ (e is the charge on the electron, m is its mass, c is the velocity of light and h is Planck's constant divided by 2π) as was predicted by Dirac's 1928 theory of the electron but $eh/2mc\ (1 + \epsilon)$, where ϵ is a very small but nonzero quantity. (The quantity $2[1 + \epsilon]$ is

called the gyromagnetic ratio.) Later measurements (D. T. Wilkinson and H. R. Crane, 1963) gave $\epsilon = 0.001159622 \pm 0.000000027$. At about the same time, W. E. Lamb, Jr., measured the position of the energy levels of hydrogen and found a shift from those predicted by Dirac's 1928 theory. It had been known from the 1930s that the hole theory predicted corrections to Dirac's original values for both these quantities, but, unfortunately, divergent ones. The existence of these experiments was an enormous incentive to make some sense out of the predictions of the theory. After this had been done in a more or less *ad hoc* way for these particular experiments, it was extended to the general theory described above. The detailed comparison with experiment gave excellent agreement. For example

$$\epsilon = \frac{\alpha}{2\pi} - \frac{0.328\alpha^2}{\pi^2} = 0.001159615 \text{ where } \alpha = e^2/hc$$

(Schwinger, 1947; R. Karplus and N. Kroll, 1950; C. Sommerfield and A. Petermann, 1957).

The renormalization process was successfully extended from electrodynamics to meson theory by J. Ward, A. Salam and others (1951). They showed that renormalization of nucleon mass, meson mass, coupling constant (g) between nucleons and mesons, and a meson scattering constant would be sufficient to yield finite answers for all physical quantities. Unfortunately, it turned out that these results were of little practical value because the entire method was based on expansions of the quantities involved as a sum of terms proportional to the powers of g^2/hc; for the large value of g^2/hc necessary to describe π mesons it is doubtful whether the sum has a finite value. The situation is different in electrodynamics, where e^2/hc is small, and the first few terms are a good approximation.

The remarks of the preceding paragraph are indications of a general difficulty. The success of renormalization represented great progress in quantum field theory but it did not go far enough. It did not permit elimination of the manipulation of infinite quantities completely from physical calculations. In fact, it left open the question as to whether a quantum field theory could be formulated without any divergences at all. Frontal attacks on this problem made little progress in the 1950s. Instead most of the effort of theoretical physicists went into a development called dispersion theory, described below.

The quantitative description of the collision of elementary particles is in terms of scattering and production amplitudes. These are complex-valued functions of the parameters describing the collisions (energy of particles, angle through which they are scattered, and so on). The square of the absolute value of the function gives the probability of the collision. Dispersion theory makes two kinds of assertions about such amplitudes. First, it makes the qualitative assertion that they are analytic functions (*see* FUNCTION). This is a strong restriction on the kind of behaviour the function can have. Second, it makes quantitative assertions; *e.g.*, that the real part of the function is equal to a certain integral transform of the imaginary part. Such an equation is usually called a dispersion relation because the first examples in physics occurred in the optics of dispersive media. In that case the function in question is the complex refractive index of the medium as a function of frequency of light and the dispersion relation connects the real part of the refractive index with the imaginary part which is essentially the absorption coefficient of the medium. It was first shown by H. A. Kramers in 1927 that this relation is a consequence of the principle that signals cannot be propagated faster than the speed of light. R. Kronig (1946) suggested that similar relations ought to hold for the amplitudes describing collisions of particles. There were a number of attempts to carry out Kronig's suggestion, but it was M. L. Goldberger, Gell-Mann and W. Thirring (1954) who first succeeded in relating dispersion relations directly to quantum field theory. Within a few years dispersion relations had been found for a large number of collision processes. Although in its modern form it was sired by quantum field theory, dispersion theory soon developed a technique and an outlook independent of its starting point. From the middle 1950s on, most efforts at quantitative description of elementary-particle reactions were worked out in the language of dispersion theory.

Most dispersion relations contain quantities (the analytic continuations of amplitudes) that are not directly observable. However, there are dispersion relations that contain only observable quantities. These provide valuable support for the ideas of dispersion theory since they are in good agreement with experiment.

Strangeness Quantum Numbers; Resonances; Symmetry Groups for the Strongly Interacting Particles.—While dispersion theory aimed at a full quantitative description of elementary particle collisions, there were other more phenomenological approaches to elementary-particle theory. A striking success along this line was the introduction of a new quantum number, the strangeness, to explain the relative stability of hyperons and K mesons and related regularities. Gell-Mann, K. Nishijima and A. Pais were associated with these developments. The strangeness number is an integer (positive, negative, or zero) associated with certain elementary particles according to Table I. The scheme

TABLE I. *Strangeness Quantum Numbers of the Long-Lived Strongly Interacting Particles**

−3	−2	−1	0	+1
Ω^-	Ξ^-, Ξ^0	Σ^+, Σ^0 Λ^0 K^-, $\bar{K}^0$	n, p π^+, π^0	K^+, K^0

*The antibaryons $\bar{p}$, $\bar{n}$, $\bar{\Lambda}^0$, $\bar{\Sigma}^0$, $\bar{\Sigma}^+$, $\bar{\Xi}^0$, $\bar{\Xi}^+$, $\bar{\Omega}^+$ should also be long-lived.

assumes that neutral K mesons are associated in pairs, with the $\bar{K}^0$ meson of strangeness -1 being the antiparticle of K^0 which is of strangeness $+1$.

The assumption that strangeness is conserved implies that in a collision of two nucleons or a nucleon and a π meson the strangeness of the K^+ and K^0 particles produced must balance with that of the particles of negative strangeness. For example, $\pi^- + p \rightarrow \Lambda^0 + K^0$ is possible but $p + p \rightarrow \Sigma^+ + p$ is forbidden. Thus only associated production of hyperons and K mesons is possible.

The strangeness conservation law is not exact because K mesons and hyperons decay into particles of zero strangeness, but at a rate characteristic of weak rather than strong interactions; *i.e.*, mean lives of the order of magnitude 10^{-10} sec. are typical rather than the 10^{-23} sec. which might be expected from a strong decay.

By the late 1950s it seemed that the experimental situation had settled down and that the strongly interacting particles were precisely those listed in Table I (with the exception of the Ω^-). There were also several resonances such as the one in the $\pi^+ p$ system already mentioned above in connection with the work of Fermi and co-workers, but such resonances were not generally regarded as elementary particles. At this point there began a series of experimental discoveries which made it clear that there is a whole family of such resonances. The viewpoint became widespread that the resonances had no less claim to be elementary particles than the particles of Table I even though their mean lives are typically 10^{13} times shorter than those of such particles as Λ^0 and Σ^+. A typical, and the first, experiment leading to a resonance with strangeness different from zero was that of M. H. Alston and co-workers (1961) who studied the reaction

$$K^- + p \rightarrow \Lambda^0 + \pi^+ + \pi^-$$

in a hydrogen bubble chamber. They found a correlation between the energy of the π^+ and π^- that could only be interpreted in terms of the reaction $K^- + p \rightarrow Y_1^{*\pm} + \pi^\pm$ followed by the decays $Y_1^{*\pm} \rightarrow \Lambda^0 + \pi^\pm$. The full complexity of the spectrum of resonances is evident from Charts 2 and 3. Note that the distinction made above between mesons and hyperons (a meson has mass less than that of the proton) has had to be abandoned; the ϕ^0 and f^0 mesons have mass greater than the proton.

As the spectrum of resonances gradually unfolded there was a succession of attempts to provide a theoretical framework for their description. The most successful of these as of the mid-1960s was the so-called eightfold way of Gell-Mann and Y. Ne'emann (1961). There are two essential ideas involved. The first is that the fundamental strong interaction consists of a dominant part that is very symmetrical, a weaker part that is very symmetrical, and a weaker

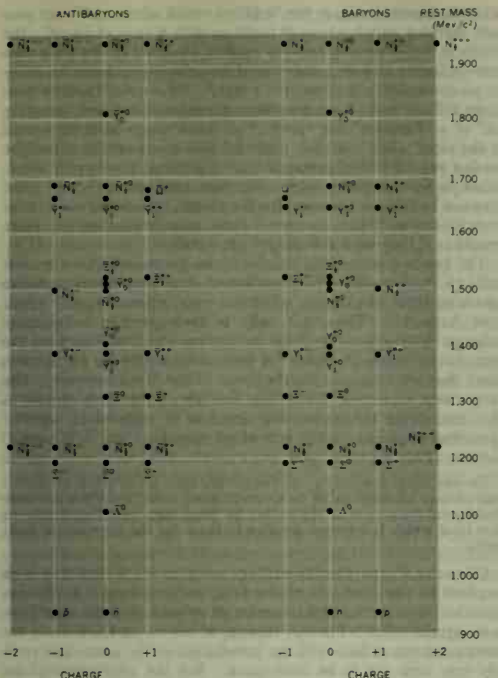

CHART 3.—BARYONS, THE STRONGLY INTERACTING PARTICLES OF MASS NUMBER +1, AND ANTIBARYONS, THOSE OF MASS NUMBER −1

The notation used for baryon resonances has the isotopic spin as subscript and the charge as superscript. Where this leads to ambiguity one may append the mass. Thus the two Y_1^* triplets are written $Y_1^*(1385)$ and $Y_1^*(1660)$

part that is less symmetrical. If the dominant part alone were present, all baryons would have the same mass and all mesons would have the same mass. The weaker part of the basic interaction is less symmetrical, and its lack of symmetry results in the splitting of the baryons and hyperons into the observed mass spectrum. (The eightfold way has this idea in common with half a dozen previous theories that failed to account for the facts.) The second essential idea is that the symmetry is expressed in a very specific way: there is a family of transformations that leave the dominant part of the strong interaction invariant and form a group (*see* GROUPS) called SU_3. SU_3 consists of all 3×3 unitary matrices of determinant one. The weaker part of the strong interaction has a specific transformation law under SU_3.

The two principal consequences of these assumptions are that the observed mass spectrum should be grouped into supermultiplets containing 1, or 3, or 8 (whence the eightfold way), or 10, or 27, or etc. particles all of the same spin and parity, and that within the supermultiplet the masses should be described by a simple formula (Gell-Mann, Okubo mass formula) depending on the isotopic spin and strangeness of the particles. Examples of supermultiplets of eight particles (octets) are the eight mesons π^+, π^0, π^-, K^+, $\bar{K}^0$, K^0, K^-, η and the eight baryons p^+, n^0, Λ^0, Σ^+, Σ^0, Σ^-, Ξ^0, Ξ^-. There was a likely candidate for a supermultiplet of ten particles (decuplet) consisting of the four $N_{\frac{3}{2}}^*$ particles, the three Y_1^*, and the two $\Xi_{\frac{1}{2}}^*$ but the tenth particle of strangeness −3, later called the Ω^-, was missing. The mass formula predicted that the mass should be about 1,680. Consequently, its decay should be by the reactions

$$\Omega^- \rightarrow \begin{cases} \pi^- + \Xi^0 \\ K^- + \Lambda^0 \\ \pi^0 + \Xi^- \end{cases}$$

(It does not have enough mass to decay into $\bar{K}^0 + \Xi^-$.) Since these reactions violate strangeness conservation, Ω^- should be an addition to the list of long-lived particles. Its discovery in 1964 at Brookhaven National Laboratory was a spectacular success for the eightfold way.

Another major advance of 1964 was the discovery by J. Christenson and co-workers that in the decay of neutral K mesons, processes take place that violate the conservation of CP (this is the operation of inverting space coordinates followed by interchange of particle and antiparticle). This left as the only surviving candidate for an exact inversion symmetry of nature, TCP, which involves in addition the reversal of the direction of motion.

Conserved Currents; Intermediate Bosons; High-Energy Neutrino Physics.—An important notion that played a large role in the description of the strong interactions and their relations to the weak interactions is that of a conserved current. It was first used in this connection in the work of S. S. Gerstein and Y. B. Zeldovitch, and of Feynman and Gell-Mann who were trying to understand the finding that the coupling constant which determines the rate of decay of the μ meson $\mu \rightarrow e + \nu + \bar{\nu}$ is the same as the coupling constant for the decay of the neutron $n \rightarrow p + e^- + \bar{\nu}$. The problem is to explain how it is that the strong interactions (which affect the n and p in the latter reaction, but none of the particles in the former) do not make the rate of the two reactions different. The explanation given can be understood by analogy with the case of the charges of particles. That the charges of all elementary particles are integer multiples of the same basic charge (even though some of the particles are strongly and some only weakly interacting) is a consequence of the conservation law of electric charge and current. Similarly, if the e^- and $\bar{\nu}$ in the decay of the neutron are coupled to a conserved current, the equality of the above-mentioned rates can be accounted for reasonably well.

Once the important role played by conserved currents in strong and weak interactions was recognized it was natural to try to extend the analogy further with electromagnetism. The conservation law of electric charge and current is associated with the existence of a field describing the photon. Are these analogous fields and particles associated with the other conserved currents? Such objects are customarily called intermediate bosons, and a major preoccupation of the mid-1960s was the search for experimental indications of their existence or nonexistence.

With the advent in the early 1960s of the great proton accelerators at the CERN laboratory in Geneva, Switz., and in Brookhaven, N.Y., a whole new class of experiments became possible; experiments with high-energy neutrinos. This led to the important discovery that the neutrinos resulting from the decay of the π meson cannot produce the reaction $\nu + p \rightarrow n + e^+$. Thus one was forced to distinguish between ν_e and ν_μ. Both are particles of mass zero and spin $\frac{1}{2}$ with their spins directed opposite to their velocities. On the other hand the antiparticles $\bar{\nu}_e$ and $\bar{\nu}_\mu$ have spins directed along their velocities. These statements about the relative direction of spin and velocity are summarized in the notation: ν_e and ν_μ have helicity -1, $\bar{\nu}_e$ and $\bar{\nu}_\mu$ have helicity $+1$ (*see* Chart 1.) The same experiments were consistent with the idea that the neutrino appearing in K decay is identical with that appearing in π decay. This would be natural if the π and K belonged to the same supermultiplet.

What Is an Elementary Particle?—The phenomena described in the preceding paragraphs are complex and full of regularities. The fragments of theory described bring some semblance of order into various parts of the experimental material but they do not constitute a systematic quantitative theory. They indicate that there is a hierarchy of interactions and symmetry groups, the weakest interactions being the least symmetrical (*see* Table II). There is no rational explanation for this. Running through the theoretical speculations since World War II has been the idea that the observed particles are not really elementary but merely the states of some underlying simple dynamical system (*Urmaterie*). Such speculations had not led very far by the 1960s. If they are expressed in the language of field theory, they suffer from the usual divergence difficulties.

Another line of speculation starts with general relativity and

TABLE II.—*Validity of Conservation Laws Under Various Types of Interaction*

Conservation law	Strong		Electromagnetic	Weak
	Dominant part	Symmetry-breaking part		
Linear momentum Angular momentum Energy	holds	holds	holds	holds
Charge	holds	holds	holds	holds
Heavy particle number* = Baryon number = Mass number A	holds	holds	holds	holds
Parity (P)	holds	holds	holds	fails
Charge conjugation (C)	holds	holds	holds	fails
Time inversion (T)	holds	holds	holds	fails
TCP	holds	holds	holds	holds
Isospin	holds	holds	fails	fails
Strangeness	holds	holds	holds	fails
SU_3 symmetry	holds	fails	fails	fails

* = (Number of baryons) − (Number of antibaryons).

the theory of gravitation, subjects that have not been touched here because no one has succeeded in connecting them with elementary particles.

What is an elementary particle? A provisional phenomenological answer is given by Charts 1, 2, and 3. A more satisfactory and fundamental answer would be provided by a quantitative theory, which as yet does not exist.

See also references under "Particles, Elementary" in the Index.

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(A. S. WN.)

PARTNERSHIP, in general, any voluntary association of two or more persons for the purpose of gain, and to manage and share profits (or losses) in a business enterprise. Partnerships that have many members, with transferable shares, are called joint stock associations; those that exist quite informally between only two or three persons, perhaps to accomplish but a single transaction, may be called joint ventures. Partnerships are to be distinguished from clubs, societies, leagues, circles, and the like, which, not being for profit, are put in a separate legal category; also from the business corporation, which may be organized only as permitted by statute. The significance of these distinctions will appear from the following account.

The early English law of partnership was written piecemeal by the courts, according to the common-law tradition, as cases came before them for decision. Though there was occasional legislation on particular matters—Bovill's Act (28 and 29 Vict., c. 86), for example, was passed to remove certain difficulties arising from the decision made in 1860 in *Cox* v. *Hickman* (*see* below)—the structure was in the main the work of the courts. While many English judicial findings were based on the earlier Roman law, the English system, as it evolved, came to have significant differences. In 1890, Parliament passed the Partnership Act, mainly to give orderly statement to the prior case and statute law. The act applies, with few modifications, to the whole of the United Kingdom.

In the United States much the same course was followed. The early courts, however, relied more heavily on prior English decisions than on Roman law for their precedents. Both the courts and the several state legislatures, moreover, felt themselves free, when faced with new (or supposedly new) conditions, to formulate new law for the occasion. Thus, by 1914, when the Commissioners on Uniform State Laws proposed the Uniform Partnership Act, there had come to be numerous diversities in the laws of the various states which the act, drafted by William Draper Lewis, was designed to remove. In the main it was patterned on the English act, but several important changes were made to codify different rules, especially when these were well conceived and had become established in a number of states. By the 1960s the Uniform Act had been adopted in about three-fourths of the states.

Both the English and the U.S. partnership acts are best construed in the light of their common-law background. The English act defines partnership as the "relation which subsists between persons carrying on a business in common with a view of profit"; the Uniform Act is similar, but—to resolve a conflict in the prior case law—it insists also on a showing of co-ownership, thus: "to carry on as co-owners a business for profit." Of course, co-ownership alone will not make for partnership; there must also be a "carrying on" of a "business" for "profit," as those terms have been used in the cases. But it is even doubtful that co-ownership should be made a general test of partnership, for, although most profit enterprises do have property held in common, some do not. The point may not be critical, however, for the courts, by treating such latter associations as "joint ventures," have usually reached the same results as if they were full-fledged partnerships.

The key to partnership, plainly, is the agreement (tacit or formal) to share profits. Partners are at once proprietors and also agents of their co-partners, when the usual rules of agency apply (*see* AGENCY). Thus, not only is each partner individually liable to third persons for those obligations which he incurs for the firm, but he is equally liable for those incurred by his co-partners when they are acting within the scope of the firm's business. The early cases, moreover, placed this liability on the same ground as that underlying the agency-law doctrine of *respondeat superior* (principal's liability for the acts of his agent). Thus, in *Waugh* v. *Carver,* 1793, the court said:

> He who takes a moiety of all the profits indefinitely shall, by operation of law, be made liable to losses, if losses arise, upon the principle that by taking a part of the profits he takes from creditors a part of that fund which is a proper security to them for the payment of their debts.

Of course, if a partner, from his personal assets, has paid or been required to pay creditors of the firm, he may have contribution from his co-partners, either equally or on such basis as may have been agreed upon. Plainly, though, if his co-partners have become insolvent or have left the jurisdiction of the court, this remedy may turn out to be inadequate. But the alternative of restricting a partner's liability to third persons on a pro rata basis, or of limiting it to the property held in common, never gained foothold in the common law. The most that the early law did was to require the creditor to join as defendants all partners when he sued to recover upon a partnership obligation. But it was never clear that this—except for its nuisance value as a delaying tactic—was ever of much help to an individual partner. Nevertheless, both the English act and the Uniform Act treat partnership obligations as joint; only tort (*q.v.*) liabilities are joint and several.

Not all sharing in profits, however, makes for partnership. Thus in *Cox* v. *Hickman,* 1860 (8 H. L. Cas. 268), it was held that a composition agreement between creditors of an iron works (by which managers were appointed to conduct the business and to pay creditors from any profits) did not constitute a partnership. Lord Cranworth, one of the five law lords sitting, said that to suppose that the directors of the Midland Railway Co., a creditor for only £39, could imagine that they were making themselves partners was absurd. In the wake of this case a number of exceptions developed which later gained recognition in the partnership acts. Thus, not only may creditors receive a share of profits without becoming partners with the debtor, but landlords, lenders, and employees likewise may receive profits by way of rent, interest, or wages, as the case may be, with similar immunity. Of course it is possible to draw a line here, since a landlord, for example, has less control over lessee operations than a general partner would have. But perhaps the courts also felt that exception should be made as a matter of policy to encourage capital.

Partnership Compared with Corporation.—The partnership differs in theory from the business corporation in that the latter is viewed as a legal person, separate and apart from its shareholders. (*See* also COMPANY; CORPORATION.) The partnership, on the other hand, is generally regarded (Scots law to the contrary) as merely an aggregation of persons doing business under a common name. In the U.S., the courts in a few states have been inclined to the entity view, but when the Uniform Act was drafted it adhered generally to the aggregate theory, in agreement with the English act. This difference in concept has practical conse-

quence. Thus, since in theory it is the corporation which deals with third persons, it follows that the corporation and not the shareholder is liable to creditors. Of course, partners also could achieve limited liability by contract (though not as to torts), but they seldom do so; third persons often trade largely on the credit of the partners and would not readily agree to look only to firm assets.

There are other consequences. One, the difficulty of taking title to real property, is easily solved. That is, while title may not be taken in the partnership name, since the firm is not a legal person (and it would often be impractical to convey to all the partners jointly), it is possible to convey to a trustee, who will hold title for the benefit of the firm. Again, there is the problem of suit. Since the firm is not a person it may only sue or be sued in the names of the several partners. But here too there are solutions. In the U.S., several states permit suit to be brought against the firm, with service on an officer, but execution in such case may be had only against firm property. An alternative, useful in the case of large partnership associations, is to bring a class suit naming only a few partners; here it is possible eventually to reach both individual and firm assets.

Other advantages of incorporation are not so easily attained. Corporations are usually organized to have perpetual existence, though they may be dissolved upon vote (usually two-thirds or more) of the shares. But partnerships may be dissolved at any time upon withdrawal of a partner, and by operation of law they are dissolved upon the death of a partner. It is possible by contract (the Uniform Act has a provision on the point) to require a withdrawing partner to leave his capital contribution in the business until the end of the term, and a similar arrangement may be made in the case of dissolution by operation of law. Dissolution may be avoided by issuing transferable shares, but this device is not feasible except with a large organization, where, as in the case of a corporation, operating control can be centralized in a board of managers.

In the usual partnership, however, each general partner has full power to act for the firm as he thinks best in carrying on its business in the usual way. This is both a strength and a weakness. It makes for prompt action, but it is difficult to control by agreement or majority vote. For, as to third persons who do not know (or have reason to know) of such limitations, each partner continues to have full power to commit the firm within the scope of its business. Thus it plainly would not do to have new partners introduced into such a firm by assignment, nor does the law sanction it; a partner may assign his interest in a firm (either outright or as security), but the assignee does not become a partner. Trust and confidence as between partners, especially in the small firms, is of the essence of the relationship; the courts insist on a high standard of fiduciary duty.

Thus, in many ways, the partnership comes off rather poorly when compared with the corporation. Yet it survives, perhaps because of its very simplicity. Then, too, there are some areas, law and medicine for example, where it is not permissible to use a corporation. But, of greater moment, the partnership way of doing business enjoys a tax advantage in the U.S. The corporation, as a legal person, must pay an income tax prior to distributing dividends to its shareholders (who also are taxed); no such tax is levied on the partnership. This corporate tax is assailed periodically as double taxation, but the pragmatic answer is that corporations continue to multiply.

Limited Partnerships.—These are a creation of statute law, patterned upon the French *société en commandite; i.e.*, a partnership consisting of one or more general partners and others, called limited partners, whose liability is limited to the amount contributed to the firm as capital. They came into use in the U.S. early in the 19th century for two reasons: the need of new commercial ventures for increased capital; and, the difficulty at that time of obtaining corporate charters, which required special legislation. The first statute was passed in New York in 1822, and it was followed by similar legislation in other states. In 1907 Parliament adopted a Limited Partnership Act, and in the U.S. in 1916 a Uniform Limited Partnership Act was drafted. The latter, like the Uniform Act for general partnerships, has been adopted in all but a few states.

The status of the limited partner is much better than that of the "silent" or "dormant" partner at common law. The latter enjoys immunity from suit, it is true, but only until discovered, when he is fully liable as a general partner. The limited partner's position is more like that of a lender, but even here there are substantial differences. In the first place, upon insolvency the lender may advance his claim against the estate as a creditor; the limited partner may not, although he may contract for priority over the general partners. Then, the lender, under the guise of preserving security for the loan, may assert rather more control over the borrower's business than the limited partner may. In fact, the limited partner may have no control over the day-to-day operations of the business without running the risk of being declared a general partner. Finally, unlike the lender, he may not accept repayment of his contribution, except on condition that it remain subject to creditors' claims.

In spite of these points, limited partnerships continue in use, particularly among brokerage houses. The limited partner's contribution, unlike that of a lender, enhances the firm's credit position. The fact that his relationship to the firm must be clearly stated and made a matter of public record makes for definiteness and gives rise to little litigation.

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PARTONOPEUS DE BLOIS, an anonymous French couplet romance, composed *c.* 1180, combining the spirit of the Celtic *lais* with the theme of Cupid and Psyche. The hero, a count of Blois, is carried off in a magic ship to a castle where he is waited on by unseen hands. An enchantress comes to him by night but forbids him to look upon her for two years and a half. Urged on by his mother and the Bishop of Paris, he takes a lantern to look upon his beloved—who is revealed as Melior, the highly educated heiress to the throne of Byzantium. Rejected by her, he runs mad in the woods, but eventually wins her hand after an elaborately described tournament. The popularity of the work is attested by ten French manuscripts and adaptations in many languages. *See* also ROMANCE.

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PARTRIDGE, the name originally applied to the Eurasian game bird *Perdix perdix*, one of the pheasants (family Phasianidae), which is now better known as the gray partridge or Hungarian partridge. Native to central Eurasia, this species has been widely introduced, becoming successfully established in the colder western prairies of North America. It is a medium-sized, stout grayish bird, up to 14 in. long, recognizable by the dark patch on its belly, broad chestnut bars on its flanks, and short chestnut tail feathers noticeable only during flight. The gray partridge is a favourite game target with hunters because of its fast takeoff and swift, erratic flight.

The nest is on the ground among grasses; the eggs, numbering to 18, are light olive. Young, which hatch after 24 days of incubation, are ready to fend for themselves and, like the adults, feed on insects.

The chukar partridge (*Alectoris graeca*) of India, also successfully introduced into North America, and the common red-legged partridge (*A. rufa*) of Europe, are likewise hunted as game.

One of the francolins, a closely related group of spurred pheasants, is called black partridge (*Francolinus francolinus*). The name "snow partridge" is given to *Lerwa lerwa*, whose many races inhabit the mountains of Asia, and to the Arctic ptarmigans. The name "partridge" has been loosely applied in North America to the ruffed grouse, the bobwhite, and other species that resemble

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GRAY PARTRIDGE (PERDIX PERDIX), A GAME BIRD NATIVE TO EUROPE BUT LONG AGO INTRODUCED INTO AMERICA

the Old World partridges. In South America the name is given to various tinamous.

PARTRIDGEBERRY (*Mitchella repens*), a North American plant of the madder family (Rubiaceae), growing in dry woods from southwestern Newfoundland to Minnesota and southward to Florida and Texas. It is evergreen, with nearly round, ¾-in. leaves, often variegated with white lines; a slender, often whitish, trailing stem; and white flowers, often borne in pairs, which are replaced by scarlet, edible but almost tasteless berrylike drupes. The flowers occur in long-styled and short-styled forms, as in the primrose. This plant, also called checkerberry, squawberry, teaberry, running box, two-eyed berry, squaw vine and twinflower, is a good wild-garden subject for shady places. It is popular in winter terrariums because of its diminutive size and attractive color contrast of berries and leaves.

PARTS OF SPEECH: *see* GRAMMAR.

PARTURITION: *see* CHILDBIRTH.

PARTY, POLITICAL, a group that attempts to bring about the election of its candidates to public office and, by this means, to control or influence the actions of the government. A political party is only one of several types of groups which, under various political systems, seeks to control the personnel and policy of government. Political parties, as defined here, are instruments of democratic or republican regimes in which the chief governmental officials are chosen by election. A clique of military officers that gains control of a government by its command of the armed forces of a country is hardly a political party although it may masquerade as such. A landed aristocracy that exerts a continuing influence on affairs of state under an absolute monarchy may play an important role in the governance of the realm, but it does not constitute a political party in the modern usage of the term. Under dictatorships one-party systems have been established to bolster the power of the dictator. Such parties may be effective props for the regime but they are in reality extensions of the governmental apparatus rather than political parties. The essential condition for the existence of political parties is freedom to form organizations that strive for power by electoral methods. Under other circumstances groups of citizens may influence the government, or they may form part of the coalition of interests supporting it; but without freedom of competition for power by electoral methods, political parties, in the strict sense of the term, cannot exist. Hence, the Communist party of the Soviet Union, the Nazi party of Hitler's Germany and the Fascist party of Italy could not be considered political parties as that term has been generally understood. The Communist party was, in fact, outlawed in the United States in 1954, and in many other countries as well, on the ground that it was not a true political party but a subversive influence and a tool of the Soviet government. In other countries, such as France, Italy and India, the Communist party gained acceptance as a bona fide political organization and wielded immense influence. (*See* COMMUNIST PARTIES; FASCISM; NATIONAL SOCIALISM; SOCIALISM.)

Differentiation from Other Groups.—Political parties are to be differentiated from pressure groups or interest groups which seek to influence government by such means as propaganda and persuasion rather than by putting forward candidates for office. These are groups of individuals or federations of associations founded on some common interest; exertion of influence on the government is generally only one of the purposes of association. Professional societies, for example, make themselves heard by public authorities when matters of concern to them are under consideration, but influencing public policy is not the sole objective of such societies.

Interest groups sometimes become constituent parts of a political party. The British Labour party, for example, originated as a federation of trade unions, trades councils and socialist societies. The American Federation of Labor (A.F.L.) originally had a different relationship to political parties. Under its nonpartisan policy it called to the attention of unionists the records of candidates of all parties on issues of interest to labour, while some of its leaders might favour one presidential candidate and others, another. The Congress of Industrial Organizations (C.I.O.) adopted a more definitely partisan policy and supported Democratic candidates by substantial campaign contributions and by other means through its political action committee. After the two organizations merged in 1955 to form the A.F.L.-C.I.O., they formed a committee on political education to work for specific political goals.

The line between political parties and pressure groups is sometimes blurred; but a distinction may be drawn from the fact that pressure groups, unlike political parties, do not nominate candidates for public office or desire to accept the responsibility for management of the government. It should also be noted that an interest group which under certain circumstances promotes its cause through pressure tactics may under different conditions act as a political party. In the United States, agriculturalists lobby for their objectives through such organizations as the American Farm Bureau federation, while in European democracies farmers' and peasants' parties have been common.

Revolutionary mass movements in recent years have taken on some, but not all, of the characteristics of political parties, including the name "party." The Congress party in India, for example, and the Muslim league in Pakistan helped spearhead the drive for their countries' national independence. Once that goal was won, both organizations encountered difficulties in fitting into the new scheme of things and assuming the normal functions of a political party.

Party Functions.—In the 18th century, on both sides of the Atlantic, the term party, like faction, suggested something politically unwholesome if not actually subversive. George Washington in his "Farewell Address" warned against "the baneful effects of the party spirit generally." Even at mid-20th century it was not uncommon to hear parties spoken of disparagingly. In West Germany, for example, political parties did not have the same historical roots and emotional attachments that they had in the United States or Great Britain. Many German voters held parties in contempt and preferred to think of themselves as "above party." Much the same was true of Japan where there was a great deal of uncertainty in the mind of the average citizen in the 1950s as to his affiliation with a political party. Powerful voices in India expressed the view that parties were unnecessary and undesirable. In Indonesia, President Sukarno declared in an address to the con-

stituent assembly in 1956 that the freedom to set up political parties did not constitute the only means "to keep the democratic system going." But in most countries, particularly in those with long traditions of successful party government, political parties were regarded as being essential to popular government. Defenders of parties argued that formal institutions of government are not enough to make democracy work. They point out that the abolition of political parties (or the outlawing of all parties but one) is usually a first step toward the establishment of a dictatorial regime.

The political party provides a method by which people of similar views can organize to contend for control of the government. Party competition for power is in a sense a sublimation of civil warfare, and parties are in a way political armies consisting of segments of the population with certain common or compatible aspirations. Men bind themselves together in parties for much the same reasons that they join together in warring factions. A tie which often brings men together in a political party is a common economic interest susceptible of promotion or defense by political methods. Labour and peasant parties are examples which are paralleled by parties dominated by industrial interests. In some countries racial or nationalistic minorities form political parties. On the continent of Europe common religion has furnished the cohesive element for some parties. (*See* ANTIMASONIC PARTY; CHRISTIAN DEMOCRATIC PARTIES; CONSERVATIVE PARTY [BRITISH]; DEMOCRATIC PARTY [U.S.]; LABOUR PARTY [BRITISH]; REPUBLICAN PARTY [U.S.].)

Whatever the factors may be that draw men together in parties, these organizations perform functions indispensable to popular government. They select candidates for public office and present them to the entire electorate, which then may choose from among the contenders. The process of nomination of candidates is in most countries highly informal; caucuses or inner cliques of the leaders of a party determine its candidates. In the United States, however, because of abuses within the party organizations in the making of nominations, the process of nomination is regulated by law. The more general method of nomination for state and local office and for representatives and senators in the national congress is by the direct primary, which is conducted as an election in which the members of the party are entitled to participate. (*See* PRIMARY.) The nomination of presidential candidates, however, is accomplished by conventions which operate in accordance with party rule rather than statute. (*See* NATIONAL CONVENTION.)

In addition to nominating candidates, parties define the issues before the electorate in campaigns and elections. They present to the electorate not only a choice among candidates but a choice among governmental programs. At times, particularly in countries with the dual party system, the differences between party programs are by no means sharp. In the United States the issues between the Republican and Democratic parties are more notable for their similarities than their differences. Nevertheless, the general direction and emphasis of one party program may more nearly approximate the beliefs of a voter than the other. In multiparty countries such as France the voter may be able to cast his ballot for the candidate of a party which reflects his viewpoint with relative exactness. The multiparty system permits the formation of separate parties, with programs tailored to fit the views of comparatively small segments of the population. Parties also carry a large part of the burden of education and debate incidental to the choice of governments by the electorate. Especially after the development of universal suffrage the conduct of campaigns and of other work incident to the electoral process became extremely burdensome and costly.

Party Organization.—As with all but the most rudimentary associations, a political party possesses organizational machinery through which it acts. Such organization is, in effect, the government of the party. It is the machinery by which party decisions are made and by which factional disputes within the party are settled. It tends, in fact, to be the party. Parties pose as mass organizations and adopt all the paraphernalia of representative government for control of their affairs, but everywhere their management tends to be oligarchical. It is productive of clearer thinking if the concept of parties as associations with vast memberships is regarded as fictitious. In practice, membership in a political party is an affiliation with no heavy obligation for participation in party management; membership is ordinarily nothing more than a voting affiliation of varying degrees of durability. The members leave the operation of the party machinery to the inner core of professional and semiprofessional party workers. When there is competition among parties, this state of affairs is not necessarily undesirable since the party oligarchy that ignores the interests of its partisans will find that its following disappears.

Commonly the supreme authority within the party is an assembly, in form directly or indirectly representative of the membership, which convenes annually or at less frequent intervals. The national conventions of the Democratic and Republican parties in the United States meet at four-year intervals. Each consists of more than 1,000 delegates selected by state party conventions or by party members in the states through direct primaries. The conventions nominate presidential candidates, adopt platforms and designate party officials.

British Conservative, Liberal and Labour parties hold annual conferences to which local party associations send delegates. These conferences, like U.S. conventions, are largely managed by the inner circle of party leaders and serve more to ratify the recommendations of the party leaders than as forums for deliberation on party affairs. Unlike the British party assemblies, the national conventions of the Canadian Liberal and Progressive Conservative parties have taken from the party groups in parliament the power to designate the party leader (who becomes premier if the party is victorious). Such conventions are held only when it becomes necessary to choose new party leaders.

Ordinarily the national party organization includes an executive. The British Conservative party, for example, has a national council, a president and a treasurer. It maintains a central office, with a paid staff to distribute literature, aid local party associations, raise money and generally keep the party machinery in tune. The Republican and Democratic parties in the United States have national committees, the chairmen being designated by the presidential nominees. The Labour party has a national executive committee in which government of the party is vested between annual party conferences. As the national committees are large and unwieldy, executive leadership is commonly handled by the chairman with the assistance of a small executive committee. The parties maintain national headquarters staffed to carry on research and propaganda activities. The typical continental party also maintains a central bureau or secretariat which operates under the direction of the national executive of the party. The party national staff varies widely in size and importance. In the United States, with elections at fixed intervals, the activities of national headquarters increase in scope and importance as an election approaches. In countries in which parties must maintain a more constant state of readiness for an election and in which the parties carry on more extensive educational, organizational and publishing activities, a larger and more stable national staff is likely to exist.

The central or national organization of the party is usually superimposed over a system of local party organizations or associations which vary in their form from country to country with the nature of the governmental system. Local associations usually developed first and the national party machinery evolved later to lead and unify the work of these associations in national politics. In England, for example, the National Union of Conservative and Constitutional associations (or the Conservative party) was formed shortly after the adoption of the Reform act of 1867 and gradually affiliated with itself local Conservative and Constitutional associations which were already in existence in parliamentary constituencies or parts of such constituencies. In the United States local party organization conforms to the structure of local government. City and county party organs are tied into state party organizations which in turn occupy a position in the national structure of the party. Although provision is often made for party committees and conventions based on congressional districts, the

city or county party machinery is more generally the centre of power in the party locally.

The nature of a nation's politics is profoundly influenced by the degree of centralization of power nationally over local party actions. The central offices of British parties, for example, are able to exert great influence over the choice of candidates by local party associations. This relation within the party organization is reflected in the fairly high degree of discipline prevailing within the party groups in parliament. Unity within the majority party lays the basis for, but does not assure, a stable and firm governmental policy. Radically different relations have prevailed between national and local party organizations within the United States. The national party organizations are only loose federations of state and local party machines. Relatively slight control of local party actions may be exercised by the national leadership of the party. Local party organizations rebuffed attempts even by such strong party leaders as Woodrow Wilson and Franklin D. Roosevelt to influence the selection of candidates for the house and senate. Local party autonomy is accompanied by weak cohesion within party groups in the congress, and by consequent difficulty in the enactment of a party program into legislation. In practice, most legislation is enacted by combinations that cut across party lines. In the French fourth republic weak national leadership within the party organizations contributed to the fluidity of party alignments in the chamber of deputies and to governmental instability.

Parliamentary and Extraparliamentary Organization.—A distinction must be made between the parliamentary party and the party organization outside the government. The party group in the parliament usually has its own organizational apparatus consisting of a chairman, president or leader, a secretary and other functionaries, differing in detail from country to country. In some instances the parliamentary group even has a different name from the external party.

The parliamentary group may enjoy considerable freedom from control by the extraparliamentary party organs. Such autonomy was established most clearly in Great Britain where the party organs of the Liberal and of the Conservative parties once adopted resolutions for the guidance of the members of parliament elected under their respective banners. Control of members of parliament (who refused to be controlled) by an external authority was soon seen to be incompatible with the sovereignty of parliament; the extraparliamentary organizations came to limit themselves principally to the tending of the party machine. Although elsewhere the issue of principle is not always so sharply settled in favour of autonomy for the parliamentary group, generally party functionaries concentrate their efforts primarily on the winning of elections—the canvassing of the electorate, the dissemination of propaganda, the maintenance of the party machinery—rather than on the formulation of policy for the guidance of the party's candidates and officials.

Party Finance.—The financing of party activity is one of the vexing problems of popular government. Party operations cost tremendous sums. The total expenditure by national, state and local party organs of the Democratic and Republican parties during the 1956 presidential campaign in the United States was estimated by a senate committee at $133,000,000. In Great Britain somewhat less is probably spent, on a per capita basis, in a general election. To get funds to meet its needs a party is tempted to yield to plutocratic influences. An ambition of managers of parties with pretensions to a broad popular base has been to organize party finance so as to obtain a great number of small contributions from the party membership.

In the United States both national and state governments attempt to limit the amounts of campaign expenditures, to prohibit contributions from such sources as corporations, to limit the size of contributions and to enforce publicity of the financial affairs of parties. The defects of legislation with these objectives, both in form and in enforcement, are serious. The difficulty of regulation of party finance has led to the suggestion that the government finance the expenses of the major parties. (*See* CORRUPT PRACTICES; ELECTORAL SYSTEMS.)

Biparty and Multiparty Systems.—A puzzling feature of party systems is that in some countries the electorate divides itself into two major parties while in others a multiplicity of parties develops. The United States is the classic example of a nation with a two-party system. Control of the national government has alternated between the Republican and Democratic parties and their predecessors. In most other English-speaking countries the two-party system does not exist in its pure form, although its essence is approached in that usually a single party has adequate strength to form a government. In Great Britain the historical cleavage was between the Conservative and Liberal parties, but after World War I the Labour party gained strength and in 1945 won control of the government. The Liberal party became a weak third party that usually elected only about five or ten members of parliament compared to approximately 300 for each of the other parties. With occasional exceptions, Canada, Australia and New Zealand also followed the two-party pattern.

In contrast, the multiparty system has been the rule in European democracies, notably France and pre-Hitler Germany. A multiparty nation may have a dozen or more parties ranging from the most radical on the left through the political spectrum to the most conservative on the right. The right-left classification arises from the custom of seating the party groups in this order in relation to the presiding officer in semicircular legislative chambers. (Data on the current strengths and programs of parties of all countries are available in such annual publications as *The Statesman's Year-Book* and *The Political Handbook of the World.*)

The two-party system is said to promote governmental stability because a single party can win a majority in the parliament and govern. In a multiparty country, on the other hand, the formation of a government depends on the maintenance of a coalition of parties with enough total strength to form a parliamentary majority. The weakness of the ties that bind the coalition may threaten the continuance of a cabinet in power. The governments of Great Britain, Canada and the United States may be contrasted with those of France and Germany in the years between World Wars I and II. In the decade that followed its liberation in 1945, France had one cabinet crisis after another; the average life span of a French cabinet during these years was less than six months. But it must be borne in mind that the weakness of the government under the fourth republic, as under the third, was not caused entirely by its party system. Constitutional factors such as the lack of power in the French cabinet to dissolve the chamber of deputies were also involved. The constitution of the fifth republic, adopted in 1958, was aimed at strengthening the position of the executive, not reducing the number of parties. The stability shown by the government of the United States was not entirely due to its party system but was promoted also by the fixed tenure and strong constitutional position of the president.

The two-party system moderates the animosities of political strife. To appeal for support of a majority of voters a party must present a program sympathetic to the desires of most of the politically active elements of the population. In the formulation of such a program an effort must be made to reconcile the conflicting interests of different sectors of the population. This enables the party, if expedient, to resist demands that it commit itself without reservation to the policies urged by any particular extremist element. In effect, the party is a coalition for the purpose of campaigning for office. In the formation of the coalition compromises have to be made, and coalition occurs outside the government prior to election rather than within the parliament after election as under the multiparty system. The necessity that each party appeal to practically all social classes for support ensures a marked resemblance in party programs and composition. Similarities between Republican and Democratic platforms in the United States are more striking than their differences. Both parties also draw electoral support from all social classes. In Great Britain and Canada differences in program and in composition between the two major parties have been perhaps greater than in the United States. Nevertheless, in these countries a broad area of agreement exists among the leading parties. With two major parties of similar views and of approximately equal strength com-

peting for control of a government it is possible for governmental control to alternate between the parties without shifts in policy so radical as to incite minorities to resistance.

Contrasts between two-party and multiparty systems are often exaggerated. The existence of two major parties in the United States obscures the fact that within each party are many factions struggling for power. Within the Democratic party the southern planters and the workers of the great urban centres came to live in uneasy union. In the Republican party the midwestern farmer and the eastern manufacturer formed a similar alliance. Presence of divergent interests under a single party canopy masks a process of struggle and compromise which under a multiparty system is out in the open. Nevertheless, party leadership under a two-party system must concentrate on building a coalition of voters; it gains strength by seeking areas of agreement and suppressing conflict rather than by exploiting points of difference. Apologists for the two-party system, however, sometimes ignore the fact that frequently under that system a single party dominates local administration over considerable areas. That is the case in the solidly Republican and Democratic areas in the United States where the only channel for expression of political differences is by factional strife within the dominant party. Party factions may be as numerous as parties under a multiparty system and yet lack the redeeming feature of clarity that comes from being labeled as parties.

Bases of Biparty Systems.—Major influences favourable to the two-party system are the use of single-member districts for the election of representatives, the presidential system and the absence of proportional representation. In Great Britain and the United States most members of the national representative assemblies are chosen from single-member districts and the candidate polling the largest number of votes is the winner. Such an electoral system compels a party to strive for a majority of the votes in a district or other electoral area. No more than two fairly evenly matched parties may successfully compete for office in a single-member district; a third party is doomed to recurring defeat unless it can swallow up one of the other parties. Parties do not thrive under the certainty of defeat.

A third party may have a substantial popular following and yet capture few seats in the representative body. With, say, 20% of the popular vote spread evenly over an entire country such a party would not win a single seat. The rise of the Labour party in Great Britain, for example, virtually deprived the Liberal party of parliamentary seats even when it had a substantial popular following. The corollary is that the strength of the majority party in the representative body is proportionately greater than it is in the popular vote.

In addition to the single-member-district system, in the United States the presidential system induces parties to seek majority support. No fractional party can elect its presidential candidate and third parties in national politics are protest movements rather than serious electoral enterprises. When minor parties exist for long in two-party countries, their strength is likely to be concentrated geographically which enables them to win seats in the parliament. In such areas of concentration, the two major parties nationally may be forced toward coalition locally which illustrates the influence of the electoral system in the formation of dual-party systems.

Systems of proportional representation, in contrast with the single-member-district system, are designed to permit party representation in the representative body more or less precisely in the same proportion as the party strength in the popular vote over the entire country. The number of seats won depends on the number of popular votes received rather than success in polling a plurality in each individual constituency. Party splintering may be encouraged by the electoral system, but there must be groups susceptible to narrow political appeals before proportional representation can facilitate party fission.

A significant factor in differences in party organization is the presence of certain influences in multiparty countries that are absent in two-party countries. The lack of consensus on constitutional issues in some European countries led to the formation of parties irreconciled to the regime. A few royalist parties persisted long after the abolition of monarchies. Parties formed to espouse the cause of the church were generated by issues not important in most Anglo-American countries. The socialist movement spawned numerous continental parties, most generally designated as Social Democratic, and the British Labour party had a socialist origin. Proletarian movements looking toward the ultimate socialist transformation of the state gained a stronger foothold in Europe than in most two-party countries. The existence of considerable bodies of people deeply attached to doctrines which cannot be readily compromised is in contrast with a state in which a broader area of consensus on fundamental issues prevails. Diversity of political beliefs on fundamental issues coupled with suitable electoral systems leads to a multiplicity of political parties.

Newly Independent States.—India, Pakistan and Indonesia may be cited as examples of the differing responses to the challenge of party government in states of the far east that won their independence during the 1940s. In India, the largest and most stable of the new states of the post-World War II era, Nehru's Congress party, which had led the fight for independence, dominated the political scene during the first decade of self-government. There was no second party of comparable strength to stand in opposition on a national scale, though fourteen national parties took part in the 1952 election and opposition to the Congress party was strong in many regions and states. Appealing to the largest free electorate in the world, the Congress party won 362 of 489 contested seats in the parliament elected in Jan. 1952, India's first election as a free nation. In subsequent elections the Congress party continued its dominance. Meanwhile, many observers, both in and out of India, regarded this situation as politically unhealthy and predicted change, either in the direction of a two-party system or the complete abolition of all parties.

The efforts of Pakistan to solve its political party problems took a different turn. The Muslim league, spearhead of the independence movement in Pakistan, held power at all levels of government from 1947 to 1954. Thereafter other groups gained influence with the result that no party was strong enough to win a working majority at the national level; coalition cabinets held office from 1955 to 1958. Elections under a new constitution were scheduled for 1958 but in October of that year the president of Pakistan abolished the constitution, dissolved all political parties, and declared martial law. The new nation's first efforts to govern itself in normal democratic fashion through political parties thus ended in failure, but a new start was made under a constitution promulgated in 1962.

The Republic of Indonesia exhibited still a different response to the problems of party government. Indonesian parties (except the Communist party) were loosely organized groups formed about locally influential individuals and were far different from parties in the western democracies. When Indonesia held its first general election as a free nation in Sept. 1955 two parties—the Nationalist party (P.N.I.) and the Muslim council (Masjumi)—captured the same number of seats in the legislature. They chose a compromise candidate for the office of premier. The two strongest parties were closely followed by the Muslim Schoolmen league and the rapidly growing Communist party. The coalition cabinet did not last long, resigning in 1957 when the Muslim council and three minor parties withdrew their support. President Sukarno, who had earlier remarked that political parties should be "buried" in the interest of national unity, then appointed a new cabinet himself without reference to party alignments. Early in 1960 Sukarno dissolved the legislature and ruled by decree; in 1963 he became premier and president for life.

The experience of these states emerging from colonial rule illustrates the obvious point that lack of agreement on constitutional fundamentals spells difficulty for any political party system, as does lack of a long tradition of governing through political parties. Mass organizations created to promote revolutionary nationalist movements proved to be poorly suited to function as political parties once their main goal had been won. To keep the situation in proper perspective, however, the shortcomings of the new regimes must be considered in relation to the fact that all the

newly independent states had to face difficult tasks in establishing new political procedures, developing public support, dealing with largely illiterate electorates, countering communist pressures, and carrying through a host of social and economic reforms. Their experience suggests that new forms and procedures are being developed and that the political parties typical of western parliamentary democracy are not being blindly transplanted to alien soil. *See* also references under "Party, Political" in the Index.

(V. O. K.; X.)

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PARWAN, a minor province of central Afghanistan lying north of Kabul Province. It includes the northern half of the plain called Koh-i-Daman with the adjoining kohistan or hill country, and extends eastward to Nangrahar, northward to Kataghan and Badakhshan, and southwestward to Mazar-i-Sharif provinces. In the south it is bounded by the northern slopes of the central Hindu Kush Mountains. Parwan is drained toward the Amu-Darya by the upper Kunduz (Surkhab) and its tributaries and by the Panjshir and its tributaries, the Ghorband and the Parwan. The province is thus a chain of valleys, of picturesque scenery. The area of the province is approximately 9,700 sq.mi. The average annual rainfall is about 16 in.

The population in 1962 was estimated at 1,221,683, mainly Tajik and Hazara with some Uzbek. (*See* AFGHANISTAN: *The People.*) The principal towns are Charikar, 50 mi. N of Kabul, which is the capital of the province and a stopping place for travelers to the north; Bamian (*q.v.*), 80 mi. WNW of Kabul and noted for its many man-made caves and the two huge rock-carved figures of Buddha; and Doab Mekh-i-Zarin and Jabal-us-Siraj, both on the main road to Kabul.

About 154 sq.mi. of the total area are cultivated, of which about 135 sq.mi. are irrigated. The chief crops are wheat, cotton, maize (corn), rice, and barley; vegetables, fruits, and the mulberry are extensively grown. There are coal deposits in the Panjshir and Ghorband valleys, and iron ore in the Ghorband Valley; the silver deposits in the Panjshir Valley are not rich enough for profitable exploitation. At Charikar metal products (steel cutlery, iron farm equipment) are manufactured. The province is linked by an all-weather road with Kabul, Kandahar, and Peshawar (West Pakistan); with the provinces of Mazar-i-Sharif, Kataghan, and Badakshan; and via Haibak with the Soviet frontier post at Termez on the Amu-Darya. (J. P. C. N. H.)

PASADENA, a city of Los Angeles county, Calif., U.S., lies 11 mi. E. of Los Angeles (*q.v.*) at the western end of the San Gabriel valley along the foot of the Sierra Madre range. *Pa-sa-de-na* is a Chippewa phrase meaning "crown of the valley."

Pasadena's site was carefully chosen by agents of Thomas B. Elliott, head of the California colony of Indiana. Though delayed by the panic of 1873, Elliott (still in Indiana) persevered in organizing the San Gabriel Orange Grove association, the founding corporation. In 1874 for the sum of $25,000 the association obtained 4,000 ac., formerly part of the Mexican Rancho San Pasqual, on the western side of the present city. Population and land values grew slowly. By 1880 Pasadena had 400 inhabitants, and good land had risen to $100 an acre.

Pasadena's great boom began in 1885 and the city was incorporated the next year. The land boom, experienced throughout southern California, was intensified locally by the advent of the Santa Fe railroad. The winter resort trade, mainly health seekers at first, reached unbelievable proportions. Speculation in real estate was rife and land was bringing as much as $1,000 per acre. The population jumped to 6,000. Although the inevitable collapse hit Pasadena hard, conditions were normal by 1890. Its permanent population had increased 15-fold during the 1880s, and with urbanization its citrus groves began to disappear.

For the next 40 years Pasadena continued to attract large numbers of middle westerners, many of the professional or retired class. In the early 1960s the city, surrounded by suburbs, was mostly a community of homeowners. The commuter replaced the midwestern immigrant, as the Los Angeles freeway system brought Pasadena to within 30 min. of the metropolis. As marketing supplanted agriculture, Pasadena became the wholesale and retail centre for much of the San Gabriel valley. After World War II the city, with a view to spreading the tax base, encouraged light industries such as ceramics, machine shop products, scientific instruments, electronics, plastics and pharmaceuticals.

California Institute of Technology, a privately endowed college, graduate school and research institute for men, established as Throop Polytechnic institute in 1891, is located there. It includes divisions of biology; chemistry and chemical engineering; civil, electrical and mechanical engineering and aeronautics; geological sciences; humanities; and physics, mathematics and astronomy. Institute facilities in Pasadena include, in addition to the main campus, the jet propulsion laboratory, operated in conjunction with the National Aeronautics and Space administration. Other institute facilities include the marine biological laboratory at Corona del Mar; an observatory on Palomar mountain in San Diego county; and a centre at Bishop for the study of radio astronomy. The institute is also associated with Mount Wilson observatory (established 1904). The Henry E. Huntington library and art gallery is located in nearby San Marino. The Pasadena college was established as Nazarene university in 1902 and is affiliated with the Church of the Nazarene. The city supports a full-fledged school system through the junior college level, with an excellent adult education program; there is also a public library and an art museum. The Pasadena Community playhouse, organized in 1916, is a nationally known little theatre with a school of drama and a laboratory theatre workshop. Pasadena adopted the commission-manager form of municipal government in 1921.

The community unites each New Year's day in supporting the Tournament of Roses, first introduced in 1890, originally inspired by the "battle of flowers" at Nice, France. After 1916 the festivities were culminated by the Rose Bowl football classic between the champion teams of eastern and western U.S. universities. Pop. (1960) 116,407. For comparative population figures *see* table in CALIFORNIA: *Population.* (J. E. P.)

PASADENA, a city of southeastern Texas in Harris county, U.S., in the Houston (*q.v.*) metropolitan area. It was founded in 1895 by J. H. Burnett and incorporated in 1929. Pasadena owes its rapid post-World War II growth to the stimulation of adjacent industry, chiefly petrochemical plants and oil refineries, on the Houston ship channel, to the north. The city's area of 100.21 sq.mi. is circumscribed by the boundaries of Houston and Deer Park. It is a residential community and many of its citizens are members of organized labour. Immigrants from the Calvinistic region of east Texas form the main population element. Northeast of Pasadena is the site of the capture, in 1836, of Antonio López de Santa Anna, the Mexican president-general, after the battle of San Jacinto.

The population was 58,737 in 1960. For comparative population figures *see* table in TEXAS: *Population.* (G. M. F.)

PASARGADAE, the first dynastic capital of the Achaemenian Empire, situated in the plain of Morghab, Fars Province, southwest Iran, about 30 mi. NE of Persepolis and about 60 mi. NE of modern Shiraz. According to tradition, Cyrus the Great

FRANCES MORTIMER—RAPHO GUILLUMETTE

THE TOMB OF CYRUS II IN PASARGADAE

(559–530 B.C.) chose the site as his capital because it lay near the scene of his historic victory over Astyages the Mede (550 B.C.). The name of the city may well be derived from that of the chief Persian tribe, the Pasargadae, although it is also possible that the original form of the name was Parsagadeh ("the throne of Pars") or Parsagert/Parsagerd ("the fortress of Pars").

As an expression of the architectural genius of the Achaemenians prior to the accession of Darius the Great, when Persepolis replaced Pasargadae as the dynastic home, Pasargadae stands alone. Indeed, the majestic simplicity of the architecture at Pasargadae reflects a sense of balance and beauty that was never equaled in either earlier or later Achaemenian times. The principal buildings stand in magnificent isolation—often with a common orientation, but scattered over a remarkably wide area. Although no single wall enclosed the whole site, a strong citadel commanded the northern approaches and individual enclosure walls protected the more important monuments.

The dominant feature of the citadel, an extensive fortified area including a long line of outer fortifications, is a huge stone platform that projects from the western slopes of a low, conical hill. This imposing structure, which boasts two unfinished stone staircases and a towering facade of rusticated masonry, was evidently intended to form part of an elevated palace enclosure. But before the original plan could be completed some abrupt event, probably to be associated with the death of Cyrus, brought the work to a halt, and, in a revised scheme, a formidable mud-brick structure was erected on the platform instead. Although further excavations may be needed to confirm the theory, it is probable that this great building represents the famous treasury surrendered to Alexander the Great in 330 B.C.

To the south of the citadel, on more or less level ground, an extensive walled park with elaborate, irrigated gardens surrounded a series of royal buildings. Those cleared by modern excavations include a tall, square tower almost identical in size and shape with the Ka'bah-e Zardusht at Naksh-e Rostam; two spacious palaces, each adorned with fragments of sculpture and each bearing trilingual inscriptions in the name of Cyrus; and a fourth building, designed as the sole entrance to the park, which is notable for the unique four-winged figure with a triple-atef crown that still stands on a surviving doorjamb. Once surmounted by a trilingual inscription in Old Persian, Elamite, and Babylonian saying "I, Cyrus, the King, the Achaemenian," this grave-faced figure remains an enigma, regarded by some as a guardian demon and by others as an exceptional portrait of Cyrus himself.

Further south again, the tomb of Cyrus still stands almost intact, its simple lines and massive strength a perfect foil for the rigours of its upland situation. Constructed of huge white limestone blocks, its gabled tomb chamber rests on a rectangular stepped plinth, with seven receding stages. Arrian's account (*Anabasis*, vi, 29) tells of Alexander's grief at finding the tomb open and despoiled on his return from his Indian campaign in 324 B.C. Alexander's general Aristobulus, who was charged with the restoration of the tomb, also left some description not only of the interior furnishings of the monument, in which the body of Cyrus lay in a gold sarcophagus on a gold couch, but also of the tomb's exterior appointments, including a description of the well-watered paradise that once surrounded it. In Islamic times the tomb acquired fresh fame and sanctity as the tomb of the mother of Solomon. During the 13th century large numbers of columns and other building materials were transported from the neighbouring Achaemenian palaces in order to erect a congregational mosque round the base of the monument, and, toward the end of the 14th century, a *madrasa* (religious college) was constructed only 200 yd. to the north of the tomb.

At the extreme southern edge of the site, where the Pulvar River (Rudkhaneh-ye Sivan) cuts through the narrow Bolaghi Pass on its way toward Persepolis, an impressive rock-cut road or canal still indicates the course of the ancient highway that once linked Pasargadae with Persepolis. Finally the northwest corner of the settlement harbours a walled area known as the "sacred precinct," where a large terraced mound looks down on a pair of free-standing fire altars. But, although the whole enclosure undoubtedly witnessed important religious ceremonies, there is still no proof that it contained the famous shrine of Anahita, which is said to have seen the celebration of certain traditional rites at the beginning of each new reign. *See* also PERSIAN HISTORY: *Achaemenid Empire*.

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(DA. B. S.)

PASCAL, BLAISE (1623–1662), French scientist and writer on religious subjects, a man whose genius gives him a unique eminence among modern thinkers, was born on June 19, 1623, at Clermont-Ferrand, where his father, Étienne Pascal, was president of the *cour des aides*. His mother, née Antoinette Bégon, died in 1626; and in 1631 Étienne Pascal moved to Paris. Étienne, who was himself highly respected as a mathematician, devoted himself henceforth to the education of his children. While his sister Jacqueline (born in 1625) figured as an infant prodigy in literary circles, Blaise proved himself no less precocious in mathematics. His *Essai pour les coniques* (1640), based on his study of Gerard Desargues, aroused Descartes' envy by its success in the mathematical world; and, between 1642 and 1644, he conceived and constructed an arithmetical machine to help his father in his calculations (Étienne having been appointed intendant at Rouen in 1639). This machine was regarded by his contemporaries as his main claim to fame, so the youthful pride which appears in his dedication to the chancellor, Pierre Séguier, in 1644 is understandable.

Up to 1646 the Pascal family had held strictly Catholic principles, even if, as a consequence of dividing life into separate compartments, they had often substituted *l'honnêteté* (conventional integrity, polite respectability, decent social behaviour) for inward religion. An illness of his father's, however, brought Blaise into contact with two disciples of the abbé de St. Cyran, who had been director of Port Royal until his death a short time before; and Blaise, himself the first to feel the necessity of entirely turning away from the world to God, won his family over to his point of view (1646). His letters indicate that he was for several years his family's spiritual adviser, but the conflict within himself was not yet resolved. Absorbed again in his scientific interests, he tested Galileo's and Torricelli's theories in Paris and on the Puy de Dôme (1646); and his publications on the problem of

GIRAUDON

BLAISE PASCAL, FROM A PORTRAIT BY PHILIPPE DE CHAMPAIGNE

the vacuum (1647–48) added to his reputation. These latter works, however, gave rise to controversies in which it became clear that self-love was still his ruling passion. When he fell ill from overwork—he was of a weak constitution—his doctors advised him to seek distractions; but what has been described as Pascal's "worldly period" (1651–54) was in fact primarily a period of intense scientific work, during which he composed his *Traité de l'équilibre des liqueurs*, his *Traité de la pesanteur de la masse de l'air* and also his *Traité du triangle arithmétique* (this last a fragment of the *De alea geometriae*, in which he laid the foundations of the calculus of probabilities). By the end of 1653, however, he had begun to feel religious scruples; and the "night of fire" which he experienced on Nov. 23, 1654, he believed to be the beginning of a new life. Though he never became one of the solitaries of Port Royal, it was henceforth only at their request that he was ever to take up his pen.

Les Provinciales.—Though the epistolary form and the pervading spirit of Port Royal serve to give unity to the collection, the 18 *Lettres écrites par Louis de Montalte à un provincial* (Jan. 23, 1656—March 24, 1657), better known as *Les Provinciales*, exhibit wide differences of style and enable us to trace a far-reaching development in the author as his spiritual and his theological potentialities are progressively revealed. Written in defense of Antoine Arnauld (*q.v.*), who was on trial before the faculty of theology in Paris, letters i–iii state the case with comic dramatization. Letter iv deals more profoundly with the question of divine grace, though the character of the Jesuit in it is extraordinarily lifelike. Letters v–ix transfer the argument to the subject of moral theology, which was the weak point of the adversaries of Port Royal; and Pascal quotes freely in their own words the casuists (especially Antonio Escobar), sometimes in a spirit of derision, sometimes with indignation. Indignation is the keynote of letter x (on the love of God), of letters xi–xiv, in which Pascal varies attack and defense, and of letters xv and xvi, in which the persecution of Port Royal is interpreted as the consequence of the Jesuits' policy. In the two last letters, xvii and xviii, dealing with the question of grace, Pascal proposes a conciliatory position that was later to make it possible for Port Royal to subscribe to the "Five Articles" (1663) and to the "Peace of the Church" (1668).

The *Provinciales* were an immediate success, and their popularity has remained undiminished. This they owe primarily to their form, in which for the first time bombast and tedious rhetoric as exemplified by J. L. Guez de Balzac and by Antoine Lemaistre are replaced by variety, brevity, tautness and precision of style; as Nicholas Boileau recognized, they mark the beginning of modern French prose. Something of their popularity, moreover, in fashionable, Protestant or skeptical circles, must be attributed to the violence of their attack on the Jesuits. In England they have been most widely read when "popery" has seemed a danger (for example, after the Restoration of the Stuarts and at the time of the Oxford movement). Yet they have also helped Catholicism to rid itself of laxism; and, in 1678, Pope Innocent XI condemned half of the propositions that Pascal had already denounced. Thus the *Provinciales* played a decisive part in promoting a return to inner religion and helped to secure the eventual triumph of the ideas set forth in Antoine Arnauld's treatise *De la fréquente communion* (1643), which thereafter remained almost unchallengeable until the French church felt the repercussion of the revocation of the Edict of Nantes (1685). Whereas the Jesuits seemed to represent a Counter-Reformation predominantly concerned with orthodoxy and obedience to ecclesiastical authority, the *Provinciales* advocated a more spiritual approach, emphasizing the soul's union with the Mystical Body of Christ through charity.

Further, by rejecting any "double standard" of morality and the distinction between counsel and precept, Pascal aligns himself with those who believe the ideal of evangelical perfection to be inseparable from the Christian life. While there was nothing original in these opinions, Pascal nevertheless stamped them with the passionate conviction of a man in love with the absolute, of a man who saw no salvation apart from a heartfelt desire for the truth together with a love of God that works continually toward destroying all self-love. For Pascal, morality cannot be separated from spirituality. Moreover, his own spiritual development can be traced in the *Provinciales*. The religious sense in them becomes progressively refined after the first letters, in which the tone of ridicule is smart rather than charitable. Contemporary with the *Provinciales*, Pascal's letters to the duc de Roannez and his sister give invaluable evidence of the depth and sensitivity of his religious perception.

Last Years.—"The miracle of the Holy Thorn," of which Pascal's niece was the beneficiary, took place at Port Royal on March 24, 1656; and it was as a consequence of his meditations on miracles and on other proofs of Christianity that Pascal finally decided to write his work of Christian apologetics (*see* below), though his efforts to convert his fashionable friends had prepared his mind for the decision. Between the summer of 1657 and the summer of 1658 he put together most of the notes and fragments that editors have published under the inappropriate title *Pensées;* and in 1658 he outlined his plan to his friends of Port Royal. He was next involved, however, in scientific work again. First, "Messieurs de Port-Royal" themselves asked for his help in composing the *Éléments de géométrie;* and secondly the duc de Roannez suggested that he should publish what he had discovered about cycloid curves (on which the greatest mathematicians of the time had been already working). Once more fame aroused in him feelings of self-esteem; but from Feb. 1659 illness brought him back to his former frame of mind, and he composed the "prayer for conversion" that the Wesleys were later to regard so highly. Henceforth, scarcely capable of regular work, he gave himself over to helping the poor and to the ascetic and devotional life. He took part intermittently, however, in the disputes to which the "Formulary" gave rise, until a difference of opinion with the theologians of Port Royal led him to withdraw from controversy (though he did not sever his relations with them).

After terrible pain, probably from carcinomatous meningitis following a malignant ulcer of the stomach (Lucien Jerphagnon, *Pascal et la souffrance*, 1956), he died on Aug. 19, 1662, assisted by a non-Jansenist parish priest who found him to be "most submissive to the Sovereign Pontiff and to the Church."

Apologie de la Religion Chrétienne.—The fragments of Pascal's great work are preserved in the manuscript known as the *Recueil original.* No edition of them, however, was even approximately correct until that of A. P. Faugère (1844); and for a further century the true plan of the work remained unknown, with the result that editors and readers could feel themselves free to interpret in accordance with modern philosophical preoccupations ideas which to the author had had an exclusively religious meaning. Eventually, thanks to the researches of Z. Tourneur, L. Lafuma, J. Mesnard and Mrs. A. Barnes, it was proved that the two "copies" in the Bibliothèque Nationale give the text of a provisional grouping made by Pascal himself in 1658. This doubtless is only a program of work and would have been replaced, in the completed book, by a complex structure developing the thought on several planes as in a musical composition (this can be seen from the way in which major themes recur again and again in the text). The division of the manuscript into 27 files reveals, however, a highly dramatic approach toward a climax and settles decisively a number of points on which previous editors were in doubt with regard to the progress of the argument and the significance of certain details. The first part of the *Apologie*, then, would have drawn a portrait of man without divine grace. Pascal shows him as an incomprehensible mixture of greatness and abjectness, since he is incapable of truth or of reaching the supreme good to which his nature nevertheless aspires. A religion that accounts for these contradictions—which philosophy and worldliness fail to do—is for that very reason "to be venerated and loved." The next chapters are transitional, dealing in an extremely complex way with the psychology of the *libertin* or emancipated freethinker and with the method of approach to be adopted before presenting him with revealed truth. The indifference of the skeptic is to be overcome by means of the "wager" (*le pari*); the true function of reason is demonstrated; and Pascal insists that we must bring men to God through Jesus Christ alone, since a creature could never know the Infinite if Jesus had not descended to assume the proportions of our fallen state. This exposes the error of other religions and even

of those worldly Christians who do not sincerely seek the truth. Light and darkness are so closely interwoven that only the pure vision of one who has triumphed over self-love can know the validity of the Christian position, even though history itself is full of rigorous proofs of it. The second part of the *Apologie*, complementary to the first part, begins by applying the Augustinian theory of allegorical interpretation to the biblical types (*figuratifs*); it then reviews the rabbinical texts, the persistence of true religion, the work of Moses and the proofs of Jesus Christ; and finally it gives a picture of the primitive church, the fulfilment of the prophecies. The grouping as shown in the "copies" concludes with reflections on the Mystical Body, which demands the renunciation of self-love; and on the faith of the humble, which does not ask for proofs. The *Apologie*, then, is a treatise of spirituality. Pascal is not interested in making converts if they are not going to be saints.

Pascal's apologetic has stood the test of time, but it is primarily addressed to individuals of his own acquaintance. To convert his *libertin* friends, he looks for arguments in their favourite authors: in Michel de Montaigne, in Pierre Charron, in the more or less heterodox followers of Nicolaus Cusanus and perhaps also in Pierre Gassendi and in Thomas Hobbes. For him, however, skepticism is but a stage. Man would not be wretched if nostalgia for his original state did not make him conscious of his wretchedness. Likewise, the fall of man is stressed to counterbalance Neoplatonic tendencies, in such a way as to enable Pascal to found an immanentist apologetic on the impossibility of the "state of pure nature" (*status purae naturae*) without having to protect himself against an idealist interpretation. Modernist theologians in particular have tried to make use of his main contention, that "man is infinitely more than man," in isolation from his other contention, that man's present wretchedness is explicable only as the effect of a fall, about which moreover we can learn what we need to know from history. This, however, is to sacrifice the second part of the *Apologie* to the first, to keep the philosophy while losing the exegesis; and it also counteracts Pascal's whole purpose by establishing deism instead of the actual coming of a Redeemer. For Pascal as for St. Paul, Jesus Christ is the second Adam, inconceivable without the first.

Finally, too, Pascal expressly admits that his psychological analyses are not by themselves sufficient to exclude a "philosophy of the absurd"; to do so, we must have recourse to the convergence of these analyses with the "lines of fact" concerning Revelation, this convergence being too extraordinary not to appear as the work of Providence to an anguished seeker after truth (*qui cherche en gémissant*).

At once a physicist, a mathematician, an eloquent publicist in the *Provinciales* and an inspired artist in the *Apologie* and in his private notes, Pascal was embarrassed by the very abundance of his talents. A. Koyré suggests that it was his too concrete turn of mind that prevented his discovering the infinitesimal calculus; and in some of the *Provinciales* the mysterious relations of the person with God are treated as if they were a geometrical problem. But these considerations are far outweighed by the profit that he drew from the multiplicity of his gifts; his religious writings are rigorous because of his scientific training; and his love of the concrete emerges no less from the stream of quotations in the *Provinciales* than from his determination to reject the method of the *Summa contra gentes* in his *Apologie*. Finally, it is as a unique experience that the moment when he believed himself to have been raised above the faculties with which nature had endowed him should be viewed; the *Mémorial* was constantly to remind him of this.

See also references under "Pascal, Blaise" in the Index.

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PASCHAL (Paschalis), the name of two popes and one antipope.

St. Paschal I (d. 824), pope from 817 to 824, was a Roman. Elevated immediately after the death of Stephen V (IV), in Jan. 817, he informed the emperor Louis the Pious, who confirmed the independence of the Holy See and the Romans' right to freedom of election. In 823 Paschal crowned Louis's son Lothair I as co-emperor. Some of Paschal's servants executed two papal functionaries who were thought to favour imperial control of Rome; the pope swore to his innocence of the crime. He intervened without success against the revival of iconoclasm in the east. Paschal I died in May 824. (A. G. Bi.)

Paschal II (Ranierus, of Bieda, Ravenna) (d. 1118), pope from 1099 to 1118, was born at Bieda di Galeata, near Ravenna. He entered a Cluniac monastery as a boy, was made a cardinal by Gregory VII about 1080, and was elected pope Aug. 13, 1099, succeeding Urban II. Paschal followed Gregory VII's policies (*see* Gregory), as had his predecessor but with less success. The long conflict of popes and rulers over which authority was supreme in the church now centred on the right of investiture for major church offices (*see* Investiture Controversy). This problem dominates Paschal's reign, although he also fostered the crusade cause. Settlements were made between St. Anselm and Henry I for England and with Philip I for France in 1107; but Paschal continued the conflict in Germany with Henry IV and Henry V (*see* Henry [German kings]). One agreement preliminary to Henry's coronation was vehemently rejected by the German prince-bishops, and Paschal's consent (after two months' harsh captivity) to the full demands of the king irked the Gregorian party. Paschal revoked this extorted act and renewed his earlier condemnations of regal investiture, but the problem remained unsolved until 1122, when Calixtus II concluded the Concordat of Worms. Paschal II died Jan. 21, 1118.

Paschal III (Guido of Crema) (d. 1168), antipope from 1164 to 1168, was one of the original supporters of the antipope Victor IV against Alexander III. Guido succeeded Victor on April 22, 1164, through the influence of Reinald of Dassel, Frederick I's chancellor and vicar in Italy, but he won only limited allegiance even in the empire. Enthroned when Frederick took Rome, Paschal crowned him emperor (Aug. 1167), but had to accompany his retreating army. His successor, antipope Calixtus III, was a less significant figure. Paschal died Sept. 20, 1168.

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Paschal III: H. K. Mann, *Lives of the Popes in the Middle Ages*, 2nd ed., vol. x (1925). (J. J. Rn.)

PASCHAL CHRONICLE (*Chronicum Alexandrinum* or *Constantinopolitanum*) was originally an outline from Adam to A.D. 628 (only extant to 627) with historical and theological notes and an introduction on Christian chronology and the Easter cycle (hence the name "Paschal" Chronicle). It was written under the emperor Heraclius (610–642) by a Byzantine cleric in the circle of the patriarch Sergius. It uses the so-called Byzantine era that calculated the creation from March 21, 5507 B.C. (which with slight modifications continued in general use in the Greek Church until its liberation from Ottoman rule in the 19th century). It was a popular work; the part covering the 7th century is of independent historical value.

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PASCHAL CONTROVERSIES, controversies in the early Christian Church about the correct date for keeping Easter (Gr. *pascha*), the annual festival in commemoration of the resurrection of Jesus Christ from the dead. The earliest of these controversies was about whether Easter should be celebrated always on a Sunday or on the actual day of the Jewish lunar month (14th of Nisan) when the resurrection was reckoned to have taken place. The latter practice, followed by the church in the Roman province

of Asia, was generally condemned at the end of the 2nd century, because it meant celebrating Easter at a time when the Jews were keeping Passover. Later controversies concerned the different methods of calculating the paschal moon, until in the 6th century the computations of Dionysius Exiguus were generally accepted in the West (*see* CALENDAR: *Western;* CHRONOLOGY: *Christian*). The Celtic Church, however, did not come into line until the 7th century, and there were some difficulties in Gaul in the 8th century. (*See* also EASTER.)

Easter in the Orthodox Eastern Church is often kept on a later Sunday than in the West, partly because it adheres to the Julian calendar for the movable year. In the West the subject has ceased to be controversial, and the second Vatican Council stated in 1963 that there was no objection in principle to keeping Easter always on a fixed Sunday (probably in early April). Because Good Friday and Easter Monday as well as Ascension Day, Whit Monday, and Corpus Christi (which also vary in date according to Easter) are public holidays in many countries, it would be convenient if Easter did not wander over so long a period as five weeks (between March 22 and April 25 inclusive).

PASCHASIUS RADBERTUS, SAINT (d. *c.* 865), fourth abbot of Corbie (near Amiens, in France), author of the first monograph on the Eucharist, was born near Soissons. Though well read in the Scriptures, Fathers, and pagan writers (certainly the Latin, perhaps even the Greek), he was of such humility that upon election as abbot he refused advancement from deacon to presbyter. During his reign there were disturbances in the monastery, for among the monks were the unfortunate Gottschalk and also Ratramnus (*qq.v.*), both of whom showed marked independence of thought. Paschasius wrote 12 books of commentary on Matthew, an exposition of Ps. 44, five books on Lamentations, besides several minor works, but he is principally now to be remembered for his earliest writing (831), *The Lord's Body and Blood.* Its importance is due to the contrast it shows with Ratramnus' *Christ's Body and Blood,* of slightly later date, which often expresses opposite views.

The chief difference between the two concepts of the Eucharist is that for Paschasius the bread and wine on the altar become, after consecration, the true body and blood of Christ, whereas for Ratramnus they are symbolically such. Paschasius is also very explicit that the true body and blood are identical with the natural body and blood visible during the Lord's life on earth and now reigning in heaven, another point on which Ratramnus takes a contrary view. For Paschasius *figura* means "outward appearance" and *veritas* "what faith teaches," but to Ratramnus they are, respectively, "what faith teaches" and "what is perceptible to the senses." During the next centuries Paschasius' views came to dominate the field, particularly during the controversy associated with Berengar (*q.v.*) of Tours, and though Roman Catholic writers are now not unwilling to see faults in Paschasius, he remains to them quite orthodox. His feast day is April 26. *See* also TRANSUBSTANTIATION.

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PASCHEN-BACK EFFECT: *see* ZEEMAN EFFECT.

PASCIN, JULES (JULIUS PINCAS) (1885–1930), an outstanding painter of the school of Paris and a typical internationalist of the early 20th century, was born in Bulgaria of Italian-Serbian and Spanish-Jewish parents. He spent a number of years in Austria and Germany working for such satirical journals as the *Lustige Blätter* and *Simplicissimus.* In 1905 he moved to Paris, where he continued to produce tragically satirical drawings of the underworld. The outbreak of World War I caught him away from France. He traveled for awhile in the United States where he became a citizen, and Cuba, returning to Paris in 1920. There he began painting a series of large-scale, representational, and very sensitively drawn biblical and mythological themes, as well as portraits. Later he turned to the material for which he is generally known, the delicately toned, thinly painted but poetically bitter and ironic studies of decadent female types, generally prostitutes. These suggest an analogy to Henri de Toulouse-Lautrec, but Pascin's characters have an individual grace and perverse tenderness that bespeak a personal identification with these creatures of sorrow. On the eve of an important one-man show of his work in 1930, Pascin committed suicide.

See Horace Brodzky, *Pascin* (1946) and Paul Morand, *Pascin* (1931). (B. S. Ms.)

PASCO, a department in the highlands of central Peru, bounded north by Huánuco, east by Loreto, southeast by Cuzco, south by Junín and west by Lima. Area 8,438 sq.mi. The department was created in 1944 out of the northern part of Junín. Pop. (1961) 126,463. The western part of the area is very high and rugged. Cerro de Pasco (*q.v.*), pop. (1961), 5,720, the capital of the department and major mining centre, is located on a gently rolling high-level surface at an elevation of 13,973 ft. Above this surface there are discontinuous ranges and clusters of peaks which reach elevations of over 18,000 ft. above sea level. The western part of Pasco is drained by the headwaters of the Río Huallaga. The eastern part of the department, on the other hand, is on the steep, rain-drenched slopes of the Andes and the forested plains beyond. This area is drained by the Río Pachitea, a river that descends through a narrow canyon to the eastern plains and then meanders through the lowland forests to join the Río Ucayali, one of the Amazon headwaters.

The western part of Pasco is one of the world's greatest mining regions. Silver ores at Cerro de Pasco were discovered in 1630, and during the Colonial Period silver was Peru's distinctive product. In the modern period, copper is more important than silver; but in addition to copper, there are gold, lead, zinc, bismuth, and vanadium. Bismuth is extracted from the dust in flues of the copper smelters. Vanadium comes from mines at Mina Ragra, more than 16,500 ft. above sea level. Coal of good quality is mined at Goyllarisquizca and Quishuarcancha.

At the higher altitudes of western Pasco cattle and sheep are pastured. The highest crop is the potato and below that the Indians grow wheat and barley. On the lower eastern slopes, colonies of pioneer farmers raise coffee, cacao, sugarcane, coca, rice, and maize. The high cost of transportation, however, permits only the sale of high-value products such as *aguardiente* (sugar brandy). (P. E. J.)

PASCOAIS, TEIXEIRA DE (real name JOAQUIM PEREIRA TEIXEIRA DE VASCONCELOS) (1878–1952), founder of the *saudosista* movement in Portuguese poetry, was the most notable and inspired poet-philosopher in Portugal in the first half of the 20th century. An intuitive and inspired visionary, Pascoais, though unsuccessful in his attempt to create a species of nationalistic mystique based on *saudade* (an untranslatable and typically Portuguese feeling: a fusion of hope with nostalgia), produced some of the most original work in Portuguese poetry. He was born Nov. 2, 1878, at São Gonçalo de Amarante in the Douro region. He studied at the University of Coimbra, taking his degree in law. For a time he practised law in Oporto but soon went to live on his estate at Pascoais (from which he took his pseudonym) in the Marão mountains.

His first volume, *Embriões,* appeared in 1895, when he was 17. But it was in 1898 that he made a name with the publication of the collection of verse entitled *Sempre,* the first revelation of his *saudosista* outlook. This developed in succeeding volumes—*Terra Proibida* (1899), *Jesus e Pan* (1903), *Para a Luz* (1904)—and gave rise to the movement known as *Renascença Portuguesa,* founded by Pascoais at Oporto in 1912, with its review *Águia. Maranos* (1911) and *Regresso ao Paraíso* (1912) are the two volumes most deeply inspired by *saudosismo,* a mingling of intuitive thought and mystical lyricism. Fernando Pessoa called the essence of Pascoais' lyricism "pantheistic transcendentalism," and it was this that Pascoais wanted to turn into a kind of religion for the Portuguese people. In *Águia* and in some of his books of this period—*O Saudosismo* (1913), *O Génio Português* (1913), *A Arte de ser Português* (1915) and *Poetas Lusiadas* (1918)—he expounded rather nebulously his *saudosista* thought. Later he

devoted himself to writing long biographies in prose—a prose interwoven with poetic passages—of which *São Paulo* (1934) is the most notable. Some were translated into German and were highly esteemed in German-speaking lands.

Pascoais was much discussed and denounced as a "thinker" because his thought is more poetry than philosophy, properly speaking. At the time of his death (at Pascoais on Dec. 14, 1952) he was recognized as the greatest poet in Portuguese.

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PASCOLI, GIOVANNI (1855–1912), Italian poet and scholar, author of graceful, melancholy lyrics, was born at San Mauro, Romagna, on Dec. 31, 1855. An orphan from childhood (his father was murdered), he knew poverty and when a student was imprisoned for socialist activity. In 1882 he became a secondary schoolteacher. He later held professorial appointments at a number of Italian universities and in 1905 succeeded to the chair of Italian literature at Bologna, where he died on April 6, 1912.

Pascoli's first poems, *Myricae*, which won him popularity in 1891, are short, delicate, musical lyrics inspired by nature and a rather feminine choice of themes (the family, the home, the garden, children, and birds). His *Canti di Castelvecchio* (1903) contains moving evocations of the poet's sad childhood and meditations on his lonely life. His Latin poems (*Carmina;* 1914) and the *Poemi Conviviali* (1904) show his erudition and refinement as a classical scholar.

Pascoli's *Opere* were edited by A. Mondadori and published in 1952.

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PAS-DE-CALAIS, a *département* of northern France formed in 1790 of nearly the whole of Artois (*q.v.*) and adjacent districts of Picardy (*q.v.*). It is bounded northeast and east by the *département* of Nord, south by Somme, and to the west and northwest extends to the coast of the Strait of Dover (Pas-de-Calais). Area 2,607 sq.mi. (6,752 sq.km.). Pop. (1962) 1,366,282. Rolling chalk country occupies most of the *département*. The chalk anticline of Artois, extending inland through Pas-de-Calais, separates the Paris Basin from that of Flanders. Round Boulogne the chalk arch has been breached to expose the varied strata underneath, and within its chalk frame the Boulonnais forms a hilly district that is the southeastward prolongation of the English Weald. Reaching 700 ft. in the highest part, the chalk hills of Artois form a watershed, whence the Rivers Aa, Lys, Scarpe, and Escaut drain northeast toward Flanders. Near Calais and Saint-Omer the chalk passes under the cover of Tertiary deposits that form the plain of Flanders. The chalk cliffs of Cape Gris-Nez and Cape Blanc-Nez (above 400 ft.) are replaced to the east by a flat, dune-fringed coast, backed by reclaimed marshland, intersected by drainage canals, and intensively devoted to dairy farming and market gardens. South of Boulogne a strip of alluvium, built up by longshore drift, now separates the chalk cliffs from the shoreline, and the estuaries of the Canche and Authie are encumbered with silt. The tract of former marshland, known as the Bas Champs de Marquenterre, has also been reclaimed for meadows and market gardens. Inland on the chalk the soils vary in fertility, but where, as often, the chalk is covered with *limon* they are exceptionally fertile. These tracts especially are the domain of sugar beet. Wheat and fodder crops, the other mainstays of the cropping system, are more widespread. A great variety of other crops is grown, but the extent of some industrial crops, such as flax, hemp, and colza, has been much reduced, whereas fodder crops have increased. Great numbers of livestock are maintained for the production of meat and dairy produce. The agricultural population lives mainly in clustered villages, in which the farm buildings are characteristically grouped round courtyards.

France's major coalfield, buried under the chalk, extends into Pas-de-Calais from the neighbouring *département* of Nord, west of Douai, and the mining area stretches west beyond Béthune. There are large coking plants and the chemical industry has experienced a considerable expansion since World War II at Mazingarbe. Iron and steel works are especially important near Lens and Hénin-Liétard, but there are others at Isbergues and Boulogne. In a belt from near Boulogne, past Arras, are numerous cement works using the chalk marl. Sugar refining, alcohol distilling, brewing, and flour milling are characteristic and important industries.

Calais, in addition to its importance for cross-Channel passenger traffic, is a considerable cargo port and is connected with the canal system of Flanders. Its lace industry is well known. Boulogne is primarily a fishing port, the largest in France, important both for herring and for long-distance trawling. Both Calais and Boulogne suffered heavily from repeated aerial bombardment during World War II. Elsewhere along the coast are numerous seaside resorts, notable among them the fashionable Le Touquet-Paris-Plage. The *département* is crossed by a network of roads, several centring on Arras. The principal railways are Calais–Paris, Calais–Saint-Omer, and Béthune–Lens–Arras–Amiens.

Arras, former capital of Artois, on the Scarpe, is the *préfecture* of the *département* and centre of the bishopric. The *département* comes under the court of appeal at Douai and, for education, under the *académie* of Lille. It comprises seven *arrondissements*, centred upon Arras, Boulogne, St. Omer, Béthune, Calais, Lens, and Montreuil.

Pas-de-Calais was the scene of very heavy fighting during World War I and there are several large war cemeteries and monuments, notably on Vimy Ridge. Near Hesdin is the historic site of the Battle of Agincourt (1415). (AR. E. S.)

PASHA, a Turkish title, derived from the Persian *padshah* (*padishah*) and influenced by the Turkish *bashak*. It was the highest official title of honour in the Ottoman Empire, always used with a proper name, which it followed. It was given to soldiers and high civil officials, not to men of religion, and was purely personal and not hereditary, except in 19th-century Egypt. Very occasionally in early times it was applied to a woman; *Validepasha* was the title of the mother of the pasha of Egypt.

The title first appeared in the 13th century among the Seljuks. Among the Ottomans it was given to a brother and son of Sultan Orkhan. Later it became the prerogative of provincial governors and the viziers of the central administration. In the Tanzimat period (19th century) its use was extended to the four highest grades of the civil and military services.

On the fall of the Ottoman dynasty pasha was reserved only for soldiers but, even after the Turkish Republic finally abandoned its use in 1934, the title survived in former Ottoman possessions; *e.g.*, in Egypt and Iraq. By Turks it is still used in conversation as a mark of respect to a social superior, though sometimes in an ironic tone. (A. D. A.)

PASHTO (PUSHTU, PAKHTO), the language of the Pathans, living in eastern Afghanistan (chief city Kandahar) and in northern West Pakistan (chief city Peshawar). The number of Pashto speakers has been estimated at 10,000,000–12,000,000, with roughly equal numbers in the two countries.

Pashto is an East Iranian language (*see* IRANIAN LANGUAGES) with strong Indian influence, many Arabic and Persian loanwords, and many archaic Iranian features. It is written with a modified Arabic alphabet. There are two main divisions of the many dialects: the southern, which preserves ancient *sh* and *zh* sounds as a prominent characteristic, and the northern (chiefly in Pakistan), with *kh* and *gh* sounds instead—hence the forms Pashto and Pakhto for the name of the language. The grammar is more complicated than that of modern Persian.

Pashto became prominent only after creation of the Afghan State in the 18th century. It is the national language of Afghanistan, which recognizes Persian as a second language.

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PASHUPATI, a sacred site of Nepal, with an ancient Shaivite temple of Pashupatinath, lies near Katmandu on the

Bagmati River where it flows through a small gorge. It is regarded by the Nepalese as the Benares (Varanasi) of Nepal, and for Hindus elsewhere it is the holiest place in that country. The temple is built in pagoda style with gilt roof, and the banks of the Bagmati are paved for several hundred yards. There are also numerous shrines in the vicinity. At the Shivratri festival in February or early March many pilgrims visit the shrine from distant places, mostly in India, in spite of the rigours of the climate. Pious Hindus also go there to die, in the belief that they will find salvation if they die with their feet in the sacred waters of the river at Pashupati. (RI. R. P.)

PAŠIĆ, NIKOLA (1845–1926), Serbian and later Yugoslav statesman, 22 times prime minister and 17 times foreign minister, was born at Zaječar on Dec. 18 (new style; Dec. 6, old style), 1845, the son of a shopkeeper and farmer. A student of engineering, he was sent with a state bursary to the University of Zürich, where he came temporarily under the influence of Mikhail Bakunin. Soon, however, he adopted the socialist views of Svetozar Marković (*q.v.*), of which he became one of the foremost exponents. Having returned to Serbia, he volunteered in 1875 to help the anti-Turkish insurgents in Bosnia-Hercegovina and there met Peter Karageorgevich, later king of Serbia. Elected to the Serbian parliament in 1878, he was one of the founders of the Radical Party in 1881.

An armed rising, the so-called Timočka Buna, which broke out at Zaječar in 1883 led to the arrest of most of the Radical leaders and fresh repressive measures. Pašić fled across the Danube and was condemned to death *in absentia*, remaining in exile until after King Milan Obrenovich's abdication in 1889. While in exile he made friendships in Russia, Bulgaria, and Rumania invaluable to him later on. He became an ardent Russophile and supporter of the Karageorgevich dynasty. On his return he was elected speaker of the national assembly and on two occasions mayor of Belgrade. He was prime minister from February 1891 to August 1892, and as foreign minister accompanied the young King Aleksandar Obrenovich on his first visit to the Russian emperor. He was made Serbian minister in St. Petersburg in 1893 but resigned in 1894 in protest against King Milan's illegal return to Serbia. The Radicals were now in keen opposition, and when an attempt was made on Milan's life in 1899 the government rid itself of their leaders by trumped-up charges of engineering the crime. As a result of Russian remonstrances, Pašić was soon amnestied on condition of leaving the country. He returned after Milan's final withdrawal. After the fall of the Obrenovich dynasty in 1903 the Radical Party became dominant, and Pašić was foreign minister in 1904 and prime minister in 1905 and again from 1909 to 1911. He shared in Milovan Milovanović's negotiations for a Balkan league and on Milovanović's death in 1912 resumed the premiership. He remained in office throughout the Balkan Wars and contributed toward the alliance with Greece and the rapprochement with Rumania.

Pašić remained prime minister throughout World War I. He was interested in the union with Serbia of provinces inhabited predominantly by Serbs, but not in the formation of a federal Yugoslavia with Serbs, Croats, and Slovenes autonomous and equal.

The Russian Revolution of March 1917 weakened Pašić's position both at home and abroad, forcing him to relinquish his plans for a greater Serbia and to negotiate, on equal terms with the Yugoslav Committee under Ante Trumbić, the so-called Declaration of Corfu (July 20, 1917), which laid down the broad lines of the future unified Yugoslav state. But his relations with the committee became increasingly strained, and he stubbornly denied to the members any status in the Allied camp and refused to admit them to a coalition cabinet. Austria-Hungary collapsed before any agreement was reached among the Allies on the Yugoslav problem; and Italy, abandoning the compromise reached in Rome at the Congress of Oppressed Nationalities of Austria-Hungary (April 1918), reasserted its full territorial claims under the secret Treaty of London. Even so, Pašić still maintained his obstructive tactics not merely toward the Yugoslav Committee but also toward the new provisional government which had been formed in Zagreb. Finally, on Dec. 20, 1918, a compromise was reached, and while Stojan Protić became the first prime minister of Yugoslavia, Pašić was made first delegate to the peace conference, with Trumbić and Milenko Vesnić as his colleagues.

In January 1921 Pašić again became prime minister and, mostly because of the abstention of the Croatian Peasant Party, was able to steer the new centralist constitution through parliament (June 28, 1921). Having maneuvered his Democratic allies out of the government in December 1921, he made three more coalitions before forming a minority Radical government in April 1923; and between March and July 1924 he headed two further coalition governments. Then, after giving place to a Democratic coalition which lasted 100 days, Pašić in November 1924 returned to power stronger than ever. In February 1925 he again dissolved parliament, threw Stjepan Radić (*q.v.*) and his colleagues of the Croatian Peasant Party into prison and, by the adoption of drastic electoral measures, secured a small working majority. Radić thereupon made his famous recantation and entered the cabinet in October, after another rebuilding of the Pašić's coalition government. The two strongest parties in Yugoslavia were now temporarily united; but the situation became increasingly difficult. Pašić, whose health was failing, relinquished the premiership on April 4, 1926, and died in Belgrade on the following Dec. 10.

The Radical Party, inspired by the doctrines of Marković, had stood originally for social reforms and peasant democracy and had been the first really popular and broadly organized party in Serbia. Led by men like Pašić, it soon became nationalist, Russophile and devoted to the Karageorgevich dynasty. It used its power effectively for the aggrandizement of the country. In spite of its great service to Serbia, its outlook was too narrow to enable it to create a stable and democratic Yugoslavia or to deal successfully with social and economic problems; and that narrowness of outlook it owed chiefly to Pašić, its greatest leader.

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PASKEVICH, IVAN FEDOROVICH (1782–1856), Russian army officer and administrator who suppressed the Polish insurrection of 1831, was born at Poltava on May 19 (new style; 8, old style), 1782. He entered the army through the imperial institution for pages in 1800 and saw much active service, notably in the wars with Turkey (1806–12 and 1828–29), France (1812–14), and Persia (1826–28). His conquest of the Armenian province of Erevan earned him the title count of Erevan.

Paskevich participated in the trial of the Dekabrists and in 1827 was made governor of the Caucasus, where he treated Dekabrist exiles with severity. By 1829 he was general field marshal. In 1830 he subdued the mountaineers of Daghestan.

In 1831 Paskevich was appointed commander in chief of the Russian forces against the insurgents in Poland. After the fall of Warsaw he was created prince of Warsaw and appointed viceroy of Poland, which he ruled dictatorially from 1832 to 1856, trying to russify the country. On the outbreak of the Hungarian insurrection in 1848, he commanded the Russian troops sent to the aid of the Austrian government. It was he who compelled the surrender of the Hungarians at Világos. His command during the Polish rebellion had been overcautious and indecisive. He displayed even less effective leadership during the Hungarian insurrection; he could claim little credit for the Russian victory. During the Crimean War he commanded the Army of the Danube (April–June 1854), but was worsted by the Turks at Silistria (June 8, N.S.). He died in Warsaw on Feb. 1 (N.S.; Jan. 20, O.S.), 1856.

See Prince Shcherbatov, *Le Feld-Maréchal Prince Paskévitch: sa vie politique et militaire*, 6 vol. (1888–99). (G. A. Lr.)

PASQUEFLOWER, the name for certain spring-flowering anemones, floral emblems of Easter, members of the buttercup family (Ranunculaceae). They are low, stemless, densely silky-haired perennial herbs, rising from thick rootstocks. They have long-stalked, deeply cut leaves and large purple or lavender flowers, followed by a dense cluster of dry, one-seeded fruit (achenes) with long feathery tails (styles).

The American pasqueflower (*Anemone patens*), called also prairie smoke and hartshorn plant, has light bluish or pale lavender flowers; it is abundant on prairies from northwestern Arctic America southeastward to Michigan, Illinois, Missouri, and Texas. The European pasqueflower (*Anemone pulsatilla*), with violet-purple flowers, is widespread on the continent and grows in chalky pastures in England.

Both species, sometimes assigned to a separate genus, *Pulsatilla*, are planted in gardens, especially in some of their horticultural forms, some of which have red flowers or variegated leaves.

PASQUIER, ESTIENNE (1529–1615), French lawyer and man of letters, famous for his part in some remarkable trials, for his speeches, his letters, and, especially, for his encyclopaedic *Recherches de la France*, ten volumes (1560–1621). He was born in Paris on June 7, 1529, and from 1546 to 1548 studied in Paris, Toulouse, Pavia, and Bologna. Called to the Paris bar in 1549, he made his name in 1565, when he defended the University of Paris against the Jesuits, to whom the university wished to deny the right to teach. Later he defended a number of important causes and famous people, acting as counsel to many of the nobility in cases connected with property, notably that of the Duc de Guise (Henry de Lorraine) in his claim to the vicomté de Martigues (1573). He was *commissaire* at the *Grands Jours* (an assize court) at Poitiers in 1579 and at Tours in 1583, and in 1585 Henry III appointed him advocate-general at the Paris *Chambre des Comptes*.

Pasquier's first publication, the *Monophile* (1554), discusses marriage, fidelity, and love. In 1557 he married a young widow whom he had defended in court, and had several children by her. He fell ill in about 1560, and withdrew to the Saintonge, and it was then that he began to publish his *Recherches*, a work which bears witness to his wide knowledge, especially in the history of monarchic institutions and French literature, and which also reveals him as an excellent prose writer, and an unusually shrewd literary critic and observer of the contemporary scene. His letters, three volumes of which were published in 1619, complement his *Recherches* in that they often deal with political, military, historical, literary, and linguistic problems. His *Pourparler du Prince* (1560) considers the best form of government and the qualities desirable in a king.

Pasquier published much inferior French and Latin verse, including a contribution to the famous anthology on the flea of Mme des Roches, a patroness of literature at Poitiers (*La Puce de Mme des Roches*, 1579). His bitterly satirical *Catéchisme des Jésuites ou examen de leur doctrine* appeared in 1602, but a remarkable work on jurisprudence, *L'Interprétation des Institutes*, remained unpublished until 1847.

Pasquier died in Paris on Aug. 30, 1615.

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PASQUIER, ÉTIENNE DENIS, Duc (1767–1862), French statesman who served the First Empire, the Restoration, and the July Monarchy and was the last chancellor of France, was born in Paris on April 21, 1767, a descendant of the great Estienne Pasquier (*q.v.*). Following his father's example, he became a counselor in the Paris *parlement* (1787); but during the Terror his father was guillotined (1794) and he himself was arrested as a Royalist. Set free by the Thermidorian reaction, he resumed his career as a lawyer and was selected by Napoleon for a barony (1808), for appointment to the council of state, and finally for the prefecture of police (1810). Though he let himself be surprised by the conspiracy of C. F. de Malet in 1812 and was regarded as incompetent by sincere Bonapartists, he retained the prefecture till the first Restoration (1814). Under Louis XVIII he was director of highways and bridges (May 1814–March 1815), twice keeper of the seals or minister of justice (July–September 1815 and January 1817–December 1818), and foreign minister (November 1819–December 1821), being created a peer of France in September 1821. Under Charles X he opposed the extreme reaction of the Ultras. When the July Revolution had made Louis Philippe king of the French, Pasquier was made president of the Chamber of Peers (August 1830). In this capacity he sat as supreme judge in the subsequent political trials, both of Charles X's former ministers and of Bonapartists and Republicans. He was named chancellor of France when that office was revived in May 1837; and in December 1844 he was created duc, the hereditary succession being secured to his adoptive son E. A. G. d'Audiffret-Pasquier. On the revolution of February 1848, the duc Pasquier retired from public life. He died in Paris on July 5, 1862. His memoirs appeared in six volumes in 1893–95 (partial English translation 1893–94). (Je. V.)

PASSACAGLIA (Italian variant of Spanish *pasacalle*—"street song"). Famous as a musical form in slow ¾ time, and little known as a court dance, the *passacaglia* appeared in the French theatre of the 17th and 18th centuries as a dance of imposing majesty. Its musical structure is identical with that of the *chaconne*, but futile attempts have been made to discover differences between them. The Baroque composers used both terms indiscriminately, writing fine examples of the rondo, theme and variations, and *passacaglia* forms under both designations. The true *passacaglia* form consists of a series of divisions (like variations) over a ground bass. Bach's great Passacaglia is an outstanding example. *See* Chaconne; Variations. (L. Ht.)

PASSAGE RITES. This term was devised in 1909 by the French anthropologist and folklorist Arnold van Gennep to emphasize the structural analogies among rites marking birth, initiation, marriage, death, etc., all of which were suggested as having the common purpose of ensuring a person's passage from one social status to another.

The basic pattern of passage rites seems to imply the underlying theory that the individual must go through the form of dying, so as to be reborn under a new guise. The different stages of the rituals everywhere exhibit a remarkable similarity: the exclusion of the noninitiated or profane members of the group; the confinement of the candidate from a few hours up to several years; the celebration of a feast; the robing and unction of the candidate; his renaming; the symbolical fight between the forces of life and death and the victory of the former, etc.

While there is no doubt that Gennep had unveiled a fundamental aspect of social life, his term came to be used indiscriminately so that every rite is sometimes considered to be a passage rite. But, as pointed out by A. M. Hocart, "passage from one sphere to another is the result of these ceremonies, not their cause," and therefore passage rites cannot be explained as a protection against emotional stress resulting from important happenings in the life of the individual. It is the rite which makes certain happenings important and thus provokes stress, not the opposite. How can the similarity of passage rites be explained, if their origin is not emotional? The purpose of the birth ceremony is to introduce the child to his or her society and subsequent ceremonies, such as those marking initiation and puberty, marriage, parenthood, installation of a chief or priest, etc., have the similar purpose of admitting the individual into a new and better-defined status. Death ceremonies may be considered as marking the admission of the deceased to the society of the dead or of his ancestors.

Hocart thought that all passage rites could be reduced to a common prototype, *i.e.*, the ritual of kingship, since, in several archaic civilizations, a man had to be killed (really or symbolically) in order to become a king or a god. This would mean that all human societies, even those of the simpler type, should be considered, at least in this respect, as heirs to a few protohistoric civilizations such as Egypt and India. It may, however, be more likely that numerous cultures tried independently to symbolize important social events on the model of the momentous natural events of birth and death.

See also Age Set; Churching of Women; Circumcision; Funerary Rites and Customs; Mana; Mystery; Purification; and references under "Passage Rites" in the Index.

See A. van Gennep, *The Rites of Passage*, trans. by M. B. Vizedom and G. L. Caffee (1960); A. M. Hocart, *Social Origins* (1954). (C. Le.-S.)

PASSAIC, a city of Passaic County, N.J., U.S., on the Passaic River 9 mi. above Newark and 4 mi. below Paterson. The site was settled by the Dutch in 1678 when Hartman Michielsen established a fur-trading post. During the American Revolution, Gen. George Washington's troops occupied the village and, following their retreat, Lord Cornwallis and his British soldiers were quartered there.

Acquackanonk, as it was originally known, became a river port and shipping point for foodstuffs raised on neighbouring farms and textiles from the nearby Paterson mills. Completion of the Morris Canal between Newark and Phillipsburg in 1831, and the advent of the railroad brought an end to the thriving river commerce.

The present name, Indian for "peaceful valley," was adopted in 1854 and in 1873 the village was incorporated as a city. The completion of a dam in the 1850s resulted in Passaic becoming a textile centre. Cottons first predominated and then woolens moved to the fore. In 1878 the first plant for making rubber products was established. From 1880 to 1910 in line with rapid industrial expansion the population increased from 6,532 to 54,773, doubling during each decade. There was a considerable influx of eastern European immigrants, especially Poles, Slovaks, and Hungarians. Passaic was noted for handkerchiefs and in the past produced more than 1,000,000 a day. The city was the scene of serious labour struggles, notably the textile strikes of 1912–13, 1926, 1933, and 1934. By mid-20th century the textile industry was on the decline and many firms either closed or moved south. However, the rubber industry expanded and electronics achieved a strong position. During the 1920s radio tubes were produced. Experimentation in television resulted in perfecting the first successful home television receiver incorporating the modern picture tube. Pop. (1960) 53,963; Paterson-Clifton-Passaic standard metropolitan statistical area (*see* Paterson) 1,186,873. For comparative population figures *see* table in New Jersey: *Population*. (E. R. D.)

PASSAU, a town of West Germany in the *Land* (state) of Bavaria (Bayern), Federal Republic of Germany, lies on a tongue of land at the confluence of the Danube, Inn, and Ilz rivers and is surrounded by mountains. Passau is on the Austrian frontier, 195 km. (121 mi.) ENE of Munich by road, and a point of departure for Austria by road, rail, and river. Pop. (1961) 31,791.

The town was the Roman camp Castra Batava, but only vestiges of the Roman walls are now visible. The most important squares are the Residenzplatz and the Domplatz which flank the Baroque cathedral (which from 1668 succeeded a 15th–16th-century Gothic building), with its characteristic three domes and interior stucco work. The high altar is modern (1953). The building contains one of the largest church organs in the world (1928) and probably the most beautiful carillon in South Germany (1733–1952). The bishop's palace, with its rococo staircase, recalls the era of the prince-bishops; a house on the Domplatz recalls the religious Peace Treaty of Passau (1552). The Gothic town hall, once the centre of the townsmen's revolt for municipal freedom, now houses pictures of episodes in the town's history.

Passau is on the railway and road from Vienna and Linz to Nürnberg. The Inn salt trade and the making of wolf badges (the town's coat of arms includes a standing wolf) are traditional occupations; industries include gear and optical manufactures, and a bell foundry. There is also a tourist trade. (O. G.)

PASSCHENDAELE, BATTLE OF, the name given to the final four weeks of the Allied offensive against the Germans in Flanders in 1917, during World War I. The whole offensive, sometimes called the Battles of Ypres (*q.v.*) of 1917, had begun on July 31 and was to end on Nov. 10. Following a series of attacks on other parts of the Ypres front, the first phase of the Battle of Passchendaele began with an offensive by Australian and New Zealand troops on Oct. 12. Heavy rain intervened; little progress was made, and the operation was halted next day. The offensive was renewed on Oct. 26, when the Canadian Corps made some progress. After a pause the attack was continued between Oct. 30 and Nov. 6, when Passchendaele village and the ridge were captured. On Nov. 10 a further advance was made: the commander in chief (Gen. Sir Douglas Haig) then decided to close the Flanders campaign.

Published casualty figures for the Passchendaele fighting are unreliable, but British losses between July 30 and Nov. 10 were 244,897; the German losses were thought to have been much higher. From Oct. 12 onward the weather and ground conditions were appalling, and Haig was severely criticized for continuing operations after that date. His advocates maintained that it was necessary to relieve pressure on the French Army, which was then in a condition bordering on mutiny. (C. N. B.)

PASSENGER PIGEON, an extinct North American bird, *Ectopistes migratorius*, ruthlessly hunted by man in the late 1800s. It resembled the mourning dove but was larger and had a blue-gray head. The passenger pigeon, which nested in great colonies, wheeled in flocks extensive and dense enough to darken the sky. But hunters attacked nesting sites and migrating flights so relentlessly that flocks formerly numbering millions were nonexistent by the turn of the century. The last of the species, a bird hatched in captivity, died in the Cincinnati (O.) zoo in 1914. A monument commemorating the passenger pigeon was erected in Wyalusing State Park, Wisconsin. *See* also Pigeon.

PASSEPIED, a gay, charming dance of Breton origin, in rather lively $\frac{2}{4}$ or $\frac{3}{8}$ rhythm, was a fashionable court dance (*c.* 1660 to 1760), in which lords and ladies emulated the pastoral characteristics of shepherds and shepherdesses. Its name probably derives from the basic step in which the feet crossed and recrossed each other while gliding forward, one foot often striking the other in crossing. The music, beginning with an upbeat in fairly rapid time, is usually syncopated in the cadence measures when three definite two-count facets occur against two three-count measures. It appears occasionally in the suite, notably in Bach's Fifth Partita and Fifth English Suite. (L. Ht.)

PASSERAT, JEAN (1534–1602), French poet, the author of some elegant and tender verse and one of the contributors to the *Satire ménippée*, was born at Troyes on Oct. 18, 1534. He studied at the University of Paris, became a teacher at the Collège de Plessis and in 1572 was made professor of Latin at the Collège de France, in which capacity he wrote scholarly Latin works and commentaries on Catullus, Tibullus, and Propertius. He also composed agreeable poetry in the Pléiade style, some of it inspired by the Italian Catarina Delbene, his best pieces being his short ode "Du premier jour de mai" and the charming villanelle "J'ai perdu ma tourterelle." His exact share in the *Satire ménippée* (1594), the great manifesto of the moderate royalist party when it declared for Henry of Navarre, is variously stated but it is agreed that he wrote much of the verse. His lines *"Sur la journée de Senlis,"* in which he commends the duc d'Aumale's ability in running away, became a celebrated political song. As a young man Passerat lost an eye and toward the end of his life he became completely blind. He died in Paris on Sept. 14, 1602.

See P. Blanchemain's preface to Passerat's *Poesies françaises* (1880); E. von Mojsisovics, *Passerat, sein Leben und seine Persönlichkeit* (1907); *Satire ménippée*, ed. by C. Read (1876 and 1878), J. Frank (1884), and F. Giroux (1897).

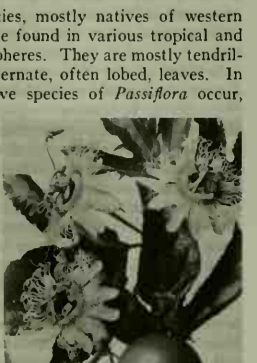
PASSERIFORMES, the largest order of birds, containing more than half of all species known, and most of the highest forms, including the songbirds. They are the true perching birds, with four toes, three directed forward and one backward, the latter, long and moved by a separate tendon from that moving the front toes. This complex order is currently in a period of explosive radiation, with many families evolving rapidly and filling a wide variety of ecological niches. The group, consisting of at least 50 families and 5,000 to 6,000 species, provides some very difficult taxonomic problems because of its radiation and wide variety of intelligence, structure, plumage, and social behaviour. To generalize, however, it might be said that the typical passeriform exhibits complicated courtship display and involved nesting behaviour; the male of many species is a remarkable songster; and the eggs are often brightly coloured and marked. In size

perching birds range from the minute wrens, sunbirds, and flowerpeckers (*qq.v.*) to the relatively large crows and birds of paradise (*qq.v.*). The order includes such songsters as the nightingale, mockingbird, skylark, song and hermit thrushes, cocks of the rock, birds of paradise, cardinal, pittas, etc. The Passeriformes have been divided in many ways. Two prominent schemes divide the order into series or suborders based on the structure of the sound-producing organ. *See* BIRD; SONGBIRD.

PASSFIELD, BARON: *see* WEBB, SIDNEY JAMES AND BEATRICE.

PASSIONFLOWER, the plant whose blossom has come to represent symbolically the Passion of Christ. It belongs to the typical genus (*Passiflora*) of the family Passifloraceae, to which it gives its name. The name passionflower arose from the fancied resemblance of the corona to the crown of thorns, and of the other parts of the flower to the nails (the styles) or wounds (the stamens), while the five sepals and five petals were taken to symbolize the ten apostles—Peter, who denied, and Judas, who betrayed, being left out of the reckoning.

There are more than 400 species, mostly natives of western tropical South America; others are found in various tropical and subtropical districts of both hemispheres. They are mostly tendril-bearing, herbaceous vines with alternate, often lobed, leaves. In the United States about 10 native species of *Passiflora* occur, chiefly in the South and Southwest. A few are cultivated as ornamentals. The wild passionflower, passion vine, or maypop (*P. incarnata*), climbing 10 to 30 ft. high, with pink and white flowers 1½–3 in. across, and a yellow, berrylike, edible fruit, 1½–2 in. long, is found from Maryland to Florida and Texas. The yellow passionflower (*P. lutea*), extending into southern Illinois, Ohio, and Pennsylvania, is a smaller plant, with greenish-yellow flowers and purple fruit.



FROM W. H. CHANDLER, "EVERGREEN ORCHARDS," 2ND ED. (1958); REPRODUCED BY PERMISSION OF LEA AND FEBIGER. PHOTOGRAPH BY W. J. POPE AND J. K. BEAUMONT

PURPLE PASSIONFLOWER (PASSIFLORA EDULIS)

The blossom consists of a receptacle varying in form from a shallow saucer to a long cylindrical or trumpet-shaped tube, and giving off from its upper border the five sepals, the five petals (rarely these latter are absent), and the threads or membranous outgrowths from the tube constituting the "corona." This corona, the most conspicuous and beautiful part of the flower of many species, is morphologically useful in favouring the cross-pollination of the flower by means of insects. From the base of the inner part of the tube rises a stalk surrounded below by a small cuplike outgrowth, and bearing above the middle a ring of five stamens. Above the ring of stamens is the ovary at the top of which arise the three widely spread styles, each ending in a button-like stigma. The stalk supporting the stamens and ovary is called the gynophore, or the gynandrophore, and is a characteristic of the family.

The ovary, which has a single compartment with three placentas where seeds are attached, ripens into a berrylike, very rarely capsular, fruit. The three groups of seeds, arranged in lines along the walls, are imbedded in a pulp derived from the stalk of the seed.

Some passion fruits are highly perfumed and afford a delicate dessert fruit, as in the case of the giant granadilla (*P. quadrangularis*). The purple granadilla (*P. edulis*) and the yellow granadilla (*P. laurifolia*) are, with the common sort, widely grown in tropical America for their fruit. *P. maliformis* is the sweet calabash of the West Indies. The size of these fruits usually does not exceed that of a hen's egg, but that of *P. quadrangularis* is like a gourd, attaining a weight of seven to eight pounds. Too perishable to ship long distances, passion fruits are used mainly locally in tropical countries and the extreme tips of southern California and Florida. In Australia, New Zealand, and South Africa *P. edulis* is grown chiefly; it is meant for the fresh fruit market. In Hawaii a yellow variant of *P. edulis* is processed for fruit juices. In tropical America the fruit is often used in beverages and sherbets, or prepared as a jam.

See W. H. Chandler, *Evergreen Orchards*, 2nd ed., pp. 306–310 (1958). (N. TR.; X.)

PASSIONISTS (CONGREGATION OF THE DISCALCED CLERKS OF THE MOST HOLY CROSS AND PASSION OF OUR LORD JESUS CHRIST; CONGREGATIO CLERICORUM EXCALCEATORUM SS. CRUCIS ET PASSIONIS D.N.J.C.; C.P.), a male religious congregation of the Roman Catholic Church comprising clerics and lay brothers, founded in Italy by St. Paul of the Cross in 1720 and approved by Pope Benedict XIV in 1741. The Passionist rule unites a missionary apostolate to the contemplative life of traditional monasticism. The institute is worldwide. The superior general resides at the Church of SS. John and Paul, Rome.

Associated with the congregation are the Passionist Nuns, a cloistered community founded by St. Paul of the Cross in 1770, and five institutes of Passionist Sisters engaged in educational and missionary work. *See* also ORDERS AND CONGREGATIONS, RELIGIOUS; PAUL, SAINT, of the Cross. (R. F. KU.)

PASSION MUSIC. Musical settings of the Passion of Christ—that is, his redemptive suffering during his last days on earth and, especially, his crucifixion—based either on biblical texts or poetic elaborations of them, date from the 4th century onward. They range from unaccompanied plainsong to compositions for soloists, chorus, and orchestra. Various terms, many of them confusing or inaccurate, were invented to describe different kinds of settings in different epochs and countries. The best guides, however, are the liturgical performances of Passion music.

Much confusion was created by a mistranslation from the German. The usual German term for plainsong is *Gregorianischer Choral*, often shortened to *Choral*, with the result that a plainsong Passion according to SS. Matthew, Mark, Luke, or John is called a *Choralpassion*. This was unfortunately translated into English as "choral Passion," a misnomer because, from the 4th to the 15th century, the Passion was sung by a single deacon. The chorus, even if one were available, had nothing to do with the performance.

The Middle Ages.—In the medieval Passion the deacon sang the entire text, changing his manner of declamation according to certain signs in the manuscripts from which he sang. A range of only 11 notes was required, but this was divided clearly into three parts: the lowest four notes (c–f) were used for the part of Christ, the middle register (f–c′) for the Evangelist (*i.e.*, Matthew, Mark, Luke, or John), and the top register (c′–f′) for the *turba* ("crowd"), which comprised all the other characters, such as Peter, Pilate, soldiers, and high priests. Each of the three vocal ranges was further distinguished by a characteristic method of performance: the part of Christ was sung in a slow and solemn manner, marked *t* (for *tarde*), the Evangelist more rapidly (*c* for *celeriter*), and the crowd in high and excited tones (*s* for *sursum*). These signs were given new interpretations in the Middle Ages, when the *t* was taken for a cross and the other two for *Chronista* and *Synagoga*, corresponding to the Evangelist and crowd respectively.

From the 15th century onward, the three parts often were chanted by three deacons, especially in larger churches and cathedrals, and in consequence the dramatic nature of the text was heightened and the congregation could follow the narrative more easily. The Passion according to St. Matthew was assigned to Palm Sunday, St. Mark to Tuesday of Holy Week, St. Luke to Wednesday, and St. John to Good Friday.

In the 13th century the Passions were adapted as music-drama on the same principle as the earlier plays of the Resurrection (*see* DRAMA: *Medieval Drama*). Two versions, mainly in Latin but with some German text, and accompanied by neumes of indeterminate pitch (*see* MUSICAL NOTATION), are found in the German Benediktbeueren manuscript, *Carmina Burana*. Later Passion plays abound in France, Germany, and England, and the tendency was for them to become longer and more complex as time went on.

Polyphonic Development.—In the early 15th century, royal

and other wealthy establishments had small choirs capable of singing polyphony, and something had to be found for them to sing during Holy Week. The most obvious choice was the *turba* music, and one of the first composers to set this music polyphonically was Gilles de Binchois, who was handsomely rewarded for his labours in 1438. It is usually assumed that this music is lost without trace, but there is a possibility that the two anonymous Passions (Matthew and Luke) in a British Museum manuscript of about 1450 may be his or else early imitations; the music, in three-part harmony, resembles some of the liturgical music of Binchois, who is known to have served the duke of Suffolk for some time. This type of Passion, in which plainsong alternated with polyphony, was set by Richard Davy and William Byrd in England, by the Italians Giovanni Matteo Asola (three settings) and Francesco Soriano (four), by the Spaniards Tomás Luis de Victoria and Francisco Guerrero, by the Frenchmen Claude de Sermisy and Loyset Compère (not strictly liturgical), and by the Netherlander Orlando di Lasso, who composed music for all four versions.

Latin and German texts of the Passion were used in Germany during the early years of the Reformation. Luther's friend and musical adviser Johann Walther composed a St. Matthew Passion first performed about 1550; it was still popular in Nürnberg in 1806. Other German Passions adopted a different style, commonly known as the "motet Passion" because the entire text—not only the *turba*—is set polyphonically. The prototype of the through-composed Passion is a work by the 16th-century French composer Antoine de Longaval (but long ascribed wrongly to Jakob Obrecht). Longaval's setting, based on a conflation of all four accounts of the Passion, makes extensive use of the chant formulas but is more concerned with declamation than with elaborate polyphony. It was thus a good model for the Germans, among whom Johannes Galliculus, Joachim a Burgk, Johann Heroldt, Leonhard Lechner, Jakob Handl, and Bartholomäus Gesius produced worthy and dignified settings which did not, however, remain in the liturgical repertory as long as Walther's Passion.

The Longaval setting inspired motet Passions by the 16th-century Franco-Flemish composer Maistre Jhan, also known as Johannes Gallus (Jehan Le Cocq), who worked at the court of Ferrara; and Cyprien de Rore, another Netherlander who spent much time in Italy. Antonio Scandello (1517–80) an Italian composer working at Dresden, produced an effective yet hybrid Passion according to St. John in German. He chose to amalgamate the two types by setting the *turba* music for five voices, contrasting this not simply with the single line of the Evangelist but also with three-part settings of the words of Peter, Pilate, and other minor characters, while the words of Jesus are in four-part harmony. Motet Passions of a more regular type were written by Johann Steurlein, Johann Machold, and J. C. Demantius.

The influence of Italian recitative, and indeed of polychoralism, made itself felt first of all in north Germany, especially in Hamburg where Thomas Selle (1599–1663) produced at least three settings (two of St. John, one of St. Matthew) for voices and instruments. Selle's St. Matthew Passion makes extensive use of a double chorus, while his larger setting of St. John brings in a group of six instruments and calls for a "distant choir" after the manner of Giovanni Gabrieli and his Venetian contemporaries. The maximum contrast between the various interlocutors is achieved by assigning a particular instrument or group of instruments to the character concerned. Thus the Evangelist is accompanied by two bass viols (or bassoons) and two bandores, and Christ by two violins and two lutes. In addition to the normal text Selle interpolates three extra musical items, each with the title of *Intermedium*. This tendency was carried further by Johann Sebastiani in his St. Matthew Passion, which brings in several chorales simply scored for unison voices and strings "for the awakening of greater devotion" among the congregation. Germany welcomed this innovation, and chorales were similarly introduced into Passions by Johann Theile, Johann Valentin Meder, and Johann Kuhnau, who preceded J. S. Bach as cantor of the Thomaskirche, Leipzig.

Heinrich Schütz.—Although Heinrich Schütz studied with Gabrieli and was considerably influenced by that master in his earlier works, the three Passions (St. Matthew, St. Luke, and St. John) indicate a return to the more austere type of Passion of Walther's day. Schütz does not even allow the modest instrumental resources used in his earlier *Sieben Worte Jesu Christi am Kreuz*, where the words of Christ are accompanied by an instrumental trio. The three Passions leave the Evangelist's words without any form of accompaniment, and the only harmony apart from the *turba* choruses appears in the duet for the false witnesses. Notwithstanding this apparent austerity, Schütz's music is moving and dramatic, both in the flexible and expressive solo line and in the vivid choruses, which are far more truly polyphonic than many of the earlier German Passions. Schütz does not avoid simple musical devices for heightening the meaning of the text, for his wish was to combine sincerity and devotion with a message that might easily be grasped. He allows an imitation of the cock's crowing, and hints at the rolling of the stone from the sepulchre and the descent of an angel from heaven, by rolling and falling musical figures respectively. His only additions to the biblical narrative are the *Exordium* at the beginning of each Passion and the *Gratiarum actio* at the end, though the St. John Passion is exceptional in its use of a stanza from *Christus der uns selig macht* at the very end.

Settings of the Passion were rare in 17th-century Italy and France, since music of an elaborate nature was unwelcome during Holy Week, instruments especially being frowned upon by the church. The Passion according to St. John of Alessandro Scarlatti is, however, a strictly liturgical work in that it follows the text with scrupulous accuracy and refrains from undue elaboration in the brief *turba* choruses. A four-part string orchestra accompanies these choruses and the words of Christ, but the other characters are supported only by the *continuo*. The Evangelist, usually a tenor voice, is here an alto or male countertenor, and is only very occasionally placed against an orchestral background. When Scarlatti set the story of the Passion once more in later life he chose to adopt the oratorio style, and made use of a specially composed text *La Vergine addolorata* (Naples, 1722). In France, Marc Antoine Charpentier also was attracted to the oratorio style and displays in his *Le Reniement de St. Pierre* an intensity of emotion and a contrast of colour that is typical of the age of Louis XIV, although there is a noticeable restraint in the matter of musical realization of the key words in the text.

Hamburg, which had seen the first German imitation of Venetian musical splendour, witnessed early attempts at sacred opera and operatic settings of the Passion, based on new libretti that paraphrased rather than borrowed phrases from the Bible. Two of the most popular of the Passion libretti were those by C. F. Hunold-Menantes and B. H. Brockes, the latter being set by such composers as Reinhard Keiser, G. P. Telemann, Handel, and Johann Mattheson. These rhymed and sentimental accounts of the Passion greatly appealed to German audiences of the time, but they were not entirely approved by the clergy, who objected to the abandonment of Bible narrative. The dramatic element maintained its hold for some time, and strong traces are found in Passion oratorio texts by J. U. von König (1688–1744), Joachim Beccau, and Benjamin Neukirch, who even goes so far as to add stage directions.

J. S. Bach.—The inevitable reaction to this trend came with C. H. Postel's version of the St. John Passion, set by Handel in 1704; and with the St. John and St. Matthew Passions by J. S. Bach, who used his own adaptation of the text of B. H. Brockes for the first work, and of a text by Picander (pseudonym of C. F. Henrici) for the second. Bach's Passions, which are really cantata cycles, placed the texts once more in a position of importance and dignity, and wedded to them music of remarkable fervour and beauty, heightening the drama by skilful interplay of choral and instrumental forces which alternate with arias, and recitatives accompanied by the organ. Bach not only avoided many of the artistic pitfalls that his predecessors had fallen into, he also succeeded in reuniting seemingly disparate elements of musical style which, in his expert hands, are both musically convincing in their sincerity and devotional in their general approach. It was the custom in Leipzig to perform Bach's Passions at vespers

on Good Friday, alternately at the Thomaskirche and at the Nicolaikirche.

C. P. E. Bach wrote two Passions, both of them for use in Hamburg, and J. E. Bach contributed a *Passionsoratorium* which did not detract from the high reputation of J. S. Bach's settings. These were seriously challenged only by K. H. Graun's *Der Tod Jesu,* first performed in 1755 and famous even outside Germany. The specially composed libretto found favour in Italy, where theatrical performances of the Passion story outside church at last freed composers of restrictions regarding the use of instruments. *La Passione di Gesù Cristo* of Metastasio was set by numerous composers, the most successful among them being Antonio Caldara, Niccolò Jommelli, Francesco Morlacchi, and Antonio Salieri.

Later Passion Music.—Throughout the Classical and Romantic periods it was the oratorio style of Passion that was most usually set, and by this time the use of a large orchestra and chorus was common. Haydn's *Die Sieben Worte Christi am Kreuz* was originally written as an instrumental work for the cathedral of Cadiz, but its subsequent adaptation by the composer proved to be an artistic success. Beethoven's *Christus am Ölberge* (1803), although not free from faults in planning and balance of narrative and dramatic elements, set a fashion in the writing of Passion oratorios that was followed by Louis Spohr in his *Des Heilands letzte Stunden* (1835) and by lesser composers. John Stainer's *The Crucifixion* (1887) achieved great popularity in English-speaking countries. Works by English composers of the 20th century include *The Passion of Christ* by Arthur Somervell and a St. Mark Passion by Charles Wood. In Italy, Lorenzo Perosi wrote a St. Mark Passion, and in Germany the Passion music of Hugo Distler and Kurt Thomas showed a return to the ideals and techniques of Bach.

See also ORATORIO. (D. W. St.)

PASSION PLAYS, plays depicting Christ's Passion (the betrayal, trial, judgment, and Crucifixion), form one group of the mystery plays (Fr. *mystères*) that developed from the church liturgy in the Middle Ages (*see* DRAMA: *Medieval Drama;* THEATRE: *Christian Revival*).

Originating from reading of the Gospels during Holy Week, early passion plays (in Latin) consisted of Gospel readings with interpolated poetical sections on the events of the passion, and on such other incidents as Mary Magdalene's life and repentance, the raising of Lazarus, the Last Supper, the lament of the Virgin Mary, etc. Use of the vernacular in these interpolations led to development of independent vernacular plays, the earliest surviving examples being in German. Such plays were at first only preludes to dramatic presentations of the Resurrection. The introduction of Satan (which became typical of German and Czechoslovak plays), and thus of introductory representations of the fall of Lucifer, the Fall of man (as in the early 14th-century Vienna Passion), and of scenes from the Old Testament and of the Last Judgment, led to development of cyclic plays similar to the Corpus Christi cycles. The great Celtic passion cycles of Cornwall and Brittany (*see* CORNISH LITERATURE; BRETON LITERATURE), and the St. Gall passion play (which begins with the entry of St. Augustine, who introduces the Old Testament prophets and patriarchs, and also includes the marriage at Cana) exemplify this type of passion play. The strength and variety of the passion play in southern and western Germany is shown by plays from Alsfeld (1501), Frankfurt, Heidelberg, etc.

The Tirol plays early formed a separate group, representing only scenes from the Passion and Resurrection; and the Bohemian plays (*e.g.,* the St. Eger Passion), developed from a simpler version of the Vienna Passion, were also distinct in style and incident.

Development in France and Flanders (1308–16th century) was distinguished by elaboration, and culminated in performances (Mons, 1501; Valenciennes, 1547) lasting more than a week. Confraternities were founded for performance of passion plays, the most famous being the *Confrèrie de Passion* (1402). The equally elaborate passion plays of London and southeast England have not survived. An early 14th-century poem, the *Northern Passion,* a version of the French *Passion des jongleurs,* may have been used as a narrative source for the Corpus Christi cycles of northern England (see *Northern Passion,* four parallel texts and the French original, ed. by F. A. Foster, 2 vol. [1913–16], Early English Text Society, Original Series 145, 149; Supplement, ed. by W. Heuser and F. A. Foster [1930], Early English Text Society, O.S. 183; also Foster's *A Study of the . . . "Northern Passion" and Its Relation to the Cycle Plays* [1914]).

Passion plays were also performed in Spain (*see* SPANISH LITERATURE), Italy, and elsewhere, with local variations.

The decennial production of a passion play at the Bavarian village of Oberammergau (*q.v.*), begun in 1634, continues, and traditional plays have been revived in villages in the Austrian Tirol. In northern Spain, during Lent and Holy Week, a Catalan passion play is performed by villagers, and in Tegelen, Limburg, a modern play by the Dutch poet Jacques Scheurs is given every five years.

See bibliographies to DRAMA: *Medieval Drama: Texts* and *Special Subjects;* articles on national literatures and their bibliographies; also PASSION MUSIC.

PASSOVER: *see* JEWISH HOLIDAYS.

PASSPORT, a formal document or certification issued by a national government identifying a traveler as a citizen or a national with a right to protection while abroad and a right to return to the country of his citizenship.

The word passport consists of two French words, *passer,* "to pass," and *port,* "port" or "harbour." Originally, it meant permission to leave a port or to sail into it, and this was extended to include generally permission of egress and of passage. In time of war, passports or safe-conduct documents have been granted by belligerent powers to protect persons and property from hostilities. In the case of the ship of a neutral power, the passport is a requisition by the government of the neutral state to allow the vessel to pass freely with the crew, cargo, and passengers without molestation by the belligerents. Passports, called Mediterranean passes, were granted U.S. vessels as protection against Barbary pirates. Passports also have been issued in time of war under international law as licences or safe-conducts authorizing a person to remove his property from a belligerent country.

In 1920, after the League of Nations appointed Fridtjof Nansen high commissioner responsible for the repatriation of prisoners of war, the international identity certificate for displaced persons, known as the Nansen passport, was created. In France, an alien without nationality or a refugee may secure a travel certificate, known as a *Laissez Passer.* It is issued under the jurisdiction of the Ministry of Interior, through the prefectures. In the United Kingdom, passports are issued and renewed by the Foreign Office.

In the United States, passports are issued by the passport office in the Department of State, or by a diplomatic or consular officer of the United States abroad, to a citizen of the United States. At one time U.S. passports were issued to other than U.S. citizens, but this is no longer so. According to the decision of the House of Lords in *Joyce and the Director of Public Prosecutions* (1946, App. Cas. 347), in English law an alien abroad holding a British passport enjoys the protection of the crown and is guilty of treason if he adheres to the king's (queen's) enemies. In time of peace and when there is no national emergency, law-abiding U.S. citizens are free to leave the United States without passports. Beginning with the American Civil War, wartime restrictions prohibited the exit or entry of persons without passports. Such restrictions were imposed during World Wars I and II. Under the Immigration and Nationality Act of 1952, whenever the United States is at war or during a national emergency proclaimed by the president, passports may be required for the exit and entry of citizens of the United States. Pursuant to this law and under a presidential proclamation and regulations of the Department of State, it is a federal criminal offense to leave the United States without a passport to travel to most countries of the Western Hemisphere. The Internal Security Act of 1950 forbids the issuance of passports to members of Communist organizations registered under the act or members of organizations against which there is an order requiring such registration.

At one time the issuance of U.S. passports was considered to be a matter within the absolute discretion of the Department of State. The Supreme Court, however, has recognized: "The right to travel is part of the 'liberty' of which a citizen cannot be deprived without the due process of law of the Fifth Amendment" (*Kent* v. *Dulles*, 357 U.S. 116 [1958]). Accordingly, passports may not be denied without granting the individual a hearing and without specifying the grounds for denial. Passports may be refused for travel to restricted areas where war is in progress or where foreign policy considerations limit entry. Passports have also been denied to persons under indictment and to those whose activities abroad would violate the laws of the United States. The extent of the state department's right to deny passports for other reasons has not been clearly defined. Where a person is denied a passport, he may appeal to the passport office of the Department of State in Washington, D.C., and to the federal courts.

A U.S. passport may be issued for three years and renewed for an additional two years. It is issued in the United States upon application filed and executed before a clerk of the federal or state court which has naturalization jurisdiction or before a passport agency of the state department. U.S. consular authorities perform this function abroad. Proof of citizenship is required. Some countries not only require that a citizen hold a passport issued by his government but also that the passport be stamped or visaed by the foreign country into which he seeks to travel. A visa or visé is evidence of permission to enter the issuing state under specified conditions and for a specified time.

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PASSY, FRÉDÉRIC (1822–1912), French economist, co-winner with Jean Henri Dunant of the first Nobel Peace Prize, in 1901, was born in 1822. He was a nephew of the economist Hippolyte Passy (1793–1880), finance minister to Louis Philippe and to Louis Napoleon's republican government. Frédéric Passy's first work, *Mélanges économiques*, appeared in 1857. He was an ardent free-trader and an admirer of Cobden.

In 1867 he founded the Ligue Internationale de la Paix, afterward known as the Société Française pour l'Arbitrage entre Nations, and devoted himself to the promotion of international peace. From 1881 to 1899 he was deputy for the Seine *département*. He died in Paris on June 12, 1912.

Passy's published works include *De la propriété intellectuelle* (1859); *Leçons d'économie politique* (1860–61); *La Démocratie et l'instruction* (1864); *L'Histoire du travail* (1873); *Malthus et sa doctrine* (1868); and *La Solidarité du travail et du capital* (1875).

PASTEBOARD: *see* PAPERBOARD: *Pasteboard*.

PASTEL is the name for a dry drawing medium in stick form and for a method of picturemaking utilizing this medium. The stick medium is essentially powder colour with a minimum of nongreasy binder, usually gum tragacanth (tending to be replaced in mid-20th century by methylcellulose). Pastels are sold commonly in a range of values, the darkest in each hue consisting of the pure pigment and binder, the others of the range having varying admixtures of inert whites. A touch on the paper leaves colour; pastel thus provides a method of drawing in full colour, as in oil painting, without need to wait for drying to know the final effect, as in watercolour. The disadvantage of pastel is that its life is precarious because it remains on the surface of the paper and is liable, unless protected by glass or fixative, to be rubbed off by mischance. Fixatives (sprays of glue size or gums in solution) tend to change the tone and flatten the grain of pastel drawings.

Pastel is also the name of the method of picturemaking in pastels; it cannot be called drawing because it is not linear and because it covers the entire support. Pastel may be applied to paper in short touches or lines, but in such usage it functions as crayon; also it may be rubbed and blended. The pastel technique, as developed in the 17th century and widespread in the 18th, was a rubbing technique, with the end of the finger or a stump of leather or paper as agent; accents and outlines, however, preserved a linear form and showed the stroke of the pastel stick. So distinguished a portrait draftsman as J. B. S. Chardin (1699–1779) used his pastel with a hatching stroke in his preparations and never quite buried the traces of drawing in his completed works. The same was true of Maurice Quentin de la Tour (1704–88), though his completed works had a more velvety blended surface.

A sort of protopastel technique had been used by Guido Reni (1575–1642), but the first consistent use was in the first half of the 18th century, particularly in the hands of Rosalba Carriera (1675–1757), one of the most successful artists of her time. Pastel soon became almost exclusively a vehicle for elegant portraiture. A. R. Mengs (1728–79), J. M. Nattier (1685–1766), Chardin, La Tour, Louis Tocqué (1696–1772), Hubert Drouais (1699–1767), and J. B. Perronneau (1715–83) led the field. By the time of the French Revolution pastel portraits were sometimes life-size. La Tour and Perronneau produced pastels equaling in brilliance and delicacy the painted portraits by J. B. Greuze (1725–1805) or the young J. L. David (1748–1825). The Swiss Jean Étienne Liotard (1702–89) was one of the few to vary the single portrait into groups and genre ("La Belle Chocolatière" is perhaps the best-known pastel anywhere). The young John Singleton Copley (1737–1815) did some admirable pastels. William Hoare of Bath (*c.* 1707–99), Francis Cotes (1725?–70), and John Russell (1745–1806) were the great English practitioners of what might be called the classic or central pastel style, regarding which Henry Tonks wrote:

> Pastel has a character of its own and should be used with an understanding of what it can do and what it cannot do. It should not be used to imitate oil-painting. It should be considered as a method of applying color, which owing to the practical absence of a medium [binder] is higher in tone than in any other method, thinly to the surface of the paper so that as in water color the actual paper itself may occasionally play a part in the design.

Special papers for pastel have been made since the great 18th-century flowering; some were almost like fine sandpaper, some had a flocked or suedelike finish, some were prominently ribbed or strongly marked by the drying felts. Since Edgar Degas's time (1834–1917), deep-tinted papers have been much liked.

Up to Degas, pastel had used a combination of colours and values resembling late Gothic and early Renaissance tempera (*q.v.*) painting in the use of full chroma in the darks and almost pure white in the lights. This was a brilliant but blond scheme. Degas changed pastel to a brilliance by contrast that was akin to the contrasts in oil paint favoured by Camille Pissarro, Paul Gauguin, and Degas himself. He kept his strokes visibly separate, used almost exclusively those pastel sticks that had the least loading of inert whites, and showed a good deal of the support. By applying a good fixative to his first strokes and letting the work dry, he was able to superimpose a second and other layers of lines in different colours, sometimes at an angle to the lower layer or layers. Thus diaphanous and at the same time startling effects could be produced without smudging; the network of lines, sometimes on a paper already providing a ground colour, was akin to the Impressionists' divided colour in oil paint.

Since the time of Degas, pastel has been something different from the pastel of Carriera and Perronneau. Gustave Moreau and Odilon Redon made it akin to stained glass or enamel jewelry. Émile Wauters and Franz von Lenbach, Mary Cassatt, W. J. Glackens, J. E. Vuillard, Pierre Bonnard, Edwin Austin Abbey, and Robert Brackman have variously mixed the old with the post-Degas method to produce portraits, still life and occasional compositions of integrity. *See* also CRAYON DRAWING.

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PASTERNAK, BORIS LEONIDOVICH (1890–1960), the most impressive Russian writer of the post-revolutionary period, and one of the great European poets of his age. Influenced

BY COURTESY OF (TOP LEFT) THE MUSÉE LÉCUYER (TOP CENTRE) WILDENSTEIN AND CO., (TOP RIGHT) THE MANSELL COLLECTION, (BOTTOM LEFT) CHARLES E. PHELPS AND MARY PHELPS FAWCETT, (BOTTOM RIGHT) THE RIJKSMUSEUM, AMSTERDAM

18TH AND EARLY 19TH CENTURY PORTRAITS IN PASTEL

Top left: "Jean Restout" by M. Quentin de La Tour (1704–88), French. A "préparation" from life, more drawing than painting. Musée Lecuyer, France

Top centre: "Mme. Chevotet" by Jean Baptiste Perroneau (1715–83), French. A full-dress pastel treated as a painting

Top right: "Girl with Cherries" by John Russell (1745–1806), English. In the Louvre, Paris. A final stage in the 18th century tradition, somewhat degenerate but retaining the character of drawing

Bottom left: "Lady Temple" by John Singleton Copley (1737–1815), U.S.-English. In the collection of Charles E. Phelps and Mary Phelps Fawcett. Standard pastel practice showing both British and French influence, with some visible linear work

Bottom right: "Mary Gunning" by Jean E. Liotard (1702–89), Swiss. In the Rijksmuseum, Amsterdam. Pastel as painting. The artist, who had lived in Turkey, set his British model in a pseudo-oriental interior. Note the extension of the paper at the top

PASTEL

"Annabel Lee" by J. A. M. Whistler (1834–1903), U.S.-English. Crayon and pastel on brown paper. In the Freer Gallery of Art, Washington, D.C. Even the artist's butterfly signature is part of the design in this example of understatement

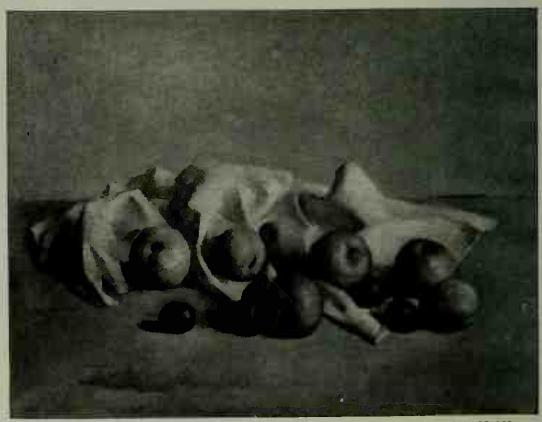
Left: "On the Terrace at Arkona" by Adolf von Menzel (1815–1905), German. In the Nationalgalerie, Berlin. A use of pastel for structure and local colour without contour, a break from 18th century tradition. *Right:* "Fleurs des Champs dans un Vase à long Col" by Odilon Redon (1840–1916), French. In the Louvre. Pastel used for flat tone and contour, almost without internal modeling

PASTEL DRAWINGS OF THE LATE 19TH AND 20TH CENTURIES

Right: "Mother Feeding a Child" by Mary Cassatt (1844–1926), U.S. In the Metropolitan Museum of Art, N.Y. A revival of 18th century technique: pastel thinly used and smudged

Below, left: "The Dancers" by Edgar Degas (1834–1917), French. In the Toledo Museum of Art, O. Widely spaced strokes, protected by fixative and overlain by lines of different colour to produce coruscating contrasts and luminous depths

Below, right: "Still Life" by Robert Brackman (1898–), U.S. In the collection of the artist. Pastel, used in some areas wetted, and on a textured support, to approximate painting



BY COURTESY OF (TOP LEFT) THE SMITHSONIAN INSTITUTION, FREER GALLERY OF ART, (TOP RIGHT) THE MANSELL COLLECTION, (CENTRE RIGHT) THE METROPOLITAN MUSEUM OF ART, (BOTTOM LEFT) THE TOLEDO MUSEUM OF ART, GIFT OF EDWARD DRUMMOND LIBBEY, 1926, (BOTTOM RIGHT) ROBERT BRACKMAN

not only by Lermontov and Pushkin, but by Shakespeare and the English Romantic poets, and by the French Symbolists and their successors, he was both a classical and a highly individual poet. His writing also early showed affinities with that of T. S. Eliot and Rilke. In addition to the mainly lyrical poetry on which his permanent reputation stands, he wrote subtly imaginative prose tales, was an outstanding translator of verse (especially of Shakespeare and Goethe), and produced some fine literary criticism. His only full-length novel, *Dr. Zhivago*, a courageous and moving story of the struggle between the old and the new way of life after the 1917 Revolution, acquired an immense vogue in western Europe partly because of the unusual circumstances of its publication. It includes, incidentally, 25 of his best poems as well as descriptive prose of rare beauty.

Pasternak was born in Moscow on Feb. 10, 1890. He was the eldest child of the painter Leonid Pasternak and the pianist Rosa Kaufman, and his upbringing combined all that was best in European artistic and intellectual culture. He first sought to express his creative impulse through music, and later studied philosophy, at Moscow University (1909–13) and, for three months in 1912, as a pupil of the neo-Kantian philosopher Hermann Cohen at Marburg. During World War I, exempted from active service by an injury received when he was thrown from a horse in 1903, he worked at a chemical factory in the Urals (1915–17). Although his parents left Russia in 1921, he remained, and for the rest of his life lived in and near Moscow, except for visits to his parents in Germany (1923), to the Caucasus (1930–31), and to the International Writers' Congress in Paris (1935).

Pasternak's literary career can be roughly divided into three parts. First came a period of individual experiment, when he was both a follower of Lermontov and a creative member of the Mayakovski circle of the early Soviet literary renaissance. During this period, his most notable publications in verse were the little volume *Poverkh bar'erov* (1917; *Above the Barriers*); the brilliant collection *Sestra moya zhizn'* (1922; *My Sister, Life*); *Temy i variatsii* (1923; *Themes and Variations*); and *Vtoroye rozhdenie* (1932; *The Second Birth*), inspired by his visit to the Caucasus. With *Stikhotvoreniya v odnom tome* (1933, 2nd ed. 1936; *Versifyings in One Volume*), a collection including earlier work, this period ended. During this time he had also produced *Vozdushnye puti* (1925; *Aerial Journeys*), a group of tales which included *Destvo Lyuvers* (*The Childhood of Lyuvers*), in which was revealed, with exquisite style and psychology, the flowering mind of an adolescent girl; and the important autobiographical memoir, *Okhrannaya Gramota* (1931; *Safe Conduct*).

In Pasternak's second period, at the height of the Stalinist regime, his poetry, because of its subjective individualism and the artistic integrity which made him refuse to write except in his own way, was denied publication, and his published work consisted mainly of translations. In his renderings of Shakespeare's tragedies, especially of *Hamlet* (1941), he shows both poetic power and unusual ability to convey the inwardness of the language.

In his final period, 1953–60, publication was still mainly denied, but to this period belongs some of his finest mature verse. With the beginning of the literary "thaw," in April 1954 the periodical *Znamya* published ten of his poems, and announced early publication of *Dr. Zhivago*. In 1956 its publication in the U.S.S.R. was refused, but meanwhile, a Milan publisher had received the copyright for an Italian edition, which appeared in November 1957 and was translated into several European languages. In October 1958 Pasternak was awarded the Nobel Prize for literature, but after he accepted it a violent campaign against him in the U.S.S.R. caused him to withdraw. He died at his home at Peredelkino, near Moscow, on May 30, 1960.

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PASTEUR, LOUIS (1822–1895), French chemist and microbiologist, whose accomplishments were among the most varied and valuable in the history of science. Pasteur proved that microorganisms cause fermentation and disease; he originated and was the first to use vaccines for rabies, anthrax, and chicken cholera; he saved the wine, beer, and silk industries of France and elsewhere; he performed important pioneer work in stereochemistry; he originated pasteurization.

He was born on Dec. 27, 1822, at Dôle, Jura, the son of a tanner. His family soon moved to Arbois, where Louis attended primary and secondary schools. In 1838 he was sent to school in the Quartier Latin of Paris, preparatory to the École Normale, but his health broke down and he was allowed to return to Arbois. He soon left to enter the Royal College of Besançon, where in 1840 he won his *bachelier ès lettres*. He became assistant mathematical master in the college, securing in 1842 the *baccalauréat ès sciences* with *mediocre* in chemistry attached to his diploma. Even in these early days the dominant note in Pasteur's life was sounded. To his sisters he wrote: "These three things, will, work and success, between them fill human existence." Throughout his entire life, work was his constant inspiration. On his deathbed he turned to his pupils and, asking about their work, exclaimed: "Where are you with it? What are you doing?" ending with his favourite words, "You have to work."

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LOUIS PASTEUR

In 1843 Pasteur was admitted fourth on the list to the École Normale and attended the lectures of Jean Baptiste André Dumas at the Sorbonne and thereby received his first incentive to the serious study of chemistry. Shortly afterward he became laboratory assistant to Antoine-Jerome Balard. He received his degree of *docteur ès sciences* in 1847.

Crystallographic Research.—He accomplished his first startling piece of research, on racemic acid, in 1848. Eilhardt Mitscherlich had shown in 1844 that ordinary commercial tartaric acid rotated the plane of polarized light to the right, while racemic acid possessed no rotary power. Being interested in crystals, Pasteur soon realized that racemic acid contained two types of crystals. He separated them and found that their solutions when tested with a polariscope gave opposite rotations. He then mixed an equal number of each kind and produced the optical neutrality of racemic acid. Thus he had proved that this mysterious acid was made up of a right-hand tartaric acid and a left-hand one, and had incidentally discovered a new class of isomeric substances. (*See* STEREOCHEMISTRY: *The Work of Pasteur.*)

Fermentation and the Germ Theory.—In the autumn of 1848 Pasteur moved to Dijon as professor of physics. Early in 1849 he transferred as professor of chemistry to the University of Strasbourg, and while there (1853) he was awarded the ribbon of the Legion of Honour for his work in connection with racemic acid. Pasteur's appointment in 1854 as professor and dean of the new Faculté des Sciences at Lille placed him in a district in which his interest in fermentation could be applied to the manufacture of alcohol from grain and beet sugar, and his energies were bent toward discovering the causes of the diseases of beer and wine. On examining the yeasts of sound and unsound beer under the microscope, he saw that the globules of the sound beer were nearly spherical, while those of the sour beer were elongated. He continued his researches, and, after his transfer in 1857 to the École Normale as director of scientific studies, definitely proclaimed that fermentation is the result of minute organisms, and that when a fermentation failed, either the necessary organism was absent or was unable to grow properly. Hitherto all explanations of

fermentation had been without experimental foundation, but Pasteur showed that milk could be soured by injecting a number of the organisms from buttermilk or beer but could be kept unchanged if similar organisms were excluded. (*See* FERMENTATION.)

The recognition of the fact that both lactic and alcohol fermentations were hastened by exposure to air naturally led Pasteur to wonder whether his invisible organisms were always present in the atmosphere or whether they were spontaneously generated. By a series of intricate experiments, including the filtration of air and the exposure of unfermented liquids to the air of the high Alps, he was able to declare with certainty in 1864 that the minute organisms causing fermentation were not spontaneously generated but came from similar organisms with which ordinary air was impregnated. His work thoroughly disproved the spontaneous generation theory of life. (*See* also BIOLOGY: *Biogenesis Versus Abiogenesis; the Origin of Life;* LIFE, ORIGIN OF.)

Pasteur was now acknowledged the leading chemist of his day and was the recipient of honours both from his own country and abroad. Lord Lister, who saw the applicability of these discoveries to surgery, revolutionized surgical practice by utilizing carbolic acid in 1865 to exclude the atmospheric germs and thus prevent putrefaction in compound fractures. The pasteurization process for sterilization of food products by controlled heat treatments was developed from Pasteur's work on the fermentation of wine and beer. (*See* also PASTEURIZATION.)

In June 1865, after much persuasion from his old teacher Dumas, Pasteur went to the south of France on an official government mission to investigate the disease of silkworms that was ruining the French silk industry. (*See* SILK: *Diseases.*) Three years later he announced that he had isolated the bacilli of two distinct diseases and had found a method of preventing contagion as well as of detecting diseased stock. These results saved the silk industry not only in France but in all other silk-producing countries as well. Meantime, in 1863, he had also become professor of geology, physics, and chemistry at the École des Beaux-Arts and, in 1867, professor of chemistry at the Sorbonne. He was elected to the Académie des Sciences in 1862, becoming permanent secretary in 1887, and to the French Academy in 1881.

In October 1868 Pasteur suffered a stroke that caused semiparalysis, but he was able to return to Paris and continue his experiments on fermentation. More desirous than ever of devoting himself to the improvement of French brewing, in 1876 he published his famous paper on fermentation (*Études sur la bière;* Eng. trans. by F. Faulkner and D. C. Robb, *Studies on Fermentation,* 1879). In 1873 he became a member of the French Academy of Medicine, and in 1874 he received a life pension from the National Assembly. Three years later Pasteur, who had already revolutionized the production of alcohols, established the germ theory and saved the silk industry, turned his attention to the fatal cattle scourge known as anthrax, and within two years had demonstrated the entire natural history of the disease.

Vaccination.—In 1880, however, his researches were diverted to chicken cholera, an epidemic of which had destroyed 10% of the chickens in France. He was soon able to isolate the germ of this disease, and, by cultivating an attenuated form of the germ and inoculating fowls with the culture, proved that they were rendered immune from virulent attacks of cholera.

He now returned to his researches on anthrax, a disease upon which C. J. Davaine and Robert Koch had been working. Following the same methods that he had used in cholera, he isolated the bacillus and, by cultivating it in oxygen at a temperature of 42° C, produced a successful inoculation material, which, by inducing a mild attack of anthrax, rendered the inoculated animal immune against a culture of full strength. These methods Pasteur called vaccination. (*See* ANTHRAX; VACCINATION.)

As to the money values of these discoveries, which had brought Pasteur world fame, T. H. Huxley expressed the opinion that it was sufficient to cover the whole cost of the war indemnity paid by France to Germany in 1870. Pasteur himself chose to remain poor and to set an example of simplicity.

Perhaps the most interesting of Pasteur's investigations concerned the preventive treatment of rabies. After experimenting with inoculations of saliva from infected animals, he came to the conclusion that the virus also was present in the nerve centres, and he demonstrated that a portion of the medulla oblongata of a rabid dog when injected into the body of a healthy animal produced the symptoms of rabies. By further work on the dried tissues of infected animals and the effect of time and temperature on these tissues, he was able to obtain a weakened form of the virus that could be used for inoculation. On July 6, 1885, Pasteur was requested by the child's mother to inoculate nine-year-old Joseph Meister, who had been badly bitten by an infected dog. The experiment was successful, and since then thousands of persons throughout the world have been kept from developing rabies by being given Pasteur vaccine after being exposed to rabies. (*See* RABIES: *Treatment.*)

Soon after Pasteur's success with the rabies vaccine an international public subscription raised 2,500,000 francs to found the Institut Pasteur in Paris for the further investigation and prevention of rabies. The institute was dedicated in 1888 and later operated branches in France and other countries. Pasteur headed the institute from its dedication until he died near Saint-Cloud on Sept. 28, 1895. His *Oeuvres complètes,* seven volumes (1922–39) and *Correspondance, 1840–1895,* four parts (1940–51) were edited by his grandson Joseph Louis Pasteur Vallery-Radot (known as Pasteur Vallery-Radot).

See also references under "Pasteur, Louis" in the Index.

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PASTEURIZATION, mild heat treatment of a liquid food or beverage for a specified period of time in order to enhance its keeping qualities and to destroy pathogenic microorganisms. It has received wide application in the dairy, wine, and beer industries. The higher the temperature applied, the shorter is the time necessary to achieve the desired results.

Pasteurization of liquid foods originated in the 1860s with the work of Louis Pasteur, who demonstrated that abnormal fermentation of wines and beer could be prevented by heating these beverages to approximately 135° F (57.2° C) for a few minutes. His classical work is credited with placing the wine and beer industries of France on a sound footing.

With respect to milk, the United States Public Health Service specifically defines pasteurization as the process of heating every particle of the milk so treated to at least 143° F (61.7° C) and holding at such temperature continuously for at least 30 minutes (low-temperature, holding method, or LTH), or to at least 161° F (71.7° C) and holding for at least 15 seconds (high-temperature, short-time method, or HTST). The minimum temperatures and corresponding times are based upon extended studies of the heat resistance of *Mycobacterium tuberculosis,* considered to be one of the most heat-resistant of the nonspore-forming microorganisms that may cause disease in human beings. Such treatment also destroys a large majority of the potential spoilage microorganisms and thus results in a prolonged keeping time of the food. Bacterial endospores are unaffected.

The term pasteurization also is applied to the mild heat treatment of some solid foods, but in such instances the amount of heat applied is more difficult to define and control because of the physical nature of the food. Radiation pasteurization refers to the application of relatively low doses of beta or gamma rays to liquid or solid foods for the purpose of enhancing their keeping quality. The dose is adjusted to kill the majority or all of the potential nonspore-forming spoilage microorganisms but yet not impair the quality of the food as a result of the treatment.

See also references under "Pasteurization" in the Index.

See E. M. Foster *et al., Dairy Microbiology* (1957). (C. F. N.)

PASTO, a city of southwestern Colombia and capital of the department of Nariño, about 76 mi. from the Ecuador border on the Pan-American highway. Pop. (1961 est.) 119,600 (mun.). The city is 8,500 ft. above sea level at the foot of the extinct Galeras volcano (13,999 ft.). Founded in 1539, it was a royalist stronghold in the revolution against Spain. Pasto controls

traffic between Ecuador and the Cauca valley of Colombia and is the commercial centre for the surrounding agricultural and mining area. Although its population more than doubled between 1950 and 1960, it is still relatively less important as a centre of trade than in the colonial era. Then, as a part of the broad manufacturing region of Quito, it produced woolen textiles, wood products, and straw and wool hats and was the major transportation centre between Quito and Popayán. Pasto is linked by road and rail with the port of Tumaco. (R. L. GE.)

PASTON LETTERS, the name given to the largest surviving collection of English 15th-century correspondence, invaluable to the historian and the philologist, preserved mainly in the British museum, London; part of which is derived from the circle of Sir John Fastolf (*q.v.*) and part from that of his neighbours in eastern Norfolk, the Paston family. The origins of the Pastons are obscure. A legend, probably carefully concocted, traced their arrival in England to three years after the Conquest. It was intended to counter an equally carefully concocted genealogy which began with "Clement Paston dwelling in Paston, . . . a good, plain husband(man)": a descent possibly closer to the truth. The rise of the family was noneconomic, and it followed in its pursuit of nobility a typical three-generation pattern. Its initial impetus came with William Paston (d. 1444), who rose to the eminence of justice of the common pleas; it continued under John I (d. 1466), a London lawyer; and its initial culmination came with John II (d. 1479), knighted in 1463, whose books gave evidence that he shared fully in the fashionable tastes of Edward IV's court, and in his brother John III (d. 1503), knighted in 1487. Although the marriages of William and John I were not unprofitable, it was not until part of Fastolf's considerable property came into their hands that the family became of more than minor significance in Norfolk. But because of the survival of the letters the Pastons and the Fastolf entourage are among the best known of a class in the 15th century normally hidden from view. The formidable and attractive Paston wives—Margaret Mautby, the wife of the unpleasant John I, is the most likeable person in the whole group—their servants, their neighbours, the circle around Sir John Fastolf, emerge vivid from the correspondence: perhaps, indeed, too vivid. There were a number of reasons for the survival of this collection of more than 1,000 letters, each one of which is concerned with a greater or smaller variety of instruction, information, news of national or local affairs and gossip. There was the need to preserve evidence for lawsuits and information for estate administration in the litigious world of 15th-century Norfolk; there was the need of estate administrators to preserve their warrants for expenditure and action in a time of particularly stringent employers; and already in Fastolf's circle in the 1440s one scholarly minded servant, William Worcester (*q.v.*), had, from collecting evidence for his master's interminable lawsuits, moved on to collecting evidence for precocious historical research; he may have had some influence in creating a tendency toward indiscriminate document hoarding in both circles.

The great lawsuit which developed after Sir John Fastolf's death in 1459, when vultures of all social levels swooped on their prey and the Pastons and Worcester found themselves on opposite sides in a ten-years dispute over the execution of Fastolf's will, both created a great deal of material and acted as a catalyst in grouping the Fastolf-Paston documents roughly in the way they are today. It is in this period alone that almost a third of the collection lies, when the two groups fought each other through repeated sessions of the archbishop of Canterbury's court of audience "to thende of v productions of lx witnesse producid of both partiez to the uttermost of the spirituell lawe" (petition of Worcester to Bishop Goldwell of Norwich, *c.* 1477) and beyond, on appeal to the Roman curia. In the end William Waynflete, bishop of Winchester, having been appointed administrator of the will in 1470, forced through a compromise; part of Fastolf's land went to Magdalen college, Oxford, and with it went part of Fastolf's muniments and a collection of material about the Fastolf estates, edited for Waynflete by Worcester in an attempt to prove the wickedness of John Paston (Magdalen College Muniment room, *Fastolf Papers*, etc.). Part of Fastolf's property went to found the fortunes of the Pastons; and so part of Fastolf's archives descended with those of the Pastons, who, in the later 17th century, achieved the shaky eminence of the earldom of Yarmouth (1679).

It is impossible to tell how the Paston letters were kept from the 15th to the 18th century; but in 1735 the antiquary Francis Blomefield explored the muniment room at Oxnead, the family seat in Norfolk. Much, he found, had already perished from the weather (and some had been lost to at least one antiquary before him); and Blomefield himself was quite prepared to burn documents relating "to family affairs only." Only those letters "of good consequence in history" did he think worth preserving; as a result, all else in the Oxnead muniment room—including the accounting material, the court rolls, the estates surveys and most of the deeds—seems to have been destroyed. The spoils which survived were shared out among a succession of antiquaries; and now some have gone via the antiquary Francis Douce to the Bodleian library (MS. Douce 393), some via the antiquary Richard Gough, the bookseller Thomas Thorpe and Sir Thomas Phillipps to the Bodleian (MS. Top. Norfolk, c. 4) and to the British museum (Additional Mss. 39848–49); but most, in the late 18th century, settled in the hands of John Fenn of East Dereham, who edited four volumes of *Original Letters* (i and ii, 1787; iii and iv, 1789); a fifth was published posthumously in 1823 by Fenn's nephew William Frere. They were eagerly and deservedly well received. The originals of Fenn i and ii were exchanged for a knighthood with George III and probably passed into the hands of George Pretyman (who took the name Tomline in 1803). They disappeared until 1889, when they were found at Orwell park, Suffolk, a house belonging to the Pretyman family. They were sold to the British museum in 1933 (Add. Mss. 43488–91). Those of Fenn iii and iv were rediscovered in 1875, together with 95 unpublished letters, at Roydon hall, near Diss, Norfolk, the seat of the head of the Frere family, and reached the British museum in 1896 (Add. Mss. 34888–89); those of Fenn v had also remained in the possession of the Frere family, were discovered at Dungate, Cambridge, in 1865 and went into the museum in 1866 (Add. Mss. 27443–46). Other groups are to be found there, in the Bodleian library and in Pembroke college, Cambridge; and strays are scattered elsewhere.

The material was re-edited (save for that in Fenn i and ii, which was simply reprinted) by James Gairdner as *The Paston Letters, 1422–1509*, six volumes (1904). In many ways this edition is unsatisfactory. The dating of the material and its transcription are erratic; its mysteries are unelucidated. For the philologist the letters, with their wide variety of subject matter, illustrate as no other documents can the capacity of the English language at a critical period of its history. For the historian the letters have three main uses. They are a primary source for the political history of the 15th century: both Fenn and Gairdner were concerned mainly with political intelligence; indeed Fenn excised matters of private business. They are an invaluable source for the domestic history of medieval English provincial society: readers and critics from Horace Walpole to Virginia Woolf have made potpourri among the duchesses and the Paston daughters. But the letters are also unequaled as a source for understanding those twin obsessions of the late medieval upper-class mind, land and lordship. On matters of estate management, litigation, patronage, "maintenance," local politics and the local background to national politics they provide a mass of unexploited material. If the class to which the 15th-century Pastons rose is difficult to get to know, so are the workings of the provincial society in which they lived. It is easy, for instance, to grasp the formal aspects of late medieval political relationships between lord and man, extremely hard to understand them in action. The intimacy of the Paston-Fastolf material, the candour of documents the writers of which did not need to conceal the advocacy of bribery and corruption behind a pious façade of disapproval, allows the historian really to comprehend that society to an extent impossible elsewhere.

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introduction, in "World's Classics Series" (1963); H. S. Bennett, *The Pastons and Their England,* 2nd ed. (1932), which contains a now partially out-of-date collation of editions and manuscripts; K. B. McFarlane, "William Worcester: a Preliminary Survey," *Studies Presented to Sir Hilary Jenkinson* (1957). For the history of the manuscripts *see* the *Annual Report of the Friends of the National Libraries* (1933–34). (P. S. Le.)

PASTOR, LUDWIG, Freiherr von (1854–1928), German author of the monumental *History of the Popes,* was born in Aachen on Jan. 31, 1854. He attended the *Gymnasium* in Frankfurt am Main, where Johannes Janssen, the author of the multivolume *History of the German People* (which Pastor was to edit after Janssen's death), was one of his teachers. During his studies at the universities of Louvain, Bonn, Berlin, Vienna and Graz, Pastor became acquainted with the leading historians of his day. Admitted as a lecturer at the University of Innsbruck in 1881, he was appointed professor of modern history in 1887. He became director of the Austrian Historical institute in Rome in 1901 and Austrian chargé d'affaires at the Vatican in 1920 and minister from 1921 to 1928. He was knighted by the emperor Francis Joseph in 1908 and created a baron in 1916.

Pastor's works include more than a dozen historical monographs, but his fame rests on his great *Geschichte der Päpste seit dem Ausgang des Mittelalters* (*History of the Popes From the Close of the Middle Ages*), published in 16 volumes between 1886 and 1933 and translated into all major languages; the English edition, published in London and St. Louis between 1891 and 1953, contains 40 volumes. Pastor caused Pope Leo XIII to open the Vatican archives to scholarly research; he also consulted archives all over Europe, thus providing his works with an extensive documentation. Writing as a Catholic, he emphasized that the task of the historian was that of the objective scholar rather than that of the apologist; his treatment of the darker periods of the papacy, in particular that of Alexander VI, is frank. As the title of his work indicates, he concentrated on the history of individual popes rather than on that of the papacy as an institution. Pastor died in Innsbruck on Sept. 30, 1928.

For a list of his publications *see* W. Wuhr (ed.), *Ludwig Freiherr von Pastor, Tagebücher-Briefe-Erinnerungen* ("Diaries-Letters-Memoirs"), pp. 911–918 (1950). For other biographical evaluations, *see* the same work, pp. 918–920. (F. A. Hs.)

PASTORAL is the kind or genre of literature that takes as its subject the society of shepherds, considered as exhibiting a freedom from the complexity and corruption of more civilized life.

Classical Origins.—Theocritus (b. *c.* 310 B.C.), the founder of pastoral, probably used the themes of primitive shepherd-poetry, and his shepherds speak the Doric dialect, but he himself was a sophisticated court poet. His celebration in his first idyll of the death of Daphnis derives from folklore, but originates the sophisticated lament for a fellow-poet known as the pastoral elegy, which reaches its full power with Milton's *Lycidas,* and survives to be used by Shelley (*Adonaïs*) and Matthew Arnold (*Thyrsis*). From Theocritus also derives the custom of representing actual poets under the names of shepherds, and of such themes as the song-contest. But the later pastoral tradition was determined not so much by Theocritus as by his imitator, Virgil, who transfers the scene from Sicily to Arcadia (a remote part of Greece, in the Peloponnese, which became symbolic of a pastoral paradise) and includes allusions to contemporary agrarian problems, to powerful politicians and to more personal concerns. Through his fifth eclogue, commemorating the dead shepherd Daphnis (who has been taken to represent Julius Caesar), he transmits the pastoral elegy to his imitators; in the fourth, the so-called "Messianic" eclogue, he added to the genre a new element. This eclogue was interpreted by medieval scholars as foretelling, by means of sibylline prophecy, the birth of Christ, and thus the pastoral eclogue's habitually nostalgic treatment of the Golden Age became connected with Christian imagery.

Renaissance Theory and Practice.—Pastoral was virtually without medieval practitioners; its revival dates from the age of Petrarch. It was not to be expected that writers of the humanist revival should treat their ancient models in the manner of modern scholarship. Relationships between court, city and country had changed; pastoral elements had long been woven into the fabric of Christian ecclesiastical imagery; and, although Renaissance pastoral owes much to direct imitation of Virgil, it also shows the influence of Virgil's medieval interpreters.

The first important modern pastoral poet was Battista Spagnoli (Mantuanus), whose *Eclogues* were published in 1498. They were dominant for over a century; Mantuan was read in the schools, and not only imitated by many other poets, including Spenser, but early translated into English by Alexander Barclay, Barnabe Googe and George Turberville. Mantuan was the authority for the Renaissance practice of using pastoral to attack ecclesiastical corruption; there are famous English examples in *The Shepheardes Calender* and *Lycidas.* Upon such neo-Latin poems was founded the Renaissance theory of the pastoral, the object of which was not, says the 16th-century English critic George Puttenham, in his *Arte of English Poesie,* "to counterfeit or represent the rustical manner of loves and communication: but under the veil of homely persons, and in rude speeches, to insinuate and glance at greater matters . . . which may be perceived by the Eclogues of Virgil . . . . These Eclogues came after to contain and inform moral discipline, for the amendment of man's behaviour, as by those of Mantuan . . . ." That pastoral treats of great matters in a low style is a humanist commonplace; Sir Philip Sidney thought it possibly a weak point in the defenses of poetry against its detractors, "for perchance where the hedge is lowest they may soonest leap over" (*Defence of Poesie*). It is probable that this humanist theory, rather than his doubtful acquaintance with Theocritus, induced Spenser to devise the provincialisms and archaisms of *The Shepheardes Calender,* a course of which Sidney disapproved.

The Development of Pastoral Kinds.—*The Eclogue.*—The 16th and early 17th centuries were the great age of modern pastoral. There were three main divisions: short poems or eclogues, romances and dramas. In the first group there is the strongest degree of contamination of "classical" pastoral by the vernacular verse of country folk. This, though it occurs in the literature of other languages, is most marked in English, where the great mass of pastoral poetry, especially toward the turn of the 16th century, has a strongly native flavour, and also recalls medieval songforms, the *pastourelle* and the *chanson d'adventure,* as well as that contrast between the simple or "silly" shepherd and the corrupt or civilized townsman which had as many implications for the Renaissance as for classical antiquity, and which, like the discovery of the new world, gave a new urgency to old questions concerning Nature and Art.

For all that, the literary prestige of pastoral was largely dependent upon its classical origins. During the 16th century the Virgilian eclogue was domesticated in the main European vernaculars. Googe's *Eclogues* appeared in 1563, and the publication in 1579 of Spenser's *Shepheardes Calender* has always been regarded as a critical date in the history of English poetry. Spenser, like Virgil, beginning with pastoral before passing on to heroic poetry, brings into the English tradition the influence of the pastoral poets not only of antiquity but of contemporary Italy and France. He "imitates" them, and, as "E.K." puts it (in his commentary, published with the first edition), follows their "footing" everywhere, "yet so as few, but they be well scented, can trace him out." In this elaborately designed sequence Spenser, exercising a wide range of styles, invents the dialects of English pastoral. Sidney, equally experimental, included poems of a pastoral kind in his *Arcadia* (first version 1581, later recast); and Michael Drayton in 1593 published his *Idea, the Shepheardes Garland,* another varied sequence of eclogues with a strong native element. But pastoral elements invaded a huge mass of verse that was not formerly bucolic, and, in France and England at any rate, it becomes difficult to separate poetry that originates in literary pastoral from that which represents a new valuation of country manners and the charm of rural life as a topic. Among poets who wrote agreeably in this kind were Thomas Greene, Thomas Lodge, Nicholas Breton and Richard Barnfield. By the time the most popular of Elizabethan anthologies, *England's Helicon,* was published (1600), the vogue was so intense that poems which origi-

nally had no element of pastoral were converted to pastoral before republication. The craze is subjected to some satirical comment in Shakespeare's *As You Like It* (1599?). A little later the pastoral element finds a place in the poetry of Thomas Campion, and among the elegances of Ben Jonson.

In the 17th century more or less formal eclogues continued to appear; examples are George Wither's collection *The Shepherd's Hunting* (1615); William Browne's Spenserian *Britannia's Pastorals* (1613), a work of allegorical narrative; and the "Piscatorie Eclogues"—exploiting a variation made by Jacopo Sannazzaro—of Phineas Fletcher (1633). But the less formal strain continued, and grew more subtle, as in the pastoral poems of Thomas Randolph; the beautiful dialogues of Aurelian Townshend, Thomas Carew and Richard Lovelace. Robert Herrick—some of whose qualities are to be found in Jean Passerat and other French poets—devised a unique blend of rural freshness and learned imitation; and in Andrew Marvell's pastoral dialogues, his poems about mowers and his "Nymph Complaining," it is reasonable to see the climax of this phase of the English pastoral tradition. In later pastoral there is a more pedantic interest in the Virgilian model, and a reduction of complexity indicated by Thomas Hobbes' simple division (in his *Answer to Davenant*, 1650) of poetry into three basic kinds—heroic, "scommatic" (*i.e.*, satiric) and pastoral—as appropriate to court, city and country.

In the 18th century divided opinions on the nature and function of pastoral were given dogmatic expression; the quarrel derived some of its sharpness from the larger conflict of Ancients against Moderns (*see* ANCIENS ET DES MODERNES, QUERELLE DES). Neoclassic doctrine held that pastoral should represent the shepherd of the Golden Age—a figure of uncomplicated virtue in a simple scene. The patron of this school of thought was René Rapin. The "modern" view, deriving from Fontenelle, was that pastoral should reflect the peace and leisure which the modern city dweller associates with country life by dwelling on the innocence (and concealing the miseries) of the contemporary rustic. The successful *Pastorals* of Ambrose Philips (1709) belong to the second or "modern" variety, which was critically defended by Thomas Tickell in the *Guardian* of 1713 (no. 22, 23, 28, 30, 32). Tickell argued that in departing from the Virgilian model English poets had the authority not only of the even more ancient Theocritus but also of Spenser and now of Philips, both of whom had introduced native shepherds and native customs. Pope took the neoclassic side. His pastorals, written, according to his own testimony, in 1704, when he was 16, had circulated in manuscript, but were not published till 1709. Much revised, they then appeared in a volume of Jacob Tonson's *Poetical Miscellanies* which also contained six of Philips' pastorals. Partly because he was annoyed at Tickell for preferring Philips' work to his own, Pope wrote an essay (*Guardian*, no. 40) in which he attacked Philips by means of ironical commendation. Pope's own pastorals have a high finish, and his *Discourses on Pastoral Poetry*, probably written at the same time as the poems, won him much critical approval. But there is still something to be said on the side of Philips; if either of them points the way to the new pastoral of Wordsworth it is he. It was as a comment on Pope that Dr. Johnson wrote: "It seems natural for a young poet to initiate himself by pastorals, which, not professing to imitate real life, require no experience." And, with the possible exception of his "Messiah," an ambitious imitation of Virgil's fourth eclogue, Pope's poems do not suffer much injustice at the hands of Johnson, whose attacks on the whole genre of pastoral as false and insipid are repeated not only in his treatment of *Lycidas* in the *Life of Milton*, but also in *Rasselas* and in *The Rambler* (no. 36, 37). The liveliest pastoral poet of the period, John Gay, was, as it happens, on Pope's side in the quarrel; his mode was burlesque, and he wrote partly to discredit Philips, incidentally achieving some brightness and authenticity of rustic detail. His most famous work, *The Beggar's Opera* (1728), originated in Swift's suggestion of "a Newgate pastoral, among the whores and thieves there," first made in a letter to Pope (Aug. 1716). This, the age of mock-epic, was also an age of mock-pastoral; and a growing reaction against the artificialities of the kind (as later the ladies of Marie Antoinette would dress as milkmaids and make syllabubs straight from the cow) combined with new attitudes to the natural man and the natural scene to overthrow the old kinds of pastoral. Wordsworth was in conscious reaction from it; his program was "plain-living people now observed/With clearer knowledge" (*Prelude*, IV:213–14). His *Michael* (1800) is called "A Pastoral Poem"; but it is pastoral of a new kind, genuinely a study of "the simple primary human affections and duties" but making its point by a use of narrative and symbolic ambiguities foreign to the pseudo-simplicities of Augustan pastoral. During the time since Wordsworth, the pastoral eclogue as such has virtually been dissolved; but modern poets may occasionally revive it much in the spirit in which they take up some ancient stanza or metre to serve some special and immediate purpose of their own. The object may be ironic, as in Louis Macneice's eclogues; or obscure, as when W. H. Auden calls his long poem *The Age of Anxiety* "a baroque eclogue."

Pastoral Romance.—Pastoral romances—extended prose fictions with interpolated lyrics in an artificial pastoral setting—originated with the *Arcadia* of Jacopo Sannazzaro (1504), a work imitated throughout the 16th century in every European language. In Spain Jorge Montemayor's *Diana Enamorada* (1524), continued after his death by Gaspar Gil Polo (1564), followed the pattern of Sannazzaro, and as a repository of amorous tales was used at least once (for the plot of *The Two Gentlemen of Verona*) by Shakespeare. Bartholomew Young's translation of it, though written earlier, was published only in 1598. Cervantes wrote a pastoral romance, *Galatea* (1584). In France there was a 17th-century vogue of the form stemming from the *Astrée* of Honoré d'Urfé, and exemplified in many works by the Scudérys. Sidney's *Arcadia* is indebted to both Sannazzaro and Montemayor, but it is an extremely ambitious work, an attempt to produce a new kind of heroic pastoral. The stories and also the style of this work proved influential; but more popular pastoral narratives existed, notably those of Greene (*Pandosto*, 1588; *Menaphon*, 1598) and Lodge, whose *Rosalynde* (1590) is a work of exceptional merit, and the source of Shakespeare's *As You Like It*.

Pastoral Drama.—An important, though to the modern eye not an attractive, part of this type of literature is pastoral drama. This has no ancient model, except in so far as eclogues used the dialogue form and could be expanded into dramatic scenes. The earliest dramatic pastoral was the *Favola di Orfeo* of the Florentine humanist Politian, first performed in Mantua in 1472; but the main European tradition of pastoral drama began with the representation at Ferrara in 1554 of Agostino Beccari's *Il Sagrifizio*, and took characteristic form in a play written for performance at the same court in 1573, the celebrated *Aminta* of Torquato Tasso. The fame of this work, and especially of the chorus "O bella età de l'oro," ensured not only a long succession of Italian imitations, but of similar attempts in other languages. The elaborate *Il pastor fido* of Giovanni Battista Guarini (1590), an attempt to "over-go" Tasso, also became one of the most famous works of the age, and the centre of an interminable controversy, which aroused universal interest, between Guarini and his supporters on one side and Jasone de Nores and his on the other. De Nores argued that pastoral could do nothing but harm to town-dwellers, and called shepherds lazy and uncivilized. Guarini replied that pastoral was the earliest kind of literature, and treated the earliest type of society; but this was so basic to later social developments that in writing about it one could pleasantly study matters of civilized concern. The controversy helped to spread pastoral drama throughout Europe. Of many French examples the best-known is Racan's *Les Bergeries* (1625). In England *The Queenes Arcadia*, Samuel Daniel's pastoral poem for court performance, appeared in 1605; Fletcher's attempt to give the form a more public airing with his *Faithful Shepherdess*—its very title reminiscent of Guarini—failed in 1608 (?), but the work enjoyed esteem among contemporary poets, and pointed the way to those tragi-comedies, strongly imbued with sexual interests, that became the stock form of Fletcher and his collaborators. He wrote no more purely pastoral plays, but the genre intrudes occasionally in other contexts, notably in *Philaster*.

The pastoral drama remained a courtly form; Thomas Goffe's

Careless Shepherdess (1625, published 1656) is interesting mainly for its part in the genesis of Ben Jonson's unfinished *Sad Shepherd* (1640), and Walter Montague's *The Shepherd's Paradise* because of Henrietta Maria's appearance in the play, which lent point to William Prynne's *Histrio-Mastix* (1633), an attack on the stage, and on women's appearance on it. The dramatic version of pastoral emphasizes all those points of unreality which have always been the main cause of irritation with the genre. The association of court ladies with nymphs, and of Platonic love with shepherds, makes of the kind, with all its rich potentialities, little more than an elaborate game. It is the more surprising that a late pastoral drama, Allan Ramsay's *Gentle Shepherd* (1725), was very popular, and is said to have remained so among Lowland reapers and milkmaids until well into the 19th century.

Decline of Pastoral.—By the 19th century almost all the original varieties of pastoral had withered away under critical ridicule and public indifference; some elements had been absorbed into other kinds of poetry and fiction, but for the most part the interests pastoral had served were differently catered for. Thus in Berthold Auerbach, in George Sand, in George Eliot and in Thomas Hardy, the conventional literary trappings of rustic stories have disappeared. But the tendency to treat of country people as more natural (whether or no this means more virtuous) did not of course entirely disappear and is satirized in a popular 20th-century novel, *Cold Comfort Farm*, by Stella Gibbons.

There lies behind pastoral an assumption that a consideration of very simple people enables one to "say everything about complex people"; and it may be legitimate to give the name "pastoral" to other works which proceed upon this assumption without using shepherds. This is the method of William Empson's influential *Some Versions of Pastoral* (1935), which studies the proletarian hero and the child among other pastoral variants. This book has given new dimensions to modern critical use of the term "pastoral." The passing of the genre itself has been accompanied by that of most of the other literary kinds thought to be immutable at the Renaissance; but clearly the broader assumptions concerning literature and life which lay behind the theory of kinds have not been overthrown, and historical pastoral will presumably always retain its interest as the form used to embody them in a period of great literary achievement. *See* also BUCOLICS; ECLOGUE; ELEGY; DRAMA; and articles on the writers mentioned here.

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PASTORAL EPISTLES, since the end of the 18th century, the designation of three smaller Epistles from the collection of Pauline writings of the New Testament, namely I and II Timothy and Titus. These three Epistles form a homogeneous unit but differ distinctly from all other Pauline writings, though they purport to be written by Paul.

Authorship.—The often-debated question of authorship is a key consideration for the interpretation of these Epistles. If they are genuine letters of St. Paul, they must be treated as extraordinary examples of private correspondence which provide (1) additional biographical material, (2) a unique picture of Paul as a church organizer, and, perhaps, (3) indications of the later development of his theology. If, however, they were written at a later time, they must, especially in the nonbiographical sections, be considered as sources of the post-Pauline development of the church, and their information about Paul would not have primary value.

The first scholar who questioned the authenticity of the Pastoral Epistles was the German theologian and philosopher Friedrich Schleiermacher (1807), who argued only against the Pauline authorship of I Timothy. His arguments remain basic; the presence of non-Pauline terminology, the absence of a coherent argument, and the difficulty of finding a setting in Paul's life for the Epistle. J. G. Eichhorn in his *Einleitung in das Neue Testament* ("Introduction to the New Testament," 1812) recognized that I Timothy could not be separated from II Timothy and Titus; consequently, the reasons against Pauline authorship of I Timothy are also valid with respect to the other two Epistles.

The most important step in the history of the question of authenticity was taken by F. C. Baur, who, in his book on the Pastoral Epistles (1835), points out that they must have been written in the postapostolic age in order to refute Gnostic heresies. Thus for the first time a persuasive attempt was made to find the original historical situation for the Pastorals. Since then critical scholarship has not added substantially new arguments against the Epistles' authenticity, but, by refining the traditional arguments, has established their non-Pauline authorship almost beyond doubt. Some conservative Protestant scholars, however, and Roman Catholic scholars still adhere to the traditional view of Pauline authorship and deny the conclusiveness of the critical arguments against it.

To enumerate the arguments against Pauline authorship is, at the same time, to describe the unique character of the Pastorals as compared with the undisputed Pauline writings (*see* PAUL, SAINT).

1. The terminology of the Pastorals is distinctly different from that of the authentic Pauline writings. The number of words which do not occur elsewhere in the New Testament is comparatively great. Many of these "new" words are to be found also in the Christian literature of the 2nd century A.D. They often prove to be terms of popular Hellenistic speech and are used in the Pastorals as substitutes for original Pauline terms.

2. Especially significant are those phrases and formulations which closely resemble Pauline wording but are often unmotivated and out of context. Rather than being genuinely Pauline, they appear to be conscious imitations of St. Paul's language (compare I Tim. 1:8 with Rom. 7:16).

3. In the Pastorals the apostle Paul himself belongs to the content of "faith" as the normative pattern for a Christian life, especially for the Christian leader. Thus the endowment of faith entrusted by "Paul" to the "pastor" includes not only Paul's "sound doctrine" but also knowledge about his own exemplary personal experience (*e.g.*, II Tim. 3:10–11).

4. The church institutions seem to be further developed than they were in the time of Paul. The formation of the offices of bishop, presbyters, and official deacons belongs to the time around the year A.D. 100 and has parallels in the writings of the Apostolic Fathers (Ignatius of Antioch and Clement I).

5. The polemic against heresies, which takes a predominant place in the Pastorals, is anti-Gnostic. It is difficult to find the errorists in any party of Paul's lifetime. But it is decisive that the polemic of the Pastorals is a rather general and indiscriminate rebuke, whereas in all truly Pauline Epistles the attack may be vigorous, often with minute argumentation.

6. I Timothy and Titus give the impression that they were written from somewhere in the eastern Mediterranean world during Paul's temporary absence from Ephesus (I Tim. 1:3) and Crete (Tit. 1:5; 3:12). II Timothy would appear to have originated in Rome, where the author was imprisoned (II Tim. 1:17). But the details and circumstances as indicated in the Pastorals (*e.g.*, II Tim. 4:9 ff.) do not harmonize with any known situation of Paul's life and often contradict more reliable information found in Paul's other Epistles and in Acts. To meet this problem, it has often been suggested that Paul later was released from his Roman imprisonment and wrote the Pastorals before and during a second Roman captivity; but there is no evidence to support this hypothesis.

7. The external evidence for the Pastoral Epistles is less good than it is for other Pauline writings. The first unquestionable references to the Pastorals come from the end of the 2nd century (Muratorian Canon and Irenaeus). The earliest witnesses for Paul's Epistles (Clement of Rome, Ignatius) never used the Pastorals. The heretic Marcion (*c.* A.D. 140) used all Pauline Epistles except the Pastorals for his New Testament canon. The earliest-known Greek codex of the Pauline Epistles (Chester Beatty papyri, *c.* A.D. 200) did not contain them.

All these arguments, whether viewed individually or cumulatively, make it very difficult to maintain Pauline authorship of the Pastorals. Some scholars have attempted to salvage at least a few biographical portions, especially II Tim. 4, as genuine frag-

ments from Paul's letters, but such a hypothesis does not eliminate all difficulties.

Contents.—The contents of these three short letters are best outlined comparatively.

1. The literary framework:
   Prescripts: I Tim. 1:1–2; II Tim. 1:1–2; Tit. 1:1–4
   Postscripts: I Tim. 6:21; II Tim. 4:19–22; Tit. 3:15
   Individual information and instruction: I Tim. 1:3; 3:14 ff.; II Tim. 2:15–18; 4:9–18; Tit. 1–5; 3:12–14
2. The apostle Paul as a normative type: I Tim. 1:12–17 (Paul's conversion); II Tim. 4:6–8 (Paul's martyrdom)
   Exemplary personal exhortation: I Tim. 1:18–20; 4:6–16; 5:21–25; 6:11–16; II Tim. 1:3–14; 2:1–13; 3:10–12; 3:14–4:2 and 5
3. Church order:
   On prayer: I Tim. 2:1–7
   Bishops: I Tim. 3:1–7; Tit. 1:7–9
   Deacons: I Tim. 3:8–13
   Presbyters (elders): I Tim. 5:17–20; Tit. 1:5–6
   Men: I Tim. 2:8
   Women: I Tim. 2:9–15
   Widows: I Tim. 5:3–16
   Old men and women: Tit. 2:2–3
   Young men and women: Tit. 2:4–8
   Slaves: I Tim. 6:1–2; Tit. 2:9–10
   Wealthy people: I Tim. 6:17–19
   Covetousness: I Tim. 6:6–10
   General catalogue: Tit. 3:1–2
4. Polemic against heresies: I Tim. 1:3–11; 6:3–5 and 20–21; II Tim. 2:14–26; Tit. 1:10–16; 3:9–11
   Within an eschatological framework: I Tim. 4:1–5 (7); II Tim. 3:1–9; 4:3–4
5. Traditional theological formulations (often placed within another context): I Tim. 2:5–7; 3:16; 6:13–16; II Tim. 1:9–10; 2:8–13; Tit. 1:2–3; 2:11–14; 3:3–8

Literary Character.—In external form, the Pastorals present themselves as personal letters to individuals (Timothy and Titus, who are known as co-workers of Paul; *see* TIMOTHY, SAINT; TITUS, SAINT), whereas all other Pauline Epistles except Philemon are directed to churches. Accordingly, the Pastorals ostensibly contain individual exhortations and personal information about the apostle. But their actual concern is the presentation of (1) church order, (2) sound doctrine and (3) a vade mecum to fight heretics. Thus the content of the Pastorals puts them in close proximity to such early Christian writings as the Teaching of the Twelve Apostles (*see* DIDACHE) or the epistles of the heresy-fighting Ignatius of Antioch (*see* IGNATIUS, SAINT).

It is the distinctive trait of the Pastorals that such matters as general instruction about church life, doctrine, and heresy are combined with remarks addressed to an individual, in a manner reminiscent of the form and style of the great apostle. This may be explained as a device of the author, by which he could give his work an external Pauline appearance. But more important is the resemblance to the "testament" type of late Jewish literature, particularly represented by the Testaments of the Twelve Patriarchs (*see* TESTAMENTS OF THE TWELVE PATRIARCHS). This is precisely the pattern of the Pastorals; and in both cases biographical references permeate the literature.

The material incorporated in these "testament-epistles" is itself entirely nonindividual. The attempt to write a church order has led to the adoption of Hellenistic moral catalogues which are used to describe the qualifications of church officers (I Tim. 3:2–12; Tit. 1:6–8). But the same catalogues are also applied to the Christian in general (I Tim. 2:8–11; Tit. 2:1–10; 3:1–2). On the other hand, catalogues of vices are employed to characterize the heretics and false teachers (I Tim. 1:6–10; 6:4–5; Tit. 1:10–16; 3:9). Some passages use traditional Christian exhortation to picture the behaviour of the pious Christian (I Tim. 1:5 and 19; 4:12–13; 6:11–12; II Tim. 2:22; 3:10).

The content of faith is represented not through reflective theological discourses but by citation of traditional formulas.

The tradition is not so much interpreted, as in the letters of Paul, as repeated, so that believers may learn the words of faith and doctrine guaranteed by Paul and handed down to his disciples. Salvation is based on acceptance of a deposit of faith entrusted to the church.

Theological Character and Historical Value.—Thus the Pastorals present a unique type of church order, for which the preservation of the Pauline tradition and the authority of the apostle is crucially important. This, seen together with the polemic against heretics, provides a clue to the original life situation of these Epistles.

The heritage of Paul is in danger of being claimed entirely by the Gnostic movement. A few passages in the Pastorals point to the fact that the heresy opposed emphasized the value of theological speculation and controversy (I Tim. 1:4 and 6; 6:4; II Tim. 2:14–16; 4:4; Tit. 1:14; 3:9). In ethical behaviour, such religious movements apparently were not immoral, but, together with a radicalized (or "realized") eschatology (II Tim. 2:18), were rather ascetic (I Tim. 4:3 and 8; *cf.* 5:23!). This asceticism was probably connected with a legalistic interpretation of the Old Testament Law (I Tim. 1:7; *see* also Tit. 1:14).

A precise identification of these heretics, however, is not possible. Scholars have pointed to Marcion (*q.v.*), who claimed Paul as his authority and whose basic work, *Antitheses*, may be referred to in I Tim. 6:20 ("godless chatter and contradictions"). But even if the Pastorals were written so late (*i.e.*, in the middle of the 2nd century; perhaps by Polycarp of Smyrna, as H. von Campenhausen suggested), it is not likely that they were issued to fight one specific heresy but rather were intended as a general guide for controversy with all contemporary Gnostic movements. This may be the reason why most references to the heretics are rather general and vague.

Against the radical and ascetic theology of the heresies, the Pastorals set forth the "sound doctrine" of the ideal of good "Christian citizenship" (M. Dibelius). A radical change had taken place since the Apostolic Age. The growing church had to face the problem of fitting itself into the ongoing history of world and society—a task with which the Gnostic movement was unable to cope. But the Pastoral Epistles emphasized the Christian responsibility in this world.

Like other writers of the early 2nd century, the author of the Pastorals considered the organization and strengthening of the church hierarchy to be an effective device in the warfare with the heretics. The ideal church constitution for the Pastorals apparently centres in the monarchical episcopate ("bishop" occurs always in the singular; I Tim. 3:2; Tit. 1:7), which is the head of the presbytery (I Tim. 5:17–19; Tit. 1:5) and/or is assisted by a number of deacons (I Tim. 3:8 and 12). The church offices are not charismatic but institutional; moral qualifications are decisive (*see* I Tim. 3:4–7 and 10–13; Tit. 1:6–9), and it is a special advantage to come from a good Christian background (II Tim. 3:14–17). Ordination as a legal act of the church (I Tim. 4:14; *see* also 5:22) is already seen as the transfer of the religious powers for this office (II Tim. 1:6)—such powers, therefore, are not presuppositions for, but rather results of, the ordination.

The duty of the ministry is primarily the preservation of correct and sound doctrine as the original endowment of the church (I Tim. 4:6; II Tim. 1:12–14; 2:2), which is guaranteed by the apostle Paul, whose archetype the Christian minister should follow (II Tim. 3:10). This is remarkable for two reasons: (1) the emphasis upon the sacramental task of the church officer (crucially important in Ignatius) is missing entirely; (2) only the church officers are responsible for administering and transmitting this endowment of faith (different in the genuine Pauline Epistles).

It is almost impossible to write a "theology" of the Pastoral Epistles, because they do not argue theologically. However, the quoted material preserves many interesting features: the frequent use of the title "Saviour" for both God and Christ (I Tim. 1:1; 2:3, etc.; II Tim. 1:10; Tit. 1:4, etc.); the term epiphany ("appearance" or "appearing") occurs for the first time as a technical designation both for Jesus' first appearance on earth (II Tim. 1:10; *see* Tit. 2:11) and for his second coming (I Tim. 6:14; II Tim. 4:1 and 8; Tit. 2:13). In general the Pastorals provide evidence for the development of theological language and thought away from the Jewish environment and toward the popular religious concerns of the Hellenistic world. The theological contribution of the Pastoral Epistles, however, lies in the fact that their author has seen the actual theological task as the mastery of life (Christians behaving as good citizens) and the reasonable organization of

church and ministry, rather than as speculative theology and ascetic otherworldliness. *See* also BIBLE.

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(H. H. Ko.)

PASTORAL STAFF: *see* CROSIER.

PASTOUREAUX (literally "shepherds"), the participants in two misguided popular outbreaks of mystico-political enthusiasm in France in 1251 and 1320.

In 1251, during Louis IX's Crusade, the news of their beloved king's lack of success against the Muslims inspired the peasants of northeastern France to take up arms, at the behest of a prophet, with the intention of going themselves to the Holy Land. The regent of France, Blanche of Castile, was at first ready to take the movement seriously as a contribution to the king's service; but it soon got out of hand, as the Pastoureaux, reproaching nobles, clergy, and bourgeois alike with indifference to the king's fate, began to pillage churches and towns. Blanche then ordered the dispersal of the Pastoureaux, which was easily effected.

More serious was the mass rising of the Pastoureaux in 1320, during Philip V's reign. Again the intention was a crusade, but this time the king himself was blamed for not undertaking one. Young peasants, shepherds, and labourers, their credulity exploited by unfrocked priests and charlatans, converged on Paris in a vast horde. There they held the king besieged and powerless in his palace while they sacked the town and swelled their ranks with released convicts from the prisons. Still clamouring for a crusade, they then marched southwestward to the Garonne Valley and thence into Languedoc, about 40,000 strong, indulging in pogroms against the Jews on their way. At last the seneschal of Carcassonne gave battle and routed them; but scattered bands of Pastoureaux were still roaming the south of France in 1322.

PASTRY, HOME MADE: *see* FOOD PREPARATION.

PASTURE: *see* GRASSLAND.

PASURUAN, a port of Djawa Timur (East Java) Province, Indonesia, lies on the Madura Strait, about 30 mi. SSW of Surabaja. Pop. (1961) 63,408. It was the capital of a Dutch residency until this was transferred to Malang (*q.v.*) in 1934. From about this date Pasuruan's commercial importance declined, much of its trade being diverted to Probolinggo (*q.v.*), to the east. Pasuruan is a centre of the declining sugar industry, and the former sugar research station still supplies seedling sugar canes to the plantations. There are two technical institutes, concerned with forestry and copper mining, a research institute for pulmonary diseases, a hospital, and a number of schools. Industries include rice milling, light engineering, shipbuilding, and cabinetmaking. The railway from Surabaja to Banjuwangi passes through Pasuruan.

PATAGONIA, a regional name applied to the southern part of South America south of approximately 39° S lat. Physiographically, it is divided into two longitudinal sections—the cordilleras of the Andes, including the islands of the Chilean archipelago, and the Patagonian tableland between the Andes and the Atlantic ocean. Thus both Argentina and Chile own parts of it. In a more restricted sense the term designates the Argentine tableland, including Tierra del Fuego (*q.v.*), and is so considered in this article. The term in this sense is usually applied to that section of the Argentine republic between the Negro river and its tributary the Limay, on the north, and the Beagle channel, on the south, together with that section of southern Chile in the region of the Strait of Magellan that lies east of the Andes (*q.v.*).

EDGAR AUBERT DE LA RUE

BEECH TREE IN PATAGONIA, LASHED BY STRONG WESTERLY WINDS ON NAVARINO ISLAND. SEEN BEHIND ARE THE BEAGLE CHANNEL AND THE SOUTHERN COAST OF TIERRA DEL FUEGO

Geological History and Physiography.—The general aspect of the tableland is that of vast steppelike plains rising terrace-fashion from high coastal cliffs to the foot of the Andes; but their true aspect is by no means so simple as such a general description would imply. Along the Negro river they rise by a series of fairly level plains from 300 ft. at the coast to about 1,300 ft. at the junction of the Limay and Neuquén rivers and 3,000 ft. at the base of the Andes. The tableland region rises to an altitude of 4,921 ft. South of the Negro river they are much more irregular. There volcanic eruptions have occurred down to fairly recent times. Basaltic sheets, apparently only recently cooled, cover the tableland east of Lake Buenos Aires and Lake Pueyrredón. On the Chico and Santa Cruz rivers they have spread to within about 50 mi. of the coast and reach almost to the coast south of the Coyle and Gallegos rivers. Basaltic massifs in places are the salient features of the landscape.

The coast consists largely of high cliffs separated from the sea by a narrow coastal plain. Thus the plateaus are formed of horizontal strata, some of sedimentary rocks, others of lava flows. Areas of hilly land, composed of resistant crystalline rocks, stand above the plateaus.

The deep, wide valleys bordered by high cliffs that cut the tablelands from west to east are all beds of former rivers that flowed from the Andes to the Atlantic, but only a few now carry permanent streams of Andean origin (the Colorado, Negro, Chubut, Senguerr, Chico, Santa Cruz). The majority either have intermittent streams such as the Chalia, Coyle and Gallegos, which have their sources east of the Andes, or, like the Deseado, are completely dry except for salt ponds in the deeper depressions and so altered by the combined effect of wind and sand as to afford little surface evidence of the rivers that once flowed in them. They serve an important purpose in the collection of the scanty surface water. Alluvial soils of considerable depth have been built up in them.

The line of contact between the Patagonian tableland and the folds of the Andes is marked by a chain of lakes, their upper ends deep in mountain canyons, their lower ends held in by glacial moraines.

From Lake Nahuel Huapí northward the lakes, except for Lake Lacar, still drain to the Atlantic. South of Lake Nahuel Huapí all of the lakes except Viedma and Argentino now drain to the

Pacific through deep canyons cut across the cordillera; and the interoceanic divide follows the terminal moraines of the old glaciers to the east of the present lake beds, leaving the majority of the transverse valleys without streams.

In the Argentine province of Neuquén the Andes lower rapidly toward the south, Cerro Domuyo east of the upper basin of the Neuquén river being the last peak that exceeds 12,000 ft. The cordillera there consists of a broad zone of mountain chains and narrow valleys. The crests that have a fairly uniform elevation have been carved by erosion from the older Andean rocks. Above them rise isolated volcanic peaks.

Two great fields of inland ice fill all the central part of the cordillera from about 46° S lat. to 51° S lat., with a break at latitude 48° S. From these ice fields great glaciers flow down to the lake region on the eastern border of the cordillera and to the fiords of the western border.

Climate.—Patagonia is the only desert on earth lying along an east coast poleward of lat. 40°. Aridity results from location in the rain shadow of the Andes and from the presence along the coast of a wide zone of cold water—the northward-moving Falkland current. The total annual precipitation ranges usually from 5 to 6 in. and never as much as 10 in. Nearly all the rain falls in winter.

Despite its high latitude, Patagonia does not exhibit extremes of temperature, largely as a result of its proximity to the ocean. The wind, which blows incessantly on the plateau at velocities of 70 m.p.h. and more, increases evaporation and thus further reduces the value of the scanty rainfall.

Tierra del Fuego, which experiences a marine type of polar climate, receives far more precipitation than the tableland, particularly the Chilean portion.

Vegetation.—The principal vegetation, except for parts of Tierra del Fuego that are covered with evergreen forest and grass, consists of a mingling of very low brush and clumps of bunch grasses. There are no trees. The vegetation is harshest and the area most desolate midway on the tableland, near the border of the territories of Chubut and Santa Cruz, but improves toward the south.

The principal range vegetation is a hard bunch grass called *coirón*, not very palatable in summer but invaluable in winter when the tips protrude through the light snow cover, guiding sheep to the grass underneath. In summer seasonal soft grasses provide pasturage for sheep.

Animal Life.—Patagonia's faunal life is quite abundant. Rodents are particularly numerous, all small in size, resistant to drought and extremely fecund. Man wages war against them because they compete seriously with sheep for the sparse vegetation. The guanaco, a camelid, has been largely extirpated. The puma is found in considerable numbers, as is the rhea, the American ostrich, which ranges throughout Patagonia. Other animals are the perdiz, fox, mara, tucutuca, and armadillo. Tierra del Fuego is one of South America's principal nesting grounds for ducks and geese, which congregate in unbelievably large numbers in summer.

As sheepmen destroyed foxes, geese increased in numbers so that sheepmen attempted to destroy them too; six geese eat as much as one sheep.

Water Resources.—Water is at a premium in arid Patagonia. Most of the west-east-trending canyons contain no surface water at any time, though several do intermittently and a few even the year round. Wells are sunk into the gravels of these exotic rivers and a substantial supply of water is obtained. Most ranches are situated in these canyons.

Of the small potential water power in the Andes of Patagonia almost none is developed because there is no market in the region and because distances to the cities in the pampa (1,000 mi. or more) are presently too great for economical transportation. The chain of lakes in western Patagonia provides a valuable water resource for the tourist industry.

Soils.—Patagonia has gray desert soils resulting from the low rainfall accompanied by moderately low temperature. While generally high in plant nutrients, particularly lime, they are low in organic matter. In some areas, however, the soils suffer from an accumulation of alkaline salts. Under their natural arid conditions they are unproductive but do support enough sparse vegetation for limited grazing. The plateau is often covered with weathered lava, river and glacial material carried from the Andes, and decomposed igneous and sedimentary rock. As these weather, the fine particles are blown by the wind. When the time factor is limited, immature soils called Azonal may be formed; they are fertile and productive when irrigated.

The alluvial soils along the river bottoms of the canyons that dissect the region (the Río Negro, Neuquén, Limay and Chubut) are examples. In some places gravel and hardpan lie close to the surface, the latter causing irrigation and drainage difficulties.

Minerals.—Patagonia appears to be poorly endowed in minerals. Coal-bearing strata have been found in many places along the eastern front of the Andes—particularly in Santa Cruz province whose Río Turbio field contributes about 95% of Argentina's coal output. Total annual production, however, amounts to only about 300,000 tons. All the deposits in Patagonia are low-grade. Because of the low quality of the coal and the poor transportation coal can be imported into the country to greater advantage.

The principal oil field in Argentina lies near the coast in Chubut territory; more than 70% of the country's total output comes from the Comodoro Rivadavia field, about 850 mi. SW of Buenos Aires. Natural gas, also present, is transported northward by pipeline, whereas the oil is moved by tanker.

Petroleum has been discovered and developed in the Argentine portion of Tierra del Fuego and near the Strait of Magellan in both the Argentine and Chilean sections.

A new mining district of about 10,000 sq.mi. bordering on the San Matías gulf in eastern Argentina, developed after 1950, has lead, manganese, fluorspar and tungsten. In 1951 a hematite-magnetite iron ore deposit with an estimated 160,000,000 tons of ore running 55% iron was discovered.

Agriculture and Pastoralism.—Agriculture is of minor importance in Patagonia. In the bottoms of several of the west-east-trending river valleys some irrigation agriculture is carried on. The irrigation works are simple. Alfalfa is the principal crop in terms of acreage. Fruits—grapes, apples and pears—are quite important, particularly in the Río Negro valley. Over most of the plateau the only crops are a few hardy vegetables—cabbage, carrots, lettuce and turnips—grown behind windbreaks.

Sheep raising dominates all economic activity in the region; Patagonia possesses about one third of Argentina's 50,000,000 sheep. Argentine and Australian Merinos predominate in the north, where, because of the poorer pastures, wool-growing is the principal enterprise. The Corriedale and Romney Marsh breeds predominate in the south, where better pastures, ports and freezing works provide an outlet for mutton. The carrying capacity on the Patagonian range is about 5 to 10 ac. for each sheep, as contrasted with 2½ ac. in Tierra del Fuego.

In no other comparable area in the world are there so many sheep in proportion to the human population as in this region. Throughout the world better-endowed areas tend to turn from sheep to more lucrative pursuits. But this is not to be expected for Patagonia, which appears to be essentially and permanently a sheep-raising region. The number of sheep will probably not increase to any great extent because wind erosion and drought are ever present and overgrazing has been reducing the carrying capacity of the range.

Transportation.—The few railways in Patagonia are essentially lines leading from ports into their hinterlands. The Southern railway, entering Patagonia where it crosses the Río Colorado from Bahía Blanca, passes through Neuquén, the capital of the Neuquén territory and extends west to Zapala. Railways south of the Río Negro include (1) the San Antonio railway, which connects with the Southern railway of Buenos Aires at Carmen de Patagones and reaches westward from Puerto San Antonio Oeste to San Carlos de Bariloche; (2) the Central railway of Chubut, which continues from Puerto Madryn up the Chubut valley; (3) the Comodoro Rivadavia railway, which extends westward to Colonia Sarmiento; (4) the Puerto Deseado line, which runs

northwestward to Colonia Las Heras via Fitz Roy; (5) the Río Gallegos-Río Turbio railway, the southernmost line in the western hemisphere, was built to connect the Río Turbio coal mines near the Chilean border with the deepwater port of Río Gallegos, 50 mi. north of the Strait of Magellan.

A road extends south along the coast to Río Gallegos and from there to Punta Arenas, Chile. In the interior the conditions of the roads vary greatly; the Nahuel Huapí National Park region is one of the best served in this respect. (L. We.)

History.—Most of the settlement of Patagonia has taken place in the 20th century. Vast numbers of sheep and a lack of population characterized the area until the fruit, agricultural and resort zones of the north developed after 1910 and oil was discovered on the coast.

During the Spanish colonial period there was virtually no settlement of the Patagonian coast, river valleys or Andean chain. Jesuit missionaries entered the northern area by way of Chile in the 17th century but were unable to effect a permanent settlement. In the late 18th century, a permanent coastal settlement, Carmen de Patagones, was founded at the mouth of the Negro river and became an important source of salt for Buenos Aires.

Expansion into Patagonia was little more successful in the early national period and only Punta Arenas (*q.v.*), a Chilean strait settlement, and Colonia Sarmiento, a Welsh colony in Chubut, were established. Extensive colonization began only in the 1880s, shortly after a series of vigorous military campaigns (1879–1883) had effectively removed the Indian menace. The pioneers were mainly European (Welsh, Scotch, English) and Chilean. There were three main routes of colonization: from the ports of Buenos Aires and Bahía Blanca came mostly Europeans spreading southward along the coast; from the Chilean village of Punta Arenas another finger of settlement extended up the eastern Andes, bringing sheep into the desolate plateau area; a final route led across the Andes from Chile into Neuquén and pushed southward past Lake Nahuel Huapí. Settlement aggravated the boundary dispute between Chile and Argentina.

Although hostilities were barely avoided during the last decade of the 19th century, mediation finally solved the dispute. (*See* Argentina: *Geographic Regions: Patagonia*).

During the 20th century, the sheep-raising industry moved away from the pampa toward the arid southern tablelands of Patagonia. Ranch headquarters sheltered in river canyons administered thousands of square miles of range. Population remained sparse and was limited to such ranch villages and tiny seaports except for the area of northern Patagonia along the Neuquén and Negro rivers, which continued to attract European settlers. Foreign land companies that obtained grants from the Argentine government brought many colonists to that area. Argentines from Mendoza and San Juan also came. It was found possible to raise a variety of crops including wheat, rye and potatoes there and the basis of a fruit industry was laid. Government aid to railroad and irrigation projects from 1910 to 1930 especially advanced the Río Negro area. Westward along the Andes a lumber industry prospered.

The lakes near San Carlos de Bariloche gained popularity as a resort, and the spread of skiing during the winter season assured further profits. Meanwhile the discovery of oil in 1907 at Comodoro Rivadavia provided another impetus for settlement in that area.

In 1955 the territories forming Patagonia were made into four provinces. The military zone of Comodoro Rivadavia, created in 1944 to safeguard oil deposits, was divided at lat. 46° S between the province of Chubut and the province of Santa Cruz, the latter also including the tip of Tierra del Fuego. By 1960, the population of the three northern provinces of Neuquén, Río Negro and Chubut (*qq.v.*) was 443,820 as compared with the 52,648 of the southern province of Santa Cruz (*q.v.*). Although Patagonia comprises about a quarter of the land area of Argentina, it had less than 3% of the population; the average density was about one and one-half persons per square mile.

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PATAN (Lalitpur), a town of Nepal, lies on the southern banks of the Bagmati River, about 2 mi. S.E. of Katmandu. Population (1961) 48,577, over two-thirds of whom are Buddhists. When Prithvi Narayan Shah (*q.v.*) conquered the Nepal Valley in 1768, Patan was plundered and the people treated with great brutality. Many fine buildings remain, however; the old palace and the temples (including the Buddhist temple of Machendranath) in the Durbar Square and in other parts of the town compare favourably with any in Nepal. A feature of the town is the number of old viharas, originally Buddhist monasteries but now inhabited by the descendants of the priests who once occupied them. The town is the headquarters of the Banra sect of the Newars (*see* Nepal). The Banras form the majority of the gold- and silversmiths whose work is well known. According to legend Asoka visited the town about 250 B.C. and built the four large stupas which still exist on the four sides of the town. (Ri. R. P.)

PATANJALI, an ancient Indian author or authors, to whom are ascribed works in Sanskrit on religious meditation (*Yoga-sutra*), grammar (*Maha-bhashya*), medicine (*Charaka-samhita*), alchemy (*Patanjala*), the Sankhya philosophy (*Adhara-karika*), liturgical music (*Nidana-sutra*), and metrics (Pingala's *Chhandah-sutra*).

The well-known "Aphorisms of Yoga" codified earlier thought, but appears itself no older than the 4th century A.D., as some aphorisms seem intended to refute the *Vijnana-vada* school of Mahayana Buddhism. It may be an earlier text remodeled. The "Great Commentary" discusses the grammatical aphorisms of Panini and Katyayana's critical annotations upon them, which it incorporates. It is of great acuity, both philosophical and grammatical. Events mentioned suggest the 2nd or 1st century B.C. for its composition. A tradition, perhaps late, appears to identify *Charaka*, a medical authority perhaps of the 2nd century A.D., with a single Patanjali, author of both the *Yoga-sutra* and *Maha-bhashya*, but neither philosophically nor grammatically do these works appear in complete accord. Al-Biruni in the 11th century frequently quotes as of great renown a *Patanjala* which appears similar in content rather than form to the *Yoga-sutra*, but includes alchemy as a means to liberation; and a *Patanjala* is elsewhere cited as an alchemical authority. Patanjali and all the authors with whom he is sometimes confounded are regarded as incarnations of the divine serpent, Sesha.

See L. Renou, *Littérature sanskrite* (1946).

PATAVIUM: *see* Padua.

PATAY, BATTLE OF, one of the most serious defeats experienced by England in the Hundred Years' War (*q.v.*) with France. After the death of Henry V (1422), the English made slow progress in extending their conquests but in Oct. 1428 began to besiege Orléans, the strategic key to the Loire river, as the prelude to an invasion of the territory of Charles VII south of that river. The siege had little success during the winter, and Orléans was still holding out in May 1429 when Joan of Arc inspired its relief. The earl of Suffolk (William de la Pole), the English commander, then withdrew his army to three towns on the Loire (Jargeau, Meung, and Beaugency), which he hoped to hold until reinforcements under Sir John Fastolf arrived from Paris. Fastolf reached Janville in mid-June with an army of about 5,000 men and was joined there by John, Lord Talbot and a small force. Jargeau had by then fallen, and the French were besieging Beaugency. Fastolf and Talbot went to its relief but arrived to find it on the point of surrender. They decided to withdraw immediately, not wishing to risk battle with a considerably larger French army. The French, spurred on by the encouragements of Joan, pursued the English northward and overtook them two or three miles south of

Patay on June 18. Fastolf and Talbot were taken by surprise and had no time to draw up their army in a defensive position. Talbot was attempting to block the enemy advance, while the army deployed behind him, when the cavalry of the French van under La Hire (Étienne de Vignolles) and Poton de Xaintrailles rode in among his men and destroyed all chance of organized resistance. A rout followed, in which Talbot was captured and a great many English were killed. Fastolf escaped with the remnants of the army.

This defeat was a blow to England's military prestige and fighting resources. England's reputation for invincibility was lost and with it all hope of striking into southern France. France north of the Loire was now almost undefended, and Charles VII was able to ride triumphantly to Reims for his coronation.

(J. W. Se.)

PATAYA (adjective PATAYAN). Pataya is the name applied to a prehistoric people and culture once occupying the lower valley of the Colorado river, surrounding deserts in California and Arizona, and neighbouring uplands to the east. Patayan sites date from about A.D. 600 onward.

In southwestern United States, archaeologists have recognized three generalized cultures among the prehistoric Indians of Arizona and neighbouring states. These have been named as follows: pueblo cultures, Anasazi (*q.v.*); desert cultures in southern Arizona, Hohokam (*q.v.*); and mountain cultures of southeastern Arizona and western New Mexico, Mogollon (*q.v.*). Since the cultures of Indians living in the valley of the lower Colorado river and surrounding areas did not fit into the other three categories, the name Pataya, a Walapai Indian word meaning "old people," was suggested. In general the Pataya occupied the area now inhabited by tribes speaking a Yuman language, such as the Yuma, Mohave, Yavapai, Walapai and Havasupai, and good evidence exists that the Pataya were their ancestors (*see* YUMAN).

Archaeologists have distinguished three main prehistoric Patayan Indian groups; the sites on which they lived can be recognized by the kinds of pottery they made. Generally they are classified into a river group, Laquish, who had an agricultural economy; a desert group, Cerbat, who lived by food gathering and hunting; and on the Colorado plateau the Cohonina, who accepted some cultural traits from the neighbouring Anasazi or Pueblo Indians.

Archaeology of the river area, centre of the culture, is very difficult to unravel because annual floods buried sites or washed them out, obliterating evidence. The Pataya cremated their dead, leaving no burial grounds on river terraces. They are the least known of the late prehistoric people of the American southwest. *See* also INDIAN, NORTH AMERICAN; NORTH AMERICA: *Prehistory and Archaeology.*

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PATENT. The term patent—derived elliptically from "letters patent" (*q.v.*), a general term referring to the documents whereby some privilege is conferred—is distinctively applied in general usage to governmental grants of the exclusive right to make, use or sell a product or commodity. In modern times the usage has become still further specialized, since governmental policies are in general adverse to the grant of monopolistic privileges in ordinary commerce and trade; such grants are in the main confined to products which are the result of invention or discovery, and are granted for limited times, as the U.S. constitution puts it, "to promote the Progress of Science and useful Arts."

(B. Ce.)

UNITED STATES

Before the U.S. federal government was established, a few patents had been granted to inventors by individual states, as special acts of the state legislatures. Some grants of this kind had even been made by the colonial governments, the earliest in 1641. The U.S. constitution empowered the federal government to issue patents, and also to protect the copyright of authors, by providing, in article 1, section 8, that congress shall have power "to promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." The first act of congress under that authority was passed April 10, 1790. It placed complete power to grant patents in a board consisting of the secretary of state, the secretary of war and the attorney general. The secretary of state at that time was Thomas Jefferson and all applications for patent were examined by him personally. This act was short lived, and only a few patents were issued under it, since the high officials who administered it had too many other important duties to devote adequate time to the work involved. A new law was passed, on Feb. 11, 1793, under which the function of issuing patents was placed under the secretary of state but they were granted merely on complying with the formal requirements of submitting a description, drawings, a model and the necessary fee. This system of issuing patents without any examination for novelty remained in force until 1836, by which time they were being issued at the rate of over 600 a year. Dissatisfaction with this method, which resulted in many patents for things which were not new and in numerous conflicting patents, led to a completely new act passed on July 4, 1836.

The act of 1836 established the "examination" system of granting patents, which has been followed since that time by many other countries. Applications were to be regularly examined by officials with the power to refuse patents, with provision for an appeal in case of refusal. The act established the patent office as a separate bureau in the department of state with a commissioner of patents at its head and contained many provisions which, as subsequently modified, form part of the present patent law of the U.S. The act of 1836 was amended from time to time until in 1870 the patent law was completely rewritten. Thereafter numerous acts of congress, about 60 in number, relating to patents were passed, and in 1952 the basic law was again rewritten and extensively revised (title 35, "Patents," of the United States Code).

The Patent Office.—The administration of laws concerning the granting of patents and related activities was placed in the United States patent office, a bureau of the department of commerce, in Washington, D.C. Originally in the department of state, it was transferred to the department of the interior when that department was created in 1849, and was transferred to the department of commerce on April 1, 1925, by executive order of the president.

The head of the office is the commissioner of patents. About half of the employees are examiners and others with technical and legal training. The chief function of the office is the examination of applications to determine whether the applicant is entitled to a patent. The specifications and drawings of patents are printed and published as they are issued, and a weekly *Official Gazette*, containing a claim and a selected figure of the drawing of each patent issued that week, decisions in patent cases and other information, is published.

The patent office also administers the federal trade-mark law, registering trade-marks used in interstate or foreign commerce. (*See* TRADE-MARKS AND NAMES.)

Subject Matter for Patents.—Patents are granted for the invention of "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof." The word "manufacture" refers to articles which are made and includes manufactured articles and products. The word "process" is defined as meaning process or method and is not limited to processes for producing articles or products, although it has been ruled that processes involving mental steps are not proper subject matter for patent. The meaning of "machine" requires no particular explanation. "Composition of matter" includes substances composed of mixtures of ingredients as well as those produced by chemical action. New chemical compounds can be patented, as well as the processes for producing them, and there are no prohibitions or special conditions in the statute relating to the patenting of food and medicinal products. The only matter specifically excluded from the field of patentable inventions is the application of fissionable material or atomic energy to atomic

weapons, which is excluded by the Atomic Energy act of 1954.

The statute uses the word "useful," which connotes that the invention must be directed to a useful purpose, and it must be capable of accomplishing that purpose. A machine which is inoperative to produce the intended result would not be called useful. However, commercial practicability is not a requirement.

Novelty and Invention.—The invention, in order to be patentable, must be new and to this end the statute provides that a patent cannot be obtained if the invention was known or used in the United States, or if it was patented or described in a printed publication anywhere, before the invention was made by the one who is seeking a patent. Mere prior knowledge in a foreign country will not prevent a true inventor from obtaining a patent. Also, prior secret knowledge and use by others will not ordinarily defeat the right to a patent.

The statute also provides that a patent cannot be obtained if the invention has been in public use or on sale in the United States, or if it has been described in a printed publication anywhere, more than one year before the date on which the inventor applies for a patent. The inventor's own printed publication or public use of the invention, as well as such publication or use by anyone else, occurring more than one year before applying for a patent, will result in the loss of the right to a patent. Publication or use during the one-year period will not affect the right to a patent if the inventor seeking the patent made the invention before the date of the publication or use.

Even if the subject matter sought to be patented is new in the sense that it is not shown exactly by the prior things known or used and includes one or more differences over them, a patent may not necessarily be obtained. It is further required that the differences between the new subject matter and the prior art be such that the subject matter would not have been obvious to a person having ordinary skill in the art. In applying this requirement, the courts have said that the new subject matter must involve "invention" over what is old. This determination has been one of the most difficult aspects of patent law and has involved the most conflicts of opinion.

Application for Patents.—Only the actual inventor can apply for a patent in the United States, except in certain special situations. If the inventor is dead, the executor or administrator of the estate can apply; if the inventor is insane, his legal representative can apply in his place. If the invention is made jointly by two or more persons, they must apply for a patent as joint inventors although it is possible to correct innocent mistakes in either omitting a joint inventor or erroneously joining a person as inventor.

The application must contain a written description of the invention, a drawing when the nature of the case admits of a drawing, an oath of inventorship executed by the inventor, and must be accompanied by the government filing fee. The description of the invention must be so complete as to enable any person skilled in the art to which it relates to make and use it, and must set forth the best mode contemplated by the inventor of carrying out the invention. Claims particularly and distinctly pointing out the subject matter regarded as the invention are required. The claims define the scope of the subject matter protected by the patent. The description and claims are called the specification.

Prior to 1870 models were required with every case admitting of a model, but this has since been discontinued as a general requirement. (A working model would be demanded by the patent office in the case of an alleged perpetual-motion machine.)

Procedure in Obtaining Patents.—After an application for patent has been filed, it is referred to the appropriate examining division of the patent office where it is examined when its turn is reached. The examiner searches through all relevant prior United States patents, and also through those of other countries and printed publications which are available to him, to determine if the invention is new and patentable under the law. His decision as to the patentability of the invention on the claims presented is sent to the applicant. The applicant can ask for reconsideration, within six months, of an adverse decision, with or without amending the wording of the specification, and the application is then re-examined and reconsidered; and this procedure continues until an issue is reached. If the final decision of the examiner is adverse on any of the claims, the applicant may appeal to a board of appeals within the patent office. A refusal by the board of appeals may be reviewed by the courts, the applicant being given the option of appealing to the court of customs and patent appeals or filing a suit in the United States district court for the District of Columbia.

When two or more applications for patent for the same invention are filed by different inventors a proceeding known as an interference may be instituted to determine who is the first inventor and entitled to a patent. The first to apply does not necessarily obtain the patent. An interference between an application and an issued patent is also possible under restricted conditions.

If it has been decided to grant a patent, a notice of allowance is sent to the applicant; a final fee is due within six months and the patent is issued shortly after this fee is paid.

The proportion of applications filed which result in patents varies, but generally it is about 60%.

Nature of Patents.—The patent is issued in the name of the United States of America, under the seal of the patent office, and includes a copy of the specification and drawings. The patent in terms contains a grant to the patentee, his heirs or assigns, for the term of the patent, of "the right to exclude others from making, using, or selling the invention throughout the United States." It should be noted that the patent does not grant the positive right to make, use or sell the invention and the patentee's own right to do any of these things is dependent upon the rights of others and whatever general laws, if any, might be pertinent. The patentee may not use his own invention if doing so would infringe a prior patent of another, without the permission of the prior patentee. Nor could a patentee sell his invention if doing so would violate laws such as, for example, the pure food and drug laws.

Territorially, the right conferred by the patent extends throughout the United States and its territories and possessions. The term of the patent is 17 years from the date of its grant. This period was adopted in 1861, replacing the prior term of 14 years with the possibility of an extension for another 7 years. The term of a patent cannot be extended except by an act of congress; a temporary law passed in 1950 (later expired) provided for extending the term of patents owned by veterans of World War II.

No fees are required after a patent has been issued for maintaining it in force, nor does the law contain any provision for revoking a patent or granting compulsory licences if the patented invention is not worked in the United States.

Patents as Property.—A patent is recognized as a species of property and has the attributes of personal property. It may be sold (assigned) to others, mortgaged, bequeathed by will, or may pass to the heirs of a deceased inventor. The patent is assignable in law by an instrument in writing, either after it is granted or while it is in the application stage. If the application for patent is assigned, and the assignment is recorded in the patent office in time, the patent will be issued directly to the assignee. A part interest in a patent may be assigned, and the patentee may also convey a grant for a specified territorial part of the United States. An assignment, grant or other conveyance may be recorded in the patent office at any time, but if it is not recorded in three months it might not serve as protection against the subsequent sale of the patent to another.

A patent may be owned by two or more persons jointly, either as a result of the patent's having been granted to joint inventors or as the result of the assignment of an undivided part interest. Unless they have agreed otherwise, each joint owner can act independently of the others; he may make, use or sell the invention for his own profit, grant licences to others or assign all or part of his interest without regard to the other joint owners.

Since the patent gives the owner the right to exclude others from making, using or selling the invention, he may authorize others to do any of these things by a licence. A licence is a contract between the parties and it may include whatever valid conditions and limitations may be agreed upon, such as the amount of royalties to be paid. Provisions relating to maintaining resale

prices or to dealing with unpatented articles are generally not legal. The patentee may not violate the antitrust laws in his dealings with patents.

Some states have laws prescribing certain formalities for the sale of patent rights.

Amendment of Patents.—After a patent is granted it can be amended or corrected in the patent office in a number of respects. Clerical errors made by the patent office whereby the patent does not correspond to the record can be corrected by a certificate of correction. Some clerical or typographical errors made by the applicant may also be corrected by a certificate of correction. An innocent mistake in erroneously joining a person as a joint inventor or in erroneously omitting a joint inventor can be corrected by the patent office by deleting the name from, or adding the name to, the patent, as the case may be.

One or more claims of a patent may be disclaimed by the patentee by filing a disclaimer in the patent office. The patentee may also disclaim or dedicate the entire term, or any terminal part of the term, of his patent.

A patent can be reissued by the grant of a new patent to replace the original one for the balance of the unexpired term. Reissues are obtained primarily when the patent is defective in claiming more or less than the patentee had a right to claim, and require the filing of a new application which is subject to examination.

Plant Patents.—Patents are also granted (since 1930) for new and distinct varieties of plants, including cultivated sports, mutants, hybrids and newly found seedlings. Tuber-propagated plants, which include the common potato, and existing plants found in an uncultivated state may not be patented. The plant must have been asexually reproduced by the inventor or discoverer before it can be patented.

The requirements and procedure for obtaining a plant patent are in general the same as those for other patents, with a few exceptions. The right granted by a plant patent is "the right to exclude others from asexually reproducing the plant and selling or using the plant so reproduced." Many new varieties of flowering and fruit-bearing plants have been patented.

Design Patents.—New, original and ornamental designs of articles of manufacture can be protected by design patents. The design patent relates only to the appearance of the article, and not to its construction or useful features. A design patent may be granted for a term of $3\frac{1}{2}$, 7 or 14 years, with a different fee for each, at the option of the applicant. Applications for design patents are examined in the same manner as other applications, although there are a few differences in the requirements.

Patent Marking.—A patentee who makes or sells patented articles may mark the articles with the word "patent" or the abbreviation "pat." and the number of the patent. This requirement is not compulsory but if the patentee fails to mark the articles he cannot recover damages from an infringer unless the infringer was notified of the infringement and continued to infringe after the notice. The marking of articles as patented when they are not in fact patented is prohibited by law. While an application for patent is pending in the patent office, articles may be marked with the words "patent pending," "patent applied for" or an equivalent expression. This marking has no legal effect but only gives information to the public that an application for patent has been filed in the patent office. The use of these expressions when no application for patent has been made or when an application is no longer pending is prohibited by law.

Infringement and Enforcement of Rights.—The statute defines infringement of a patent as the unauthorized making, using or selling of the patented invention, within the United States, during the term of the patent. Active inducement of infringement by others may also constitute infringement.

If a patent is infringed, the patentee's remedy is by a suit against the infringer in the appropriate district court of the United States. The court may award the patentee damages to compensate for the infringement (which may include the profits made by the infringer) and has the power to increase the damages up to three times the amount found. The court may also grant an injunction to prevent the continuation of the infringement. The defendant in the suit, in addition to maintaining that what he is doing does not in fact infringe the patent, may raise the question of the validity of the patent. The court may find that the patent is invalid on grounds specified in the statute as conditions for patentability. A holding of invalidity operates only between the parties and does not constitute a cancellation or revocation of the patent; the patentee may conceivably sue someone else on the same patent, but such subsequent suits on patents once held invalid are not common and are rarely successful.

The question of infringement is determined by the claims of the patent, which define the scope of the rights granted; if the defendant's activities do not fall within the language of any of the claims of the patent, he will ordinarily not be held to infringe. The losing party in the suit may appeal to the court of appeals for the circuit in which the district court is located. There is no right of appeal to the supreme court, but that court may accept a case by writ of certiorari.

A person who is charged with infringing a patent by a patentee who has not sued for infringement has the right to initiate a suit against the patentee and obtain a judgment on the question of infringement as well as the validity of the patent.

The United States government may make or use any patented invention without the consent of the patentee, but the patentee has the right to compensation which may be recovered by suit in the court of claims if not paid.

See also COPYRIGHT. (P. J. F.)

GREAT BRITAIN

The Statute of Monopolies, passed in 1624, marked a revolt against the practice of granting to private individuals monopolies of branches of manufacture or commerce; *e.g.*, the making of playing cards, the sale of salt, etc. This statute declared such grants in general to be invalid, but excepted grants for a term of 14 years or less "of the sole working or making of any manner of new manufactures within this Realm to the true and first inventor or inventors thereof, which others at the time of making such Letters Patents and grants shall not use"—and this exception is the origin of British patent law and, indeed, of the patent laws of the world.

At first the monopoly granted was merely defined by a title and there was no provision obliging the patentee to make his invention (throughout this article the word invention is used with the statutory meaning, viz., as including an alleged invention) known to others, save that some grants required him to take apprentices and train them in the new manufacture; but in the reign of Queen Anne (1702–14) it became customary to make it a condition of the grant that the patentee should within a fixed period file a written description of his new manufacture and, in time, this description also came to embody a statement as to the monopoly claimed and so became the progenitor of the modern specification. Originally patents were issued by the lord chancellor under the great seal, and Charles Dickens draws a lively picture of the trials of the unhappy inventor bandied about by a host of officials, none of whom took the slightest interest in the invention but all of whom must be suitably feed before the grant would be made. By an act passed in 1850, however, a new body—the commissioners of patents—was created under whose seal grants were thereafter to be issued. One effect of this change was that whereas the great seal was recognized throughout the dominions, such recognition was not given to the commissioners' seal, so that the patent monopoly was thenceforth confined to the United Kingdom and the Isle of Man, though its effect can still be extended to the Channel Islands and certain colonies by registration. This act also provided that the specification should be filed before instead of after the grant, and created the provisional specification.

The act of 1883 created the patent office in its present form, presided over by the comptroller general of patents, designs and trademarks, but though the comptroller was given considerable powers concerning the form of specifications he had none over their contents—applicants could still claim what they would at their own risk and embody the most diverse inventions in one application—and it was not till 1907 that the system of search was inaugurated

and power given to refuse patents for inventions which had been clearly anticipated.

All the self-governing countries of the Commonwealth of Nations have their own patent offices, their patent laws being in substance those of Britain, though there are some detailed variations.

The whole British patent law is now contained in the Patents act, 1949.

Patent Office Procedure.—Application for a patent may be made by a person claiming to be the "true and first inventor," or by his assignee or personal representative, and any other persons may join in the application. Normally the true and first inventor is the person who substantially originated the invention, even though he may have accepted suggestions (not amounting to separate inventions) from others. Where two persons have conceived the invention independently, the one who first applies for protection is the "true and first inventor." Since, however, the primary object of the provisions dealing with patents for invention was the creation of new manufactures within the realm, a person who introduces an invention from abroad has always been considered as its inventor, and no question has ever been asked about how he acquired it. A person, for example a patent agent, to whom an invention has been communicated from abroad may apply as a "communicatee." The application must be accompanied by a specification which in the case of an original application may be either a "provisional specification" stating broadly the nature of the invention, or a "complete specification" describing in detail the invention and the manner of its performance with claims defining the monopoly sought. Where a provisional specification is used, a complete specification must be filed within a year (a period which may be extended to 15 months by payment of a fee) and in the case of a convention application a complete specification must be filed in the first instance. A single complete specification may be lodged in respect of two or more provisionals or convention applications for cognate inventions, but the application must relate to a "single" invention—a term to which a wider interpretation is given in the case of an invention relating to a new type of machine than to one relating to improvements in parts of a known machine; if this rule is infringed the applicant may be required to file divisional applications for the different inventions. The application must be for a "manner of new manufacture"—a phrase which covers either a process or an article. Processes which produce, improve or preserve a vendible article are considered to come within this definition, which also includes processes or methods for the control of manufacture, but processes relating to agriculture or the like, or medical or surgical treatment, are not within it, although agricultural or surgical instruments, medicinal substances, etc., may be. Processes depending mainly on the intellectual faculties, *e.g.*, literary or artistic compositions, methods of advertising, etc., are not considered to be patentable, nor are documents, charts, etc., relating to such processes.

When a complete specification has been lodged it is referred to an examiner who makes a search among British specifications not more than 50 years old (the search may in certain cases extend to documents of other classes) to ascertain whether the invention as claimed in any claim has been wholly or in part published, and the result of the search is embodied in a report, which may also draw attention to faults in drafting; *e.g.*, that the claims are not "clear and succinct." After consideration of the report the comptroller may require the applicant to amend the specification and, in default of compliance, or if the invention has been wholly anticipated, he may refuse the application. "Subject matter," *i.e.*, the existence of an "inventive step," cannot be considered at this stage, though it may be in the case of an opposition. The comptroller may also refuse a patent for an invention that is clearly impossible, *e.g.*, perpetual motion, or such that its use would be contrary to law or morality, or for certain inventions relating to food or medicine.

Searches are also made to ascertain whether the invention has been claimed in a specification of prior date, or whether the use of the invention would involve risk of infringement of the claims of a prior specification, and if so references may be inserted to such specifications. When all is in order the specification is accepted and is open to inspection, and shortly after it is published; *i.e.*, copies are put on sale. During a period of three months after publication opposition may be lodged to the grant of a patent, the grounds of opposition including most (but not all) of those on which the validity of a patent may be challenged, but the opponent must show a real interest which would be adversely affected by the grant. Sealing may take place four months after publication of the specification unless an opposition is pending. Within a year of sealing an application may be made to the comptroller to revoke a patent on any of the grounds on which the grant might have been opposed.

Where an applicant or patentee makes an improvement on an invention, in respect to which he has applied for protection or holds a patent, he may obtain a "patent of addition" even though the improvement does not show an inventive step over what is disclosed in the specification of the main patent. No renewal fees are payable for patents of addition, but they lapse with the main patent, although in certain cases the comptroller may allow them to continue as original patents.

Where a complete specification is not accepted, neither it nor any provisional specification is ever published except by order of a court. The reports of examiners are also confidential documents, but after a complete specification has been accepted lists of the specifications referred to in such reports may be obtained on payment of a fee.

The term of a patent is 16 years from the date when the complete specification was filed, but renewal fees must be paid after the fourth year, rising annually from £5 for the 5th year to £20 for the 16th year. This scale can be increased, with a maximum of £30. Where a patent has lapsed because of accidental failure to pay renewal fees restoration may be granted. The term of a patent may be extended either on the ground that the remuneration of the patentee has been insufficient in view of the importance of the invention, or that the patentee has suffered loss as such as the result of hostilities.

The comptroller has many other powers and duties: for example, he may direct the mention in the specification of the name of the actual inventor (though this has no effect on patent rights); he may decide disputes between coapplicants or copatentees, and (by consent of the parties) certain disputes about infringement. In many cases, though not in all, an appeal lies from his decision to the patent appeal tribunal (*i.e.*, to a high court judge who is normally the judge by whom patent cases are tried), and in certain cases, as when a patent has been revoked by the comptroller, there may be a further appeal to the court of appeal. It is the general practice of the comptroller and the tribunal to give the applicant the benefit of any doubt, since the validity of the patent can, if necessary, be subsequently determined by the courts. Application forms may be obtained from the patent office. The fee payable on application is £1; on lodging a complete specification, £10; on application for sealing, £3. An inventor may draft and lodge his own specification and appear himself before the comptroller or the tribunal, but in a large proportion of cases this work is done by patent agents. No one may practise as a patent agent unless he is registered as such, and registration can be obtained only after passing severe scientific and legal examinations.

The expenses of the office substantially exceed its revenue. The office publications include the official journal giving notices of acceptances, etc., the reports of patent, design and trade-mark cases and the comptroller's annual report, a document of great interest containing, *inter alia,* important notes on the trend of invention.

Property in Letters Patent.—Letters patent are choses in action and devolve like other personal property. A register is kept at the patent office giving particulars of ownership and licences. Although no notice of a trust may be entered on the register, documents giving equitable rights are entered. The register is prima-facie evidence of what is entered therein and in general no document, which should be entered but is not, can be given in evidence save by leave of the court.

Patentee means the person entered on the register as owner of a patent. If two or more persons are entered as co-owners, then

(in the absence of a special agreement) each has an equal undivided share in the patent rights and may use the invention for his own benefit, but he may not assign his share or grant a licence, save the implied licence to the purchaser of an article made by him. Consequently all co-owners must join in an assignment or licence, but the comptroller has extensive powers to require co-owners to concur in such matters. Legal assignments and licences must be by deed, and cannot be executed until the grant has been sealed, but the courts recognize and enforce agreements giving equitable rights.

There is also a species of property in unpatented inventions; *e.g.*, the right to apply for a patent can be assigned and passes by death. Agreements relating to present or future inventions are also enforced, and there may be read into a contract of employment a provision that any invention made by the employee in the course of his employment shall become the property of his employer, unless the terms of the contract negative this inference.

The sale of an article by the patentee or a licensee normally gives the purchaser or subpurchasers an unlimited licence to use or dispose of the article, but limitations may be placed on such licence and are effective if it can be shown that the purchaser knew of them when he acquired the article. This is of special importance in regard to price restrictions on resale.

Patentable Inventions and Requirements for Validity.—A patent can be granted only for "a manner of new manufacture" and although an invention may be "new" and relate to a "manner of manufacture" it is not necessarily a "manner of new manufacture"—it may be only a normal development of an existing manufacture. It is a necessary qualification of a craftsman that he should have the knowledge and ability to vary his methods to meet the task before him—a tailor must cut his cloth to suit the fashion of the day—and any monopoly that would interfere with the craftsman's use of his skill and knowledge would be intolerable.

A patentable invention, therefore, must involve something which lies outside the probable capacity of a craftsman—which is expressed by saying it must have "subject matter" or involve an "inventive step." Novelty and subject matter are obviously closely allied, and in the days when patent actions were tried with a jury the two issues were generally put to them in the composite form, "Is what the patentee claims a manner of new manufacture?" Although these issues must be pleaded separately, both are invariably raised by a defendant, and in fact "subject matter" is the crucial test, for while there may well be novelty not involving an inventive step, it is hard to conceive how there can be an inventive step without novelty.

The existence of an inventive step of course depends on the particular circumstances of each case, but there are certain classes of evidence which are generally considered to point to inventiveness: the surprising nature of the result achieved; the fact that the invention was reached only after long research and experiment; or proof that such invention has supplied a long-felt want as evidenced by its commercial success.

Both the novelty and subject matter of a claim must be judged by the state of public knowledge and practice in the country at the "priority date," which is defined as follows: if the claim is fairly founded on matter contained in a provisional specification or convention application the priority date is the date of filing such specification or application; in any other case it is the date of lodging the complete specification. The objection of disconformity between the provisional and complete specifications which formerly, if substantiated, invalidated the patent, has gone, the only penalty now being loss of priority date. The test of whether a document is a publication which would negative novelty or subject matter has been expressed as follows: "Had the document been placed in the hands of a competent craftsman, endowed with the common general knowledge at the priority date, who was faced with the problem solved by the patentee but without knowledge of the patented invention, would he have said, 'this gives me what I want'?" "Craftsman" in this context means not the artisan but the engineer, chemist or manager who directs the work, and "common general knowledge" means such knowledge as the craftsman may be presumed to have acquired from his training, or could obtain from such works of reference as he would normally use; *e.g.*, textbooks and dictionaries. Similar rules would apply in the case of other forms of publication; *e.g.*, public working or sales of articles. A document is published when it comes into a library or other place where the public or a section of the public have right of access, or into the possession of an individual who is under no obligation, legal or moral, to keep it secret. Specifications of any country or official abstracts thereof more than 50 years old at the date of filing of the complete specification are not deemed to be publications.

Publications based on information obtained from the patentee and made without his consent do not generally affect validity, nor do certain publications by the patentee himself; *e.g.*, papers read to learned societies or working for necessary trial, if a patent is applied for within a fixed period. Secret working for commercial purposes, either by the patentee or others, before the priority date, invalidates the patent.

Subject to these qualifications an invention is in general patentable if it produces a new article, a better article or a cheaper article, or affords a useful choice. It may be a combination of old integers so placed together that by their working interrelation they produce a new or improved result. The use of a known article, machine or process for a novel purpose may also be patentable if such purpose is not analogous to that for which it was formerly used.

Somewhat special considerations apply to chemical inventions. At the beginning of the 20th century it was accepted that there was no prevision in chemistry; today the balance has swung over to such an extent that almost complete prevision is assumed of the existence and properties of new substances lying within known classes of chemical compounds, and this has resulted in the coining of the term "selection patent" for patents relating to such cases, the requirements for such a patent being that it relates to a subclass of compounds having special and advantageous characteristics, named in the specification, not generally possessed by substances outside the subclass.

Other requirements for a valid patent are that the invention must be "useful" in the sense that it achieves the results described or claimed; the specification must be "sufficient" in that it properly describes the invention and the method of carrying it out and gives the best method of performance known to the patentee; further it must give warning against the use of improper materials or methods and must contain no false statements, and the claims must clearly define the monopoly sought and must not include an invention which is the subject of a valid prior grant. The primary object of the invention must not be illegal. Failure to comply with any of these requirements may be raised as an objection to the validity of the patent in an action or petition for revocation.

Patent Litigation.—Actions relating to patents must be brought in the high court, the palatine court or the court of session in Scotland. In England they are assigned to a special judge. No action can be commenced until the patent is sealed. Normally the plaintiff is the patentee, but an exclusive licensee, or a licensee of right, may sue an infringer making the patentee a codefendant. Usually the plaintiff alleges infringement, giving certain specific instances, while the defendant denies infringement, alleges that the patent is invalid on certain statutory grounds, the most important of which have been considered in the preceding section, and counterclaims for its revocation. It may also be pleaded as a defense that the plaintiff is a party to a contract or licence relating to the patent which contains certain statutorily prohibited terms; *e.g.*, concerning the purchase or use of articles not covered by the patent.

In construing the specification the court leans neither toward nor against the patentee. The scope of the patent monopoly is determined primarily by the claims, since what is not claimed is deemed to be disclaimed, but the documents must be read as a whole, so that the term used in the claims may be explained by reference to the body of the specification.

Infringement may be by "making, using, exercising or vending" the invention. There is no doctrine of "constructive infringement" so that a claim for the use of an article for a special purpose gives no rights against the manufacturer or vendor, only the user can be sued—consequently such claims are often of little value. Only acts

within the realm are considered; for instance, posting patented articles from abroad is not an infringement. Further, the use of apparatus forming part of the equipment of vessels, airplanes or vehicles temporarily in the country does not in general constitute infringement.

A successful plaintiff is generally granted an injunction against future infringement, an inquiry as to damages or an account of the profits made by the defendant, an order for delivery up of infringing articles and a "certificate of validity" entitling him to claim costs on an increased scale in any subsequent action on the patent. Partial relief may be given to a plaintiff who establishes infringement of a valid claim though other claims are invalid. An inquiry as to damages covers all infringements committed after the publication of the specification down to the date of the writ, but no damages are awarded for infringements committed when the defendant did not know and had no reasonable grounds for supposing that the patent existed. The fact that the patentee marks his article "patent," but without a patent number, does not displace this defense.

Any person interested may present a petition for the revocation of a patent on any of the statutory grounds of invalidity. If an order for revocation is made, either on a petition or a counterclaim, it is generally suspended to give the patentee the opportunity of appealing, or applying to amend the specification. It is a ground for revocation that the invention was obtained from the petitioner, and when a patent is revoked on this ground the petitioner may apply for a patent with the priority date of the revoked patent. A similar rule applies where the grant of a patent is refused, or a patent is revoked by the comptroller, on this ground.

Any person who claims that he has been injured by threats or statements that articles are infringements of a patent may bring an action for an injunction to restrain such threats and for damages. Frequently the defendant responds by commencing an infringement action and the two actions are tried together.

Amendment.—An application to amend the specification of a patent is normally made to the comptroller, but if an action for infringement or a petition for revocation is pending it must be made to the court. The application is advertised and any person may appear and oppose it. Only amendments by way of disclaimer, correction or explanation are permissible and, except in the case of an obvious error, the amendment must not lead to the specification describing or claiming matter not already disclosed, or claiming anything not within the scope of an existing claim. In the case of amendment before publication or in the course of an opposition the comptroller may excuse advertisement. Much wider amendments may be made before acceptance, provided that they do not introduce new inventions. A provisional specification can only be amended by excision.

Once an amendment has been allowed its propriety cannot be questioned save on the ground of fraud, and the amended specification replaces the unamended for all purposes, but reference may be made to the unamended specification in construing the amended specification.

Abuse of Monopoly.—In certain cases the comptroller may grant compulsory licences. Since the original object of the patent laws was the establishment of new industries, the main grounds for the grant of such licences are that the patented invention is not being worked within the country to the fullest practicable extent, or that the demand for patented articles is not being met on reasonable terms, or is being met by importation in place of home manufacture. Other grounds are that the existence of the patent monopoly, or the terms imposed on licensees, unfairly prejudice the development of commercial or industrial activities. The owner of a patent of later date may also apply for a licence on the ground that the earlier patent precludes the use of his invention, but in such a case the later patentee may be required to grant a cross licence. No application for a compulsory licence may be made within three years of the date of sealing. The comptroller may also in certain cases order the revocation of a patent, but no such order was made in recent years. No order for a compulsory licence, revocation or endorsement may be made which would contravene any treaty, etc., with a convention country.

Applications for licences under patents relating to food or medicine may be made at any time and without alleging abuse of monopoly. Such licences are to be granted unless there is good reason for refusal, and are to be on such terms as will secure that the patented articles shall be available to the public on the lowest terms consistent with fair remuneration to the patentee.

Patents may be endorsed "licences of right," either on the application of the patentee or in certain cases compulsorily, and in such case any person can claim the grant of a licence on terms to be settled by the comptroller. Only half the normal renewal fees are payable for patents so endorsed.

The Restrictive Practices act, 1954, would probably have little effect on patent rights, since agreements and licences relating to patented inventions were exempted from its principal provisions.

Crown Rights.—A patent has the same effect against the crown as against a subject, but government departments have the right to use patented inventions on terms to be fixed by the court. Certain government departments may require that a specification be kept secret, and no person resident in Great Britain may apply for a patent abroad unless he has previously applied for protection in Great Britain and no requirement concerning secrecy has been imposed within six weeks of the application.

Patents and Industry.—There are about 50,000 applications for patents annually in Great Britain, and about 60% of grants, of which about 3,000 are kept in force for the full period of 16 years. Yet of these only a trifling number are subjected to the acid test of judgment by the courts, and of these judgments the majority are unfavourable to the patentee either on validity or infringement or on both issues, especially in the case of patents for chemical inventions.

The industrial value of patent protection cannot, however, be judged by these figures. In many branches of industry, and particularly in those relating to chemistry or the various applications of electricity, the amount of research and experiment necessary for evolving and bringing to perfection new processes or products is so great that the individual inventor has been displaced by teams of technicians who may labour for years before achieving any result of practical importance, and in other branches an invention has little chance of practical success unless it is adopted by a strong manufacturing company.

Consequently patents of value gravitate toward powerful corporations, who keep a watchful eye on applications and grants bearing on their own line of industry and are chary of trespassing on ground marked out by their rivals, since to do so might involve a costly action, with the possibility that all the capital sunk in the new venture might be rendered useless by an adverse judgment. Thus the practical value of patents must be judged rather by their general deterrent effect than by the few instances when they become the subject of actual litigation. There can be no doubt, however, that the prospect of obtaining a monopoly is one of the great incentives to the technical research necessary for the maintenance of commercial prosperity, and therefore patent law still achieves its original purpose of introducing new industries. (H. F. M.)

INTERNATIONAL

The rights granted by a patent extend only throughout the jurisdiction of the country granting the patent, hence, in general, one who desires patent rights in a number of different countries must obtain a separate patent in each. There is no universal patent, although the laws of a few countries provide that under certain conditions a patent granted in another country may be registered and become effective.

Practically every country in the world, the exceptions being few and comparatively minor, has a patent law. These laws differ in many details. Variations exist in the subject matter for which patents are granted, the conditions which defeat novelty, the requirements and procedure in obtaining patents, the length of the term and other matters, although most of the laws follow common basic principles. The law of the U.S.S.R. provides for patents, of which only a few are obtained, and "author's or inventor's certificates" which give the inventor the right to some compensation but not the exclusive right of the patent. (Several publica-

tions noted in the bibliography give digests of the patent laws of all countries.)

During the decade before World War II the total number of patents granted by all countries averaged approximately 180,000 a year. This number decreased by more than half during the war and the years following, but by five years after the end of the war the number had risen above the prewar average and during the 1960s it surpassed 250,000 annually. The total number of patents issued does not represent the same number of separate inventions, since one invention might be patented in several countries; nearly half the patents represent such duplications. The countries that issue the largest number of patents are the United States, France, Great Britain, Germany, Canada, Italy, Japan, Belgium, the U.S.S.R. (inventor's certificates), Switzerland, Spain, Australia and Sweden, in approximately the order named.

International Convention.—There are a number of bilateral treaties relating to patent matters, but the important patent treaty is the multilateral International Convention for the Protection of Industrial Property, which was first signed by 11 countries in Paris in 1883 and which came into effect on July 7, 1884. This treaty was revised at Brussels in 1900, at Washington, D.C., in 1911, at The Hague in 1925, at London in 1934, and at Lisbon in 1958, each revision superseding the former version between the countries adhering to the revision. By the mid-1960s more than 60 countries were parties. Under the first article of the convention the countries constituted themselves a "Union for the Protection of Industrial Property."

The convention establishes rights in patent, trademark and related matters of the nationals of the participating countries and in some respects has the aspect of international legislation on these subjects. One of the basic articles of the convention provides that the nationals of each country enjoy in the other countries the same advantages that the other countries grant to their own nationals, without prejudice to any rights specially provided for by the convention.

One of the most important articles of the convention deals with what is called the right of priority. By the operation of this provision, any person who has duly applied for a patent in one of the countries of the union is entitled to apply for a patent for the same invention in one of the other countries of the union within a period of 12 months and be considered in the latter country as having applied there on the earlier date. This article is of considerable importance in facilitating the obtaining of patents by inventors in a number of countries, since in most countries publication of the invention before applying for a patent will defeat the right to a patent.

Other articles of the convention provide that patents obtained in the different countries of the union shall be independent of each other; that the inventor shall have the right to be mentioned as such in the patent, this provision applying when the inventor has transmitted his right to a patent to another in those countries in which the owner may apply for the patent; that a period of grace shall be provided for payment of the fees required by most countries for maintaining a patent in force; that the use of an invention on board ships or on land or aircraft temporarily or accidentally in the territory of a country shall not be considered as infringing the rights of a patentee in that country; etc. One article prescribes certain limitations which must be observed if a patent is to be revoked, or compulsory licences granted, for failure to work the invention or for other abuse of the exclusive rights conferred by the patent. The convention also includes provisions dealing with trademarks, trade names and the suppression of unfair competition.

Under the convention, a central office known as the International Bureau for the Protection of Industrial Property, in Geneva, Switz., under the general supervision of the Swiss government, serves as a clearinghouse for information on patent and trademark laws and issues a monthly periodical in French and English, *La Propriété industrielle* and *Industrial Property*, dealing with patents, trademarks and related matters.

Other International Cooperative Efforts.—An Inter-American Convention Relating to Inventions, Patents, Designs and Industrial Models was signed at Buenos Aires, Arg., in 1910 and adhered to by a number of Latin-American countries and the United States. Some of its provisions are similar to earlier versions of the International Convention for the Protection of Industrial Property. The Council of Europe has sponsored treaties relating to uniformity of formalities required for patent applications, an international classification of patents, and unification of certain points of patent law, which were ratified by some European countries. Twelve of the African countries forming the African-Malagasy Union have established a single patent for the group and a common patent office. Other movements for greater international cooperation in patent matters, including a joint patent for the Scandinavian countries and Finland and a proposed European patent by the European Economic Community countries, are under way.

See also INVENTIONS AND DISCOVERIES; MONOPOLY.

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PATER, WALTER HORATIO (1839–1894), English critic and essayist, celebrated for the fastidious delicacy of his style, was born at Shadwell, London, on Aug. 4, 1839. Educated at King's School, Canterbury, and at Queen's College, Oxford, he settled in Oxford and read with private pupils. In 1864 he was elected to a fellowship at Brasenose College. Pater then began to write for the reviews, and his essays on Leonardo da Vinci, Botticelli, Pico della Mirandola, and Michelangelo, with others of the same kind, were collected in 1873 as *Studies in the History of the Renaissance* (later called simply *The Renaissance*). The volume had a Conclusion which promulgated a sort of aesthetic gospel. Pater omitted it from the second edition, being apprehensive about its tendency, only to restore it in 1888.

The publication of this volume made Pater the centre of a small group in Oxford. He had relations with the Pre-Raphaelites, of whom he was to some extent the heir, and he began to insinuate something of their spirit into his academic world. By the time *Marius the Epicurean* appeared in 1885 he had a following of disciples. *Marius* is his most substantial work. It is a romance of ideas in which Pater's ideal of an aesthetic and religious life is scrupulously and elaborately set forth. The setting is Rome in the time of Marcus Aurelius; but this is a thin disguise for a characteristically late-19th-century spiritual development. *Imaginary Portraits* (1887) are shorter pieces of philosophical fiction in the same mode. *Appreciations* (1889) is a return to the critical essay, this time largely on English subjects. In 1893 came *Plato and Platonism*, giving an extremely literary view of Plato and neglecting the logical and dialectical side of his philosophy. Pater's *Greek Studies* (1895), *Miscellaneous Studies* (1895), and *Essays from The Guardian* (privately printed, 1896; 1901) were published posthumously; also his unfinished romance *Gaston de Latour* (1896).

His life was uneventful. It was almost all spent in Oxford, with short periods of residence in London and visits to the continent, and he died at Oxford on July 30, 1894. He wrote with difficulty, correcting and recorrecting with infinite care. There is a reserve and reticence about his writing, maintained also in his personal life, except perhaps with a few favoured disciples. The primary influence on his mind was his classical study, coloured

by a highly individual kind of more or less Christian devotion, pursued largely as a source of refined artistic sensations. But he was also affected by German idealist philosophy and modern French literature, especially the work of Baudelaire. In his art criticism he does not attempt connoisseurship or expertise; he tries above all to seize the emotional genesis and effect of painting and sculpture. His literary criticism too shows a similar reliance on receptivity and the personal impression. Indeed his writing as a whole is a sort of halfway house between scholarship and original artistic creation.

His early influence was confined to a small circle in Oxford, but he came to have a widespread effect on the next literary generation. Oscar Wilde, George Moore, and the aesthetes of the 1890s were among his followers, and show obvious and continual traces both of his style and his ideas. Through the early work of William Butler Yeats and James Joyce his influence was transmitted to the 20th century. A more rigorous ideal of criticism arising in the 1920s caused his work to fall into neglect or impatient depreciation; but that period is past. The fineness of his sensibility has again become apparent, and it can be seen that his somewhat precious style conceals more close and directed thought than was at one time suspected.

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(G. G. HH.)

PATERA ISLAND (LAPPA), an island on the Kwangtung coast of south China at the eastern mouth of the West River or Hsi Chiang (*q.v.*). Its geology is predominantly of igneous rocks, mainly granites and quartz porphyries. In 1958 an 800-yd. causeway built across Duck channel in the north cut off the flow of water from the Hsi Chiang, causing silt from the Canton delta rapidly to fill up inner Macao Harbor and also controlling the supply of fresh river water for Macao.

Negotiations between Macao and the Chinese authorities for a pipeline and pumping system became necessary. The island is now connected to Canton by motor road. Cultivation is mostly on reclaimed land.

The principal industries are agriculture, quarrying, fishing, and the manufacture of fireworks. In 1958 the entire population of Patera was formed into a commune of the Chinese Communist pattern. Illegal immigration from China to Macao and Hong Kong has continued.

Wanchai, the chief settlement (pop. [1959 est.] 2,000), faces Portuguese Macao across the river. Until 1949 it was a station of the Chinese maritime customs, but since that time its import and export trade has decreased to a minimum. (S. G. D.)

PATERSON, WILLIAM (1658–1719), British writer on money, commerce, public finance, and contemporary political and social issues, founder of the Bank of England and prime mover of the unsuccessful settlement at Darién (*q.v.*) on the Isthmus of Panama. He was born at Tinwald, Dumfries, Scot., in April 1658. In his youth Paterson left Scotland to escape religious intolerance and traveled in Europe and the West Indies, gaining experience as a merchant. Returning to England he tried unsuccessfully to induce the government of James II to back an expedition to Darién. Efforts to get support for his plan on the continent also failed. By 1686 he had become a London merchant and a member of the Merchant Taylors' Company. In 1694 Paterson organized the Bank of England, long desired by the London merchants. He withdrew as a director the next year, following a disagreement on bank policy. After an unsuccessful attempt to organize a rival bank in London, Paterson resumed his interest in the Darién venture. Along with a group of Scottish and English merchants who were seeking investment outlets, he secured in 1695 the passage by the Scottish Parliament of the Act for a Company Trading to Africa and the Indies. William III opposed the expedition because of the state of affairs in Europe and the opposition of some of the London merchants, insofar as the expedition was becoming entirely Scottish in character.

Paterson was deprived of his position by the directors of the company because of a loss of company funds, though he was almost certainly innocent; nevertheless, he accompanied the expedition in 1698 as a private citizen, using his influence and administrative skill to save the company from the ruin that its bad management made inevitable. Paterson's own financial losses were great. His wife and only child died while at Darién, and he was gravely ill before he was forced to leave, arriving home in December 1699.

After Darién, Paterson was involved in a number of projects: the development of resources by a proposed council of trade; proposals for monetary reform; continued agitation for new expeditions to the West Indies; and the parliamentary union of Scotland and England. He was responsible for the sinking-fund method of retiring the national debt which was known as Walpole's sinking fund of 1716. He was an early advocate of free trade and opposed John Law's various schemes by a vigorous attack on inconvertible paper currency. Shortly before his death (on Jan. 22, 1719) the British government finally paid him an indemnity for his losses at Darién.

See *The Writings of William Paterson,* ed. by Saxe Bannister, 3 vol. (1859).

(L. N.)

PATERSON, a city of northeastern New Jersey, U.S., and the seat of Passaic County, is located on the Passaic River, 13 mi. N of Newark and 17 mi. NW of New York City. The city occupies a restricted area of 8.36 sq.mi. within the bend of the river, and is surrounded by the city of Clifton (*q.v.*) on the south and by the boroughs of West Paterson, Totowa, Haledon, Prospect Park, and Hawthorne on the west and north. East Paterson lies across the river to the northeast and east. The population of the city in 1960 was 143,663. Previously part of the New York-Northeastern New Jersey standard metropolitan area, in 1960 Paterson was designated a central city of the Paterson-Clifton-Passaic standard metropolitan statistical area (SMSA) which is part of the New York-Northeastern New Jersey standard consolidated area. Population (1960) of the SMSA (Bergen and Passaic counties) was 1,186,873. (For comparative population figures *see* table in NEW JERSEY: *Population.*)

After the American Revolution, Alexander Hamilton, first secretary of the treasury, advocated setting up manufacturing plants to ensure industrial independence from Europe. He selected as the best site on the Atlantic seaboard the falls on the Passaic River, which have a perpendicular drop of 50 ft. This area had been sparsely settled by the Dutch since the late 17th century. After some political debate the enterprise was chartered by the New Jersey Legislature in 1791 as The Society for Establishing Useful Manufactures (SUM). The charter also provided for a six-mile square within which the society might establish its manufactory. The SUM appointed a committee to select a site. On May 18, 1792, the committee recommended and the directors agreed to locate the manufactory at the Great falls of the Passaic. The city was named after Gov. William Paterson of New Jersey, one of the framers of the United States Constitution.

The SUM was not a successful enterprise and ultimately sold water power and building space to private manufacturers who saw possibilities of industrial development. The earliest industries were cotton mills. By 1837, when the locomotive industry was established by Thomas Rogers, machine manufacturing had become important. The cotton mills and skilled labour attracted the silk industry permanently introduced by John Ryle and George W. Murray in 1839, and at one time a grove of mulberry trees was planted to provide food for silkworms. Linen thread manufacturing was started in 1864.

Paterson, formerly the principal silk manufacturing and dyeing centre in the U.S., was the scene of many labour disputes. By mid-20th century the city had become a centre of widely diversified industrial activity and attracted enterprises of all types. It is the retail centre for the area, with more than 2,100 retail outlets and approximately 700 wholesale houses.

Paterson was a township until 1851, when it was granted a city charter. A new charter was granted in 1871 and this was considerably revised by the change to a commission form of government in 1907. After that time the city operated under a unique form

of government. The people elect a mayor every three years, who appoints bipartisan governing bodies: boards of finance, public works, fire and police, health, and education.

Rutgers University, the state university, has a branch in Paterson as does Seton Hall University. Paterson State College (established as Paterson City Normal School in 1855) is located in the neighbouring borough of Haledon. There is also the Danforth Memorial Library with several branches, and a city museum, famous for its collection of New Jersey rocks and Indian relics. The original submarine built by John P. Holland (*q.v.*) failed and sank in the Passaic River in 1878. It was recovered in 1927 and is on exhibit in Westside Park. There are many outdoor playgrounds and various indoor recreational centres. The 570-ac. Garret Mountain reservation, 502 ft. above sea level, overlooks the Passaic Valley. (S. He.)

PATHAN, the name applied to the Pashto-speaking tribes of southeastern Afghanistan and northwestern Pakistan. Pashto, an eastern Iranian language, has two dialects: the soft, called Pashto (or Pushto), is spoken by the tribes of Afghanistan and those of Pakistan south of the towns of Kohat and Thal; the hard, called Pakhto (or Pukhto), is spoken by the tribes of Pakistan north of these towns. The word Pathan is a Hindi variant of the Pakhto word *Pakhtana* meaning "speakers of Pakhto" and commonly refers to speakers of both dialects (*see* Pashto).

By their own traditions, the Pathans originated in Afghanistan and are descended from a common ancestor. Several tribes are known to have moved from Afghanistan to Pakistan between the 13th and 16th centuries. Each tribe, consisting of kinsmen who trace descent in the male blood line from a common tribal ancestor, is divided into clans, subclans and patriarchal families. Tribal genealogies establish rights of succession and inheritance and the right to use tribal lands and to speak in tribal council. Pathans are intensely individualistic but they abide by a code of honour, the *pakhtunwali*, which imposes on them three obligations: to grant all fugitives asylum (*nanawatai*); to proffer openhanded hospitality (*melmastia*) to even their deadliest enemies; and to wipe out dishonour by revenge (*badal*).

Disputes over property, women and personal injury often result in blood feuds between families and whole clans; these may be inherited unless settled by the intervention of clan chiefs or by tribal council.

Pathans are farmers, herdsmen and warriors. Most tribesmen are sedentary farmers, combining cultivation with animal husbandry; some are migratory herdsmen and caravaneers. Individuals are engaged in business or government service in towns throughout Afghanistan and Pakistan and large numbers have always been attracted to military service.

In the arts they are noted for their stirring drum and flute music, their vigorous, often wildly martial dancing, and their romantic or heroic stories and poetry. The most famous Pathan writers, both of the 17th century, are the warrior-poet Khushhal Khan Khattak and the philosopher Abdur Rahman. Pathans are Muslims, mostly of the Sunni sect, with a reputation for fanaticism when aroused by their religious leaders.

Pathans numbered (1960s) 5,000,000 in Afghanistan and 4,000,000 in Pakistan. They comprise about 60 tribes of varying size and importance and occupying particular territories. Most lie wholly within Afghanistan or Pakistan; a few, notably the Mohmand and Shinwari, overlap the international boundary between the two countries. In Afghanistan Pathans are the predominant ethnic group and the main tribes are the Durrani south of Kabul and the Ghilzai (Ghaljai) east of Kabul. The Muhammadzai line of the Durrani has ruled Afghanistan since 1826. (*See* Ghilzai.)

In Pakistan Pathans predominate north of Quetta between the Sulaiman mountains and the Indus river. Here a tribal border separates the so-called tribal areas from the settled areas. The former include hill tribes governed by their own chiefs but subject to the Pakistan government through political agents. Control over the tribal areas has frequently been thwarted by the refusal of tribesmen to obey their chiefs. The main tribes here are, from south to north: the Kakar, Sherani and Ustarana south of the Gomal river; the Mahsud, Darwesh Khel Waziri, and Bhittani between the Gomal river and Thal; the Zaimukht, Turi, Bangash, Orakzai, Afridi and Shinwari from Thal to the Khyber pass; and the Mohmand, Utman Khel, Tarkani and Yusafzai north and northeast of Khyber.

The settled areas include lowland tribes subject to direct administration by the provincial government of West Pakistan. The main tribes here are, from south to north: the Bannuchi and Khattak from the Kurram river to Nowshera; and the Khalil and Mandanr Yusafzai in the Peshawar valley.

See also references under "Pathan" in the Index.

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PATHOLOGY is the science of disease; *i.e.*, the study of disease agents and the responses they produce in living humans, animals, and plants. In the living human, disease causes abnormal function of the body or organs, with or without changes visible to the naked eye or detectable in the tissues with the aid of the microscope. These changes are usually due partly to the agent and partly to the reaction of the body (but may be entirely due to either). They are described in the sciences of morbid physiology, morbid anatomy, and morbid histology.

During the Renaissance the dogma of authority gradually gave place to inquiry and experiment. A lively interest in the medical sciences developed as men began to realize that the cure and prevention of disease could only be based upon a knowledge of the structure and function of the body in health. The functional anatomy of Andreas Vesalius, Gabriel Fallopius, and Hieronymus Fabricius was followed by the discovery of the circulation of the blood by William Harvey, the father of physiology. The famous book of Giovanni Battista Morgagni, *On the Seats and Causes of Diseases as Disclosed by Anatomical Dissections* (1761), founded morbid anatomy. The next two generations of physicians went from bedside to postmortem room and added to a growing knowledge of the naked-eye appearance of the organs after death. Early in the 19th century improvements in the microscope confirmed previous suspicions of the cellular nature of the tissues; then Rudolf Virchow's book, *Cellular-pathologie* (1858), founded the science of pathology and finally Louis Pasteur, Robert Koch, and others initiated the science of bacteriology, demonstrating that many important infectious diseases were due to invasion of the body by minute parasites.

Cause of Disease (Etiology, Pathogenesis).—"At the heart of pathology there lies a battle—a battle waged between man and his unfavourable environment." Many and widely different factors may upset the delicate physiological balance of the body and cause disease. These, classified in terms of fundamental biological principles, include some that disrupt the internal harmony of the body (for example, faulty development or nutrition) and others that harm the body from without, such as injury or parasitism.

The following fundamental biological principles are the underlying causes of disease:

1. *Faulty Heredity.*—Abnormal genes are the basic abnormality causing certain rare diseases such as hemophilia and mongolism.

2. *Abnormal Development.*—This is the cause of congenital abnormalities such as harelip, cleft palate, and clubfoot.

3. *Faulty Nutrition.*—Starvation or vitamin deficiencies cause diseases such as nutritional edema, scurvy, beriberi, and rickets.

4. *Local or General Failure of Tissue Nutrition.*—The tissues require a constant internal environment described by Claude Bernard as the *milieu interne*. This constant "sea-water" environment bathing the tissue cells includes the correct concentration of inorganic ions in their correct proportions (the electrolyte balance), a sufficient pressure of oxygen and carbon dioxide, and the adequate removal of waste products of metabolism. The tissues are therefore dependent both on the local blood supply and on the proper functioning of the lungs, heart, blood and lymphatic vessels, and kidneys. Any breakdown of the respiratory, circulatory, or excretory systems will result in local or widespread dam-

age to the tissues. Numbers 3, 4, and 5 (*see* below) could all be considered under the general heading of diseases due to the breakdown of physiological mechanisms.

5. *Morbid Physiology.*—The endocrine glands (*i.e.*, pituitary, adrenals, thyroid, and parathyroid and parts of the pancreas, ovaries, and testes) exert a profound influence upon metabolism by the chemical substances that they secrete into the blood. Upset of the delicate balance of these hormones produces diseases such as diabetes, toxic goitres, gigantism, etc. (*See* also ENDOCRINOLOGY; METABOLISM, DISEASES OF.)

6. *Trauma.*—This category includes wounds, fractures, burns, chemical injury, radiation injury, and injury from electric shock. Chemical injury includes poisoning by animals and plants, chemicals, and noxious gases.

7. *Parasitism.*—This term is used when a foreign organism invades and grows in the body. The majority of diseases are due to this cause. Parasites include viruses, bacteria, fungi, unicellular organisms of the class protozoa, and multicellular organisms, or metazoa. (*See* PARASITOLOGY.)

Virus diseases include such scourges of mankind as influenza, smallpox, yellow fever, typhus, poliomyelitis, measles, mumps, chicken pox, and German measles. Viruses cause many important diseases of domestic animals; *e.g.*, foot-and-mouth disease, rinderpest, hog cholera, fowl pest, canine distemper, and rabies. There are also many virus diseases of plants, such as tobacco mosaic. Many viruses are so small that they cannot be seen with the ordinary light microscope, but they can be demonstrated with the electron microscope. They pass through filters and require high-speed centrifugation to concentrate them out of suspensions. Viruses are obligatory parasites, living and multiplying within the cell upon which they are dependent for many of their enzyme systems. Tissues react to viruses in various ways. There may be rapid degeneration and necrosis of the parasitized cells (*e.g.*, ulcers of foot-and-mouth disease), or on the other hand the affected cells may proliferate (as in the virus tumours of fowls). Frequently a combination of both processes is seen, as in the pustular lesions of smallpox. (*See* VIRUSES.)

The bacterial diseases include wound infections (staphylococci, streptococci, tetanus, gas gangrene, etc.), diphtheria, scarlet fever, typhoid fever, tuberculosis, plague, cholera, and dysentery. (*See* BACTERIAL AND INFECTIOUS DISEASES; BACTERIOLOGY.)

Diseases due to fungi include ringworm, thrush, athlete's foot, and actinomycosis.

The diseases due to protozoan parasites include malaria, sleeping sickness, and amoebic dysentery. Metazoan parasites include parasitic worms such as roundworms, tapeworms, and flukes. The hookworm disease of the tropics belongs to this class.

8. *Neoplasms.*—Cancer is usually put in a class by itself. This is partly for clinical convenience, but also because many different factors are known to produce malignant growths. In a strict biological classification of disease, cancer should be classed as an abnormality of growth due to overstimulation of cell division or breakdown of the controls exerted by the body over individual cells and organs.

Defense Reactions of the Body.—The importance of finding the cause of disease is self-evident, but equally important in pathology is a study of the defenses of the body. The early pathologists naturally studied first the most pressing problems—those presented by disease and injury. The phenomena of inflammation engaged their attention, and this is not surprising because the inflammatory reaction is the standard pattern of the body's response both to injury and to many types of infection. The clinical signs of inflammation, *rubor, et tumor, cum calore et dolore* ("redness and swelling, with heat and pain"), were described by Celsus in *c.* A.D. 30. John Hunter wrote (published 1794): "Inflammation in itself is not to be considered as a disease but as a salutary operation, consequent either to some violence or some disease." A. Thomson, A. P. W. Philip, and C. Hastings were all experimenting with the effects of injury on the web of the frog's foot between 1813 and 1817. J. F. Cohnheim in 1867 described the microscopic changes seen in inflammation. Immediately after the injury there may be a momentary constriction of the capillaries followed by a period in which the blood flow becomes more rapid. Later the blood stream slows and white blood corpuscles stick on the walls of the dilated capillaries and then migrate into the tissues. But it was E. Metchnikoff (1884) who first realized that the emigration of the phagocytic white cells into the damaged tissues was the fundamental protective phenomenon in inflammation, and that the vascular reactions were merely a preliminary to this. The inflammatory reaction is the body's mobilization of defense and brings to the site of injury phagocytes and a fluid rich in plasma proteins. Inflammation is a response to products from damaged cells; it is therefore produced by all types of injury—chemical, mechanical, heat, cold, cutting off the blood supply (ischemic damage)—and by many types of bacterial infection (*e.g.*, staphylococci, streptococci, pneumococci). These latter are often called the pyogenic infections because they cause the outpouring of large numbers of leukocytes to form pus. These organisms produce substances that cause leukocytes to move toward them (chemotaxis).

The pathology of a boil will illustrate the principles of both infection and defense. Most bacteria are harmless, in fact many are beneficial to man and to animals, but certain bacteria are able to grow in the tissues, to spread, and sometimes to invade the blood stream. Such organisms are called pathogenic, and the term virulence is used to indicate their power to invade and harm the body. In the production of a boil, first the staphylococci enter by a small scratch in the skin or down a hair root and then multiply. Each coccus may divide at half-hourly intervals, so that if all the progeny survive, in 24 hours a prodigious number of staphylococci will have been produced. These invaders damage the cells of the body by diverting foodstuffs to their own nutrition, by producing by-products of their own metabolism, which are harmful to man, and by producing enzymes that clot plasma or digest the ground substance of the fibrous tissue. Some of the products of the organism are so poisonous to tissue cells, white cells, and red blood corpuscles that they are called toxins, leucocidins, and hemolysins, respectively. Thus the organisms grow, destroying cells and eliciting an inflammatory reaction in the surrounding tissues. This causes an outpouring of leukocytes and plasma. The amoeboid white cells engulf the staphylococci and attempt to kill them by digesting them within their bodies. This process is called phagocytosis (*see* below). The plasma clots into a tangled meshwork of fibrin threads, and this helps to prevent the staphylococci from spreading. V. Menkin has called it "the fibrin barrier." In a few hours or days the staphylococci are killed and the dead tissues, dead organisms, and living and dead leukocytes liquefy to form pus, which is discharged to the exterior. Large cells (macrophages) from the blood and the tissues eat up the dead cells and clean up the mess, acting as scavengers or undertakers. The fibrin barrier now acts as a scaffolding along which creep cells that can lay down fibrous tissue—fibroblasts—and a wall of scar tissue is formed to repair the breach in the tissues. (*See* INFLAMMATION.)

Phagocytosis.—Metchnikoff called the polymorphonuclear leukocytes of the blood microphages because they were chiefly responsible for the eating of microorganisms. He recognized that the monocytes of the blood and certain cells in the tissues called histiocytes would ingest and destroy foreign cells. He noted that injection of red cells taken from a goose into the peritoneal cavity of a guinea pig was followed by aseptic inflammation during which large numbers of monocytes appeared, ingested the red cells, and subsequently digested them. He therefore called these cells macrophages and noted that their function was to phagocytose dead and dying leukocytes and red cells found in the tissues after inflammation or hemorrhage. Macrophages form the main line of defense in typhoid fever and tuberculosis and are active against protozoan parasites such as malaria. Many tissues have histiocytes, which become motile macrophages when occasion demands. They are important in the lungs, where they form the "dust cells."

W. Wyssokowitch (1886) injected organisms into the blood stream of rabbits and found that they were quickly taken up by phagocytic cells lining the vessels of the liver and spleen. These form a phagocytic filter designed to remove bacteria from the blood stream. Small numbers of bacteria often enter the blood

stream even in apparently healthy people. The organisms cannot, however, multiply to produce septicemia until these defenses have been overcome. Similar phagocytic filters are present in the lymph glands and remove organisms that have entered the lymph flowing from a site of infection. These networks of phagocytic cells, demonstrated by their ability to ingest bacteria, carmine, or trypan blue, were grouped together by Ludwig Aschoff (1913) as the reticuloendothelial system. (*See* also PHAGOCYTOSIS.)

Immunity.—The bacteria present in the tissues during infection (*e.g.*, staphylococci) may produce poisons by the disintegration of their dead bodies; these are called endotoxins. On the other hand, when the causative organisms of diphtheria, tetanus, gas gangrene, botulism, and scarlet fever are grown in a fluid culture medium, this fluid is found to be highly toxic even when all the organisms have been removed by filtration. Each of these latter organisms produces a specific exotoxin, and this upon injection will reproduce the symptoms and the pathological changes characteristic of that particular disease. The body takes seven to ten days to produce an adequate defense against such exotoxins. A new globulin, called an antitoxin or an antibody, then appears in the plasma. This will unite with the toxin and when mixed in the right proportions the toxin and antitoxin will precipitate together as fine floccules of protein. Knowledge concerning the site of formation of antibodies is becoming more precise. The plasma cell certainly produces antibodies; this cell is probably formed from the lymphocyte or has a common precursor cell. Lymph nodes and the reticuloendothelial system can produce antibodies. In chronic infections plasma cells appear in the affected zone and probably make antibodies on the spot.

When foreign cells such as bacteria or red blood corpuscles are injected into an animal, antibodies are formed that will clump these cells together. These antibodies are called agglutinins. A third factor present in the plasma called complement will then lyse the foreign cells. Complement acts on all foreign cells after they have been sensitized by their specific agglutinin or antibody. It is a complex of different substances, one of which is an enzyme. The plasma poured out in the inflammatory exudate thus has several protective functions: it dilutes toxins; it clots to form the fibrin barrier; it may contain antitoxins, agglutinins, or other antibodies; and it coats the bacteria and facilitates their phagocytosis by leukocytes. This latter property is due to substances called opsonins. (*See* IMMUNITY AND IMMUNIZATION.)

Hypersensitivity or allergy is one of the outstanding problems of pathology. Each year tuberculosis causes many deaths, yet no endo- or exotoxins active against normal man or normal animals have ever been isolated from *Mycobacterium tuberculosis*. Stranger still was the discovery by Koch in 1891 that once an animal is infected with tuberculosis it reacts with great violence to a subsequent injection of the organism or its products. This appears at first sight exactly the opposite to a protective reaction such as might be expected in an acquired immunity; it is the first example on record of allergy or heightened reaction. However, the response of the animal to the first injection of *Myco. tuberculosis* is too little and too late, so that the organism is able to spread without much difficulty. The tissues then become hypersensitive so that a second injection, even of dead organisms, damages cells and thus calls forth an inflammatory response—a mobilization of cellular defense. It is possible that such a cellular defense is the only adequate protection against this organism, which grows slowly but relentlessly. The reactive intolerance shown by the tissues prevents the spread of infection. (*See* TUBERCULOSIS.) Other manifestations of the allergic state are seen in other diseases (*e.g.*, asthma, hay fever and urticaria). (*See* also ALLERGY AND ANAPHYLAXIS.)

Injury.—A clean surgical wound illustrates the response of the body to an injury uncomplicated by infection. The skin and superficial tissues are severed by an aseptic knife. The cut vessels bleed, the blood clots, and the severed tissues are "glued" together with fibrin. Tissue damage is minimal, but some cells are inevitably destroyed by the knife. These damaged cells cause some inflammatory reaction, and there is some outpouring of leukocytes and plasma. Then macrophages assemble and remove the debris. Some substance liberated in the wound arouses the fibrous tissue cells that "sleep" in the margins of the wound, and these cells assume an embryonic activity, divide, creep in along the fibrin threads, and replace the fibrin by fibrous tissue. This new tissue joins the severed tissues in a permanent union, the scar. New capillary blood vessels are likewise formed by outgrowths from capillaries in the margins of the wound.

Many different physical and chemical agents can cause injury. Mechanical injury fractures bones, causes wounds, or may damage the brain or the organs in the chest or abdomen. In wounds and fractures, hemorrhage is an important factor. In burns, tissues undergo heat or chemical coagulation. All types of trauma expose the patient to certain dangers—primary and secondary shock, infection, and imperfect repair. Primary shock is the loss of consciousness that occurs immediately after an injury, probably because of pain. Head injuries also cause loss of consciousness due to concussion of the brain. The passage of an electric current through the body may affect the heart or brain and cause unconsciousness in electric shock.

Secondary, or surgical, shock follows severe injuries within 2 to 24 hours. The extensive inflammatory reaction that follows a severe injury results in the leakage of a great deal of plasma and salts out of the circulation into the damaged tissues or into the blister fluid of burns. This process reduces the volume of blood in circulation and lowers the quantity of blood pumped out each minute by the heart to such an extent that the tissues do not receive sufficient oxygen. The patient lies pale, cold, and only semiconscious, the pulse is rapid and weak, and the blood pressure falls. If the plasma is immediately replaced, the circulation is restored, but if not, the tissues are still further damaged by the lack of oxygen that causes still more plasma loss, and the irreversible stage of shock is produced. Other factors that may cause shock include toxic products from damaged tissues, exhaustion of the adrenal cortex, and leakage of sodium ions into the damaged tissues and potassium ions from the damaged tissues into the blood. Many severe diseases end in a shocklike state. Environmental stress, such as exhaustion by physical effort, hunger, thirst, and cold, all predispose to shock. A sudden loss of circulating blood volume in hemorrhage produces a shocklike state. The body can compensate for a slow hemorrhage by withdrawing fluid from the tissue spaces into the circulation, but the loss of red cells will produce anemia. (*See* also SHOCK.)

Damage to Specialized Cells.—As a rule, the brunt of injury by physical agents falls upon skin, fibrous tissue, and bone. These respond to damage by inflammation and then repair. On the other hand, injury by chemical and bacterial poisons often falls chiefly upon organs like the liver, kidney, and brain, which have highly specialized cells performing vital chemical work. These cells may be poisoned without visible signs of damage, but often obvious histological changes are produced (*e.g.*, fatty change in liver or heart; cytoplasmic or nuclear degenerations). The tissues atrophy in starvation, after disuse, or in old age. Specialized cells differ greatly in their power of regeneration after injury. The nerve cells of the brain cannot be replaced. The cells of the heart muscle are usually replaced by fibrous tissue, and the heart can grow strong again only if each remaining cell increases in size. Liver cells have considerable power of regeneration, but repeated damage will result in their replacement by fibrous tissue.

Disturbances of Blood Supply to Tissues.—The clotting of blood when it is shed is a most valuable protective mechanism. But sometimes blood may clot in the vessels during life. This is called thrombosis and is brought about by infection, damage, or disease of the vessel wall and sometimes by changes in the blood that make it clot more readily. A thrombus may cut off the blood supply to a limb or to an organ (*e.g.*, the heart or brain) by blocking an artery. Or a thrombus may become detached and be carried along the blood stream to block a vessel farther on; it is then called an embolus. If the embolus blocks the blood supply to an area of tissue, that tissue will form an infarct as the cells die from lack of oxygen. The enzymes in the dead cells go on working and break down the nuclei and alter the cytoplasm of the cells; this process is known as autolysis. It is as if the tissues "stew

in their own juice." The dead tissue of the infarct will excite an inflammatory reaction and will eventually be walled off by fibrous tissue. If the thrombus was infected, an abscess will form. (*See* also DEATH [BIOLOGICAL]; THROMBOSIS AND EMBOLISM.)

Diseases of the arteries, kidneys, and heart are closely interrelated. Arterial disease may throw strain upon the heart or interfere with its blood supply, and in either case cause cardiac failure. This also occurs when certain diseases of the kidneys raise the blood pressure. Diseases of the arteries and the heart may in their turn affect renal function. (*See* also ARTERIES, DISEASES OF; HEART, DISEASES AND DEFECTS OF; URINARY SYSTEM.)

Failure of the kidneys to maintain the constant "sea-water environment" bathing the tissue cells or failure of the circulation to maintain the supply of oxygen will have profound effects upon all the organs. Similar effects are produced by anemia, which reduces the oxygen-carrying power of the blood.

Tumours.—A mass of growing cells that appears in a particular tissue without any obvious physiological purpose is called a tumour. Some tumours grow slowly, resemble the tissue of origin, and are limited by a fibrous-tissue capsule; these are said to be benign. Malignant tumours often differ from the parent tissue (in arrangement and in the appearance of the cells), grow rapidly, infiltrate locally into the surrounding structures, and may spread to distant parts of the body via the lymphatics or the blood stream.

Tumours differ from the normal tissues from which they were derived in three respects—anatomy, cytology, and function.

Anatomy.—The tissue arrangement varies from a poor imitation of the tissue of origin to a complete loss of any resemblance to the normal structure. The new tissue forms a lump, spreads into the surrounding parts, and distorts them. The anatomy of the bowel or a bronchus, for example, may be so altered that these tubular organs are blocked.

Cytology.—The cells of malignant tumours show great variations of size and staining reactions. Cells that are much larger than normal can be seen lying adjacent to cells that are much smaller than normal. The cells may sometimes lose all resemblance to the tissue of origin.

Function.—Most physiological functions are lost by tumour cells. For example, the important function of the skin is that of protecting against the "insults" of the environment. When a malignant growth arises from the skin, the protective function of the skin breaks down, an ulcer is formed, bacteria enter the body, and the blood and tissue fluids leak out. Some primitive functions are retained by certain malignant growths that may produce bone, fibrous tissue, mucus, or even hormones.

Experimental Production of Tumours.—Tumours have been produced in experimental animals by a great variety of different agents. E. L. Kennaway and his co-workers, during the period 1920–33, managed to isolate the carcinogen (*i.e.*, cancer-producing substance) from coal tar, which proved to be benzpyrene, a polycyclic hydrocarbon. Several hundred chemical substances have since been shown to be carcinogenic. Other factors known to produce tumours include radiation by X rays, radium, and ultraviolet light; estrogens; certain viruses in fowls, mice, and rabbits; and genetic factors in special inbred strains of laboratory animals. Most carcinogens are known to damage the cell but they need to be given in small doses over long periods of time to produce malignant change.

Experiments show that two or more different types of carcinogen acting together produce tumours more readily than when acting alone. It is possible that cancer in man may be due to the combined action of the many different types of carcinogen to which he is exposed. (*See* TUMOUR; CANCER; CANCER RESEARCH; CARCINOGENIC CHEMICALS.)

Progress.—Great advances have occurred since 1940 in the fields of metabolic diseases, endocrinology, vitamin deficiency, and virus diseases. The new remedies—the sulfa drugs and the antibiotics (penicillin, streptomycin, etc.)—have given new insight into bacterial metabolism. Advances in physiology, biochemistry, and microscopy have increased the knowledge of important pathological states including inflammation, shock, cardiovascular and renal disease, anemia, rheumatism, and cancer. Modern treatment has altered profoundly the relative importance of certain diseases. Tuberculosis, syphilis, and malaria are decreasing, cardiovascular disease and cancer are increasing in relative importance.

Pathological investigations play an important part in diagnosis and in the control of therapy. The close liaison between clinician and pathologist has reappeared with the development of clinicopathological conferences and the realization that the natural history of disease can be described adequately only in terms of the clinicopathological picture. (D. B. C.)

Practice of Pathology.—The practice of medicine includes the clinical practice of the physician who directly attends and manages the care of the patient and the laboratory practice of the physician (pathologist) who reports to and consults with the attending physician. The types of laboratory specimens examined by the pathologist include surgically removed parts, blood and other body fluids, urine, feces, exudates, etc. Not ordinarily included are X-ray films (radiology) and electrical recordings (electrocardiography, electroencephalography, etc.).

The pathologist is customarily selected by the clinical practitioner and conveys his opinions on the nature and care of the case to the practitioner. In all approved hospitals in the United States (approved by the Joint Commission on Accreditation of Hospitals of the American Medical Association, American Hospital Association, American College of Physicians and American College of Surgeons) it is mandatory that all specimens from patients be examined and interpreted in the light of other knowledge available concerning the patient. Pathology practice also includes the reconstruction of the last chapter of the physical life of the patient through the procedure of autopsy (*q.v.*), which provides information, not obtainable by any other means, concerning the presence or absence of important as well as minor disease processes. Application of clinical, surgical, and laboratory procedures for diagnosis while the patient is alive has reduced but not eliminated the number of major surprise findings at the autopsy examination, and medical progress, as well as legal and public health protection, is still fundamentally dependent upon this aspect of the practice of pathology.

Pathology is regarded as a medical specialty. The knowledge required for the proper general practice of pathology is too great to be attainable by single individuals, so that, wherever conditions permit it, subspecialists collaborate. Some of the laboratory subspecialties that occupy the time of pathologists are neuropathology; pediatric pathology; general surgical pathology; dermatopathology; forensic pathology; biochemical pathology; microbiology; serology; hematology; and blood banking. In Great Britain the term morbid anatomy is commonly used to describe postmortem pathology and clinical pathology to signify all types of laboratory investigations of disease (and health) in the living person.

Pathology is practised in hospital laboratories, private laboratories, public health agencies, and private medical institutions including pharmaceutical manufacturers.

Formal medical education with the attainment of the M.D. degree or its equivalent is required prior to admission to pathology postgraduate programs in the United States, Canada, and Great Britain. Such training in the United States is supervised by the American Board of Pathology in collaboration with the Council on Medical Education and Hospitals of the American Medical Association. The board requirements for certification (five years of study and training) establish a minimum level that, although not a legal requirement for pathology practice, becomes an effective one because approved hospitals generally demand board-qualified pathologists. In Canada the postgraduate period has been similarly described and the practice opportunities correspondingly influenced. In Great Britain no board exists to set minimum specifications for the development of a pathologist; instead, the Royal College of Physicians and the Association of Clinical Pathologists have been more concerned with optimum types of training and favourable conditions for practice.

See also references under "Pathology" in the Index.

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PATIALA, a municipal town and district of Punjab, India. The town, headquarters of the district and formerly the capital of a princely state known as Patiala, was founded in 1763 by Maharaja Ala Singh and lies 127 mi. NNW of Delhi. Pop. (1961) 125,234. The fort, a majestic structure, stands in the centre of the town. Ten colleges, including those of commerce and medicine (with a dental wing), and an institute of engineering and technology are all affiliated with Punjabi University, established there in 1962. There is a modern sports stadium. The town has cotton-ginning and oil mills and a distillery; electrical goods are also manufactured.

Patiala District (area 2,261 sq.mi.; pop. [1961] 1,048,778) lies in the northeastern sector of Punjab and forms a part of the Sutlej-Jumna Divide, with elevations reaching about 800–850 ft. above sea level. A few seasonal torrents (the *choas*) cross the district, but there is no perennial stream. Wheat, gram, cotton, and maize (corn) are the main crops. During the 1950s chemical, hosiery, cotton-ginning, and metal industries were developed. Besides Patiala, the other main towns are: Nabha (pop. [1961] 30,603), Rajpura (27,925), Samana (16,133), and Bassi (13,042). Patiala District once comprised the eastern part of the main area of the former Patiala State. This state was the most important state of the Punjab. It was founded by the chief of the Phulkian Sikh family about 1763 and was merged in the Patiala and East Punjab States Union (PEPSU) on July 15, 1948, its maharaja being appointed *rajpramukh*. The present district was formed under the Reorganization of States Act on Nov. 1, 1956.

(S. S. Bh.)

PATINIR (Patinier, Patenier), **JOACHIM (DE)** (*c.* 1475–1524), Flemish painter, the first to specialize in landscape, was born either at Bouvignes or at Dinant. He was received in 1515 into the painters' guild at Antwerp, where he continued to live until his death on Oct. 5, 1524. Albrecht Dürer visited him there in 1521.

Patinir seems to have made a practice of supplying landscape settings for figure compositions painted by other Flemish masters. He did not, however, paint pure landscape pictures, and all his work has a nominal religious subject. Its novelty, anticipated in different vein by Hieronymus Bosch, lay in the fact that the religious motif was much reduced in scale and immersed, as it were, in the phenomena of the natural world. The basic elements of his landscape style—the high viewpoint overlooking vast tracts, where earthy brown foregrounds merge into woodland and meadow greens and again into the hazy blues of distant mountains—do not differ from those of his predecessors, particularly Gerard David. Yet the picturesque melancholy with which he invests the woods and rivers and the great ghostly rocks that jut up abruptly in the middle distance strike a personal note that won Patinir instant success and many imitators. Patinir's favourite subject was the "Rest on the Flight Into Egypt," of which representations may be seen in Vienna, Berlin, Madrid, Minneapolis, Minn., Philadelphia, Pa., and elsewhere. Many of his paintings are unsigned, and many paintings in his manner and commonly ascribed to him are probably not from his hand. (D. Kg.; X.)

PATIÑO, JOSÉ PATIÑO, Marqués de (*c.* 1666–1736), Spanish statesman, who was one of the most outstanding ministers of the Spanish crown during the 18th century, was born in Italy at Milan, probably in 1666 or 1667. His family came from Spanish Galicia. Patiño followed his father in entering the service of the Spanish government in Italy. Later, during the War of the Spanish Succession, he went to Spain and Philip V nominated him to a place on the Council of Military Orders (1707). In Nov. 1711 he was sent as intendant to Extremadura, where his success was such that in little more than a year he was transferred to the much more important *intendencia* of Catalonia (March 21, 1713). There he rendered important services during the siege of Barcelona (1714) and the reconquest of Majorca (1715), and was responsible for implementing the new financial and administrative system introduced by Philip V in 1715. Giulio Alberoni (*q.v.*), who now came to direct Spanish affairs, regarded Patiño as his only reliable subordinate and placed him in charge of the rebuilding of the Spanish Navy as *intendente general de marina* (Jan. 1717). At the same time he was appointed superintendent of Seville, where he also exercised the presidency of the *casa de contratación*, controlling trade with the Spanish colonies. In these various capacities, Patiño was responsible for the fitting-out and dispatch of the expeditions which conquered Sardinia and Sicily in 1717–18, and although he shared Alberoni's disgrace at the end of 1719, he was able to recover the *intendencia* of Seville in 1720.

Sudden promotion came to Patiño in May 1726, when, following the fall from power of the Baron de Riperdá, he was appointed Minister for the Navy and the Colonies. Shortly afterward he was also placed in charge of the national finances and foreign affairs. He retained all these offices until his death at the royal palace of San Ildefonso on Nov. 3, 1736.

Patiño's great achievement was his creation of the Spanish Navy. This twice enabled Spain to go to war with Great Britain (1718 and 1739), permitted the conquest of Oran in 1732 and allowed a vigorous enforcement by Spain of its traditional monopoly of trade with its American colonies. As minister of finance, Patiño was faced with a yearly deficit of some 130,000,000 reals. He wished to remedy this by extending to the whole country the simplified tax system he had introduced in Catalonia, but Philip V would not allow more than piecemeal reforms. Patiño was an able administrator rather than the author of a policy of reform. Most of his ideas were borrowed, but his achievements were the more considerable in that they were carried out in difficult circumstances and in the face of an unhelpful and belligerent foreign policy imposed by Philip V and his second consort.

Bibliography.—A. Valladores de Sotomayor (ed.), *Fragmentos históricos para la vida [de] . . . Patiño* (1790); A. Rodriguez Villa, *Patiño y Campillo* (1882); A. Béthencourt Massieu, *Patiño en la política de Felipe V* (1954). (B. J. R.)

PATIO, the Spanish name for an inner court or enclosed space open to the sky. The patio recalls the classical atrium (*q.v.*), which provided a private sunlighted area for each dwelling. Contemporary architects have used the inner court with notable success in large office buildings (Connecticut General Life Insurance Co., Bloomfield, Conn., 1956), museums (Museum of Modern Art, Kamakura, Japan, 1951), urban housing complexes (Bogotá, Col., 1952) and single family residences (Hodgson house, New Canaan, Conn., 1953). The term patio is also commonly used, incorrectly, to describe any small semienclosed residential terrace. (H. Mn.)

PATKUL, JOHANN REINHOLD (1660–1707), the Baltic-German diplomatic adventurer who played a part in engineering the Northern War, was born on July 27, 1660, at Stockholm, Swed., where his father was detained in prison. After completing his studies at the University of Kiel he lived on his ancestral estate at Wenden (Cesis) in Livonia, devoting much time to litigation. In 1687 he was appointed captain in the Swedish Army, in the garrison at Riga. Between October 1690 and November 1691 he was in Stockholm as one of the two deputies sent by the Livonian landowners to explain to Charles XI of Sweden their views on the crown's program of land recovery. The report submitted by Patkul to the Livonian Diet in March 1692 led to a petition to the king to redress the gentry's grievances. The government reacted by summoning Patkul and his associates to Stockholm, where his trial on a charge of sedition began in June 1694. At the end of October he fled before the impending death sentence to Courland and thence, via Berlin, to Western Europe.

In 1698 Patkul met Gen. J. H. von Flemming, an intimate adviser to the elector Frederick Augustus I of Saxony, who was also king of Poland as Augustus II; and in October Flemming invited him to Poland. Early in 1699 Augustus received him in Grodno. In two memorandums submitted to the king later in the year, Patkul suggested snatching Livonia from Sweden by a surprise attack on Riga, to be carried out in conjunction with the Russian tsar Peter I, whose acquisitions would be restricted to Ingermanland and Karelia. Patkul's visits to Livonia and to Copenhagen prepared the ground for action also anticipated in the secret "capitulation" concluded in August between Augustus

and Patkul: in this, the Livonian gentry declared its adhesion to Augustus as king of Poland and received extensive political and economic privileges. In September 1699 Patkul went to Moscow to remind Peter of the benefits to be derived by Russia from a foothold in the Baltic. His efforts were crowned by the coalition between Russia, Saxony, and Denmark formed in autumn 1699, and by the premature attack on Riga launched by Augustus in February 1700. The curtain was thus raised for the Northern War (*q.v.*). While the basic conflict was not of Patkul's making, he bears the responsibility for the moment and the manner of its outbreak.

Though Augustus had made him a major general, Patkul was glad to accept, in November 1701, Peter's invitation to enter the Russian service. In 1703 he was appointed privy councillor, major general and envoy extraordinary to Saxony and Prussia. In Berlin his task was to draw Prussia into the war and into the eventual partition of Sweden's overseas possessions; and his private hope was that Prussia would be a countercheck to Russia. This was the hinge of his plan, which was to have satisfied all concerned: Peter, Augustus, Frederick I of Prussia, the Livonian gentry, and Patkul himself. He failed to inveigle Prussia, but succeeded in bringing about the Russo-Polish alliance of August 1704.

In November 1704 Patkul removed the Russian corps under his command from Poland into Saxony; and in December 1705 he negotiated its temporary transfer to the service of Austria. The Saxons seized on this action as a pretext for arresting him in Dresden. In April 1707 he was extradited to Charles XII of Sweden under the Treaty of Altranstädt (1706) as a deserter. The sentence of 1694 was aggravated to fit a traitor; and on Oct. 10, 1707, he was broken on the wheel and quartered at Kazimierz, near Poznan.

See B. H. Hornborg, *Konspiratören: Johann Reinhold Patkul* (1946); R. Wittram, article in the *Nachrichten der Akademie der Wissenschaften in Göttingen*, 1 and 4 (1952–54). (L. R. Lr.)

PATMORE, COVENTRY KERSEY DIGHTON (1823–1896), English poet and essayist, was an independent-minded Victorian, whose poetry deals almost wholly with love, human and divine. The eldest son of Peter George Patmore, he was born at Woodford, Essex, on July 23, 1823. His youthful verses were encouraged by his father, who sponsored their premature publication in 1844. As a young man, he was friendly with Tennyson and the Pre-Raphaelites. When his father took refuge from his creditors in France, Patmore obtained a position in the British Museum Library, which he held for 19 years. He married Emily Andrews, the daughter of a Congregationalist minister, in 1847.

Tamerton Church Tower (1853) contained revisions of Patmore's *juvenilia*, together with the impressive title poem. In 1854 appeared *The Betrothal*, followed by *The Espousals* (1856), issued together as *The Angel in the House* (1858). Its continuation, *The Victories of Love* (1863), comprised *Faithful for Ever* (1860) and *The Victories of Love* (1862). A further section was abandoned on the death of Emily in 1862. This verse-novel tells the story of two marriages, interspersed with lyrical "preludes" which form a philosophical commentary on the narrative. Patmore's profoundly Christian concept of marriage, influenced by St. Thomas Aquinas and Emanuel Swedenborg, suffuses the realistic details of Victorian domesticity. The allusive, often gnomic, poetry reflects his close knowledge of Donne and the metaphysical poets. In 1864 he was converted to Roman Catholicism and married a Catholic, Marianne Byles. Together they translated *St. Bernard on the Love of God* (1881). Until 1874 he lived in Sussex as a landed proprietor.

The Unknown Eros and Other Odes (1877) contained mystical odes of divine love and of married love, which Patmore saw as reflecting Christ's love for the soul. Poems of high originality, in form and outlook, assimilating his wide reading in Catholic mystics and the Church Fathers, they were little appreciated by the wide audience that had welcomed *The Angel. Amelia* (1878) virtually ended his poetic output. In later years, he produced many essays on literature, art, philosophy, architecture, and politics, chiefly for the *St. James's Gazette*. These were partly collected in *Principle in Art* (1889) and *Religio Poetae* (1893). His seminal study of *English Metrical Law* (1857), admired by Gerard Manley Hopkins and Robert Bridges, appeared in a revised form in 1878. After Marianne's death in 1880, he married Harriet Robson. His last work was a collection of Pascalian aphorisms, *The Rod, the Root, and the Flower* (1895). He died at Lymington, Hampshire, on Nov. 26, 1896.

Patmore was an outspoken Tory, with a waggish sense of humour and a love of paradox, who left prudery "to the Puritan half-believers." His highest poetic achievement lies in *The Unknown Eros*, odes of an "incandescent austerity," full of "wedded light and heat" and, in their mystical eroticism, unique in his age; but *The Angel in the House* is full of subtle wit, poetry, and psychological insight, and his essays are original and provocative.

Bibliography.—*Poems*, ed. by F. Page (1949); *Courage in Politics* (uncollected essays), ed. by F. Page (1921). *See* also Basil Champneys, *Memoirs and Correspondence of Coventry Patmore* (1900); F. Page, *Patmore: a Study in Poetry* (1933); D. Patmore, *The Life and Times of Coventry Patmore* (1949); E. J. Oliver, *Coventry Patmore* (1956); J. C. Reid, *The Mind and Art of Coventry Patmore* (1957).
(J. C. Re.)

PATMOS (Gr. Pátmos), an island of the Dodecanese, Greece, in the Aegean Sea, about 28 mi. SSW of Samos; length about 8 mi., greatest breadth about 4 mi.; area 13 sq.mi. Pop. (1961) 2,564. Sickle-shaped, volcanic, bare, and rocky, it rises to about 800 ft., with a deeply indented coast. The harbour, opening eastward, divides the island into two nearly equal portions with a narrow isthmus where the ancient town stood. Remains of the ancient acropolis survive on the hill above. The modern town of Patmos stands on a ridge in the southern half. A steep paved road runs between the port and the fortified monastery of St. John.

Patmos is rarely mentioned in antiquity; its population was Ionian. It was at Patmos that the Apocalypse was revealed to John (Rev. 1: 9). Christian tradition soon explained this by the exile of the apostle John to Patmos *c.* A.D. 95 under the emperor Domitian (*see* discussion in John, Gospel According to and Epistles of Saint); a grotto near the harbour is claimed as the site of the revelation. Later the Gospel was also said to have been revealed on Patmos; the apocryphal (5th century) *Acts of John* under the name of his reputed disciple Prochorus give an account of this and of miracles performed by the saint there. The bare rock of Patmos frequently appears in paintings of St. John.

During the Middle Ages Patmos apparently was deserted, probably because of attacks by pirates. In 1088 the emperor Alexius Comnenus granted the island to St. Christodulus to found the monastery of St. John, which acquired the greater part of the southern half of Patmos, as well as farms in other Greek islands. The library contains a celebrated collection of manuscripts, begun by St. Christodulus, whose embalmed body is buried in a side chapel of the monastery church. The autonomy of the monastery was confirmed under Venetian (1207–1537) and Turkish occupation. Between 1821 and 1832 Patmos declared itself free, but the Turks regained and held it until it was annexed by Italy in 1912; it was ceded to Greece in 1947 (*see* Dodecanese).

See G. Jacopi, *Patmo, Coo e le minore isole italiane dell' Egeo* (1938); A. Philippson, *Die griechischen Landschaften*, Band iv, pp. 276 ff. (1959).

PATNA, a city, district, and division of Bihar, India. The city (pop. [1961] 364,594), administrative centre of the state, lies 290 mi. NW of Calcutta. It is a riverside city, with one main street, and extends along the right bank of the Ganges for about 12 mi. The city is dominated by the unbridged and embanked Ganges, and the chief buildings in the older town are strung along the waterfront. The main street is filled by a succession of small shops and houses, broken by public institutions and cultivated fields, with little to suggest the importance of a capital. West of the city lies the section called Bankipur, and west and southwest of Bankipur is the well laid out and spacious new capital area with wide roads, shady avenues, and new buildings. The principal buildings are Government House, the Secretariat, the council chambers, the radio station, the high court, and the Patna Museum. Between the old town and the new capital area is the big, oval public park, about a mile in circumference. The city is a rail

and road junction and has an airport about 2 mi. W of the new capital area.

The oldest intact building is a mosque, with a courtyard of glazed tiles, built by Husain Shah, king of Bengal, in 1499; other noteworthy mosques are those built by Sher Shah and Prince Parwez, son of Jahangir. A Sikh temple, in the place where the great guru Govind Singh was born in 1675, contains a copy of the *Granth*, the holy book of the Sikhs. The Golghar or Gola, a beehive-shaped brick building 96 ft. high, was built in 1786 to serve as a granary for rice in case of famine.

The University of Patna was founded in 1917. It became a purely teaching university in 1952, including the colleges of Patna town only. In July 1960 it changed its character and extended its jurisdiction over Patna Division, but in 1962 it again became a teaching university. There are a number of colleges and institutions, including those of arts, science, medicine, law, engineering, and music, affiliated to Patna University.

History.—Patna stands on the site of ancient Pataliputra, the Palibothra of Megasthenes, who was sent there about 302 B.C. as an envoy to Chandragupta Maurya by Seleucus Nicator. According to Megasthenes the city stood on the tongue of land between the Ganges and the Son (which has since migrated westward); it was elongated and had twice as much population as the present Patna. Pataliputra was the capital of the Mauryan empire of Asoka. The seat of government was moved to Ajodhya (Ayodhya) by Chandra Gupta II in the 4th century A.D., and Pataliputra subsequently fell into ruin; the causes of its fall are obscure, but excavations show the effects of fire and flood. The city was sacked by Huns in the 6th century. From that time on the story of Patna is one of decadence until Sher Shah made it the capital of Bihar in A.D. 1541 and built a fort there. After its capture by Akbar in 1574 it continued to be the seat of the Mogul viceroys, and became a centre of commerce which led to the establishment of trading companies by the English and the Dutch. By 1586, when Ralph Fitch visited it, Patna was "a very long and a great town." After a struggle with Mir Kasim Ali Khan, the nawab of Bengal, the British forces finally captured Patna in 1763.

After the construction of railways, traffic from up-country, which originally passed along the Ganges to Calcutta, was attracted by the railroads, and the commercial standing of Patna, which had been largely due to river transport, began to decline. The ancient Pataliputra lies buried deep under the silt of the Ganges, but most interesting remains have been unearthed in the southwest suburbs (Kumhrar). Among them is the hall of 100 columns built by Asoka.

PATNA DISTRICT (area 2,164 sq.mi.; pop. [1961] 2,949,746) consists largely of a level, fertile alluvial plain, but toward the south the quartzitic Rajgir Hills (*q.v.*) project into it and divide it from Gaya District for about 30 mi. Because of the obstruction of high ground along the south of the Ganges the drainage from the south is diverted eastward, creating a low-lying tract 5 mi. wide, known as *tal*, which is flooded during the rains. The chief rivers are the Ganges, Son, and Punpun. The Punpun is liberally used for *pain* (petty canal) irrigation. The Son Canal irrigates 150,000 ac. to the northwest. The principal crops are rice, gram, barley, wheat, maize (corn), oilseeds, sugarcane, and potatoes.

Apart from Patna City, there are other places of historical interest. The Rajgir Hills are associated with Buddha's life. Mahavira, the founder of Jainism, died at Pawapuri (a village near Rajgir), which is consequently a place of Jain pilgrimage. Nalanda near Rajgir was a famous seat of Buddhist learning; it has been called "the Oxford of Buddhist India." Sir Alexander Cunningham saw the finest sculptures of India there; and excavations begun in 1916 have disclosed a maze of *viharas* (monasteries) with seven levels of occupation and buildings of nine different periods. The town of Bihar had a Buddhist *vihara* during the 5th to 12th century A.D., whence its name.

PATNA DIVISION comprises the districts of Patna, Gaya, and Shahabad. Area 11,336 sq.mi. Pop. (1961) 9,812,358.

(E. AH.)

PATRAS (Gr. PÁTRAI), the chief seaport on the west coast of Greece, capital of the *nomos* (prefecture) of Achaea (Akhaía), is situated on the Gulf of Patras, 70 mi. WNW of Corinth. Pop. (1961) 95,364. It was rebuilt after the War of Greek Independence (*q.v.*), is the seat of a law court and of a metropolitan bishop, and has railway communications with Athens via Corinth and with Kalamáta (Kalámai) via Pyrgos (Pírgos). It has a medieval castle on the site of the ancient acropolis. Its harbour, formed by a mole and breakwater, is the third largest in Greece. Chief exports are currants and sultanas, tobacco, olives and olive oil, figs, citrons, wine, brandy, and hides. Patras is an important stage on the passenger shipping route between Greece and the West.

In ancient Greek legend, Eumelus established three townships, Aroe ("ploughland"), Antheia ("the flowery"), and Mesatis ("the middle settlement"); after the Dorian invasion Aroe was enlarged by a colony of Achaeans led by Patreus (who gave his name to the city) and became one of the 12 cities of Achaea (*q.v.*). In 419 B.C., on the advice of Alcibiades, the town was connected with its harbour by long walls. About 280 B.C. it was active in the formation of the anti-Macedonian Achaean League, but it had passed into insignificance even before the Roman conquest of Greece in 146 B.C. The emperor Augustus resettled it as a military colony after the Battle of Actium; and under the name of Colonia Augusta Aroe Patrensis it was one of the most prosperous commercial cities of Greece until at least the 3rd century A.D. Christianity was established early in Patras; St. Andrew was supposed to have been crucified there; the cathedral reputedly is his burial place and enshrines his head, returned from Italy in 1964 (*see* ANDREW, SAINT).

In the 8th and 9th centuries its population was increased by refugees from the Slav invasions of the Peloponnese, and in 807 it resisted a siege by the Slavs. In the Byzantine Empire Patras was noted for its silk industry. Conquered by the French nobleman Geoffroy de Villehardouin (1205), it became one of the baronies of the Frankish principality of Achaea. In 1387 John de Heredia, grand master of the Knights Hospitallers, endeavoured to master Achaea and took Patras by storm. Later the city was governed in the name of the pope by its Latin archbishop, who leased it to Venice (1408); but early in 1430 Constantine Palaeologus, as despot of the Morea, held it for a while. Captured by the Turks in 1458, it was surrendered in 1687 to the Venetians. In 1715 it again fell into Turkish hands. It was at Patras that the Greek Revolution began in 1821, inspired by its bishop Germanos; but the Turks burned the city and held out until 1828. Patras was occupied by Axis troops from April 1941 to October 1944.

See Pausanias, vii, 18 ff.; W. Miller, *The Latins in the Levant* (1908).

(D. M. N.)

PATRIARCH, a title used loosely of some Old Testament leaders in the early period (chiefly Abraham, Isaac, Jacob and Jacob's 12 sons) and given to the bishops of certain important sees. Since the 6th century the bishops of Rome, Constantinople, Alexandria, Antioch and Jerusalem have been patriarchs. Apart from the pope, who is the patriarch of the West, few Western bishops bear the title (*e.g.*, the patriarchs of Venice and Lisbon), which is used more frequently in the East. The Greek Orthodox patriarch of Constantinople is the ecumenical patriarch, and the chief bishop in each of the other autocephalous Orthodox Eastern Churches is frequently a patriarch also (Greece being a notable exception). The same is true of the Uniate Churches and some of the lesser Eastern Churches. The title is occasionally assumed by *episcopi vagantes* (*q.v.*) and other unauthorized ecclesiastics.

See H. Cazelles in L. Pirot *et al.* (eds.), *Supplément au dictionnaire de la Bible*, vol. vii, col. 81–156 (1961); L. Hicks in *Interpreter's Dictionary of the Bible*, vol. iii, pp. 677–678 (1962); R. Naz (ed.), *Dictionnaire de droit canonique*, vol. vi, col. 1254–65 (1957).

PATRICIANS (Lat. *patricius*, an adjectival form from *pater*, "father"), a group of citizen families who, in contrast with the *plebs*, formed a privileged class in early Rome. The origin of the class remains obscure, but the *patres* were probably leaders of the more important families or clans who formed the major part, if not all, of the senate of the primitive period, and the families from whom were drawn the most distinguished part of the early

cavalry (*see* EQUITES). They constituted an early nobility of birth. At what stage they hardened into the clearly defined and exclusive caste of the early historical period is uncertain, but there are indications of the gradual extension and development of the group in the distinction between greater and lesser patrician families (*gentes maiores* and *minores*), in the mention of *conscripti* (unless these were later plebeian additions), in the admission of a Sabine family like the Claudii, and perhaps in the early appearance of patrician and plebeian branches of the same family. The plebeians were also citizens, but they were probably drawn from the masses of clients of the greater families and from the commercial and industrial people of the prosperous Rome of the Etruscan period. The new organization attributed to King Servius Tullius (*see* COMITIA), by registering all citizens in regional tribes and in classes arranged according to wealth, helped to unify the plebeians and give them a share, according to their wealth and the equipment they could provide, in the military and financial burdens of citizens, while the development of the assembly of the centuries from a military to a political body gave the wealthier plebeians an influential vote in elections and legislation.

After the expulsion of the kings, who may have been some check on patrician control, the patricians attempted to keep sole possession of magistracies, priesthoods, and legal and religious knowledge, basing their claims on their exclusive possession of the auspices (*see* AUGUR), by which the will of the gods was determined; there was even a prohibition against intermarriage with plebeians in one of the final two of the Twelve Tables of the law. The great internal struggle of the early republic was the continued effort of the plebeians to achieve political equality, to secure economic relief for their poorer members, and to break the religious monopoly of the patricians. Creation of the tribunate of the *plebs* (494 B.C.; *see* TRIBUNE) was followed by the rise of a plebeian tribal assembly (471). Then came the publication of the code of law, the Twelve Tables (450), and repeal of the prohibition against intermarriage (443). Meantime the institution of military tribunes with consular power (444) opened the way for plebeians to hold high command. Yet few plebeians attained the office in the first few years, and none of the large plebeian colleges of the later years was without a patrician. The consulate was opened to plebeians in 366, but even though one consul had to be a plebeian and two might be, there was one patrician each year until 172. The sacerdotal element in the law kept the praetorship patrician at its institution in 366, but it was opened to plebeians in 336. In the meantime the other patrician magistracies had gone the same way, the curule aedileship almost immediately after 366, the dictatorship in 356, and the censorship in 351. Finally in 304 Gnaeus Flavius made public the procedures of the civil law and the calendar, and in 300 the plebeians gained a majority in the major priestly boards, the pontiffs and the augurs.

Politically, the patricians were gradually overshadowed by the new plebeian aristocracy of office, but some religious distinctions remained. Certain old priesthoods, that of the *rex sacrorum* and the flaminates (*see* FLAMEN), were reserved to them, while their number in the priestly colleges, one short of a majority, represented an influence out of proportion to their numbers. All known leading men in the senate (*principes senatus*) belonged to the greater patrician families; the auspices returned to them during an interregnum; only a patrician could be *interrex* (chief magistrate provisionally appointed when there were no consuls in office); and the *patrum auctoritas* ("authority of the senators") rested with the patrician members of the senate.

Yet there are many examples of patricians who, by adoption or other means, secured their transfer to the *plebs*. In the late republic the core of the conservative aristocratic element in the senate consisted of a closely knit group of long established plebeian families (for example, the Licinii and the Caecilii Metelli), while many of the patricians who attained some prominence rose from families that had been comparatively obscure for several generations. Such were L. Cornelius Sulla, M. Aemilius Scaurus, and Julius Caesar himself. In the late republic the opposition of patrician and plebeian had ceased to be significant. The struggle was rather between groups in the nobility, between conservative aristocrats and popular leaders, while the word *plebs* referred to the rabble of the city.

Although several patrician families continued to be important, such as the Fabii and some branches of the Cornelii and Claudii, and others, like the Iulii, rose from obscurity, many early families died out. They were reduced by passages to the *plebs* and by adoption into plebeian families, and no new patricians were created. As a result, of about 50 patrician families of the 5th century B.C. only about 15 are attested in the 1st. Caesar (by the *lex Cassia*) and Augustus (by the *lex Saenia*) were empowered to create patricians. Both they and later emperors after Tiberius created many, but as grants to individuals and their descendants, not to the families as a whole. The right to create patricians came to be considered an inherent power, and possession of patrician rank became a necessary attribute, of the emperor. Surveys of senators who held or received this rank during the empire indicate that Italians continued to form a higher proportion of the patriciate than of the senate. Quite apart from their tradition of ancient birth and high nobility, they were needed to maintain the ancient cults and priesthoods in the capital. An advantage in their careers was that they were regularly *quaestores Augusti* and could advance to the praetorship without holding intermediate offices, but they received a smaller share than others of military and provincial commands.

In the late empire after Constantine *patricius* was a personal, nonhereditary title of honour conferred for distinguished services. *Patricii* ranked next after emperor and consuls, and held first place in the sacred *consistorium* (the imperial council), but the title bestowed no peculiar office or power. Naturally, officials of high rank, provincial governors, and praetorian prefects received it, and, though Romans were favoured, the title was also given to a number of barbarian leaders, among them Odoacer, Theodoric, and in later days even princes of Bulgaria and of the Saracens. It was a sort of ex officio title of the exarchs of Ravenna. Associated with the rank were the further titles *eminentia, magnitudo,* etc. Honorary *patricii* were termed *honorarii* or *codicillarii;* those in active service were called *praesentales*. All were distinguished by special dress and drove a carriage in public.

A further change in the meaning of the name is marked by its conferment on the Frankish king Pepin III by Pope Stephen II (III). The Italian *patricius* of the 6th and 7th centuries had come to be regarded as the *defensor, protector, patronus* of the church, but the conferring of the title by the pope was entirely unprecedented. It is clear that the patriciate of Pepin was a new office, as the title is henceforward generally *patricius Romanorum,* not *patricius* alone. It was conferred on Charlemagne at his coronation and was borne indiscriminately by subsequent emperors and by a long line of Burgundian rulers and minor princes. After the fall of the Carolingian house the title passed to Alberic II. Subsequently it was held by John I and II of the Crescentii. Others received it from Otto III. The Holy Roman emperor Frederick I (Barbarossa) was the last to wear the insignia, in 1167.

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PATRICK, SAINT (fl. 5th century A.D.), the patron saint of Ireland, venerated in both ecclesiastical and popular tradition as the national apostle who converted most, if not the whole, of the country to Christianity. This has now become the official image of the saint, but it is based on untrustworthy materials, for no reliable source of information about his life and labours survives apart from his own two short works: the *Confessio*, written in his old age as a reply to charges made against him by British

ecclesiastics; and the *Epistola*, addressed to the soldiers of Coroticus (probably a king of Strathclyde) protesting against their leader's treatment of Irish Christian captives. All the other allegedly contemporary sources are of later date, including the hymn *Audite omnes* (*c.* 600) ascribed to Secundinus, the canons of the "First Synod of Patrick" (7th century), and the *Lorica* ("St. Patrick's Breastplate," 8th century). From Patrick's genuine writings the following facts about his life can be gleaned.

Autobiographical Details.—Patrick was born in—or at least his family was associated with—a place called Bannauenta (still unidentified) in Britain. His father, Calpornius, was a deacon and a *decurio* (a minor local official), the son of Potitus, a priest. At the age of 16 Patrick was captured by Irish raiders, shipped to Ireland, and sold as a slave. For six years he tended his master's sheep "in the woods and on the mountain . . . in snow, frost and rain"; and, during this bleak interlude, religion, which had hitherto meant little to him, became the centre of his life. At the end of that period, having received a sign in sleep, he made his escape by traveling about 200 miles to the coast and securing a passage in a ship manned by Irish pagans. After a three-day voyage they landed beside a "desert" through which they wandered for 28 days without seeing a human being. When he had been reunited with his kinsfolk in his native land, the "voice of the Irish" constantly haunted his thoughts and dreams until, after many years, he returned to preach the gospel to them. In this arduous task he endured a great many trials and hardships, including imprisonment on at least one occasion. The prospect of being slain or languishing in chains was daily before his eyes.

At the same time he was humiliated by the contempt and criticism of some of his British colleagues who despised him as illiterate and even accused him of simony. On the other hand, providence had most richly rewarded his faith and toil, allowing him to make numerous converts and to carry the gospel into regions where no missionary had hitherto set foot. Finally, he declared himself more than once to be a bishop, with the firm purpose of remaining with his newly won flock until death.

The Problems.—The last thing that this man of deep humility had in mind was to write his own biography; hence the few incidental remarks that have been summarized here fail to answer most of the questions that interest the historian. When did Patrick live? Where did he study for the priesthood? When, where, and by whom was he raised to the episcopate? How long was the interval between his escape from slavery and his return to preach the gospel? And who was responsible for his mission?

Patrick's earliest biographers, Muirchú and Tírechán, writing two centuries after his death, provide full—and sometimes contradictory—information on these matters. The later lives are of no independent value, though the *Bethu Phátraic* (*Vita tripartita*), put together in a mixture of Latin and Irish at the close of the 9th century, is important as evidence of the growth of the Patrick legend. Other works in Irish derive from Latin sources and contain no independent information save for the hymn *Génair Pátraic*, composed before 800, in which the tradition (discussed below) that there were two Patricks is clearly indicated. Before the end of the 7th century Patrick had become a legendary figure, and the Patrick legend has maintained a vigorous growth down to modern times; indeed, some of its more picturesque features, such as the banishment of the snakes, the blessing of the shamrock, and the vision of purgatory (*see* DERG, LOUGH), are of comparatively late origin.

It would be difficult to imagine a greater contrast than that between the historical Patrick of the *Confessio*—humble, charitable, deeply conscious of his own defective qualifications, and perfectly resigned to the prospect of suffering still greater hardships, even death itself, at the hands of the pagan Irish—and the fictitious Patrick of the "lives"—a conquering hero altogether in the style of a Celtic saga, marching from one triumph to another, making a victorious circuit of the whole of Ireland, and vanquishing the druids by his superior skill in manipulating their own weapons of magic and malediction. Most modern writers on Patrick have drawn the line between fact and theory substantially as J. B. Bury drew it in his *Life of St. Patrick and His Place in History* (1905).

The Official Theory.—The official version of Patrick's life, based on Bury's book, may be summarized as follows: Patrick was born about 385 and taken as a slave to Ireland in the opening years of the 5th century. After his escape the ship in which he secured a passage brought him not to Britain (as one might infer from his own words) but to Gaul, where the crew landed early in 407 and found before them a "desert" created by the recent Vandal invasion. His education for the priesthood took place not in his native land but on the continent of Europe, either at Lérins or at Auxerre, where he was made deacon by Bishop Amator (*c.* 418) and remained a further 14 years under the spiritual direction of St. Germanus, the famous successor of Amator. Some time before 431, when the dispatch of a missionary bishop to Ireland was considered at a synod of British bishops attended by Germanus, Patrick's name was put forward, but his candidature was rejected owing to the action of a friend (Germanus himself according to Paul Grosjean), who revealed the story of a sin committed by him in extreme youth. The deacon Palladius was chosen, consecrated bishop, and formally commissioned by Pope Celestine I; but less than a year after his arrival in 431, having failed in his mission, he left Ireland and died in "Pictland" on his way home. Thereupon Germanus hastily consecrated Patrick, who went as the second missionary bishop in 432.

With the assistance of some Gaulish clerics (notably the bishops Secundinus, Auxilius, and Iserninus, who arrived a few years later), he rapidly evangelized most of the country, meeting with remarkably little opposition from the druids after his initial triumph over them in the presence of King Loigaire near Tara. The organization of the church established by him was episcopal, not monastic (the majority of scholars now appear to hold that he had never been a monk), and he himself established its headquarters at Armagh on a site which had been presented to him by a local king named Dáire. His death took place not at Armagh (which lay in the territory of a group of tribes known as the Airgialla) but at Saul in the Ulidian kingdom in 461, on March 17, his feast day.

This reconstruction of Patrick's life and labours, though still accepted by some eminent authorities (foremost among them the Bollandist scholar Paul Grosjean), has been subjected to some devastating criticism. Bury accepted as historical the date 432 which the Irish annals declare to be the year of Patrick's arrival. But the Irish annals for the 5th century are not contemporary, and the various Patrician entries represent an attempt made in the 8th century at earliest (and possibly as late as the end of the 9th) to provide the whole of the Patrick legend with a chronological framework. In fact, the only firm date in Irish history during the whole of the 5th century is not concerned with Patrick but with his predecessor, Palladius, whose appointment by Celestine I as "first bishop to the Irish who believe in Christ" is recorded under the year 431 in the contemporary chronicle of Prosper Tiro of Aquitaine. Since a copy of this chronicle was available in Ireland to Patrick's biographers Muirchú and Tirechán, Bury should at least have considered the possibility that the whole story of the failure of Palladius and the immediate succession of Patrick was conditioned by this solitary "firm" date. Certainly, if Patrick was to come armed with the same high credentials as his predecessor—which is implied by both biographers—he had to come in 432, for Celestine died during that year. And this, of course, he could only do if the previous mission had collapsed. But how and why had it collapsed?

Muirchú says that the departure of Palladius was due to the opposition he had encountered from "fierce and lawless" men and to his own unwillingness "to spend a long time in a strange land," though the "additamenta" to Tirechán's memoir in the Book of Armagh report that, according to ancient tradition (*ut tradunt sancti antiqui*), Palladius suffered martyrdom at the hands of the Irish. It looks, therefore, as if Palladius was a grave embarrassment to the panegyrists of Patrick and had to be removed from the scene as quickly as possible—whether by pusillanimous retreat or by martyrdom—in order to leave the path free for their conquering hero.

The date of Patrick's death presents an equally difficult problem. "Tradition," as recorded in all the lives, credits Patrick with a mission of 61 years, which would mean that he died on March 17, 493. But an entry in the Irish annals records the date of *Senex Patricius* (= Irish *Sen-Phatric*, "the older Patrick") about 30 years earlier (461/462) and Bury, starting from his "firm" date of 432, decided that this was the true date of death, and that the entry under 492/493, chronicling the death of "Patricius" without qualification, was spurious, having been suggested by the attempt of his biographers to equate Patrick with Moses in as many respects as possible. As for "the older Patrick" (*Sen-Phatric*), who is attested in Irish sources from the 8th century onward, Bury dismissed him as a phantom who had been conjured up to explain the later date of 492/493. This solution is reiterated by all who believe in only one Patrick, but it is in no way convincing, for the tradition of two Patricks can be traced back at least as far as the poem *Génair Pátraic*, written well before the Patrician entries were inserted in the annals.

O'Rahilly's Theory.—In 1942 T. F. O'Rahilly reasserted the historicity of the two Patricks. The first was the Gaulish bishop Palladius, who, according to the notice of him in the Book of Armagh quoted above, was also called Patrick. He came in 431 from Auxerre as the head of a papal mission staffed by continental clerics and laboured in Ireland (chiefly in the east and the midlands) until his death *c.* 461. He was succeeded by Patrick the Briton, author of the *Confessio* and the *Epistola* and founder of Armagh, whose mission lasted until approximately 492. Only in terms of the later date for Patrick's death can one explain the fact that at least 13 persons who figure in the lives as his contemporaries are recorded in the Irish annals as dying after 500 (five of them after 520). A couple of centuries later, the *acta* of these two homonymous saints were conflated, whether by genuine confusion or deliberate design, in order to produce the national apostle and thus support the claim which was then being asserted by Armagh to ecclesiastical hegemony over the whole island.

O'Rahilly's thesis is brilliantly expounded, but some of his supporting arguments are open to serious doubt, notably his explanation of the difference between the earlier and later series of Latin loanwords in Irish as reflecting the contrast between the continental and British pronunciation of Latin in the 5th century (it seems more probable that both series were borrowed from Britain). Further, he estimates the historical value of the Irish annals more highly than some scholars are willing to do. Yet he has demonstrated that the single "national apostle" of Armagh tradition is unhistorical.

Mario Esposito's Theory.—In 1956 a different chronology for the two Patricks was proposed by the medievalist Mario Esposito, who, while fully accepting O'Rahilly's bisection of the traditional apostle, claimed that Patrick the Briton preceded his Gaulish namesake Palladius-Patricius. The first Patrick began his work in Ireland in the closing years of the 4th century. His mission was organized and financed by a group of British higher ecclesiastics, who, after he had laboured for 30 years, were about to raise him to the episcopate when a friend to whom he had entrusted the secret of his youthful sin revealed the story. Thereupon the synod declined to consecrate him, and hence he claimed only to be a "bishop" in the sight of God; this is the meaning of the words *episcopum me esse fateor . . . a Deo accepi id quod sum* at the beginning of the *Epistola*. It was as a result of his successful preaching that Ireland already had a sufficient number of Christians to warrant the sending of a regularly consecrated bishop by Pope Celestine in 431. The 7th-century lives are a blend of the *acta* of both missionaries but tell far more about Palladius-Patricius than about his British predecessor.

There are some serious objections to Esposito's chronology; for example, if Patrick's *Confessio* was really written *c.* 420, the references to the spread of monasticism among the Irish converts would be difficult to reconcile with its comparatively recent importation into Western Christendom. On the other hand, his theory might also offer the best solution of a number of problems, the most important of which concerns the foundation of Armagh. Patrick's church (in which his cult, celebrated annually with solemn ritual, can be traced as far back as the end of the 6th century) was situated within two miles of what was once the capital of the most powerful kingdom in Ireland, Emain Macha, seat of the Ulidian monarchy (Ulster). The story that his selection of this site resulted from a chance meeting with a local minor king may be dismissed as a legend which originated long after the power of the Ulaid had been grievously maimed by a new and expanding dynasty, the descendants of Niall (d. 405) of the Nine Hostages, whose over-king had his capital at Tara. Originally Patrick, following ecclesiastical practice throughout the Roman Empire, had made Armagh his headquarters simply because it was beside the capital of the kingdom to which his mission was mainly directed. Hence he must have come to Ireland while the Ulidian kingdom was still dominant and before Emain Macha was destroyed by the conquering Uí Néill (Irish kings descended from Niall). This revolutionary event must have occurred during the 5th century, and more probably in the first quarter of it, which would accord very well with Esposito's proposed chronology. But if he is right, then the numerous 6th-century death dates for Patrick's "contemporaries" (assuming that these are even approximately correct) can only be explained by postulating yet a third missionary, who succeeded Palladius and was active for most of the remaining years of the 5th century. Some of the later Latin lives do in fact mention a third Patrick, and though their testimony is extremely unreliable, it is just possible that the composite Patrick of the Book of Armagh is an amalgam of three separate missionaries.

Conclusion.—It is probably safe to dismiss what Esposito calls "the compromise St. Patrick of Bury" and his followers as an artificial synthesis. For the statement that Patrick spent at least 15 years at Auxerre, one of the leading centres of Western Christian culture under its famous bishop Germanus, surely cannot refer to the author of the *Confessio* and *Epistola*, who writes a barbarous and eccentric Latin, shows no knowledge of any book other than the Bible, and constantly deplores his own ignorance and lack of proper schooling, on which his enemies among the British clergy openly deride him. On the other hand, this account could very well be true of Palladius, who (as his family name suggests) may even have been a deacon of the church of Auxerre. Again, various incidents connected with the spread of Christianity throughout the southern half of Ireland, for which Patrick of Armagh receives the official credit, seem to have been taken over from the *acta* of Palladius and his Gaulish helpers.

Patrick himself is more likely to have confined his missionary labours to the modern province of Ulster and northern area of Connaught. He may have come before, during, or after the official papal mission led by Palladius, but there is no reliable evidence that he was ever in Gaul or that he was directly appointed by Rome, for the *seniores* who had been responsible for dispatching him to Ireland were a group of British ecclesiastics. After his death his cult was at first limited to the districts which had been the main centres of his apostolic work, notably Armagh, whereas in the rest of Ireland ecclesiastical jurisdiction came to be divided among the "families" (monastic federations) of native saints such as Columba and Ciarán. Only so can one account for the silence about him in the principal Hiberno-Latin writings of the 6th and 7th centuries. The growth of the Patrick legend was stimulated by the so-called Easter controversy, during which the community of Armagh, backed by the now dominant Uí Néill dynasties, played a prominent role in the fight against the Columban federation and other champions of local usage. The legend in turn provided a basis for the claim advanced by the abbot of Armagh as "heir" (Ir. *comarbae*) of Patrick to ecclesiastical authority over all the other monastic churches (significantly enough, a very similar claim, on equally pseudo-historical grounds, was at this time being put forward by the king of Tara to secular hegemony over the other provincial kings). In order to justify the pretensions of Armagh, then, the career of this humble servant of God, who speaks so movingly in his own writings, was transformed into a national epic, a "success saga," which only too often succeeds in obscuring the true greatness of the man.

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(D. A. Bi.)

PATRIOTIC SOCIETIES, as they are found in Western Europe and particularly in the United States, are organizations of four kinds—hereditary, veterans, historical, and international.

Historical societies work so modestly and with so little fanfare that they usually are neglected in classifying patriotic groups, although many of them, especially the numerous small societies, explicitly emphasize patriotism as well as encourage an interest in history. Every state of the United States, and nearly every city, has at least one historical society, usually bearing the name of its locality; similar organizations are fairly common in Anglo-Saxon regions of the British Commonwealth. They preserve historical records, memorabilia, and sites, encourage the study and preservation of historical materials, maintain museums, and cooperate with schools in fostering a sense of patriotism. Except those that are privately endowed, such as the historical societies of Massachusetts (1791), New York (1804), and Pennsylvania (1824), most are forced to fit their functioning within the scope of voluntary services and modest membership dues. Throughout the middle western and far western sections of the United States, regional pride has established state-maintained societies with broad patriotic programs such as those of Illinois (1899), Ohio (1885), and Wisconsin (1849). Where state or city support is furnished regularly rather than merely occasionally, public sensitivity to patriotic appeals is enhanced.

Hereditary and veterans' patriotic societies vary in organization, objectives, locale, and emphasis on patriotism. They are most numerous in the United States, partly because ardent patriotism is there coupled with habitual "joining." On the other hand, among people like the British, where honours are bestowed by the crown, hereditary societies are fewer in number; and among people like the Germans, where from the time of Bismarck the state acknowledged a considerable responsibility to ex-servicemen, the formation of organizations of war veterans was relatively slow. In France, veteran officers early won official recognition in Bonaparte's establishment in 1802 of the Légion d'Honneur with its five grades of decoration for distinguished military and civil service. For special distinction among privates and noncommissioned officers the Médaille Militaire was created (1852), carrying with it a small pension; and this medal, granted also to field marshals, commanders in chief, and admirals, became a most prized decoration. Holders of various French military decorations founded (1905) the Société Nationale des Médailles Militaires. In Europe more aggressive forms of organized patriotism waited mostly upon the 20th-century wars.

The oldest patriotic society in the United States, the Society of the Cincinnati (1783), is both hereditary and military. (*See* CINCINNATI, SOCIETY OF.) In imitation of it, officers who took part in the Mexican War founded a hereditary-veterans' society, the Aztec Club (1847). Precedents were established for military groups when the Veterans of the War of 1812, belatedly convening in 1854, welcomed veterans of all grades and staged a big, colourful convention. This group contributed its share to the multiplication of patriotic societies by producing as offspring (1892–1900) typical rival hereditary groups—the Military Society of the War of 1812, also the General Society of the War of 1812, and the Society of the Second War with Great Britain.

The American Civil War was followed by the formation of several societies for ex-servicemen. Among those formed chiefly for officers were the Loyal Legion (1865) and the "army" societies such as the Society of the Army of the Cumberland (1868), the Potomac (1869), and the Tennessee (1865). For enlisted men the most important organization before 1918 was the Grand Army of the Republic (GAR), founded in 1866. After a setback in the depression years of the 1870s, the GAR revived with a strong pension appeal in the 1880s, and reached its peak in leadership and influence in 1890. It was meanwhile fortified by philanthropic feminine affiliates such as the Women's Relief Corps (1883) and Ladies of the GAR (1886). The Sons of Union Veterans of the Civil War (1881), Daughters of Union Veterans of the Civil War (1885), Veteran Nurses of the Civil War (1892), and Dames of the Loyal Legion (1899) indicate the branching of the veteran family tree in northern soil. Confederate patriotism bloomed in the United Confederate Veterans (1889), United Daughters of the Confederacy (1894), United Sons of Confederate Veterans (1896), and Children of the Confederacy (1896).

The hereditary patriotic societies meanwhile flowered in a renaissance of patriotism in the United States. There developed the Sons of the Revolution (1883); Daughters of the Revolution (1891); Sons of the American Revolution (1889); Daughters of the American Revolution (DAR; 1890); Colonial Dames of America (1890); National Society of Colonial Dames of America (1892); Society of Colonial Wars (1892); General Society of Colonial Wars (1893); Military Order of Foreign Wars (1894); Society of Foreign Wars (1897); and many others. Among women's groups the DAR attained the largest following (*see* DAUGHTERS OF THE AMERICAN REVOLUTION). The most notable exception to separation between men's and women's organizations was the Society of Mayflower Descendants (1897). Britain's Royal Society of St. George (1894) undertook to nourish English patriotism and culture at home and abroad.

Veterans' patriotic societies and their affiliates grew during the war-torn 20th century, some becoming important politically, socially, and economically. In the United States the most important were the Veterans of Foreign Wars, the American Legion (*qq.v.*), the American Veterans Committee, and Amvets (American Veterans of World War II and Korea). For the British Commonwealth there was the British Legion (*q.v.*) and other legions affiliated in the British Empire Service League; for France the Fédération des Anciens Combattants Françaises and Fédération Nationale; for Germany the Bund der Frontsoldaten, known as Stahlhelm or "Steel Helmets" (1918, lapsing in 1935, reconstituted in 1951). These were in addition to the many patriotic societies surviving from the 19th century.

International patriotic societies reached out for protection against the chauvinism of some national groups. The French continued their Alliance Française, in existence since 1883. The British sponsored the Pilgrim Society (1902) and the English Speaking Union (1918). In 1945 the American Association for the United Nations was formed in New York City, apparently the patriotic society with the widest field to till, the greatest obstacles to overcome, and the broadest possible definition of patriotism—world patriotism.

See W. E. Davies, *Patriotism on Parade* (1955); L. W. Dunlap, *American Historical Societies* (1944).

(J. P. N.)

PÄTS, KONSTANTIN (1874–1956?), Estonian statesman, many times chief of state, was born in the Pärnu District, the son of a farmer, on Feb. 24, 1874, while Estonia was still under Russian rule. He graduated in law at Tartu University in 1896 and founded *Teataja*, the first Estonian-language daily newspaper in the north, at Tallinn in 1901. Whereas Jaan Tõnisson, editor of *Postimees* in Tartu, put national and cultural problems in the forefront, Päts concentrated on the economic and social advancement of the Estonian people. In the municipal elections of 1904 the

Estonian candidates, led by Päts and Jaan Teemant, captured the majority in Tallinn from the local Germans, and Päts became deputy mayor. He tried to restrain the excesses in the rising of 1905 but was condemned to death by the Russians and fled abroad. Returning to Tallinn in 1910, he was sentenced to a short term of imprisonment. Deprived of political rights, he yet took a leading hand in the struggle for Estonia's autonomy from 1911.

After the Russian Revolution of 1917, Päts became chairman of the executive committee of the Estonian National Council. On the declaration of independence on Feb. 24, 1918, he was appointed head of the provisional government, but the Germans, who occupied Tallinn on Feb. 25, arrested him. After Germany's capitulation he returned in November 1918 to head the provisional government until May 1919, by which time the Red Russian Army had been expelled from Estonia. In 1921–22, in 1923, and in 1932–33 he was *riigivanem*, that is, both president of the republic and prime minister. A referendum in October 1933 approved a constitution sponsored by the "Vaps" movement with provision for a directly elected president with extensive powers; on Oct. 21 Päts became again *riigivanem;* and in January 1934, when the second constitution came into force, he became acting president. Presidential elections were fixed for April, but on March 12 Päts declared a state of emergency and arrested the leaders of the Vaps. Eventually a third constitution came into force on Jan. 1, 1938. On April 24, by 219 votes to 19 of a special electoral college, Päts was elected president for a six-year term. On the occupation of Estonia by the Soviet Army in June 1940, a Soviet-controlled government was installed. Päts was formally dismissed on July 21, arrested on July 30, and deported to the U.S.S.R. It is believed that he died there in 1956. (E. Ar.)

PATTANI, a *changwad* on the east side of peninsular Thailand, is between *changwads* Narathiwat on the south (which separates it from Malaya) and Songkhla on the north. With an area of 777 sq.mi., it is one of the smaller of Thailand's *changwads,* although prior to a revolt in 1800, Pattani was a much larger political unit. Pop. (1960) 281,587. Much of the area consists of sandy ridges alternating with strips of lowland covered with clay soils. The ridges are old abandoned offshore sand bars and the lowlands are filled lagoons. Average annual rainfall amounts to 67 in. Houses, settlements and coconut groves occupy the ridges, while rice and other crops are grown in the lowlands. Most of the inhabitants are Muslims. The last Muslim ruler, however, was set aside in 1902. Pattani is the most important salt-producing *changwad* in the peninsula.

The capital, Pattani, a fishing centre and seaport and the largest settlement, is 65 mi. north of the Malayan border; it has a roadstead harbour which also serves the *changwad* of Yala. Coconut products, rubber and tin are the chief exports. Manufactured goods and rice are imported. Pop. (1960) 16,804. (T. F. B.)

PATTERSON, JOSEPH MEDILL (1879–1946), U.S. publisher and editor, was born in Chicago, Ill., Jan. 6, 1879. He graduated from Yale University in 1901 and joined the staff of the *Chicago Tribune.* In the year 1914 he became associated with his cousin, Robert Rutherford McCormick (*q.v.*), as co-editor and publisher of the *Chicago Tribune,* which, under their direction, rose to be one of the most influential and successful papers in the United States. He acted as war correspondent in China, 1900, and in Belgium and France, 1914–15. In 1919 he founded the *New York Daily News,* the first successful tabloid newspaper in the U.S., and it soon acquired an immense circulation. Patterson died in New York City on May 26, 1946.

His works include *A Little Brother of the Rich* (1908), *Rebellion* (1911), and *Note Book of a Neutral* (1915).

PATTI, ADELA JUANA MARIA (1843–1919), known as Adelina Patti, one of the great coloratura singers of the 19th century, was born at Madrid on Feb. 19, 1843. She went to the U.S. at an early age and appeared at concerts in New York City from 1850. She made her debut in opera as Lucia in *Lucia di Lammermoor* at New York City in 1859, and two years later she sang Amina in *La Sonnambula* at Covent Garden, where she appeared regularly until 1885. She sang many roles in the operas of Rossini, Bellini, Meyerbeer, Gounod, and others, and also several in the early operas of Verdi. Her voice was considered small but remarkable for its wide range, evenness of production, and purity of quality. She achieved her greatest successes in comedy, notably in the roles of Dinorah, Zerlina, and Rosina, Rossini having rearranged much of the music of this part for her. In 1868 she married Henri, marquis de Caux, from whom she was divorced in 1885; she then married the tenor Ernesto Nicolini (real name Ernest Nicolas), who died in 1898, and in 1899 the Swedish baron Rolf Cederström. She made her last public appearance in 1914 in London. She died at Craig-y-Nos Castle, Brecknock, Wales, on Sept. 27, 1919.

See H. Klein, *The Reign of Patti* (1920).

PATTISON, MARK (1813–1884), English scholar, rector of Lincoln College, Oxford (1861–84), memorable for his devotion to an intellectual ideal rather than for positive achievements. His life, dedicated to learning, bore fruit only in biographies of Isaac Casaubon (1875) and John Milton (1879), and in two volumes of *Essays,* posthumously published in 1889. Born on Oct. 10, 1813, at Hornby, Yorkshire, he was the eldest of 12 children (10 of them daughters) of a country clergyman, and was educated at home by his father. This upbringing gave him a lasting pleasure in country pursuits, especially fishing, but did not eradicate a morbid sensitivity and lack of self-reliance which later caused him much frustration and unhappiness. In 1832 he entered Oriel College, Oxford, where he came under the spell of John Henry Newman (*q.v.*), and after taking second class honours in classics (1836), he studied theology, being ordained in 1843.

As fellow (1839) and subrector (1847) of Lincoln College, Pattison developed a genius for influencing the young and a passion for "mental culture" which inspired him with the ambition to become head of his college and to see a radical reform of the studies and organization of the university. The first aim was finally achieved in 1861, after intrigue among his colleagues had led to a defeat in 1851 which permanently warped him; the second was brought about by the university commissions of 1850 and 1872, but in a form which, while it realized the educational aims of Benjamin Jowett (*q.v.*), the master of Balliol College, frustrated Pattison's desire that the university should become a real seat of learning.

His later years were embittered by the failure of hope, the loss of religious faith, and an unhappy (and childless) marriage (1861) to Francis Strong (1840–1904), a beautiful girl much younger than himself, but with a personality and intellect almost as powerful as his own, who became known as a writer on art and who, after Pattison's death (at Harrogate, on July 30, 1884), married Sir Charles Dilke (*q.v.*). In 1885 she published Pattison's *Memoirs* (to 1860); their merciless self-analysis and the quality of mind they reveal make them perhaps the most remarkable volume of confessions in English. (J. Sp.)

PATTON, GEORGE SMITH (1885–1945), U.S. Army officer, an able tactician, and an outstanding practitioner of mobile tank warfare in World War II, was born in San Gabriel, Calif., Nov. 11, 1885, and graduated from the United States Military Academy, West Point, N.Y., in 1909. Descendant of a Virginia family with a military tradition, Patton became a student of the American Civil War, particularly of its great cavalry leaders. This interest continued throughout his career as a soldier and contributed to the concept of bold, highly mobile, armoured operations that became associated with his name. His professional interest turned from the cavalry to the new tank arm as the result of battle experience with the U.S. tank corps in World War I. Between the two world wars, Patton forcefully espoused the cause of the tank. Having taken part in the North African campaign (1942), Patton commanded the U.S. 7th Army in Sicily, employing his armour in a rapid drive that captured Palermo.

The apogee of his career came with the great sweep of his 3rd Army across France in the summer of 1944, in a campaign marked by great initiative, ruthless drive, and disregard of classic military rules. Patton, who died after an accident in Germany, Dec. 21, 1945, was a colourful soldier, "Old Blood and Guts" to his troops. His memoirs appeared under the title, *War As I Knew It* (1947). (H. M. Ce.)

PAU, a city of southwestern France, the capital of the *département* of Basses-Pyrénées and former capital of Béarn and French Navarre, lies 106 km. (66 mi.) ESE of Bayonne on the railway to Toulouse. Pop. (1962) 57,476. The city stands on the edge of a plateau, 130 ft. above the right bank of the Gave de Pau, an affluent of the Adour. A small stream, the Hédas, flowing in a deep ravine and crossed by several bridges, divides the city into two parts. Pau derives its name from the word *pal*, in allusion to the outer stakes of the castle which, from the 11th century, guarded the ford across the Gave. The existing castle, which contains a collection of Gobelin and Flemish tapestries, dates in part from the 12th century; it was the residence, from 1512, of the kings of Navarre and thus the birthplace of Henry IV of France in 1553. The house where Bernadotte (Charles XIV of Sweden and Norway) was born in 1763 is a museum. Pau is a winter sports centre and has two international events—a horse show and a grand prix motor race. It is the centre of a rich agricultural region, specializing in stock breeding and the growing of hybrid maize (corn). The discovery of oil at Lacq, to the northwest, in 1951 accelerated Pau's industrial development; manufactures include turbines, chemicals, and shoes.

PAUL, SAINT. The interpretation of Christianity, and its spread into the western world, are so bound up with the apostolic ministry of St. Paul that neither can be discussed intelligently apart from the story of this man and his work. He saw the universal implications of the new faith, struggled passionately to have them recognized and applied, and endured the most severe hardship and persecution to extend the faith to the uttermost parts of the Mediterranean world. Without the consecrated labours of this Christ-intoxicated man it is debatable whether Christianity would ever have become a world-wide religion. No figure in church history stands so high or has had such far-reaching influence as this apostle to the non-Jewish world. Centuries have not dimmed the lustre of his personality nor changed the significance of his place in Christian history. Whenever and wherever the impact of a secular world and the spread of unworthy religious practices have left the church in need of revitalization, it is to Paul that men have turned, as to a fountain from which again the pure water of the evangelical faith could be drawn and the essence of the Christian gospel republished.

Many have found in the radical transformation of this "Pharisee of the Pharisees" the most convincing evidence of the truth and the power of the religion to which he was converted, as well as the ultimate worth and place of the Person of Christ to whom he gave, in absolute surrender, all his powers of heart and mind and spirit. Toward his ministry's close, Jesus asked his disciples: "Are you able to drink the cup that I drink, or to be baptized with the baptism with which I am baptized?" (Mark x, 38). Paul was not among the group who heard that question. He was, however, the finest embodiment of that discipleship of self-sacrifice which the "cup" and the "baptism" symbolized. For so completely did he identify himself with Christ and "share his sufferings" (Phil. iii, 10) that from the day of his conversion to the moment of his execution, almost 30 years later, he found life and liberty only in being "the slave of Christ," whose love controlled his every activity and constrained him to live no longer for himself but for him who for his sake "died and was raised" (II Cor. v, 14–15).

Clearly this is no ordinary or average man. Whatever truth lies in Carlyle's contention that "History is the biography of great men," that and much more must be said of Paul's part in the shaping of the Christian mind and his influence upon subsequent Christian development in western civilization and elsewhere.

CAREER

Background and Training.—What is known of Paul comes from his letters and from the Acts of the Apostles. "I am a Jew, born at Tarsus in Cilicia, but brought up in this city [Jerusalem] at the feet of Gamaliel, educated according to the strict manner of the law of our fathers, being zealous for God as you all are this day" (Acts xxii, 3). Thus Paul spoke to the angry mob in Jerusalem who a few minutes before would have killed him. The words speak volumes, and there is no reason to doubt their historical accuracy. Tarsus, the capital of Cilicia, a province of Asia Minor, was built at the mouth of the Cydnus river and commanded a place of considerable importance commercially because of its location on one of the most important overland trade routes of the ancient world. Tarsus was also a centre of culture, a university city, and a number of Stoic philosophers lived there. Strabo, the famous Greek geographer, contemporary of the emperor Augustus, praised the Tarsians highly for their interest in education and philosophy and compared the city very favourably with Athens and Alexandria. Clinging to oriental habits and customs, however, Tarsus never became completely hellenized.

There, shortly after the beginning of the Christian era, Paul (Sha'ul, his Hebrew name; Paulus, his Roman cognomen) was born of a Jewish family of strict Pharisaic persuasion, descended from "the tribe of Benjamin" (Phil. iii, 5) and thus closely associated with the centre of Judaism in Jerusalem. The Jews of Tarsus, like similar colonies elsewhere, were doubtless related to the business life of the city. Some were Roman citizens. Paul's family shared this distinction, whether by bestowal or purchase is not known. No foundation exists, except an unsupported tradition of Jerome (4th century), for the view that Paul's parents were from Gischala in Galilee and that his father obtained his citizenship after going to Tarsus as a prisoner of war.

Though Roman citizens, Paul's family remained loyal, as most Jews did, to their Jewish faith and practice. He was raised strictly after the manner of his people, attending the synagogue school and learning, it may be assumed with some devotion and brilliance, all that was required of him as a student of the Scriptures and the Law of his fathers. His mind was alert to the contrast between the strict moral and religious behaviour expected of him and the generally loose ethical life reflected in an environment given over to idolatry (Rom. i, 20–32). Tarsus, with its hellenistic-oriental character, furnished Paul with a background which later proved invaluable as he ventured into the Roman world to proclaim the gospel of Christ. For what better preparation than firsthand knowledge both of the soil out of which Christianity came and the pagan soil into which he wished to plant it? That he knew the latter as intimately as he did the former cannot be maintained. There is little evidence that Paul was trained in Greek culture or had firsthand knowledge of the mystery cults. It would be surprising if, in presenting the gospel to pagan audiences, he did not reflect the language and thought patterns of the time. He could not escape the terminology of his day any more than modern man, without much formal training, can avoid slipping into words and phrases from current science or philosophy or religion. He was not slow to observe the world about him generally, and his national pride stimulated him to rejoice that he was of the people of the Covenant and shared the privileges and promises extended to Israel. Far from weakening his monotheistic faith and his love for God's Law, or leading him to compromise with pagan thought, his early home training intensified his purpose to live and labour that God's name might be reverenced and his Law meticulously kept.

It occasions no surprise, therefore, to find Paul in Jerusalem studying under Gamaliel, the most famous rabbinic teacher of the day, a man liberal in mind and tolerant in spirit (Acts v, 34–39). That Paul applied himself assiduously to his rabbinic studies is indicated by his later devotion to the Law and his frequent use of the rabbinic method, though the latter should not be stressed unduly. One thing is certain, his Jerusalem period served to reveal to him more clearly than ever that a real Jew is not one outwardly but inwardly (Rom. ii, 28–29). There was something fundamentally beautiful and noble about the studies of Pharisaism. The concept of the Torah as embodying God's purpose for men, the eagerness and devotion with which rabbinic learning was pursued, the many fine characters who loved the Law of their fathers immensely and found intense delight in observing it, the deep religious experience that the Law could and often did effect in its devotees and that was expected to meet the profound spiritual needs of the soul—all this reveals a system of religious life and practice that cannot but be highly valued and praised by anyone having even a superficial acquaintance with it. Pharisaism has suf-

fered much at the hands of its critics.

Nevertheless, the Torah had become so overlaid with multitudinous oral interpretations that the Law as precept had begun to overshadow the Law as moral, its inward spiritual character subordinated to its external and legal aspects. Paul must be seen as representing the Pharisee at his best, zealously observing the Law and seeking, at the same time, the inward peace and satisfaction which such observance was calculated to provide. He was evidently well on the way to becoming a rabbi when a crisis occurred which changed the whole trend of his life radically and completely.

Conversion.—Within Judaism a new sect had appeared, followers of Jesus of Nazareth, whom they affirmed to be Messiah and themselves to be the new and true "Israel of God," the people of the New Covenant, bringing to fulfillment all that God had purposed for his people and inheriting all the promises given in Hebrew history to the people of the old covenant. Such claims, particularly that of a crucified Messiah, struck at the very conceptions which Paul's Jewish training had nourished and his rabbinic studies had so recently confirmed, and threatened the essential features of Judaism itself. To exterminate this sect and to destroy this blasphemous heresy root and branch became the supreme passion of his life (Gal. i, 13). Nothing could be more surely the will of God than that he should oppose with all means at his disposal "the name of Jesus of Nazareth" and pursue to the death all who belonged to "the sect of the Nazarenes" (Acts xxvi, 9–11). Thus he literally "laid waste the church" (Acts viii, 3).

To further this purpose he set out for Damascus fortified with documents from the religious authorities in Jerusalem, authorizing him to secure the followers of Jesus of Nazareth who had gone there and possibly to bring some back to face trial for heresy. Paul reached Damascus but not as he expected, for on the way he was confronted with Jesus of Nazareth and soundly converted to the new sect which he had been so zealously persecuting, certainly one of the amazing reversals of purpose in the whole history of mankind. Four accounts of this event appear in the New Testament (Acts ix, 3–19; xxii, 6–21; xxvi, 12–18; Gal. i, 12–16), differing slightly in details respecting accompanying phenomena—the light, the sound, the fall to the earth, the blindness—but agreeing substantially as to what Paul saw and heard and said, and his subsequent relationship with Ananias in Damascus. Supernatural, mystical, psychological explanations have been given of this remarkable experience. What appears to be a sudden conversion had no doubt been the last stage of a long preparatory process. The following factors should be noted:

1. His growing disillusionment respecting the Law. Paul had an exceedingly sensitive approach to the Law, which he observed meticulously (Phil. iii, 6). It is doubtful that Pharisaism took the view that only complete fulfillment of the Law could save a man from being accursed, yet Paul believed this (Gal. iii, 10). We can only assume that his understanding of the moral law, embodied, as he held, in the Torah, was so keen that he despaired of fulfilling it. External observance and inward fulfillment were to be one and issue in victory and emancipation of soul, but this was not the case. Actions, he found, could be controlled, but not desires (Rom. vii, 7). This condition, known to himself prior to his conversion and typical, Paul believed, of all men, is described with remarkable vividness (Rom. vii). His intense, almost savage attempt to obliterate the Christian movement reflects a sense of insecurity prompted by misgivings and doubts. Like a stubborn ox he was kicking "against the goads" and hurting himself more than anyone else (Acts xxvi, 14).

2. The impact made by early Christians and particularly by the work and martyrdom of Stephen. A man does not persecute people of whom he knows nothing. We may be sure Paul knew a great deal about the Nazarenes and must have been impressed with their quality of life and conduct. They possessed inner joy, peace, confidence and courage, which he had sought without success. Stephen, whose stoning he approved and probably encouraged, was the supreme example of this. This young martyr, representing the view of hellenistic Christians, had surveyed the course of Hebrew history to show that special privilege no longer existed for the Jewish nation; that Christianity, sprung from that history, had superseded the Law and the Temple; and that all this had resulted from the coming of "the Righteous One," Jesus Christ, who had been rejected and crucified by the very people whose prophets had anticipated him. This was anathema to Paul, and yet it was the argument of a man who could die with singular assurance, committing his spirit to his Lord and praying mercy upon his murderers (Acts vii, 59–60). The argument incensed him; the death, we are persuaded, moved him, for, being the kind of man he was, Paul could scarcely look upon the cruel martyrdom of this young saint and at once erase the scene from his memory. His eagerness to discover truth, coupled with his sense of insecurity and perplexity, must have driven him to think more deeply than ever about the people whom he was persecuting and about the man Jesus, the master whom they served.

3. The probable influence of the Person of Jesus. Whether he ever saw Jesus in the flesh is not known. Some scholars think that he did, otherwise he could not have carried in his mind the impression of Jesus' character suggested by various allusions in the Epistles. He refers to having known Christ "after the flesh" ("from a human point of view"; II Cor. v, 16), by some interpreted to mean "the Jesus of history"; but scholars are not unanimous on the meaning of this somewhat difficult passage. That he learned much about Jesus while pursuing Jesus' followers can scarcely be doubted, since knowledge of them and their convictions was inseparable from knowledge of the character and claims of him whom they declared to be Messiah. Moreover, being a member of that strict sect of the Pharisees, the prime movers in the events that brought Jesus to his death, Paul could hardly be ignorant of what was known, or professed, concerning him. John Knox maintains that the reason Paul was able to identify Jesus as the Lord revealed to him near Damascus was that he already had knowledge of him through his contact with the primitive Christian community. "Christ had begun to make himself known to Paul—perhaps against the latter's will—as the Spirit of the persecuted *koinonia* before he made himself known in the visual experience in which Paul's conversion culminated." (John Knox, *Chapters in a Life of Paul*, p. 126, Abingdon Press, New York, 1950.)

With reasonable certainty, then, it may be affirmed that the radical redirection of life which Paul described as God being pleased to reveal his Son to him (Gal. i, 16) was not without considerable preparation; as G. A. Deissmann wrote (in *The Religion of Jesus and the Faith of Paul*, 1923), "the lightning of Damascus" struck "no empty void" but found "plenty of inflammable material" in Paul's soul.

Certain convictions followed from his conversion: (1) that the crucified Jesus of Nazareth was the living Christ; (2) that the cross was no longer a shameful thing, a stumbling block, but central to the messianic redemption, since God had vindicated him who was nailed to it; (3) that God had called Paul to undertake the apostolic ministry, must indeed have destined him to be a minister even before he was born (Gal. i, 15). These three convictions became the foundation stones of all his subsequent theology.

Of the period immediately following his conversion little is known, except that he spent about three years, partly in Damascus and partly in Arabia southeast of that city (Gal. i, 17; Acts ix, 19, 22), after which he made his first postconversion visit to Jerusalem, where he spent two weeks with Peter and saw James, the head of the Jerusalem church (Gal. i, 19). He then returned to Tarsus and worked as an independent missionary, it seems, for about ten years, in "the regions of Syria and Cilicia" (Gal. i, 21; Acts ix, 30). These silent years were formative years, when he thought deeply about the new faith and gained rich experience in teaching and preaching. The later expression of his thought as an apostle to the gentile world owed a great deal to those years before the summons came to undertake the work which was to set him apart forever as the first great missionary of the Christian church.

Missionary Activity.—The Christian movement, meanwhile, was making great progress in Antioch, and Barnabas was sent from

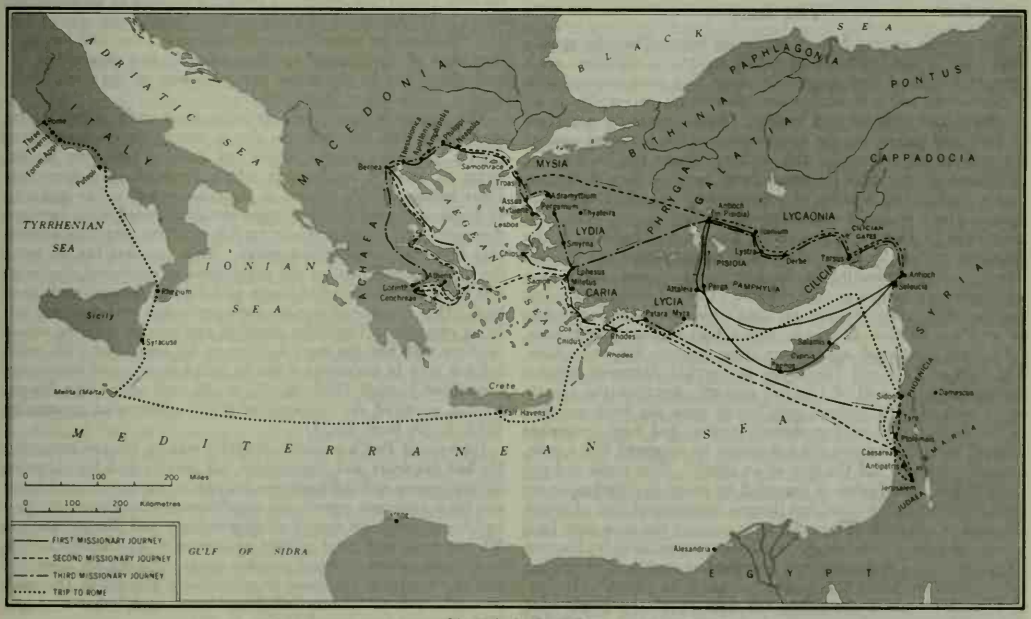
Jerusalem to visit. He must have sensed in that large and vigorous congregation a growing missionary imperative, for he continued on to Tarsus, found Paul and returned with him to Antioch. For a year they ministered there and then together were commissioned to carry the gospel to the wider world (Acts xiii, 2 ff.). Paul was thus launched upon a missionary career that brought him ultimately to Rome itself. He was doubtless encouraged by the gentile contacts he had made in the area of Tarsus and by the success attained in the approach to non-Jews in Antioch (Acts xi, 20–21). He was beginning to see the universal implications of the faith and appears to have conceived a grand assault upon the Roman empire. That he was influenced in this by the impression made upon his mind by the empire, with its possibilities of unity and solidarity, is quite possible, and he may even have conceived of Christianity, as Sir William Ramay contended (*Pauline and Other Studies*, 1906), as the power capable of achieving this ideal. He saw what splendid opportunities the empire offered for the spread of the gospel, with its vast and comparatively safe system of communication, as well as the advantage of a common (Greek) language. He later looked upon it as providential that the gospel could be preached without hindrance under the protection of Roman law and order (Rom. xiii, 1–7), and his own experience often demonstrated this (Acts xviii, 12 ff.; xxiii, 23 ff.). Armed with a passion to extend the gospel and a vision of a pagan world desperately in need of it (Rom. i), anticipating doors of opportunity that would open in the cities and provinces of the Roman empire, Paul with Barnabas and Mark began the movement which was destined, in less than three centuries, to make Christianity the official religion of the Roman state.

The narrative of Paul's missionary tours given in Acts may be accepted with confidence. Paul wished to reach as far as possible into the west and kept his eye upon strategic cities and areas of the empire. Ill health and other factors, interpreted by him as being "forbidden by the Holy Spirit" (Acts xvi, 6, 7), sometimes prevented his proceeding according to plan; but when one considers that his journeys took him to Cyprus, to a large area of Asia Minor, into Macedonia and Greece and possibly Illyria, and finally to Rome, his achievement is an astonishing one.

Final Phase.—Paul always maintained close touch with the Christian community at Jerusalem. He had kept its welfare in mind by collecting an offering in his gentile churches, a gesture which demonstrated both their oneness in Christ and gentile gratitude for "spiritual blessings" received (Rom. xii, 5; xv, 27; II Cor. ix). He wished to revisit Jerusalem before going to Rome (and possibly Spain), to take this offering with him. The Judaean Christians were poor, due in all likelihood to famine, persecution and their earlier experiment with communism (Acts ii, 44, 45). Paul attached great importance to this visit and took with him representatives of the contributing churches (I Cor. xvi, 1–4; II Cor. viii–ix; Rom. xv, 25–27), a gesture no doubt intended to be practical proof of their Christian fellowship, to cement the bond of love between the Jewish and gentile Christian communities and to anticipate the day when all barriers between them would disappear and they would be "one new man" in Christ Jesus (*cf.* Eph. ii, 11–16).

This generous and commendable plan was the beginning of the end for Paul. He was warned repeatedly that "imprisonment and afflictions" awaited him, but he was determined to carry out his purpose (Acts xx, 22 ff.; xxi, 10–14). Arriving at Jerusalem he was warmly greeted by the Christian leaders, was soon in conference with James and the elders, and mutual accounts were given of the growth of the church in their separate spheres. Paul had been under suspicion by the Jerusalem church because of reports that he sat rather loosely by the Law in his relations with Jews in the gentile world (Acts xxi, 21), teaching them "to forsake Moses, telling them not to circumcise their children or observe the customs." To allay this suspicion, and for the sake of the plan which he had so prominently in mind when he returned to Judaea, he consented to observe a week of ritual purification. He was discovered by Asian Jews in the Temple, set upon, and only by the intervention of the Roman authorities, who accused him of disturbing the peace, was he spared death at the hands of an angry mob.

Learning that Paul was a Roman citizen and that the Jews were plotting his death, the Roman tribune had him taken under military escort to Caesarea Palestinae (Qisarya), where he was tried first by the procurator Felix, then two years later by Felix' successor Festus, who, wishing to show some favour to the Jews, sug-



ST. PAUL'S TRAVELS

gested that he might be tried in Jerusalem. Paul, knowing that certain death faced him if he accepted this proposal, appealed instead to Caesar. Accompanied by Luke and Aristarchus (Acts xxvii, 2) he set sail for Rome. After a most hazardous and stormy passage, including shipwreck, he arrived there in the spring of either 59 or 60, fulfilling a lifelong ambition but not quite as he had hoped.

Of his subsequent life little is known. There is no good reason to doubt Luke's account that as a Roman citizen he was given freedom to live for two years in his own house, under guard, could meet his friends and was permitted to preach the Kingdom of God and to teach "about the Lord Jesus Christ quite openly and unhindered" (Acts xxviii, 30–31). It is fairly certain also that his latest, and in some respects his ripest, letters were written from Rome. Scholars have been puzzled over the ending of Acts. Why is there no account of Paul's death? Was Luke's writing complete before Paul's martyrdom? Was Paul acquitted, and did he go, as he had intended, to Spain (Rom. xv, 28)? Those who accept I and II Timothy and Titus as authentic letters of Paul (and few modern scholars do) find evidence for his continued activity in the reference to "my first defense" and his rescue "from the lion's mouth" (II Tim. iv, 16–17), suggesting that his trial and release are indicated here and that he returned to the scene of his earlier labours in Macedonia and elsewhere. No other evidence exists for Paul's further ministry beyond Rome except an uncertain and ambiguous reference in I Clement (*c.* A.D. 95) that before his death the apostle "had reached the limits of the west," interpreted by some to mean Spain. The Muratorian Fragment (a fragmentary list of New Testament writings, with comments, dating from the end of the 2nd century) expressly states that Paul departed from Rome for Spain. No firsthand sources exist, however, upon which to build a reliable account of his movements prior to his execution. There are two possibilities: (1) that he never left Rome but was condemned and executed after his first trial; (2) that he was released, went to Spain and perhaps revisited the east, was rearrested, tried and condemned. It is reasonably certain that he died a martyr's death in Rome sometime between A.D. 62 and 64, and that very probably his approaching end is reflected in what is believed by many to be a fragment of a letter written to Timothy (II Tim. iv, 6–8).

THE MAN

Few men in ancient history are better known than the apostle Paul. His letters, with one exception written to churches, are a primary source of first magnitude, since they were written with a spontaneity and a frankness that disclose his personality in all its depth and richness and variety. Every letter "is a picture of Paul, and therein lies the unique value of the letters as sources for a historical account of this author. There can be but few Christians of later days for whose inner lives we have such thoroughly undesigned sources of information" (G. A. Deissmann, *Paul, a Study in Social and Religious History*, p. 25; 1926. By permission of Hodder & Stoughton, London.) The Acts of the Apostles, written by Luke 20 or so years later than the Pauline letters, and incorporating in the latter part a travel diary, is a supplementary source of considerable value. Letters and diary, together with other sections of Luke's history, make it possible to see Paul the man, as he was, with a high degree of confidence.

Of Paul's personal appearance these sources say very little. The Acts of Paul and Thecla, an apocryphal document written during the latter half of the 2nd century, describes the apostle as "a man of little stature, thin-haired upon the head, crooked in the legs, sturdy with eyebrows joining, and nose somewhat hooked, but full of grace, for sometimes he appeared like a man, and sometimes he had the face of an angel." This frank and not too flattering description is regarded by some as based upon an early and reliable tradition, but there is no surety of this. Certain allusions in available sources seem to support the view that Paul was not physically impressive. At Lystra he was taken for Hermes (Acts xiv, 12), a god sometimes described as small and vivacious; his enemies described "his bodily presence" as "weak" (II Cor. x, 10). He himself contrasted the treasure of the gospel with the "earthen vessels" containing it, a contrast which might well have been suggested by his own frailty (II Cor. iv, 7). He came to the church at Corinth "in weakness and in much fear and trembling" (I Cor. ii, 3). His "thorn in the flesh" (II Cor. xii, 7), variously interpreted to mean epilepsy, malarial fever, erysipelas or ophthalmia, was certainly a recurring illness which produced a physical condition to which Paul was very sensitive (Gal. iv, 14) and which sometimes hindered his movements. It seems clear that his physical condition was not all that he desired; and yet the catalogue of trials endured, adventure undertaken and work achieved makes it abundantly certain that the apostle was no invalid, that he was, on the contrary, possessed of a physical sturdiness and strength which his appearance belied (II Cor. xi, 23–29). We must not underestimate, however, the strength derived from passionate commitment to a supreme purpose, often able to overcome seemingly insurmountable obstacles. Such Paul attributed to no power of his own, but to God's grace which had made divine power perfect "in weakness" and had assured him that "when I am weak, then I am strong" (II Cor. xii, 9–10).

We have considerable knowledge of Paul's personality. His letters, particularly the Corinthian correspondence, open his very heart and mind and spirit, so much so that psychologists have even attempted to psychoanalyze, label, categorize him. More than once he has been described as a man of conflict, and this has been suggested as a criterion of judgment for his many-sided character. Paul, however, manages to escape all such narrow classifications supremely because he was too great for any one of them.

Paul was a man of resolute character, whose distinctive mark was a quality of absoluteness. Honesty of mind, integrity of purpose, zeal for truth, longing for the ultimate, passionate earnestness in the search for certainty—all these were so much part of this man that he could undertake nothing lightly nor give himself to anything halfheartedly. Thus he was loved by those who stood with him, hated by those who stood against him. It is not surprising that he stressed his independence almost to a point of exaggeration, maintaining that he owed nothing to his predecessors in the Christian faith (Gal. i, 11–12; ii, 6). This claim cannot reasonably be that he had known nothing about the new faith and had not inherited the primitive traditions associated with the apostolic gospel but rather that all this had no secondhand quality for him, indeed had become so firsthand because of his encounter with Christ that he could speak of it as "my gospel" (Rom. xvi, 25). Similarly he viewed his apostleship as not one whit less valid than that of the original apostles, since he had received it not secondhand but by the direct commissioning of the risen Christ (Gal. i, 1, 15–16; *cf.* Acts xxvi, 16–18).

This insistence upon inner certitude, upon truth authenticating itself in his own experience so that it was no dogma transmitted from a secondary source, marks out Paul as belonging to that strain of Hebrew tradition to which Jeremiah, and supremely Jesus, belonged. The witness of Jeremiah, as well as the authority of Jesus, stemmed from an inner certainty based upon personal discovery; and it was precisely on this platform that Paul's insistence upon his independence rested. This accounts for his being the living embodiment of the convictions he professed, for never was there a more complete fusion of faith and personality than in him. This correspondence between profession and practice, this living example of Christlike devotion and service, inspired others to share with him the work so close to his own heart. He could not ask men to undertake a life to which he was not thoroughly committed himself (Phil. iii, 17; iv, 9), and many, like Epaphroditus, accepted the challenge of Paul's consecrated personality (Phil. ii, 30; Rom. xvi, 4).

Underlying Paul's resolute character was an intense humanity. He had his fears and frustrations, his defeats and his victories, his intolerance and stubbornness, his passionate outbursts of anger and his subsequent regrets, his sensitiveness to criticism, his joys and his sorrows, his moods of despondency and disappointment. He also possessed great powers of sympathy and understanding, keen appreciation of other people's needs, capacity for deep and lasting friendship, readiness to subordinate himself to the work of Christ and to become "all things to all men," that he might "by all means save some" (I Cor. ix, 22).

This does not mean that he was willing to compromise, to concede principles or to moderate his views in order to gain an advantage or to secure some temporary conciliation. There were instances when, without adequate understanding of his motives, we might accuse Paul of this—his submission to the vow in Jerusalem (Acts xxi, 23) or his having Timothy circumcised preliminary to his becoming a missionary (Acts xvi, 3). But this was something different from compromise or indeed from sentimental attachment to an outgrown system. Paul, through his commitment to Christ, had come to a new understanding of the Law, had come to believe that Christ was both the end of the Law and its ultimate fulfillment. The Wisdom of God had become flesh when the Messiah appeared, but this did not mean abandoning altogether customs which belonged to the religion of one's fathers, so long as they were put in their proper perspective, no longer regarded as central and essential, and practised with the purpose of making possible the preaching of Christ within an unbroken church fellowship. Paul was no dissimulator precisely because he was a man of love (Rom. xii, 9), and to love, he believed, was to fulfill the Law (Rom. xiii, 10). His actions, within the context of both individual and corporate life, were dictated primarily with a view to achieving the ends of love, that is, to strengthening Christian character and building up the Christian community. His intense humanity, to some extent native to his personality, was nourished by his absorption in the new humanity, the company of those "in Christ" who, like himself, had entered a community in which all barriers had been removed and in which the chief concern was for "the brother for whom Christ died," whatever his race or class.

What sympathetic imagination and deep personal feeling are expressed in such concern! This is to be human in the best and highest sense, for it is sharing the life of him who brought humanity to its peak of perfection, Jesus Christ, the Son of God. When Paul so superbly describes Christian love (*agape*), he paints a portrait of the man Jesus and, at the same time, reveals to what heights human behaviour may rise when motivated by the love of God (I Cor. xiii). Paul had his weaknesses. He longed for companionship and appreciation. He objected angrily when his actions or motives were questioned. He was proud and temperamental. But these, and many other traits of his character, were completely subordinated when he became a "new creation in Christ." His intense humanity, therefore, issued not merely from what he was but from what he became under the constraining love of Christ.

Paul frequently described himself as the "slave" or "servant" of Christ (Rom. i, 1; Phil. i, 1). He was a man under a new authority, which, paradoxically, had rendered him free. Before his conversion he was a slave of a different kind, demanding of himself, even as of others, conformity to the absolute moral ideal which he believed to be revealed in the Law of his fathers—the Torah. This slavery did not issue in freedom; rather it deepened the sense of imprisonment, led indeed to frustration and futility because there was no sense of inward victory, a realization only of defeat. It was his uncompromising search after absolute achievement, and his eagerness to find complete inward satisfaction, that led him to cry out in that acute autobiographical passage, "Wretched man that I am! Who will deliver me from this body of death?" (Rom. vii, 24). Such absoluteness and eagerness for inward purity are not found in every good man; many are content to remember that moral perfection is unattainable in this life. Paul could not rest his case there. He had to be right before God, and to achieve that condition there had to be inward witness that the requirements of the Law had been met. This inward witness was lacking. He did not know it, but at this point Paul was a man in search of grace, and this is what he found when he found Christ. He discovered that he was to cease taking the initiative in his own salvation and to behold, in the life and death and resurrection of Christ, the initiative God had taken. He was to understand that the divine act in Jesus Christ was God's declaration to man that the divine-human relationship is a gift imparted on the ground of faith and issuing in a sense of inner emancipation enabling man to live according to a new law, the spirit or law of Christ, the law of love.

Thus the apostle passed from slavery to one law to slavery to another, from the Torah to the new Torah, Christ "the Wisdom of God," with the difference that now he had found "the glorious liberty of the children of God" (Rom. viii, 21; Gal. v, 1). Moreover, this love became his supreme passion and directed his whole being (II Cor. v, 14), so that he became a man controlled by Christ, with one supreme passion to preach Christ (I Cor. ix, 16). Now he was content to have one ambition only, to know Christ, to have him formed within (Gal. iv, 19), to share his resurrected life; and that life was one of power within, morally and spiritually quickening and cleansing, enabling him to share the sufferings of Christ and to partake of the future redemption (Phil. iii, 10–14). The zeal of the Pharisee had been transmuted into the zeal of Christian apostleship. It is evident in his love for the churches, in the sufferings and privations which followed his course, in his indomitable courage (II Cor. xi, 23–29; Acts xxi, 13), in his purpose to push the frontiers of Christianity to the farthest limits of the west (Rom. xv, 28), in his willingness at last to die for the sake of the gospel. Paul had come a long way in his spiritual pilgrimage, from the intolerant, bitter, persecuting religious bigot to the patient, kind, enduring, self-sacrificing temper of him whom he owned Master and Lord. In this lay his greatness, that, with unswerving loyalty and complete subordination of self in sacrificial service, all his diffuse powers were so fully brought into captivity to Christ that he lived only and wholly and magnificently for the fulfillment of God's redemptive purpose.

THE CHRISTIAN THINKER

Paul was the first great theologian of the church, but his was not the first Christian theology. When he became a Christian the primitive church already possessed convictions about God, the Messiah, the Holy Spirit, the people of God, forgiveness and redemption and beliefs associated with the practice of the two gospel sacraments; and though he constantly affirmed his independence of others in respect to what he had received, this was to emphasize the genuineness of his faith rather than to deny his relationship to primitive tradition. He built his theology upon his own experience, plus the living gospel tradition of the church which had been passed on to him and upon which he brought to bear his own vigorous mind. He did not create a theology; he drew out rather the implications of what already existed in the mind of the early church, though few of his predecessors had the spiritual insight to anticipate, were in a position to see the necessity for, or were so well-equipped to appreciate, the far-reaching affirmations to which the apostle's study and experience of the gospel led him.

He was not a systematic thinker. Much of his thought was expressed spontaneously, stimulated by a request from some church or prompted by news of some heretical teaching or moral weakness. System, and even consistency, were difficult to maintain under pressure from many quarters at once, and Paul was neither systematic nor always consistent. Nevertheless he is original in that he was the first great interpreter of Christianity to the world at large and took responsibility for expressing the Christian faith in forms that enabled it to transcend those limitations that would have kept it sectarian. He is original also in that, despite his lack of system, he does offer the first clearly formed, though simple, theology of the Christian religion.

Paul was a courageous thinker. His ten or more silent years in Cilicia and Syria as a pioneer missionary must have been years of intense and at times agonizing thought. He was compelled, by reason of his conversion, to reconsider his whole position respecting the nature of God, man's relationship to God, the meaning of life and history, and particularly the significance of Israel's history. In doing so, he was forced by the very logic of events in his own experience to abandon many of the convictions most treasured from his youth. The world of his traditional ideas had been turned upside down, and he was forced to make a profound adjustment to an entirely new set of ideas. The action of God in Jesus was so utterly out of line with everything that he had held concerning the Messiah, the road to salvation, the absolute character of the Law, the place of Israel in God's economy, and yet

so incontrovertible, that necessity was laid upon him to make the matter clear both to himself and to others. He never shrank from the pain of that mental readjustment which the reconstruction of his faith must surely have caused him. His theology, therefore, is an attempt to give rational expression to the meaning of Christian experience, particularly his own experience, and to give what he believed to be the theological implications of what God had been pleased to accomplish in history through Christ and his church. Certain fundamental concepts, outlined below, characterize Paul's theological thought.

Many opinions have been expressed concerning the sources of Paul's thought. Men have searched the pagan mystery religions, the hellenistic environment, the current philosophies (particularly Stoicism) to find parallels and dependence. This search has produced far less than the labour put into it might lead us to expect. Modern scholarship tends to find the sources for the essentials of Paul's thought mainly in his Jewish background, in the Old Testament and in rabbinic Judaism. The discovery of the Dead sea scrolls revealed the Qumran community to have had a common background of ideas and terminology with Paul in many instances, but there is little to indicate direct dependence of the apostle on the sect (*see* Dead Sea Scrolls). Whatever he borrowed, however, from any source, he transformed under the power and presence of him "in whom are hid all the treasures of wisdom and knowledge" (Col. ii, 3).

Justification by Faith.—How can a man be "justified," or "put right," before God? For Paul this was the vital question. This language of justification came from the law courts, where the judge, having found the accused innocent of the charge against him, was said to "justify" him by acquittal and restoration to society. Paul transferred this familiar legal language of Judaism to the personal realm and supremely to the soul's personal relationship to God. He had been seeking strenuously to become acceptable to God (justified) through his meticulous observance of the Law (Torah), which for him embodied the holy will and purpose of God for every aspect of human life. Only through such observance could he meet God's moral requirements and thus be at peace. The more sincere his desire and effort to find peace in this fashion, the less capable he found himself of achieving it. He concluded that no man could find himself in right relationship with God simply by moral striving. And yet so long as God was regarded as a moral being, communion with him necessitated ethical fitness. But who could be ethically fit before the "blazing throne" of God's holiness and purity? Such reasoning, supported by moral impotence, led Paul to despair of ever attaining communion with God. A man of less sensitivity to ethical ideals would doubtless have found refuge in some form of accommodation, but not Paul. The resolution of this impasse came when he experienced the love of God in the transforming power of the death and resurrection of Christ. Then he saw a completely new road to God. No longer did man need to initiate the approach by his own moral effort, for the initiative had been taken. God did not expect man by long and arduous ethical struggle to make himself fit for divine acceptance. On the contrary, the act of God in Jesus Christ means that, even while man remains in his sinful state, God manifests his love to him (Rom. v, 8), indeed shares his love with him, and thus creates in him a new "life in the Spirit" in which man walks pleasing to God because he walks in love, partaking of the very nature of God himself. God is not, therefore, a moral judge standing over man with a moral lash and demanding ethical goodness. He is rather a heavenly Father, eager to welcome wandering sons, to confer upon them the gift of his grace, desiring only that they share a new righteousness, his righteousness of love.

At this point the apostle was driven to reassess the Law, for meticulous observance of legal precepts had never provided that emancipation of spirit which accompanied the abandonment of life to the unfathomable love of God. Now the old sense of impotence had gone, a new sense of peace and power had taken its place. Never again could the Law hold the place it first held in Paul's thinking. He often referred to it, sometimes even observed its traditions, but always there is the underlying assumption that Christ has brought the Law to its ultimate fulfillment, and that all the attributes formerly ascribed to the Law belong to him (I Cor. i, 24; Col. i, 16 ff.). "What the Law could not do" had been done by the gracious action of God in Christ (Rom. viii, 3). It remains for man to see this action of God, to lay hold upon it by faith, to surrender the heart and mind and will to it in trust, and thus to find the soul ushered into newness of life. This is the first step in man's salvation; he is justified by faith or, as Paul puts it, "made righteous." Not that he is transformed at once into an ethically perfect being. Rather, God, on the ground of a man's faith, brings such a one into right relationship with himself, accepting the soul in advance, far in advance, of that soul's ethical perfection. For without this kind of divine acceptance there would be hope for no man and, indeed, no gospel.

Paul uses a variety of terms to describe what has happened to the man who has been justified by faith. He had been *redeemed.* As a slave might be emancipated from bondage to a master, so the justified man is free from the bondage of sin, because of "the redemption which is in Christ Jesus" (Rom. iii, 24–25; viii, 21; Gal. iii, 23–iv, 5). He has been *reconciled.* Here the apostle departs from analogy and falls back upon experience. Where moral values are emphasized, sin is held to alienate man from God, and he has no peace of soul. All men are in this state, since all have sinned (Rom. v, 12). But when man in faith beholds God's love in Christ's death (Rom. v, 8) and understands that the alienation rests with man and not with God, that the work of reconciliation begins from the divine side (II Cor. v, 19), God is seen no longer as an angry being to be appeased but as one who freely offers his forgiving grace and bestows peace and joy upon him who has faith (Rom. v, 1–11). Thus the justified man is both redeemed and reconciled and "transferred" to "the kingdom of [God's] beloved Son" (Col. i, 13).

The Life in Christ.—This new life into which a man enters on the ground of faith, as a consequence of his new relationship to God, Paul describes as "sonship." The justified man is now conscious that God is Father and that he has the freedom of a son in the Father's house. This sonship is but the anticipation of the final consummation of God's purpose. It is the pledge or earnest of that bringing forth, at the last, of the "sons of God" for which the whole creation itself was designed (Rom. viii, 19), when the Kingdom is delivered up to God the Father, and God is "everything to every one" (I Cor. xv, 24–28). In the meantime those who share this life are "in Christ," and they imitate Christ by walking in love.

In this lies the central concept in Pauline thought, for to be "in Christ" sums up the full meaning of salvation. It must be understood in the light of his doctrine of the Holy Spirit, and, true to his heritage, he thought of the Spirit as the divine power or energy coming into human life and enabling men to do what they could not do of themselves. This power was clearly at work in the church, evidence that the messianic community had emerged and that Christians were living the life of the Spirit, sharing the creative life of the Kingdom which Jesus by his death and resurrection had begun. Since all this stemmed from Christ himself, Paul had no difficulty in affirming that "the Lord is the Spirit" (II Cor. iii, 17). This was an experiential fact rather than a metaphysical identification, since Paul thought mainly in terms of religious experience and saw no necessity for distinguishing between his experience of the Spirit and his experience of Christ. Those who are "in the Spirit" are also "in Christ," and the truest and most genuine expression of this is to have "the Spirit of Christ" (Rom. viii, 9), the Spirit of love. It follows that the life "in Christ" is primarily corporate, expressed in the life of the church, of which Christ is the head. Those who are baptized and enter the church are really baptized into Christ. They live in him and he in them, with the expectation that ultimately they will be with him (Rom. viii, 23; Phil. iii, 21). Paul viewed salvation in three tenses: as an accomplished fact in the life, death and resurrection of Jesus; as made accessible to men in the present experience of life "in the Spirit"; and as yet to be brought to its consummation when the soul is "with Christ" and shares perfectly the life of which the new life here is but the foretaste.

The centrality of the concept of being "in Christ" or "union

with Christ" has led many to describe Paul as a mystic and to find here the influence of hellenistic mystery cults. This is a mistaken view. Union with the god in a mystery cult meant the obliteration of distinction between the devotee and the god; it meant complete absorption in the divine. Paul was too loyal to his Jewish background ever to contemplate such union between Creator and creature. Moreover, mysticism strives to reach the divine, whereas the apostle stresses the divine reaching for and finding man. Though Paul does show signs of the ecstatic rapture associated with mystical states (II Cor. xii, 2–4), such rapture was not unknown in 1st-century Judaism, nor were spiritual warmth and emotion absent from the psalms of Israel or from the writings of the prophets, to both of which Paul must have been greatly indebted. His so-called Christ-mysticism is not mysticism at all in the strict sense, for there is no losing of his identity. This "union with Christ" is an identity of life with Christ and with the purpose of God in Christ, which issues in the most intense form of self-giving rather than in self-losing; and the apostle achieves this identification, and at the same time sharpens his own personal existence, as he faces the dangerous and difficult life of the Christian missionary, seeking to complete "what is lacking in Christ's afflictions for the sake of his body, that is, the church" (Col. i, 24; Gal. ii, 20; Phil. iv, 12, 13). It was difficult for Paul to speak of this identification, the deep and lasting communion associated with it and the spiritual strength derived from it, without being moved to moods of exultation and rapture. To this extent he was mystical, but no more.

The Person of Christ.—Paul's theology was Christ-centred, for he had no doubt that Jesus was the Messiah. It followed that the new age had dawned, the day of God's long-promised redemption had come. The new life into which the justified man, redeemed and reconciled, had entered, with all its privileges and promises, was the work of Christ, its source and its sustainer (Rom. viii, 1 ff.). Paul, however, had no doubt that Christ was human, truly man. He had come "in human form" (Phil. ii, 8), had appeared "in the likeness of sinful flesh" (Rom. viii, 3), had been "born of a woman," sharing the same subjection as others of his race (Gal. iv, 4), and had identified himself with sinful men for their redemption. As the second Adam, Christ, by his obedience, in contrast to the disobedience of the first man, had reversed the stream of death and had brought life and immortality to the human race (Rom. v, 12–21; I Cor. xv, 21–22). But the second Adam is also "the man of heaven" who became the first-born Son of God, the prototype of the Sons of God yet to appear. These Sons are the new humanity made after "the image of the man from heaven," for whom the whole creation was designed, the new humanity which God purposed to create through much travail and suffering (I Cor. xv, 45–49; Rom. viii, 19; Col. i, 15). By the power of the resurrection this first-born Son had been "designated Son of God in power" (Rom. i, 4), had become " a life-giving Spirit" (I Cor. xv, 45), had created the church, the fellowship of those who are united with him and in him, its Lord and Head. And since the redemption wrought by him in his church but anticipates, and is prophetic of, the redemption which is ultimately to be coextensive with creation, Christ is Lord of the universe, the power of God and the wisdom of God (I Cor. i, 24; Col. i, 15–19).

The People of God.—The church as the people or Israel of God held a place in Paul's thinking difficult to exaggerate. He could never forget that the purpose of God was to bring into being a people of the covenant, whose supreme mission would be to bring the knowledge and the salvation of God to all people. He saw in the Christian fellowship the fulfillment of that purpose, the embodiment of that community which God had been seeking to create. In this he was not unique, for his predecessors, the earliest fellowship of believers, held that they had inherited all the promises and privileges of the old Israel and were indeed the new Israel of God, the messianic community, sharing the life of the Spirit and committed to a gospel with universal application. Jesus too had proclaimed the presence of God's sovereign rule in human life. He had invited men to receive it as the life and love of God, had actually formed a group of disciples to be the beginning of a community dedicated to live under God's rule. And he had declared that he was creating a new family of God, to include all of like mind and purpose; membership was dependent not upon race or class or any such external criterion but rather upon commitment to the will of God (Mark iii, 31–35).

All this Paul inherited and accepted and continued to affirm throughout his ministry. In that life "in the Spirit" which distinguished the church, he saw the life of the Kingdom. Through the life, death and resurrection of Christ the new spiritual order had arrived, and those who shared this divine life constituted a new race, a new type of humanity, were citizens of two worlds, their citizenship being also in heaven (Phil. iii, 20). At this point the apostle, in his description of the church, introduced a number of rich metaphors which conveyed precisely the essential character and mission of the church. Such figures as the bride of Christ (Eph. v, 23–27) or the body of Christ (I Cor. xii, 27) all point to a community one in spirit, united to Christ, embodying his life, built upon him. Such other figures as "the temple of the living God" (II Cor. vi, 16) and "the dwelling place of God" (Eph. ii, 22) indicate the sacred character of the church as that fellowship where men may expect to find mediated to them the very life of God. Paul was realistic enough to know that the church was not actually all that these metaphors suggest. Painful experience taught him otherwise. Nevertheless, the life of the Spirit in the life of the church pointed forward to that day when the reconciliation begun in the church would be complete and all-embracing, and the church would be presented "in splendor, without spot or wrinkle . . . holy and without blemish" (Eph. v, 27).

Development and Change.—Despite his absoluteness, indeed because of it, Paul had a flexible mind, ready to adjust to new truth when new facts made such adjustment necessary. A case in point concerns eschatology, the belief concerning the "last things" or the final consummation of all things. Early in his career he shared, with the early church, the belief that the return of Christ was imminent and that it would happen to the accompaniment of spectacular apocalyptic phenomena (I Thess. iv, 15–18). But as time progressed he came to a deeper understanding of the nature of the life "in Christ" and affirmed what Jesus had taught, that the age to come (the Kingdom of God, that is) had already begun. It had penetrated the present, had ushered those who by faith had accepted Christ into present possession of a life which only awaited ultimate completion; and he contemplated the possibility of dying before that ultimate consummation took place. Again, early in his career and not entirely separate from his views on eschatology, he saw very little value in the state as such. But it is possible to detect his growing belief that the empire, though belonging to the Old Age, has a restraining power over evil and is keeping it in check (II Thess. ii, 1–12); and later still he feels that the state, in keeping order and punishing wrongdoing, is fulfilling a divinely ordained function. He went still further and came to express the hope that even demonic powers would at last find redemption and reconciliation in Christ (Phil. ii, 10; Col. i, 20). It seems clear, therefore, that Paul's mind was charitable to new ideas, open to new movements of thought, always in search of the truth that would enrich and enhance the Christian faith.

THE ETHICAL TEACHER

In Paul's thought religion and ethics go together; morality is never divorced from its theological reference. This was true for him as a Jew since morality in Judaism was grounded in the will of a living, personal, holy God. It was no less true for him as a Christian, for always the norm of his ethic was found in the will of a personal God, sometimes referred to as "the law of God," sometimes as "the law of Christ" (Rom. vii, 22; I Cor. ix, 21; Gal. vi, 2). Moreover, the goal of his ethics was always the same, that Christ may be formed within (Rom. viii, 29; Gal. iv, 19). This inseparability is demonstrated frequently in his letters, in which he invokes the loftiest theological conceptions to support and commend Christian conduct. Christian living is always the result of true Christian thinking; ethical fruits have theological roots.

The basis and primary motivation of this ethical position are found in the Christian experience of being "in Christ." In that experience Paul found the very highest category of Christian

ethics, namely the indwelling Holy Spirit, the Spirit of Christ, the Spirit of love. Christian ethics are not, for Paul, a list of virtues added to the experience as a sort of addendum. The experience and the ethic are one. The man in Christ is born into a new manner of life; a spiritual inwardness takes possession of him, his ethical standards spring up spontaneously because his mind and heart and will are captive to Christ (II Cor. x, 5). The slave of Christ finds that he is free, bound by no law other than the law of Christ, the law of love, at work in his inmost being. Thus Paul found in this experience the secret of moral emancipation. That he should look upon Christian conduct as the harvest of the Spirit is not surprising (Gal. v, 22; Eph. v, 9); and when one recalls that he virtually identified the experience of the Spirit with the experience of the indwelling Christ, it is clear why that inward law of the Spirit becomes the law of love. This is one of the great contributions Paul made to the development of the Christian religion. By emphasizing the ethical aspects of the Holy Spirit's activity, he rescued primitive Christianity from mystical and emotional extravagances and made clear the view that the practice of Christian faith is always inseparable from the life of goodness.

Two basic principles of Christian ethics followed from Paul's understanding of the experience of being "in Christ": (1) the autonomy of the individual; and (2) the interdependence of Christians and, therefore, the necessity of a sense of mutual responsibility. Both are illustrated in the practical affairs of the Pauline churches. Christian freedom meant that a man is under his own self-mastery because he is under Christ. His conscience is his own and will guide him in his conduct. Nevertheless, since living within the fellowship of the Spirit is to be walking in love, such a free man will not stand firmly on his own right to act according to his own conscience; he will have regard for the conscience of the weaker brother whose spiritual insight may not be equal to his own, remembering that if Christ died for "the weak brother" the fellow Christian should at least consecrate his freedom on the brother's behalf lest "the weak brother" perish (Rom. xiv; I Cor. viii). This sense of mutual responsibility is stressed in the larger sphere of the total well-being of the church, since Christians "are members one of another." Their conduct, therefore, based on love —that is, the exercise of redemptive care and concern for others— will be motivated by desire for both the well-being of the individual and the building up of the Christian community.

This is made abundantly clear in the way Paul deals with the question of "spiritual gifts" in the Corinthian church, particularly the *glossolalia*, or "speaking in tongues." This phenomenon, common to many ancient religions and pagan cults, was the uttering of unintelligible sounds or babblings when the subject, under emotional excitement, seemed to lose control of his speech faculties and to become possessed by an external power. It came upon the disciples at Pentecost (Acts ii, 1 ff.) and was quite prominently manifested in the church at Corinth. Many Christians coveted this gift, since it seemed to them to be genuine evidence of possession by the Holy Spirit. Paul, however, though he shared it himself, applied to it, as to other questions, his criterion of judgment as to whether this practice really was useful in the service of the church. Did it build up individual members in the faith? His answer was negative, since unintelligible utterances could scarcely have much value unless interpreted and the matter of interpretation was dubious. Did it build up the church? On the contrary, it might well turn away those who were interested in the church by suggesting the mental instability of its members. The apostle advised his converts to be mature in their thinking on this subject and to judge the relative value of their gifts by the measure of their use in building up the members of Christ's body and attracting others to the Christian community (I Cor. xii–xiv). The same concern is seen in his handling of the abuse of the Lord's Supper that had taken place in the Corinthian church. The words of the institution of this sacrament, so clearly given by Paul (I Cor. xi, 23–26), might never have been written had he not been primarily occupied with the ethical behaviour of the church. Up to this point the Lord's Supper had been celebrated in association with the social meal or "love feast" (*agape; q.v.*), a meal to which all contributed and which all, rich and poor, were to share alike, thus representing the unity of fellowship among the members. This fine ideal, however, had been repudiated by the individualism and selfishness of many who by their conduct were making it impossible of achievement (I Cor. xi, 17–22). Paul could not commend this sort of behaviour because it was antithetical to love and quite contrary to all those spiritual blessings to which the sacrament bore witness.

In addition, however, to the primary ethical motivation of being "in Christ," issuing in conduct based upon the exercise of Christian love, there was another, secondary ethical motivation—the eschatological. It may be said to include the wrath of God, the divine judgment and the prospect of future salvation. To have part in the Kingdom of God it is necessary to break with sin, for sin brings the wrath of God upon men (I Cor. vi, 10; Gal. v, 21; Eph. v, 5). This does not mean that God wreaks his vengeance upon sinners after the manner of human vindictiveness. Rather, the apostle is stressing the working out of the moral law of the universe, which cannot be infringed with impunity. Closely related to this is his appeal to the judgment of God. Christians are to "appear before the judgment seat of Christ" (II Cor. v, 10). They must not be presumptuous or overconfident, knowing that they are to be accountable for their conduct at the last day. It is possible that here he is reverting to the teaching methods of the synagogue in order to have a sobering effect upon his readers. Future salvation is inseparable from the wrath of God and the divine judgment. It must not be supposed that this emphasis upon good behaviour for eschatological reasons meant that future redemption is a reward for good conduct. Salvation comes by grace and is the gift of God. Christians anticipating this gift might well desire to live in blameless expectation of it (I Cor. i, 8).

Ideally Paul should have left his churches alone to do what was pleasing to them. This he did not do. He was a realist. He knew that Christian freedom is achieved gradually, in proportion as the subject is committed to Christ and comes under the control of his Spirit. Obstacles in the environment often hindered this development. He found it necessary, therefore, to give instructions and warnings to his churches, to guide the weak and to remind the strong that by good example they might both strengthen their brethren and commend Christianity to others (Rom. xii; Col. iii). The assumption behind all such ethical advice is that Christians belong to a new family relationship and must act worthily of it. This is why the apostle is sometimes very specific in his instructions and deals with quarrelsomeness, sexual impurity, selfishness, lying, stealing, right relations between husbands and wives, parents and children, masters and slaves (Col. iii; Eph. iv–v), and exhorts his churches to follow all the positive virtues. Such suggested patterns of conduct, however, in no way qualified the ideal ethic of Paul, the law of Christ, the law of love which fulfills every other law of God (Gal. v, 14; Rom. xiii, 9–10).

LETTERS AND STYLE

Though Matthew, Mark and Luke are the first documents in the New Testament and contain material some of which probably existed in written form by A.D. 50, these Gospels, as we have them, are subsequent to A.D. 65–70, as also are the Acts of the Apostles and the general epistles. Paul was the author of the first New Testament writings, his own letters. When the King James version of the Bible appeared (1611) 14 New Testament Epistles were ascribed to Paul. Actually, however, only ten, including Ephesians, can be credited to him, and there are many scholars who question the authenticity of Ephesians, mainly on the ground of differences in language and style. Hebrews does not belong to him. I and II Timothy and Titus (*see* PASTORAL EPISTLES), though they contain genuine fragments of his correspondence, are the work of a follower of the apostle 20 years after his death.

Chronological arrangement of Paul's letters, all written between A.D. 49 and 61, is difficult and raises two questions: (1) the date of Galatians; and (2) the place from which the Captivity Epistles were written. Some scholars assign first place to Galatians, others place it with the Corinthian and Roman letters. Ephesus and Rome have both been suggested as the place of origin of all or

some of the Captivity Epistles, with the weight of evidence going to Rome. The following order is suggested:

Galatians (from Antioch)	49 or 55–57
I and II Thessalonians (from Corinth)	50–51
I Corinthians (from Ephesus)	
II Corinthians (from Macedonia)	55–57
Romans (from Corinth)	
Colossians	
Philemon	59–61
Ephesians(?)	
Philippians (from Rome)	

Ancient letters were either literary, prepared with precision, formal and impersonal in character and intended for public consumption; or nonliterary, informal, intimate and casual and addressed to individuals. Nonliterary letters were much more self-revealing, as indicated by many examples recovered from Egypt. Paul's letters may be said to bear the mark of both and therefore defy placement in either category. They disclose deeply personal relations with people and at the same time reveal the inner life of the writer. But since he wrote frequently on great issues, to instruct and to give leadership to the church, the letters also show evidence of deep reflection and studied preparation. They were intended to be read to churches, some indeed to be circulated among churches (Col. iv, 16). Paul would see to it that the dictated form was revised with care. Much was at stake when the apostle undertook to address a church. Usually he was dealing with some specific theological, moral or practical issue upon which the well-being of the church depended, and he wrote with a sense of personal involvement which is reflected in moods of anxiety, fear, anger, warning, conciliation, tenderness, gratitude, joy, exultation and almost every other emotion of the human heart. And all are the expression of his love for the church and his desire that nothing should sully her name or hinder her purpose.

Christianity owes a great deal to the letters of Paul. It has been seen how vital they are to a portrayal of his personality. They are equally significant for an account of the early church, its worship and its early form of organization, for little of this is found in the Acts of the Apostles. Without them we would know very little about the thinking of Paul and how his Christian thought developed over the years and equally little of the way this great protagonist of Christianity made his appeal to the Greco-Roman world. We would not know of the varied life or of the crucial issues that characterized the local church in the pagan environment and that are so vividly painted in the Corinthian correspondence. Nor would we have any means of judging Paul's relationship to his predecessors, particularly to Jesus himself. All in all, the letters are essential as a source of early Christian history; this is to say nothing of their influence in the later history of the Christian church. As to when they were collected and formed into what is sometimes called the Pauline Corpus, it is difficult to say. That they were so collected after the apostle's death, and came to be known as scripture (II Pet. iii, 16), is beyond question.

Paul's style too has been the subject of much discussion. It is obvious, and yet true, to say that "the style is the man." His words and his individuality go together and they bear witness to the depth and wealth and intensity of his thought and experience. He dictated his letters with a passionate earnestness; Christian faith and Christian practice were not matters upon which he could write with detachment, so complete was his identification with Christ and the church. He lived his letters, in sympathetic imagination being present with the groups to which he wrote (I Cor. v, 3–4). Hence in the style we often catch something of the firm and fervent tones as he pleads or expostulates, questions or instructs, praises or blames. It may be true, as many have held, and as Paul himself seems to have suggested, that he was no orator and did not wish to indulge the art of rhetoric (I Cor. ii, 1; II Cor. x, 10; xi, 6). Nevertheless, he must surely have been on occasion a moving speaker, eloquent because filled with an all-consuming eagerness to share with others the knowledge and convictions which he himself possessed.

He was a Jew, yet he wrote and thought in Greek; and while he imitated no classical models and betrays little formal knowledge of Greek culture, either by quotation or allusion, he was at home in Greek. The book which clearly influenced his style was the Greek Bible (the Septuagint). Sometimes he got involved in rabbinic exegesis, not always to the clarification of the subject under discussion. At other times, under constraint to express the wonder of the gospel, his grammar got disorganized. Often he piled up superlatives and even created words, so eager was he to express the truth about Christ. And yet his style does not lack care, even artistry of expression. His sense of rhythm is clear and his use of parallelism and antithesis very marked. In his hands the diatribe, the form of public speech that was popular among the Stoics and Cynics of his day and that he no doubt often heard on street corners, is used with great effectiveness (I Cor. xv, 35 ff.). Passages such as the hymn on love (I Cor. xiii), the hymn on wisdom (I Cor. ii, 6 ff), the chapter on the resurrection (I Cor. xv), the description of the new life in the Spirit (Rom. viii) are written with consummate literary skill, beauty and dignity, indicating much deliberation in choice of language and structure of sentences. This does not rule out what seems to have been a characteristic of Paul's writing and speaking, namely a remarkable ability to see the universal implication of some particular truth and to rise to poetical and even rhapsodic heights in the expression of it (Rom. viii, 31–39; I Cor. iii, 21–23).

It is not to be doubted that Paul acquired some of the religious and philosophical terminology of the pagan world of his time. It is equally certain, however, that all such borrowings were baptized into the Christian faith and became vehicles in his hands for a more adequate presentation of the gospel to his gentile audiences. Whatever Paul used, whether forms or images or metaphors or literary devices from whatever source, all were subordinated to his supreme purpose of portraying Christ to men and introducing them to the power of the gospel.

ACHIEVEMENTS AND INFLUENCE

Paul grappled with all the problems of the church at once. At the same time, he sought to interpret Christianity to the world. In his letter to the Romans he gave Christianity its first theological exposition of the gospel, which has remained through the centuries a vital source book for all Christian theologians.

In Galatians, sometimes called the "Magna Carta of Christian liberty," he made the first great defense of the gospel against those who would return to religion of legalism and depart from that inward liberty which is the true mark of the Christian man. So thorough was his defense that Christianity was saved from becoming a sect of Judaism and its universal outreach was forever secured.

In Colossians he came to grips with heresy, a perversion of Christian teaching which, seeking to accommodate the gospel to current cultic observances and ascetic practices, recommended the worship of angels and other spiritual beings and reduced Christ to much less than the supreme place he should hold. In this the apostle may be seen struggling to keep the stream of Christianity pure and to give Christ the pre-eminent place which belonged to him, thus paving the way for the great affirmation that nothing in the whole universe can be interpreted wisely apart from him (Col. i, 13–20).

In I and II Corinthians he is supremely the pastor, in touch with a church, directing, exhorting, concerned mainly with practical issues and with the relevance of doctrine and ethics to a living situation in the pagan environment. Out of this may be seen emerging the beginnings of early church worship and discipline and the development of a church consciousness.

Philemon introduces us to Paul's attitude to slavery, an institution which he accepted as part of the old order, but whose ultimate passing was anticipated in that Christian relationship which he suggests to Philemon in respect to his runaway slave Onesimus.

In Ephesians, that grand ecumenical letter, the goal of all Paul's thinking, as indeed the purpose of the gospel, is seen to be the final breaking down of all barriers that divide men and the reconciliation that results in all becoming one humanity, members of "the household of God," fulfilling God's redemptive purpose in his-

tory and anticipating the ultimate and final salvation (Eph. i, 10).

Men go back to Paul because they find in him the first courageous and competent handling of essential beliefs and practices of the church. That is why he has exercised, through the centuries, a critical function. Whenever the Christian faith has been in danger of losing its soul, of becoming fettered with legalisms and ceremonialisms, of allowing the tyranny of traditions and institutions to become a substitute for a man's personal approach to and trust in God, Paul has returned like a refining fire, and men have rediscovered the essence of Christianity in his doctrines of the free grace of God and the liberty of the Christian soul. Augustine, Luther, Wesley, Karl Barth, all witness to the influence of Paul's thought in crucial periods of history. It is doubtful whether, without him, Christianity would have survived in its pristine character, much less become the religion of the western world. And, had this not occurred, much would have been lost to western civilization itself.

As Samuel Sandmel has written: "One needs only a glimpse at the history of Europe and America since the veritable rediscovery of Paul by Martin Luther to discern the permanent and imperishable. It was out of a renewed emphasis upon Paul that there developed, albeit in secularized form, those attitudes toward the individual, toward freedom of the conscience, and toward the inviolability of the conscience which made the transition from the middle ages to modern times." (Samuel Sandmel, *The Genius of Paul*, p. 219, Farrar, Straus and Cudahy, Inc., New York, 1958. Copyright 1958 by Samuel Sandmel.)

See also references under "Paul, Saint," in the Index.

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PAUL, SAINT, of the Cross (Paolo Francesco Danei) (1694–1775), Italian religious, founder of the Congregation of the Discalced (Barefooted) Clerks of the Most Holy Cross and Passion of Our Lord Jesus Christ, called the Passionists (*q.v.*), was born in the town of Ovada, Italy (then the Republic of Genoa), Jan. 3, 1694, the second of 16 children. From earliest years, Paul showed signs of great love for prayer and contemplation and a capacity for spiritual leadership. On Nov. 22, 1720, he dedicated his life to God and was clothed in the habit of a hermit by the bishop of Alexandria. The following day he began a 40-day retreat in a room off the sacristy in the Church of St. Charles at Castellazzo. He states that during the retreat he was divinely inspired to write a rule of life for a new religious institute in the church. The rule, subsequently modified and repeatedly approved by the church, breathes a spirit of prayer, penance, poverty, solitude, and devotion to Christ Crucified, issuing forth in intensive apostolic work for God's glory. The rule was simply approved in 1741 and solemnly approved in 1746 by Benedict XIV. In 1773 the splendid Church of SS. John and Paul in Rome became the headquarters of his congregation. He founded the Institute of the Passionist Nuns, at Corneto (Tarquinia), in 1770.

Paul died Oct. 18, 1775, and was canonized June 29, 1867, by Pius IX. His feast day is April 28.

At his death, Paul had established 12 monasteries in Italy, and since then his institute has spread throughout the world. Members of the institute are popularly known as Passionists, because of a special vow they take to spread devotion to Christ in His sufferings.

See Gaétan du Saint Nom de Marie, C.P., *Saint Paul de la Croix et la fondation des Passionistes* (1956). (G. Ro.)

PAUL, SAINT, of Thebes (Paul the Hermit), a shadowy figure of whom little is known and that little highly suspect, was one of the earliest hermits in the desert. For knowledge of him modern scholarship is dependent solely upon the *Life of Paul* written by St. Jerome, which is probably the source also of extant Greek and Oriental lives of Paul. According to Jerome, Paul was a native of the Thebaid in Egypt who fled the Decian persecution (249–251) and thereafter lived a life of prayer and penitence in a cave, dying about 341 at an advanced age. Jerome was inclined to give priority to Paul as the first Christian hermit, an honour in modern times generally accorded to St. Anthony. However that may be, it is claimed that Anthony (born *c.* 250), when he was 90 years old, visited Paul who was then 113. The aged man asked Anthony to bring the mantle given to Anthony by St. Athanasius and to wrap him in it for burial.

Paul has been thought possibly identical with a certain Paul of Oxyrhynchus; in later art he is often represented with a palm tree or two lions. His feast day is Jan. 15.

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PAUL, the name of six popes.

Paul I (d. 767), pope from 757 to 767, succeeded his brother Stephen II (III) in April 757. To secure himself against both the Lombards and the Byzantines, he relied on the papacy's understanding with the Franks, which his predecessor had done so much to cement. He died on June 28, 767.

Paul II (Pietro Barbo) (1417–1471), pope from 1464 to 1471, was born in Venice Feb. 23, 1417. Raised to the college of cardinals by Eugenius IV in 1440, he became a favourite of Calixtus III and was unanimously and unexpectedly elected the successor of Pius II. He immediately declared that election "capitulations," which cardinals had long been in the habit of affirming as rules of conduct for future popes, could affect a new pope only as counsels, not as binding obligations. He opposed the domineering policy of the Venetian government in Italian affairs. His repeated condemnations of the Pragmatic Sanction (*q.v.*) of Bourges impaired his relations with Louis XI of France. He pronounced excommunication and deposition against the king of Bohemia, George of Podebrady, on Dec. 23, 1466, for refusing to enforce the Basel Agreement against the Utraquists and prevailed on Matthias I Corvinus, king of Hungary, to declare war against George in 1468 (*see* Bohemia: *History;* Hussites), and he carried on fruitless negotiations, from 1468, with the emperor Frederick III for a crusade against the Turks.

Paul endeavoured to make drastic reforms in the Curia. By suppressing the College of Abbreviators and the Roman academy of Julius Pomponius Laetus (*q.v.*), both of which had become strongholds of humanists of the paganizing type, he incurred the enmity of the humanists, who represented him as an enemy of letters. In fact, however, he was a patron of scholars, a collector of antiquities, and a restorer of monuments; and it was under his aegis that the first printing presses were set up in Rome. He died at Rome July 26, 1471.

Paul III (Alessandro Farnese) (1468–1549), pope from 1534 to 1549, was born in February 1468. As a pupil of Julius Pomponius Laetus and as a member of the circle of Lorenzo de' Medici, the Magnificent, he received a finished education. His advancement was rapid. To the liaison between his sister Giulia, wife of Orsino Orsini, and Alexander VI he owed his title of cardinal-deacon of SS. Cosmà e Damiano (1493); but the steady favour which he enjoyed under successive popes was due to his own cleverness and capacity for affairs. His election to the papacy, on Oct. 13, 1534, to succeed Clement VII, was virtually without opposition.

Paul's instincts and ambitions were those of a prince of the Renaissance, but circumstances forced him to become the patron of reform. By the promotion to the cardinalate of such men as Gasparo Contarini, Giampietro Carafa (later Paul IV), Reginald

Pole, and Giovanni Morone and by the appointment of a commission to report upon existing evils and their remedies, the way was opened for reform; and the revival of the papal Inquisition in Italy (1542), the establishment of the censorship (1543), and the approval of the Society of Jesus (1540) constituted agencies for combating heresy.

From the outset Paul was firmly resolved on summoning a general council for the reform of the church, and he carried this plan in the face of strong opposition within the college of cardinals. The choice of a site for the council and the question of its composition led to acrimonious disputes with Francis I of France and with the emperor Charles V; and it was not until Dec. 13, 1545, that it opened at Trent (Trento). This site, however, was so near to the emperor's own lands on the other side of the Brenner Pass that the council's independence seemed to be threatened; and on the outbreak of an epidemic at Trent, the fathers of the council voted its transference to Bologna (March 1547). Before the pope finally suspended it, the council achieved a number of doctrinal definitions and important decrees for the reformation of clerical discipline and the remedy of abuses. (*See* TRENT, COUNCIL OF; COUNCIL: *Councils of the Western Church: Council of Trent* [1545–63].) Paul's relations with Charles V were increasingly strained, from 1547, both by the transference of the council and by Charles's efforts to conciliate the German Protestants after his victory over the Schmalkaldic League. (*See* CHARLES V, Holy Roman emperor.)

In his lax personal morality, in his gross nepotism (*see* FARNESE), and in his lavish patronage of the arts, Paul was a pope of the Renaissance. He restored the Roman university (1534 ff.) and commissioned Michelangelo to paint "The Last Judgment" in the Sistine Chapel (1535) and to resume work on St. Peter's (1546). He also undertook grandiose public works in the city. He died on Nov. 10, 1549.

PAUL IV (Giampietro Carafa) (1476–1559), pope from 1555 to 1559, was born on June 28, 1476, of a noble Neapolitan family. His ecclesiastical preferment he owed to the influence of an uncle, Cardinal Oliviero Carafa. Having filled the post of nuncio in England and Spain, he served successive popes as adviser in matters pertaining to heresy and reform. But he resigned his benefices and, in conjunction with Gaetano da Thiene, founded the order of the Theatines (so called from Theate, the Latin name for Carafa's diocese of Chieti) in 1524 with the object of promoting personal piety and of combating heresy by preaching. In 1536 Paul III made him cardinal-archbishop of Naples and a member of the reform commission. After the failure of Gasparo Contarini's attempt at reconciliation with the Protestants in the colloquy of Regensburg (1541) the papacy committed itself to the reaction advocated by Carafa: the extermination of heresy in Italy was undertaken with vigour.

Elected pope, on May 23, 1555, in the face of the veto of the emperor, Paul regarded his elevation as the work of God. With his defects of temper, his violent antipathies, notably his hatred of the Spaniards, and his haughty insistence on papal prerogative, his pontificate was filled with strife. In December 1555 he allied himself with France in order to drive the "accursed Spaniards" from Italy. But the Spanish victory at St. Quentin (August 1557) and the duque de Alba's threatening advance upon Rome forced him to come to terms and to abandon his French alliance. He denounced the Peace of Augsburg as a pact with heresy; nor would he recognize the abdication of the emperor Charles V and the election of Ferdinand. By insisting upon the restitution of the monastic lands which had been sold, by requiring Elizabeth I of England to submit her claims to him, and by his mistrust of Cardinal Pole, he facilitated the ultimate victory of Protestantism in England.

Paul was known before his elevation to the papacy as a man of austere life and as an uncompromising reformer with an exalted conception of papal authority. He was no friend to conciliar methods, and he made no effort to reassemble the Council of Trent, which had been suspended since 1552. He preferred instead to work through commissions or congregations, and by this means he stopped many of the grosser abuses, enforced residence on prelates, disciplined vagrant religious and introduced a stricter life at the papal court. His nepotism was curiously at variance with his high ideals: his unworthy nephew, Carlo Carafa, was made cardinal and placed over the finances of the Holy See; and other relatives were given positions of trust in the states of the church. Paul indeed was the last to appreciate the unworthy character of his nephews; but in 1559 his eyes were opened, and he deprived them all of office and exiled them. Paul was a man of narrow vision. He alienated the best minds of his age by his roughness and aroused antagonisms which were fatal to the success of his cause. He died on Aug. 18, 1559. (C. H. LE.)

PAUL V (Camillo Borghese) (1552–1621), pope from 1605 to 1621, was born in Rome on Sept. 17, 1552. He was a distinguished canon lawyer and became vice-legate in Bologna in 1588 and auditor of the apostolic chamber in 1590. He was sent to Spain on a special mission in 1593 and, as reward for its successful conclusion, was made a cardinal by Clement VIII in 1596. After a protracted conclave in which the favoured candidates each ruined the others' chances, Cardinal Borghese was elected the successor of Leo XI on May 16, 1605, being the candidate of no particular party. Paul continued his independent attitude careless of what interests he upset, secular or ecclesiastical. A conflict soon broke out with Venice over a number of questions all connected with the extent of papal jurisdiction inside the republic. The quarrel took on an added significance when Paolo Sarpi (*q.v.*), an eminent Venetian scholar who had already criticized the papal claims to temporal authority as inconsistent with its spiritual position, brought the weight of his learning to support the Venetian cause. The pope replied by putting Venice under an interdict (May 1606), a characteristic gesture from one so imbued with the medieval conception of the papal prerogative; but this action brought only more determined defiance. Paul was prepared to appeal to arms, but neither Spain nor France was ready; and so, when Henry IV offered his mediation, it was accepted, and the interdict was eventually lifted in April 1607. In England, a similar attitude of uncompromising resistance to the demands of the secular arm was taken, and Paul gave complete support to the Jesuits in forbidding Roman Catholics to take the oath of allegiance demanded by James I after the discovery of the Gunpowder Plot (briefs of 1606 and 1607). In matters of doctrine, Paul was surprisingly undogmatic. Nor was he anxious to renew the military contest with the Protestants, instead devoting his attention to the possibility of another crusade against the Turks, though without success. When the fighting that was to develop into the Thirty Years' War had broken out (1618), Paul gave no support to the Catholic powers, but once again his point of view was ignored. He was most successful in lesser things: he encouraged missions; confirmed many new congregations and brotherhoods; and authorized a new version of the *Rituale Romanum*. He was a spectacular supporter of building and the arts, but against this must be set his practice of nepotism; under his patronage, his family became inordinately wealthy (*see* BORGHESE). He died on Jan. 28, 1621. (I. F. B.)

PAUL VI (Giovanni Battista Montini) (1897–), elected pope in 1963 to succeed John XXIII, was born at Concesio, near Brescia, on Sept. 26, 1897. His father was editor of a Catholic newspaper, a banker, and briefly a member of the Italian Parliament. Under the influence of the Oratorians at Brescia Montini developed a vocation for the priesthood. Delicate as a boy, he studied at home instead of living in the seminary and was ordained in 1920. After higher study in Rome he entered the Secretariate of State (1922), where, except for a few months in 1923 at the nunciature in Warsaw, he remained for 32 years. From 1924 to 1933 he was chaplain to the Catholic University students, who were at that period molested by the young Fascists. He served three cardinal secretaries of state: P. Gasparri, E. Pacelli (later Pius XII), and L. Maglione (d. 1944), who had no successor as Pius XII preferred to work instead through two pro-secretaries. One was Montini, pro-secretary for the internal business of the church, who lived in the Vatican and was always accessible, soon becoming a favourite with the foreign diplomatic representatives. For portrait *see* article PAPACY.

After the fall of Mussolini and the emergence of the Christian Democrat Party supported by Catholic Action, Montini's brother

became first a deputy and then a senator, and Montini himself was generally credited with political sympathies on the left side of the Christian Democrat coalition.

In 1954 Pius XII made him archbishop of Milan, where he was at first acclaimed by both employers and workers as a man whose sympathies were more with them than with their opponents; each group in turn expressed itself disappointed later, which has been seen as suggesting that he held a good balance between them. John XXIII, who made Montini a cardinal as his first creation in 1958, continually brought him forward to associate him with the work of the Second Vatican Council (*see* VATICAN COUNCILS). As John XXIII had openly hoped, Montini was elected his successor in June 1963, and he declared his intention of reigning in the spirit of Pope John. He sought however to give more streamlined efficiency to the proceedings of the council and moved carefully, showing himself progressive in some matters and conservative in others. He went on pilgrimage to the Holy Land in January 1964, and in Jerusalem met and embraced the ecumenical patriarch of Constantinople. In December 1964 he undertook the longest journey ever made by a pope when he went to Bombay, India, to attend the International Eucharistic Congress. In the same year he issued his first encyclical, *Ecclesiam suam*, on the role of the church in the world.

See also PAPACY. (J. D. W.)

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PAUL I (PAVEL PETROVICH) (1754–1801), emperor of Russia from 1796, was born in St. Petersburg on Oct. 1 (new style; Sept. 20, old style), 1754, the son of the grand duchess Catherine, later empress as Catherine II (*q.v.*). The notion that Catherine's husband, the future emperor Peter III, was not Paul's father has probably no foundation but gossip and the cynical malice of Catherine. The infant was immediately taken from Catherine by the empress Elizabeth, whose ill-judged care undermined his health. Catherine's *coup d'état* against Peter III in 1762 was a shock from which the boy's mind never recovered.

Paul believed that his mother had instigated the murder of his father, and though he had been proclaimed heir he suspected that he too would be deprived of his rights or even killed. His character deteriorated steadily, and the distrust grew on both sides accordingly. Paul occasionally expressed the desire to play an active part in affairs, but Catherine consistently kept him at a distance. In 1773 she arranged his marriage with Wilhelmina of Darmstadt (renamed Natalia Alekseevna), but Wilhelmina died in 1776, and within the same year Catherine arranged his marriage with the beautiful Sophia Dorothea of Württemberg (renamed Maria Fedorovna). In 1781–82, the couple were allowed to travel through Western Europe, where Paul managed to make a fairly favourable impression. In 1783 Catherine gave him an estate at Gatchina, where he spent his time dreaming of reforms and drilling a contingent of soldiers on the Prussian model—which he admired as fanatically as Peter III had done. After the birth of Paul's eldest son, Alexander (1777), Catherine contemplated setting Paul aside in favour of Alexander, but no definite step was taken; and when Catherine died Paul was recognized as her successor.

Paul's reign was a period of frenzied despotism. At pains to change anything that Catherine had done and anxious to strengthen his autocracy, Paul attempted to curb the rights of the privileged class and even to protect the peasants. However at the same time he turned 600,000 state peasants into privately owned serfs. Obsessed by fear of the French Revolution, he resorted to crazy internal measures in order to protect Russia against its infection. He also joined the second coalition against France (1798); but in the end he turned against Great Britain (1800) and did not hesitate to give a Cossack force the order to invade India. His only lasting service to the country was the introduction of a statute which stabilized the order of succession (1797). Yet Paul was soon ready to violate his own law. Having long ago made a favourite of his barber, I. P. Kutaisov (a Turkish prisoner of war), and having fallen under the spell of two of his wife's maids of honour in succession (Ekaterina Ivanovna Nelidova and Anna Petrovna Lopukhina), he started to display an ever increasing animosity against the empress and against his son and heir Alexander in particular, finally expressing preference for a German nephew of his wife. In March 1801, Paul's sinister moves induced Alexander to connive at a plot in his favour which was already in the making among guards officers embittered by Paul's harsh treatment. The driving power in the conspiracy was Gen. Count Peter Ludwig (Petr Alekseevich) von der Pahlen (1745–1826), military governor of Petersburg, who now found an energetic helper in Gen. Count L. A. von Bennigsen. In the night of March 23 (N.S.; 11, O.S.), 1801, a band of officers, led by Bennigsen, penetrated into the strongly protected St. Michael Palace in St. Petersburg, and Paul was murdered.

See K. Waliszewski, *Le Fils de la Grande Catherine, Paul I-er* (1912; Eng. trans., *Paul the First of Russia . . .*, 1913). (Lo. L.)

PAUL I (1901–1964), king of the Hellenes from 1947, was born in Athens on Dec. 14, 1901, the third son of the future King Constantine by his wife Sophia of Prussia. He was educated at the Greek Naval Academy. He left Greece on June 12, 1917, when his father, acceding to the demands of the Allies that he should leave the country, appointed his second son, Alexander, to be king in his place. On the death of King Alexander (Oct. 25, 1920) the throne was offered to Prince Paul, but he declined it. He returned to Greece on Dec. 20, 1920, when his father was recalled. King Constantine abdicated on Sept. 27, 1922, being succeeded by his eldest son George; and Prince Paul then became *diadoch*, or crown prince. As republican feeling grew in the country, Prince Paul in December 1923 left Greece once more with his brother, ex-King George. He spent much of his time during the next ten years in the United Kingdom or in the United States. In October 1935 King George was recalled, and Prince Paul returned to Greece with him, resuming his career as an officer in the Greek Navy. He served on the staff during the Albanian campaign (1940–41), escaped from occupied Greece to Allied territory, and spent some time in South Africa.

Paul ascended the throne on the death of King George on April 1, 1947. His accession coincided with the assumption by the United States of responsibility for assisting his country in its economic recovery from World War II and in the war against the Communist guerrillas, which lasted till 1949. There was political instability until the premierships of Field Marshal Alexandros Papagos (1952–55) and Konstantinos Karamanlis, under whom the dispute with the United Kingdom and Turkey over Cyprus was temporarily settled.

Paul had married Princess Frederika of Brunswick (b. April 18, 1917) on Jan. 9, 1938, and had a son, Constantine (b. June 2, 1940), and two daughters, Sophia (b. 1938) and Irene (b. 1942). He died at Athens on March 6, 1964. (B. S.-E.)

PAUL OF AEGINA (PAULUS AEGINETA) (*c.* 615–690), the last of the great Greek compilers, was born on the island of Aegina. He traveled widely among the Arabians and flourished during the Muslim conquest. He was the last great physician of Byzantine culture to practice and teach in Alexandria just prior to the destruction of the great city in 640 by the forces of the caliph Omar I. Although little is known of his personal life, it is certain that Paul's obstetrical skill placed him in great demand among the Arabians. Much of his material is taken from Galen, Oribasius and Aëtius.

Greek manuscripts of the following works are extant: *Epitomae medicae libri septem*, *De succedaneis ex Galeno*, *De urinis libri VII*, *De mensuris et ponderibus* and *Excerpta varia*. There are Arabic manuscripts in Rome, Munich and Paris. The *Epitome*, Paul's most valuable work, consists of seven books containing practically everything known about the medical arts in his time. Rhazes, in his *Kitabu 'l-Maliki*, copiously employed it, and Al-

bucasis excerpted most of the surgical material in his *Surgical Tracts* from its sixth book. Thus Paul's surgery profoundly affected not only Arabian medicine but also medieval medicine in the west.

See also ABUL KASIM.

See D. Campbell, *Arabian Medicine* (1926); B. Gordon, *Medieval and Renaissance Medicine* (1960). (B. L. G.)

PAUL OF SAMOSATA (3rd century A.D.), heretical bishop of Antioch and proponent of a kind of Adoptionist (*see* ADOPTIONISM) doctrine on the nature of Christ. The only indisputably contemporary document concerning him is a letter written by his ecclesiastical opponents and preserved in Eusebius' *Church History* (bk. vii, ch. 30), according to which he was a worldly cleric of humble origin who became bishop of Antioch in 260.

Paul held that it was a man who was born of Mary, through whom God spoke his Word (*Logos*). Jesus was a man who became divine, rather than God become man. Paul's Christology was therefore a speculative form of the Adoptionism found among the primitive Ebionites of Judaea; in Theodotus and Artemon of Rome; and perhaps in other early Christian writers (and suggested by phrases in the New Testament such as Acts 2:36). Lucian (*q.v.*), the great exegete of Antioch, and his school were influenced by Paul and link him with Arianism. The later Paulicians of Armenia may have claimed to continue his traditions, hence their name.

Between 263 and 268 at least three councils were held at Antioch to debate the bishop's orthodoxy. The third synod condemned his doctrine and deposed him, nominating Domnus as bishop and notifying the bishops of Rome and Alexandria of the decision in the letter referred to above. But Paul enjoyed the patronage of Zenobia, queen of Palmyra, to whom Antioch was then subject, and it was not until late in 272, when the emperor Aurelian defeated Zenobia and brought Antioch under imperial rule again, that the sentence of deposition could be executed.

From the scattered fragments of Paul's writings his historical and philosophical interests can only be surmised. The Council of Nicaea in 325 condemned the Paulianists to be rebaptized (as not believing in the Trinity); but, paradoxically, the term consubstantial (Western counterpart of the Greek *homoousios*), condemned at the synod of Antioch in Paul's sense of the identity of the Father and his Word, became the watchword of orthodoxy and its condemnation a source of embarrassment. *See* also MONARCHIANISM.

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PAUL, (CHARLES) KEGAN (1828–1902), English author and publisher, was born on March 8, 1828, at White Lackington, Somerset. Educated at Eton and at Exeter College, Oxford, he was ordained deacon in 1851 and accepted a curacy at Tew in Oxfordshire. Two years later he returned to Eton as a chaplain and later became a master. Through his friendship with Charles Kingsley he became associated with the Christian Socialists F. D. Maurice and Tom Hughes. After Bishop Wilberforce's objection to his almost Unitarian outlook, Paul left Eton in 1862 for Sturminster Marshall, Dorset, and broke with the Church of England in 1874; in 1890 he became a Roman Catholic.

In 1877 he became a partner in the publishing firm of Henry S. King, and, on King's retirement in 1881, Paul took over, inaugurating the house of C. Kegan Paul and Co. In the same year he took in A. C. Trench, who, as proprietor and with Paul as literary adviser in Kegan Paul, Trench and Co., published poems by Tennyson and William Barnes, Meredith's *The Egoist*, R. L. Stevenson's first books, and Gen. Charles George Gordon's *Journals*. In 1889 the firm merged with the late Nicholas Trubner's Oriental publishing business, following a take-over bid by Horatio Bottomley. Later, in 1911, the firm amalgamated with Routledge, but the two remained separate companies until 1947 when they became Routledge and Kegan Paul.

Kegan Paul died on July 19, 1902. His works and writings included *William Godwin, His Friends and Contemporaries* (1876), *Memories* (1899), numerous books and articles on faith and religion, and translations, including Goethe's *Faust* (1873) and Pascal's *Thoughts* (1885). (Co. E. F.)

PAUL-BONCOUR, JOSEPH (1873–), French left-wing politician, and for 16 years France's permanent delegate to the League of Nations. He was born at St. Aignan, Loir-et-Cher, on Aug. 4, 1873. After leaving the university and joining the bar, he apprenticed himself to politics as private secretary of P. M. R. E. Waldeck-Rousseau. His book *Le Fédéralisme économique* (1900) showed his interest in trade unionism. He was elected deputy as Independent Socialist in 1909 for his native *département*, and was minister of labour in 1911. He lost his seat in 1914, returned to parliament as a Socialist after World War I, but resigned from the party in 1931 and thereafter presided over a group of Independent Socialist deputies. Paul-Boncour was minister of war in Édouard Herriot's government of June–December 1932, prime minister December 1932–January 1933, and minister of foreign affairs in his own government, as well as under Édouard Daladier, Albert Sarraut, and Camille Chautemps (December 1932–January 1934). He was again minister of foreign affairs under Sarraut (January–June 1936) and in Léon Blum's second ministry (March 1938). In June 1940 Paul-Boncour advocated the continuation of the war from Algiers and voted against Marshal Philippe Pétain in July. A member of the consultative assembly in 1944, he led the French delegation at San Francisco after Georges Bidault's departure and signed the UN charter on behalf of France. He was a senator during 1946–48. (D. R. GE.)

PAULDING, JAMES KIRKE (1778–1860), U.S. public official and man of letters chiefly remembered for his early advocacy and use of native American material in literature, was born in Dutchess (now Putnam) County, N.Y., on Aug. 22, 1778. Starting his public career in 1815 as secretary of the Board of Navy Commissioners, he became in 1824 a Navy agent in New York City, and from 1838 to 1841 he served as secretary of the Navy under Pres. Martin Van Buren.

His literary work, however, overshadows his routine labours as a government official. As a boy of 18 he went to New York City, where he formed a lasting friendship with the Irvings. This association aroused his enthusiasm for literature, and he and Washington Irving founded the *Salmagundi* (1807–08), a periodical consisting mainly of light satires on local subjects. The outbreak of hostilities between England and America encouraged the assertion of Paulding's nationalism; in *The Diverting History of John Bull and Brother Jonathan* (1812) and *The Lay of the Scottish Fiddle* (1813), he satirized England's conduct toward America during the war. The same spirit of nationalism found expression in two satires on the English traveler entitled *A Sketch of Old England: by a New England Man* (1822) and *John Bull in America* (1825).

The advantages and hardships of western migration are the theme of *The Backwoodsman* (1818), a poem written to call the American author home in his search of literary themes. Novels, such as *Koningsmarke* (1823), *Westward Ho!* (1832), and *The Old Continental* (1846), represent Paulding's attempts to employ the American scene in fiction. His popular play, *The Lion of the West* (1831; ed. by J. N. Tidwell, 1954), introduced frontier humour to the stage by depicting a character based upon Davy Crockett (*q.v.*); the latter, as a consequence, inaugurated the long series of Davy Crockett publications. In his *Life of Washington* (1835), once commended by Edgar Allan Poe, lies further evidence of his staunch Americanism. Plain, even at times vulgar in style, he yet possessed a playful irony which he shared with the New York writers of his day.

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PAULET (PAWLET or POULETT), the name, derived from Pawlett near Bridgwater in Somerset, of a well-known English family, different branches of which have held the baronies of St. John of Basing (from 1539), of Poulett of Hinton St. George (from 1627), and of Pawlet of Basing (1717–54), the earldoms

of Wiltshire (from 1550) and of Poulett (from 1706), the marquessate of Winchester (from 1551), and the dukedom of Bolton (1689–1754).

The first Paulet of whom anything is certainly known was Sir John Paulet (d. 1356). His grandsons Thomas (d. 1407) and William (d. 1436/37) were the ancestors respectively of the Earls Poulett and of the marquesses of Winchester.

Sir William Poulet (d. 1488), son of Thomas, married Elizabeth, daughter and heiress of John Denebaud of Hinton St. George in Somerset. Their great-grandson, Sir Amyas (*c.* 1536–88), had charge of Mary Stuart from 1585 until her execution in February 1587. Sir Amyas's grandson, John (*c.* 1585–1649), created Baron Poulett of Hinton St. George on June 23, 1627, fought for Charles I in the Civil War. His great-grandson, another John (*c.* 1668–1743), was created Viscount Hinton of Hinton St. George and Earl Poulett on Dec. 24, 1706. From him is descended the 8th earl, George Amias Fitzwarrine Poulett (1909–).

Sir John Paulet (d. 1437), son of William (d. 1436/37), married Constance, a co-heir of Sir Hugh de Poynings, 6th Baron St. John of Basing, Hampshire. His grandson, Sir William (*c.* 1483–1571), was created Baron Seynt (St.) John of Basing on March 9, 1539. Lord president of the council (1547–50), he was created earl of Wiltshire on Jan. 12, 1550, and marquess of Winchester on Oct. 11, 1551. He held the post of lord high treasurer from 1550 until his death. His great-grandson William (*c.* 1560–1629), 4th marquess, entertained Queen Elizabeth I at Basing for 13 days in September 1601. His son John (*c.* 1598–1675) held Basing House for Charles I until it was sacked by Oliver Cromwell's troops in October 1645. His son Charles (*c.* 1630–99) was created duke of Bolton on April 9, 1689. For his immediate descendants, *see* Bolton, Dukes of. On the death without male heirs (Dec. 25, 1794), of the 6th duke, Harry, the dukedom became extinct, while the other honours passed to George Paulet (1722–1800), a descendant of the 4th marquess. The 17th marquess of Winchester is Richard Charles Paulet (1905–).

PAULI, WOLFGANG (1900–1958), Austrian physicist, born in Vienna, April 25, 1900, was awarded the 1945 Nobel Prize for physics "for the discovery of the exclusion principle, also called the Pauli principle." He received his early education in Vienna and then studied under Arnold Sommerfeld at the University of Munich, where he took his doctor's degree in 1921. He spent a year as assistant to Max Born at the University of Göttingen and a further year with N. H. D. Bohr at Copenhagen. In 1923 he was appointed lecturer at the University of Hamburg, where he remained until 1928 when he became professor of theoretical physics at the Federal Institute of Technology in Zürich, Switz. Under his direction this institution became a great centre of research in theoretical physics in the years preceding World War II. In 1935–36 he was visiting professor at the Institute for Advanced Study (Princeton University) and he held similar posts at the University of Michigan in 1931 and 1941 and at Purdue University in 1942. In 1940 he was appointed to the chair of theoretical physics at the Institute for Advanced Study; and in 1946 he became a naturalized United States citizen. Following World War II he returned to Zürich. Pauli became one of the most brilliant of the mid-20th-century school of physicists. While still a student he wrote a masterly exposition of the theory of relativity. The work for which he received the Nobel Prize relates to quantum mechanics (*q.v.*) and played an important part in the wave theory of the atom. Pauli was also the first to posit (1931) the existence of the neutrino (*see* Particles, Elementary). He died in Zürich on Dec. 15, 1958.

See S. A. Goudsmit, "Pauli and Nuclear Spin," *Physics Today*, vol. 14 (June 1961). (W. J. Bp.; X.)

PAULICIANS, a dualist Christian sect, influenced most directly by Marcionism and Manichaeism, which originated in Armenia in the 7th century. Most of what is known of them comes from the *Historia Manichaion* by Peter of Sicily, who was sent by the Byzantine emperor Basil I to the Paulician stronghold of Tephrice to make peace (869). The identity of the Paul after whom the Paulicians are called is disputed.

The fundamental doctrine of Paulician dualism is that "there are two principles, an evil God and a good God; the former is the creator and ruler of this world, the latter of the world to come." From this they deduced the docetic doctrine (*see* Docetism) that Jesus was the son of Mary not in truth but only in seeming, because the good God could not have taken flesh and become man. Like other dualist sects the Paulicians, though recognizing the Scripture as uniquely authoritative, rejected the Old Testament and also the Epistles of St. Peter. They especially honoured St. Luke's Gospel and the Epistles of St. Paul. Their belief that all matter was the creation of the evil God led them to reject the sacramental efficacy of water, bread, wine, and oil, and therefore all the seven sacraments, though they later conformed to the practices of the church to escape detection and persecution. They rejected the divine establishment of the church and in their own worship did not use its liturgy and rites. Their rejection of the sacrament of orders made them anticlerical; their early leaders they called merely "companions in travel" (Acts 19:29).

The founder of the Paulicians seems to have been an Armenian, Constantine (fl. between 641 and 648), who took the additional name of Silvanus (one of St. Paul's companions). He gave a more distinctively Christian character to the Manichaeism which at that time was prevalent in the Asiatic provinces of the Byzantine Empire (*see* Manichaeism). The sect seems early to have started a widespread political and military rebellion within the empire. Between 668 and 698 Constantine III and Justinian II sent two expeditions to repress it. Constantine-Silvanus was stoned to death, and his successor, Simeon-Titus, was burned alive. In the early 9th century Paulicianism was revived. It expanded into Cilicia and Asia Minor under Sergius-Tychicus, who made it strong enough to survive the persecution and massacre instigated by the emperor Michael I and the empress Theodora. The number and power of the Paulicians were at their greatest under their leaders Carbeas and Chrysochir in the third quarter of the 9th century. An expedition sent by Basil I in 872 broke their military power, but they survived in Asia at least until the Crusades. Their importance after the 9th century lay chiefly in Thrace, whither many Paulicians were forcibly transported (757, 778, *c.* 970) to serve as a frontier force against the Bulgarians. Paulician doctrines were disseminated among the Macedonians, Bulgarians and Greeks, especially among the peasants, and they contributed much to the development of the doctrines and practices of the Bogomils (*q.v.*), who first appeared in Macedonia in the early 10th century.

See S. Runciman, *The Medieval Manichee* (1947); D. Obolensky, *The Bogomils* (1948). (R. R. Bs.)

PAULING, LINUS CARL (1901–), U.S. chemist, winner of the Nobel Chemistry Prize for 1954 and the Nobel Peace Prize for 1962, who discovered fundamental principles determining the nature of the chemical bond and the structure (shape and size) of molecules, and their application to the explanation of the properties of matter. He was born on Feb. 28, 1901, in Portland, Ore., and educated at Oregon State College (Corvallis) and the California Institute of Technology (Pasadena). He joined the staff of the California Institute of Technology in 1922.

In large measure his work led to the general realization that the nature of the chemical bond and molecular structure is the central and most fruitful theme of modern chemistry. His discoveries about the nature of the chemical bond include directed valence and the hybridization of bond orbitals, electronic structure, and magnetic properties, and the effect of resonance on the shape and stability of molecules (*see* Resonance, Theory of).

From 1936 he and his colleagues applied this knowledge to the study of the properties of living systems. Their work includes the discovery of some of the arrangements of polypeptide chains in proteins, especially a linear helical structure called the α-helix, and the discovery that an abnormality in the molecular structure of hemoglobin is associated with sickle cell anemia, a hereditary disease. (N. Dx.)

PAULINUS, SAINT, of Nola (Meropius Pontius Anicius Paulinus) (353–431), bishop of Nola (in Campania, southern Italy) and one of the most important and attractive Christian Latin poets of his time, was born at Bordeaux, where his family, of Roman patrician origin, was settled. His father was

rich and influential and Paulinus, who was the favourite pupil of Ausonius (*q.v.*), was marked for a public career; he became successively a Roman senator, consul, and governor of Campania. Though not baptized until 389, he was brought up as a Christian and was dedicated to St. Felix, whose tomb at Nola was on one of the family estates. Returning to Aquitaine, he married a Spanish lady, Therasia, with whom in 389 he retired to Spain. The death of their only child in 392 made them decide to forsake the world; they sold their possessions in Gaul and Spain, and in 395, when Paulinus was already in priest's orders, they settled at Nola to live a life of ascetism and boundless charity.

This act of renunciation created a profound impression. Paulinus' old master Ausonius uttered his reproaches in verse to which Paulinus replied in poetical epistles. This exchange belongs to the time when Paulinus was still in Spain. He also corresponded in poetical epistles with Nicetas of Remesiana. His verses, in lyric measures, show how a Christian poet could subdue rhetoric to Christian ends. His poems as a whole abound in reminiscences of classical authors such as Virgil, Horace, Ovid, and Lucan, for he could not forget the methods of the schools. His charm as a poet is best seen in his poems on the feast day of St. Felix.

The collection of his letters is of equal interest, as he corresponded with famous men of his day: Augustine, Jerome, and Sulpicius Severus. His prose style, often rhetorical and exuberant, never descends to puerilities. He could describe in dignified language his cold reception by the pope, or satirize the ignorance of those who could not perceive the beauty of the life of renunciation, but his letters breathe above all the atmosphere of what has been called the cult of Christian friendship. About 409 Paulinus was consecrated bishop of Nola, where he died June 22, 431. His feast is still celebrated on the anniversary of his death.

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PAULINUS, SAINT (d. 644), first bishop of the Northumbrians and bishop of York, was sent to England by Pope Gregory I in 601 to assist St. Augustine in his mission. He was consecrated in 625 and escorted the daughter of Aethelberht to the Northumbrian king Edwin (*q.v.*). As a result of his preaching, in 627 Edwin was baptized and assigned York to Paulinus as his see. In 632 Edwin was slain at Hatfield Chase and Paulinus retired to Kent, where he became bishop of Rochester. He received the pallium in 634 and died in 644. His feast day is October 10.

See Bede, *Historia ecclesiastica*, ed. by C. Plummer, vol. ii (1896); R. H. Hodgkin, *A History of the Anglo-Saxons*, vol. i, pp. 273–280 (1935).

PAULIST FATHERS (Society of Missionary Priests of St. Paul the Apostle; C.S.P.), founded in 1858 by Isaac Hecker and four other Redemptorist priests, are dedicated to the conversion of non-Roman Catholics. Except for establishments in Toronto, Ont., Johannesburg, S.Af., and Rome, the society exists only in the United States. *See* Hecker, Isaac Thomas; Orders and Congregations, Religious.

PAULO AFONSO FALLS are formed by the confluence of several branch streams about 190 mi. from the mouth of the São Francisco River on the Alagôas-Bahía border in Brazil. Set amid splendid scenery in the centre of a national park, the rapids reach a height of 279 ft. The falls are the site of a great hydroelectric project, begun in the late 1940s, to supply power to northeast Brazil. *See* São Francisco.

PAULSEN, FRIEDRICH (1846–1908), German philosopher and advocate of educational reform, was born at Langenhorn in Schleswig on July 16, 1846. He was educated at Erlangen, Berlin, and Bonn. He was professor of philosophy and pedagogy at Berlin from 1878 until his death there on Aug. 14, 1908. Paulsen was the greatest of the pupils of G. T. Fechner and his major philosophical work, *Einleitung in die Philosophie* (1892; Eng. trans. 1895), which attempted an epistemological account of our knowledge of the psychophysical, gave great prominence to Fechner's doctrine of panpsychism. He also paid considerable attention to Kantian philosophy, on which he wrote several studies, including *Immanuel Kant, sein Leben und seine Lehre* (1898; Eng. trans. 1902). In general, however, Paulsen's best-known philosophical works are somewhat oversimplified and his ideas unoriginal (partly because he deliberately wrote for a wide audience); he is best remembered for the part he played in the reorganization of higher education in Germany by leading the attack on the monopoly of the *Gymnasien* in the preparation of students for the university. His educational writings include *Geschichte des gelehrten Unterrichts auf den deutschen Schulen und Universitäten vom Ausgang des Mittelalters bis zur Gegenwart* (1885; Eng. trans. 1895), and *Das deutsche Bildungswesen und seine geschichtlichen Entwicklung* (1906; Eng. trans. 1908). He also wrote a *System der Ethik, mit einem Umriss der Staats- und Gesellschaftslehre* (1889; Eng. trans. 1899).

See T. Lorenz (trans. and ed.), *Friedrich Paulsen, an Autobiography* (1938).

PAULUS (Silentiarius) (d. A.D. 575), Greek poet, surnamed from his office of "silentiary" or usher at the court of Justinian I, was a member of the circle of classicizing writers at the imperial court in Constantinople. He was a contemporary and friend of Agathias. He wrote two elaborate poems describing Justinian's new church of Hagia Sophia, read at the dedication of the church in 537, which are important sources for the history of Byzantine art and architecture. About 80 of his epigrams on various subjects are preserved in the Greek Anthology.

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PAULUS, FRIEDRICH (1890–1957), German army officer, field marshal in World War II, was born at Breitenau, Hesse, Sept. 23, 1890. He served in World War I and helped plan World War II. He was chief of operations from Sept. 1940 to Jan. 1942, when Hitler entrusted him with the command of the 6th army in southern Russia. By late summer he reached Stalingrad (now Volgograd), high-water mark of Nazi conquest. Then, cut off by the Soviet counter-offensive that started in November, Paulus and his 300,000 men were abandoned by Hitler. He surrendered remnants of his army, after a bitter defense, on Jan. 31, 1943. On the same day, Berlin announced his promotion to the rank of field marshal.

In Soviet custody, Paulus joined the National Free Germany committee to agitate against the Nazis and he later testified at the Nürnberg trials. After his release in 1953, he settled in East Germany and publicly attacked the West German government for its rearmament and pro-United States policies. Paulus died in Dresden on Feb. 1, 1957. (P. N. T.)

PAULUS (older form Paullus), **LUCIUS AEMILIUS,** surnamed Macedonicus (*c.* 229–160 B.C.), Roman general and patrician, son of the consul of the same name who fell at Cannae. Praetor in 191 and consul in 182, he campaigned against the Lusitanians (191–189) and the Ligurian Ingauni (181). Consul again in 168, he ended the Third Macedonian War at Pydna (*q.v.*). A commemorative monument was erected at Delphi, and the captive king Perseus was shown at Paulus' triumph. He settled Greece and on senatorial orders he sacked the cities of Epirus. He was censor in 164 and died in 160. At his funeral games the *Hecyra* of Terence was acted for the second and the *Adelphi* for the first time. Of the vast sums brought by him into the Roman treasury from Spain and Macedonia he kept nothing for himself. A fine general and a strict disciplinarian, an aristocrat, yet popular, he united Roman tradition with Hellenism. His most famous son was Scipio Aemilianus.

Bibliography.—Plutarch, *Aemilius Paulus;* Polybius, xxix–xxxi; Livy, xliv, 17 ff.; xlv–xlvi; H. H. Scullard, *Roman Politics, 220–150 B.C.* (1951). (H. H. Sc.)

PAULUS DIACONUS (Paul the Deacon) (*c.* 720–?799), the historian of the Lombards, came of a noble Lombard family in

Friuli, and was educated at the royal court at Pavia. During the reigns of Ratchis and Desiderius he remained in close contact with the royal family. He taught Desiderius' daughter Adelperga and probably followed her to Benevento after her marriage with its duke. he composed for her his first historical work, the *Historia Romana* (ed. by A. Crivelluci, 1914), an expansion and continuation of Eutropius's *Breviarium*. Probably after the collapse of the Lombard state in 774, he entered the monastery of Monte Cassino. In 782 he went to Charlemagne to plead for his brother Arichis who had taken part in an anti-Frankish rising; he thus joined the group of scholars whom Charlemagne had gathered at his court, and became a prominent figure in the Carolingian Renaissance. His interest in classical Latin grammar is reflected in his *Epitome* of Festus' *De verborum significatu*, while his poems (ed. by K. Neff, *Die Gedichte des Paulus Diaconus*, 1908) are outstanding examples of the classical revival. He continued his historical writing with a history of the bishops of Metz, which became a model for later similar histories, and with a life of Gregory the Great. But his greatest achievement was his *Historia Langobardorum* (ed. by L. Bethmann and G. Waitz, in *Monumenta Germaniae Historica, Script. rer. Langob.*, II, 1878; also ed. *in usum scholarum*; Eng. trans. by W. D. Foulke, 1907) to the death of Liudprand (744). Based on written sources such as the *Origo gentis Langobardorum*, and on oral tradition, which would otherwise have been lost, it is the work of a scholar and a patriot, and remains the most important source of Lombard history. The *Historia* was written in Monte Cassino where Paul had returned by 787, and where he died on April 13, perhaps in 799. His other works include a collection of homilies for the ecclesiastical year, and a commentary on the Rule of St. Benedict.

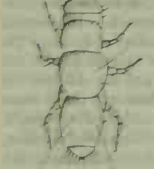
BIBLIOGRAPHY.—For editions of other works *see* M. Manitius, *Geschichte der lateinischen Literatur des Mittelalters*, I, pp. 263–272 (1911), and for other material, pp 257–262; W. Wattenbach–W. Levison, *Deutschlands Geschichtsquellen im Mittelalter Vorzeit und Karolinger*, II, pp. 203–224 (1953). (N. R.)

PAUROPODA, a class of many-legged, air-breathing arthropods that superficially resemble tiny centipedes or millipedes. In fact, when Sir John Lubbock announced the discovery of pauropods in 1866, he regarded them through a representative genus *Polyxenus*, as linking forms between centipedes and millipedes. The largest pauropods are only about 1 mm. in length, the smallest about 0.5 mm. Their soft, pale or whitish bodies may be found in decaying vegetation upon moist soil; they are quite inconspicuous in this habitat where they feed and lay their eggs.

FROM J. LUBBOCK IN "TRANSACTIONS"

FIG. 1.—PAUROPUS HUXLEYI ADULT SEEN FROM ABOVE (greatly magnified)

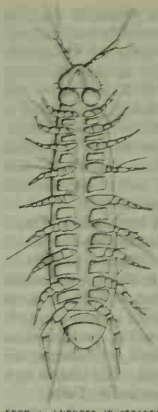
The body is composed of 12 segments, but because of the coupling of dorsal plates (tergites) of the first 10 segments, the number appears to be less than 12 when the animal is viewed from above. The adult has nine evident pairs of legs. Pauropods resemble centipedes in body form and in number of legs per segment: one pair of legs is found on each true segment except the last two, which are legless; the legs of segment one are so degenerate that they are hardly noticeable. Fusion of tergites indicates a beginning of the process, carried to completion in millipedes, of the doubling of segments.



FROM J. LUBBOCK IN "TRANSACTIONS"

FIG. 2.—YOUNG PAUROPUS WITH ONLY THREE PAIRS OF LEGS (greatly magnified)

The most distinctive characteristic of pauropods is the possession of branched antennae, a characteristic separating them from other arthropods. Each antenna consists of four segments, of which the end one bears two branches; the upper branch is a simple filament of many segments; the lower branch bears two filaments, between the bases of which is a characteristic rounded knob (globulus) thought to be a special sense organ. Eyes are absent, but behind the base of each antenna is an eyelike spot (pseudoculus) possibly homologous with the organ of Tömösvary of centipedes. The mouthparts resemble those of millipedes.



FROM J. LUBBOCK IN "TRANSACTIONS"

FIG. 3.—PAUROPUS HUXLEYI SEEN FROM BELOW (greatly magnified)

The internal structure is relatively unspecialized; pauropods lack both special respiratory and circulatory systems. The simple alimentary canal, though it bears a pair of degenerate excretory tubules (Malpighian tubules), appears to effect excretion chiefly through its own epithelium. As in millipedes the reproductive organs open at the bases of the second legs, males having a pair of penes. From the egg arises a pupoid larva, which in turn gives rise to a free larva having three pairs of legs. Later larval phases have been observed with five, six and eight pairs of legs.

Pauropods are classified under three families: Pauropododae, Eurypauropodidae and Brachypauropodidae.

BIBLIOGRAPHY.—A good summary is given by K. W. Verhoeff in Bronn's *Klassen und Ordnungen des Tier-reichs* (1933–34); and C. Graf Attems in Kukenthal and Krumbach's *Handbuch der Zoologie* (1926). (R. V. C.)

PAUSANIAS, of the Agiad royal family of Sparta, succeeded his father Cleombrotus in 480 B.C. as regent for Leonidas' young son Pleistarchus. As commander of the Greek army he defeated the Persians under Mardonius at Plataea in 479 (*see* GRECO-PERSIAN WARS). Next year he led an allied fleet to Cyprus, then captured Byzantium, to command the crossing between Asia and Europe. Here his arrogance and his adoption of Persian clothes and manners offended the allies and raised suspicion of treachery. Recalled to Sparta, he was acquitted on the major charge but was not restored to his command: the allies now separated from Sparta and formed the Delian League (*q.v.*) with Athens. Pausanias returned privately and held Byzantium until dislodged by the Athenians, probably in 477, when he retired to Colonae near Troy. Eventually the Spartan ephors again recalled him, and he obeyed the summons and successfully defied his enemies to bring him to trial. In the end one of his messengers opened and gave to the ephors a letter from Pausanias to the Persian king, and this letter and an overheard conversation between Pausanias and the messenger encouraged the ephors to arrest him. He took refuge in the Temple of Athena of the Brazen House but was walled in and starved to death, probably between 470 and 465.

Pausanias' real plans and the degree of his guilt are hard to estimate. Herodotus had some doubt about the story, whereas Thucydides, writing later and in different circumstances, had none: the Spartans had perhaps made Pausanias a scapegoat for their failure to retain the leadership of Greece. The ephors' long delay in acting against him suggests that he had supporters who believed him innocent, and it is likely enough that he headed a party wishing to dispute the leadership with Athens. But some of his actions do not look innocent, and his agent Gongylus, who held Byzantium for him during his first recall, certainly received large rewards from Xerxes afterward. (A. As.)

PAUSANIAS, Greek traveler and geographer of the 2nd century A.D., was probably a native of Lydia. It has been stated with perfect justice by J. G. Frazer that "without him the ruins of Greece would for the most part be a labyrinth without a clue, a riddle without an answer."

Before visiting Greece he had traveled widely in Asia Minor, Syria, Palestine, Egypt, Macedonia, Epirus, and parts of Italy. His *Description of Greece* takes the form of a tour starting from Attica. It is divided into ten books: (i) Attica and Megara; (ii) Corinth and Argolis; (iii) Laconia; (iv) Messenia; (v) and (vi)

Elis, including Olympia; (vii) Achaea; (viii) Arcadia; (ix) Boeotia; and (x) Phocis, including Delphi. He probably planned to write on the remaining regions as well. The books seem to have been written in the order in which they stand, over a period of about 15 years. No event after about A.D. 176 is mentioned.

The work has no formal preface or conclusion. The author's aim may be inferred from his statement at the close of his account of Attica: "Such (in my opinion) are the *most famous* of the Athenian *traditions* and *sights;* from the mass of materials I have aimed from the outset at selecting the really *notable*." In the hope of giving variety to the topographical details the author intersperses them with lengthy historical disquisitions. In the subsequent books his account of each important city begins with a sketch of its history; in his descriptions he adopts a topographical order. He gives a few glimpses into the daily life of the inhabitants, ceremonial rites and superstitious customs. He frequently introduces history, legend, and folklore; but it is only rarely that he allows something of the scenery to be seen.

He was inspired by interest in the ancient glories of Greece and seems to have had little love for Roman rule. He is most at home in describing the religious art and architecture of Olympia and Delphi and was interested in visiting the battlefields of Marathon and Plataea, in viewing the Athenian trophy on the island of Salamis, the tombs of famous men, and the colossal lion guarding the tomb of the Thebans on the Boeotian plain.

At Olympia he takes note of the ancient quoit of Iphitus inscribed with the terms of the Olympia truce, the tablets recording treaties, and the memorials of victories. At Delphi he marks the trophies of the Athenians, the united Greeks, the Spartans, the Thebans, and the shields dedicated in memory of the repulse and defeat of the Gauls at Delphi. At Athens he sees pictures, portraits, and inscriptions recording the laws of Solon, on the Acropolis the great bronze statue of Athena, and outside the city the monuments of famous men and of all the Athenians who fell in battle, except the heroes of Marathon, "for these, as a meed of valour, were buried on the field."

In the topographical part of his work, he is fond of digressions on the wonders of nature, the signs that herald the approach of an earthquake, the tides, the icebound seas of the north, and the noonday sun which at the summer solstice casts no shadow at Syene (Aswan). His main interest is in works of art: he prefers the works of the 5th and 4th centuries B.C. to those of later times.

In all parts of Greece the accuracy of his descriptions has been proved by the remains of the buildings; but he made appalling mistakes especially when he followed other authors. His style, despite rhetorical artifice, is undistinguished. Pausanias' work was little known in antiquity, but now it is an invaluable guide to the ruins of ancient Greece.

See Teubner Series text by F. Spiro (1903); "Loeb Series" ed. by W. H. S. Jones, H. A. Ormerod and R. E. Wycherley (1918–35). Commentary with trans. by J. G. Frazer (1898). (E. BA.)

PAVANE (Italian PADOVANA, from Padua), a slow 16th-century dance in duple or quadruple rhythm. It became important as the first of the 15th century *basses danses* (popular dances) to enter aristocratic court circles. It traveled to France by way of Spain where its vogue undoubtedly added Spanish characteristics as a result of performances on solemn occasions in the churches of southern Spain. Thus arose the possibly disputable claims of its Spanish origin, and the still widely believed derivation of its name from *pavo* ("peacock"). A stately processional, its basic movements consisted of step close, step close, and step, step, step, close, alternately forward and backward. Customarily followed by the lively Galliard, it retained its popularity as a dance until about 1650. (L. Ilt.)

PAVELIC, ANTE (1889–1959), Croatian nationalist leader, dictator of the independent Croatian state sponsored by the Germans and Italians during World War II, was born at Bradina, in the Bosnia Region, on July 17, 1889. He studied at Zagreb University and later practised law at Zagreb. He joined the nationalist Croatian Party of Rights and became its secretary. In 1920 he was elected city and county alderman at Zagreb. A deputy to the Yugoslav *skupstina* from 1927, he opposed the amalgamating policy of the government. In January 1929, when King Alexander established his dictatorship, Pavelic escaped to Italy where he organized a revolutionary Croatian nationalist movement, the *Ustasa* (insurgent). It was this movement that organized the assassination of King Alexander in Marseilles on Oct. 9, 1934. Aiming to destroy Yugoslavia and to establish an independent Croatian state, Pavelic joined forces with Hungarian, German, and Italian adversaries of the existing territorial settlement in Europe and ultimately became an instrument of Fascist imperialism in the Balkans. In April 1941, when Germany and Italy conquered and dismembered Yugoslavia, an independent Croatian state was established, and Pavelic became the head (*poglavnik*) of the new state. He ruled as a dictator and, because of wide popular opposition to his regime and policy, with ruthlessness and brutality. In May 1945 when the Croatian state ceased to exist, Pavelic left Zagreb to escape capture by Yugoslav Communists. After hiding under false names in Austria and Italy he arrived in Argentina in 1948. In 1957 the Yugoslav government demanded his extradition as a war criminal, but this was refused by the Argentine government. Wounded during an attempt on his life in Buenos Aires (April 10, 1957), Pavelic fled from Argentina and settled secretly in Spain where he died in Madrid on Dec. 28, 1959. (A. S. PA)

PAVIA (ancient TICINUM), a city of Lombardy in northern Italy, capital of the province of Pavia, is situated on the left bank of the Ticino River, 4 km. (3 mi.) above its junction with the Po and 36 km. (22 mi.) S of Milan by road and rail. Pop. (1961) 78,069 (commune). On the other side of the river is the suburb of Borgo Ticino, connected with the city by a covered bridge, the Ponte Coperto, dating from the Middle Ages (rebuilt 1951). Pavia still retains the ancient plan of a Roman *castrum*, with *cardo* (main street running north-south; now called Strada Nuova), *decumanus* (running east-west; Corso Cavour and Corso Mazzini), *quadrivium* or main crossroads (Demetrio), and network of streets for *centuriae* (companies). In the centre of the city stands the cathedral with its vast cupola. Begun in 1488 by Cristoforo Rocchi, and completed in 1898 according to Rocchi's still extant model, the cathedral has the form of a Latin cross. Close by is the Piazza Grande with the ancient Broletto or town hall (12th and 16th centuries) in the background; in the square stands the Palazetto Dei Diversi (14th century). Particularly important are the Romanesque churches, including: S. Michele Maggiore (11th century), the ancient Lombard cathedral where for more than 200 years the medieval "kings of Italy" were crowned; S. Pietro in Ciel d'Oro (12th century), mentioned by Dante, Petrarch, and Boccaccio, with a marble tomb (1362) containing the bones of St. Augustine of Hippo; and S. Teodoro (12th century), decorated with 13th-century Byzantine frescoes and 16th-century stories of saints and virgins. Other churches are the beautiful Gothic Sta. Maria del Carmine (14th century) and S. Francesco (13th century). Other buildings of note are the 16th-century palace of Del Maino and the 18th-century palaces of Botta-Adorno, Brambilla, Olevano, Mezzabarba, Arnaboldi, and Vistarino (all ancient patrician families). In the rooms of the 14th-century castle of the Visconti valuable artistic collections are kept, and the magnificent Romanesque department is devoted to sculptures and mosaics.

The University of Pavia was founded in 1361 by Gian Galeazzo Visconti: it is linked with the ancient law school which was in existence in 825 in the time of Lothair I. The oldest part of the building dates from the 14th century and Maria Theresa of Austria had extensions built in the 18th century. Christopher Columbus once studied there. The colleges of Ghislieri and Borromeo were founded in the 16th century by Pope Pius V and St. Charles Borromeo. The University of Pavia is particularly noted for the study of law, science, medicine, and surgery; and has a central library of more than 400,000 volumes and 1,500 manuscripts. The civic library has 60,000 volumes, principally concerned with local history. The Pinacoteca (Palazzo Malaspina) boasts works by many famous artists and its collection of more than 30,000 prints is one of the most important among such collections in Europe.

Pavia is on the railway from Milan to Genoa. The Naviglio, a

navigable canal along which sand and gravel from the Ticino are transported, runs to Milan; Leonardo da Vinci devised the 12 locks which raise the canal 148 ft. between the two cities. The chief industry is the manufacture of sewing machines. There are also mechanical engineering, ferrous metal working, and the manufacture of thermionic valves and chemicals. The city is an important agricultural centre.

Pavia was originally a Roman municipality, Ticinum, of the Papiria tribe and it increased in importance, owing to its geographical position, in the time of the empire. It was pillaged by Attila in A.D. 452 and by Odoacer in 476 but later became an important centre of Gothic resistance against the Byzantine Empire. From the 6th century, under the Lombards, it was one of the leading cities of Italy, remaining so even when it fell under Frankish dominion in 774. After a series of wars with Milan from the 11th to the 13th century, it was subdued by the Visconti in 1361 and under Gian Galeazzo became the political centre of Italy. In 1525 a notable battle took place between the Spanish emperor and the French king (*see* below). During the 18th century Pavia was occupied variously by the Austrians, French, and Spaniards. It was one of the leading cities of Venetian Lombardy in the campaigns of the Risorgimento.

Battle of Pavia (1525).—The battle took place in the huge park of the Visconti Castle, to the north of Pavia, between Francis I of France and Charles V of Spain. In 1524 the French king occupied Milan and brought against Pavia an army of more than 30,000 men, attacking it from every quarter. But the defense, conducted by the troops of Antonio de Leyva and the Pavians, aided by Swiss militia, forced the French to concentrate their forces in the park of the Visconti. At dawn on Feb. 24, 1525, the imperial troops attacked the French and threw the German infantry, mercenaries of Francis I, into confusion. De Leyva then made a sortie from Pavia and, having destroyed the ranks of Giovanni de Medici, attacked from behind the Swiss reinforcements, annihilating the French army, whose king fell prisoner. The Battle of Pavia showed the superiority of firearms over cold steel and revolutionized military tactics.

Certosa di Pavia.—A Carthusian monastery, the most magnificent religious monument in Lombardy and one of the most beautiful in the world, is situated 8 km. (5 mi.) N of Pavia, on the extreme boundary of the park of the Visconti. Begun in 1396 by Bernardo da Venezia, it was continued by Andrea and Cristoforo Solari and others in a transitional style between Gothic and Renaissance. The facade is a marvelous piece of architecture of Renaissance Lombardy, with a splendid array of sculptures and marbles. In the north transept of the church is the tomb of Lodovico Sforza (il Moro) and his wife by Cristoforo Solari, and in the south transept that of Gian Galeazzo. The terra-cotta ornaments surrounding the slender marble pillars of the small cloister are the work of Rinaldo de Stauris, who executed similar decorations in the great cloister, which is 412 ft. long and 334 ft. wide and contains 24 monks' cells, each in the form of a small house with three rooms and a garden.

G. CHIOLINI

THE CERTOSA DI PAVIA, A CARTHUSIAN MONASTERY COMPLETED IN THE 17TH CENTURY

Pavia Province lies to the south of the province of Milan. It comprises three distinct regions: Pavese, Oltrepò, and Lomellina. Area 1,145 sq.mi. (2,966 sq.km.). Pop. (1961) 514,994. Pavese produces grain, Lomellina rice, and Oltrepò wine. The industrial centres of Lomellina include Vigevano (footwear) and Mortara (carpets, biscuits, and rice processing). Among places of historic interest are Lomello's 8th-century baptistery and Vigevano's Piazza Ducale, to which Leonardo da Vinci contributed. Varzi, Pietra Gavina, and the 4,000-ft. Passo del Brallo and Passo del Giovà in Oltrepò are holiday centres.

See also references under "Pavia" in the Index.

Bibliography.—G. Chierici, *Guida alla Certosa di Pavia* (1950); P. Vaccari, *Profili storico di Pavia* (1950), *Pavia nell'alto Medioevo e nell'età comunale* (1956); A. Annovazzi and F. Biancoli, *Pavia e la sua Provincia* (1952). (De. M.)

PAVÍA Y LACY, MANUEL, Marqués de Novaliches (1814–1896), Spanish general who remained loyal to Isabella II in the revolution of 1868, was born in Granada on July 6, 1814. He fought for Isabella in the First Carlist War (1833–39), being appointed colonel for his success at the fall of the castle of Onís and brigadier at the capture of Solsona. In 1840 he was created marqués de Novaliches. He emigrated to France in 1841, and on his return in 1843 took part in the overthrow of Gen. Baldomero Espartero. Pavía became minister of war in 1847. Afterward he was captain general of Catalonia and in 1853, as captain general of the Philippines, he went to Manila and crushed the revolt of the mestizo José Cuesta in 1854. At the revolution which deposed Isabella in September 1868 he was defeated at Alcolea by Gen. Francisco Serrano, and was badly wounded. He emigrated at the accession of Amadeo (December 1870) but returned at the restoration of Alfonso XII (December 1874), when he was restored in his honours and received the Order of the Golden Fleece. He died in Madrid on Oct. 22, 1896. (R. S. Ll.)

PAVÍA Y RODRÍGUEZ DE ALBURQUERQUE, MANUEL (1827–1895), Spanish general who carried out the *coup d'état* of January 1874, was born at Cádiz on Aug. 2, 1827. Appointed captain in 1848 and major in 1854, he joined in 1865 the staff of Gen. Juan Prim whom he supported in the unsuccessful uprisings in 1866 and, after two years in exile, in the successful revolution of September 1868 which deposed Isabella II. After the abdication of King Amadeo (February 1873) and the proclamation of the republic by the *Cortes*, Pavía suppressed (1873) the chief cantonal insurrections in the south of Spain. He was appointed captain general of New Castile in the same year. Pavía hoped to establish a dictatorial, military republic with Pres. Emilio Castelar (*q.v.*), but when, on Jan. 3, 1874, Castelar was defeated by, and refused to dissolve, the *Cortes*, Pavía carried out a *coup d'état* and expelled the *Cortes*. Free from personal ambition he summoned Gen. Francisco Serrano to take over the government. After the restoration of Alfonso XII (December 1874) Pavía was elected to the *Cortes* in 1876. He was captain general of Catalonia (1880–81) and of New Castile (1885–86). He died in Madrid on Jan. 4, 1895.

PAVLODAR, an *oblast* and town in the Kazakh Soviet Socialist Republic, U.S.S.R. Formed in 1938, the *oblast* has an area of 49,344 sq.mi. (127,801 sq.km.). It is divided into 11 *raions* and has two towns and four settlements of town type. Since Dec. 1960 it has formed part of the newly created region of Tselinny Krai (the New Lands Region). The *oblast* lies across the Irtysh River and forms part of the West Siberian Depression. The climate is continental and dry. There are important deposits of coal, copper, gold, and sodium chloride. Main industries are coal mining (Ekibastuz), salt production from the salt lakes, and gold mining (Maikain). More than 3,500,000 ha. are under cultivation (mainly wheat and millet) and dairy cattle are also raised.

The population was 455,013 in 1959, of which 73% was rural. Russians probably predominate over Kazakhs. The towns are

Pavlodar, the administrative centre, and Ekibastuz. In addition to about 580 schools there are several special middle-school training establishments. The main railway is the Tselinograd (Akmolinsk)-Pavlodar-Kulunda line. The Irtysh is navigable and there are many metaled roads.

Pavlodar town has a population (1959) of 90,096. Situated on the Irtysh, it was founded as Koryakovski outpost in 1720 and became the town of Pavlodar in 1861. It has a number of light industries (mostly connected with food), teacher-training and medical institutes, a theatre, and a museum. (G. E. WR.)

PAVLOV, IVAN PETROVICH (1849–1936), Russian physiologist, achieved world renown for his researches on blood circulation, the action of the digestive glands, and the formation of conditioned reflexes. He was awarded the Nobel Prize in 1904 for his work on the physiology of digestion, but his name is known far beyond scientific circles for his systematic experimental studies of conditioning of dogs and other animals. These studies, begun in 1902, profoundly influenced the experimental psychology of learning, while his discovery of techniques for creating "experimental neuroses" in dogs did much to pioneer the scientific approach to the study of human mental disorders. Although Pavlov was unrivaled in the surgical skills and objective methods of animal experimentation, his theory of the cerebral processes in conditioning was much criticized, and his later extension of conditioning principles to account for complex human mental processes, such as language, lacks validity.

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IVAN PETROVICH PAVLOV

He was born in Ryazan on Sept. 14, 1849, the son of a priest. After four years spent at the Ryazan Seminary, he studied science, then medicine, at the University of St. Petersburg (Leningrad). Having graduated as doctor of medicine (1883), he worked in Germany (1884–86) under two great physiologists, Karl F. W. Ludwig and Rudolf Heidenhain. On returning to St. Petersburg, his first major appointment was to the chair of pharmacology at the Military Medical Academy in 1890. In 1891 he directed the construction of the first surgical department in the world to be set up in a physiological laboratory, at the new Institute of Experimental Medicine.

In 1895 he became professor of physiology at the Military Medical Academy. His honours included election as member of the Russian Academy of Sciences (1906), foreign member of the Royal Society (London, 1907), and honorary fellow of the Royal College of Physicians (London, 1928). His first publications, on blood circulation, date from 1878, and his major work on the physiology of digestion appeared in Russian in 1897 and subsequently in German, French, and English. The account of his 25 years of experimental work on conditioning became available in English first through G. V. Anrep's translation (1927) and W. H. Gantt's (1928).

From 1928 until his death Pavlov concentrated upon applying his conditioning principles to the problems of the psychiatric clinic, as is described in a second book translated by Gantt (1941).

Pavlov died in Leningrad on Feb. 27, 1936. After his death, his conditioning theory and account of cerebral activity retained considerable influence over research in the U.S.S.R. on the higher nervous activity of man. The essence of the Pavlovian approach to the study of complex mental processes is its emphasis on objective experiment, its rejection of the subjectivity of older traditional psychology and of the mind-body dualism supposedly inherent in it.

Pavlov's works available in English include *The Work of the Digestive Glands*, translated by W. H. Thompson (1902); *Conditioned Reflexes*, translated and edited by G. V. Anrep (1927); *Lectures on Conditioned Reflexes*, translated by W. H. Gantt (1928); and *Conditioned Reflexes and Psychiatry*, translated and edited by W. H. Gantt (1941). Gantt's two translations are introduced by useful biographical sketches.

See CONDITIONING; LEARNING; NEUROSES, EXPERIMENTAL; etc. *See* also references under "Pavlov, Ivan Petrovich" in the Index.

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PAVLOVA, ANNA (1881–1931), Russian ballerina, the most celebrated dancer of her time, was born Jan. 31, 1881, in St. Petersburg. She studied at the Russian Imperial Ballet School under Ekaterina Vazem and Paul Gerdt, graduating as soloist in 1899. Seven years later, after triumphs in *Swan Lake* and *Giselle*, she was named prima ballerina. She participated in Diaghilev's first Paris season, 1909, but, dissatisfied with her position in the company, she soon withdrew.

In 1910, with Mikhail Mordkin as her partner, she appeared with sensational success at the Palace Theatre, London, and Metropolitan Opera, New York City.

Forming her own company, Pavlova began the series of world tours which continued until her death. Before World War I, she returned regularly to the Mariinsky Theatre, St. Petersburg. She appeared in all the principal countries of North and South America, Europe, Africa, and the Orient, bringing the art of ballet to numerous communities where it was unknown, and inspiring many young dancers. She made her home in London with her husband and manager, Victor Dandré. She died Jan. 23, 1931, at The Hague.

Pavlova's repertoire consisted chiefly of classic ballets, including *Chopiniana, Don Quixote*, and *Coppélia*. Her favourite was *Giselle*. Her superb performance of the famous solo, *The Dying Swan*, created for her in 1905 by Michel Fokine, was legendary.

See Victor Dandré, *Anna Pavlova* (1932); Arthur H. Franks, *Pavlova, a Biography* (1956). (LN. ME.)

PAWNBROKING is the business of advancing loans on the security of goods or chattels. The precise definition of the trade depends on the legislation by which it is regulated. In Great Britain, for example, pawnbroking used to relate to loans not exceeding £10 in a single transaction; this figure was increased to £50 by the Pawnbrokers Act of 1960. There are precise conditions as to the right of the borrower to redeem articles pledged, and of the pawnbroker to dispose of forfeited goods.

From the middle ages to the 20th century pawnshops have attracted the custom of a declining aristocracy. Jewelry and plate form the typical collateral for such loans. In the 19th century the small middle class joined the aristocracy in these transactions as principal borrowers. At the same time, a far poorer class of customers fell into the habit of pledging clothing, bedding and cheap personal effects. In Great Britain the latter is termed by pawnbrokers the "industrial," the former the "city," trade.

The trade of the pawnbroker is one of the oldest known to mankind. It existed in China 2,000 to 3,000 years ago. Greece and Rome were familiar with its operation; they laid the legal foundations on which modern statutory regulation is built. The forces which nurtured pawning, particularly among the poor, were need, habit and convenience. The industrial trade in the 19th and 20th centuries was fed neither by extreme poverty nor by severe unemployment, but by the continuing pressure of family incomes low enough to stimulate borrowing, while regular enough to enable borrowers to redeem pledges. Moreover, occasional interruptions of earning by unemployment and sickness contributed substantially to the growth of pawning. The convenience of having a pawnshop nearby and the habit which grows from the first failure to live within current income strengthened the bond between pawnshop and borrower. It is said that the first half of the 20th century witnessed an important growth of borrowing in Great Britain by the middle class.

In the 20th century, after a long period of income redistribu-

tion and growing social service benefits, it became difficult to assess the relative importance of the various motives which led people to the pawnshop. The meaning of the word "necessity" is very elastic; its boundaries can be made to extend to any reduction in the real income of the indigent. But as long as low incomes, temporary difficulties and shiftlessness among poor and rich alike continue to stimulate demand for borrowing, there will doubtless be willing lenders. The disappearance of the pawnbroker would in many instances enforce readjustment and a new discipline among the poor; in other cases it might promote the growth of different forms of small-scale lending beyond the reach of present legislation. The same thing applies to those who have insufficient or inadequate articles to pledge; this situation might breed an equivalent to the "dolly shop." Such shops specialized in the very small loan, too small to be profitable under the usual conditions.

It would be impossible to estimate to what extent illegal forms of lending still exist, but they can hardly be of anything like the same magnitude, at least in Great Britain, as they were in the past. In the first half of the 19th century, for example, there are said to have been many hundreds of unlicensed pawnshops in London. They made very small loans at very high rates of interest, without always taking in pledges. In Germany this type of business evaded legislation by assuming the form of resale, the debtor selling his pledge to the lender and repurchasing it after an interval at an enhanced price. In the late 1870s attempts were made by legislation to stop this practice by declaring that transactions of this nature fell under pawnbroking regulations. The Netherlands tried to meet an analogous need by setting up a special type of public institution prepared to make very small loans of short duration with a minimum of formalities.

HISTORY OF PAWNBROKING IN THE WEST

Pawnbroking in the west traces its origin to three different institutions which existed in the middle ages: private pawnbrokers, public pawnshops and *montes pietatis*.

Private Pawnbrokers.—The first person to satisfy the needs of his contemporaries for small consumption loans was the private pawnbroker. Usury laws in most countries prohibited the taking of interest. Pawnbroking was therefore carried on chiefly by classes exempt from these laws by religion or regulation, such as Jews and Lombards. The three golden balls, traditionally the pawnbroker's trade sign, once denoted the establishment of a Lombard merchant. In these transactions, the pledge represented legal evidence of debt, as is known from an Augsburg municipal law of 1276 regulating the trade of Jewish pawnbrokers. To the expansion of economic activity between the 12th and the 14th centuries corresponded a considerable increase in pawnbroking. Not only the poor and needy but also the well-to-do made use of pawnshops and were ready to pay rates of interest ranging up to 86% a year. Such rates were stigmatized as exorbitant exploitation and gave rise to periodic riots and violence against Jewish and other pawnbrokers. Attempts were made by public authorities to limit rates of interest. Florence in 1415 laid down a maximum rate of 15% but found control of transactions at that level impossible and had to raise it to 20% five years later. In another determined attempt the Florentine authorities in 1469 refused to renew the licences of moneylenders of any kind, but this merely drove intending borrowers to seek accommodation outside the town at rates of 30% or more. By this time the church was adapting its law to the realities of the secular world. While maintaining its prohibition against pure interest, it condoned remuneration given to lenders for damage suffered or profit forgone.

Public Pawnshops.—Much as public authorities deprecated the practices of private pawnbrokers, they realized the social need to which pawnshops ministered. Exploitation could be effectively prevented only by provision of alternative facilities for obtaining consumption loans, and as early as 1198, Freising, a town in Bavaria, set up a municipal bank which accepted pledges and made loans against moderate interest charges. Salins in Burgundy followed in 1350, and Michael of Northburgh, bishop of London, established a similar institution in 1361; municipal pawnshops were founded at Frankfurt am Main (1402), Florence (1473), Nürnberg (1498) and Augsburg (1591). In all these establishments charges in the form of limited interest or fees were levied merely with a view to covering costs; if profits were made, they went to public funds. However much they embodied a modern concept of social service, all these pawnshops enjoyed only a comparatively short existence; their moderate charges did not cover the risks incurred in this type of business.

Montes Pietatis.—Provision of social services in the middle ages was even more a task for the church than for public authorities. Canon law enjoined the faithful to refrain from usury, but the church saw the need for institutions to make lawful loans to indigent debtors. The Friars Minor (Franciscans) in Italy were the first to establish *montes pietatis* (*mons* denoted any form of capital accumulation), which were charitable funds to grant interest-free loans, secured by pledges, to the poor; the money was obtained from gifts or bequests. Barnabas, a Franciscan, raised the first *mons pietatis* at Perugia in 1462; others were founded at Turin (1519), Rome (1539), Bruges (1572) and Avignon (1577). Here again, the charitable intentions of the founders were frustrated by the economic difficulties. In order to prevent premature exhaustion of funds *montes pietatis* saw themselves compelled to charge interest, usually at rates between 4% and 12%, and to sell by auction any pledges which had become forfeit. These modifications raised the question of how far *montes pietatis* themselves offended against the usury laws. The fifth Lateran council in 1515 recognized *montes pietatis* as charitable institutions, and Pope Leo X issued a bull to this effect which authorized any charges necessary to cover expenditure. However, a number of these *montes*, especially that in Rome, developed into large-scale clerical banks, receiving deposits at interest and lending money to popes and foreign princes.

18th and 19th Centuries.—Many states reverted to public pawnshops as a means of preventing exploitation of the poor in the 18th century. The structure of national states had been sufficiently strengthened to bear the financial and administrative weight of institutions incurring considerable financial risks. Municipal establishments often enjoyed national backing, as for instance the Imperial Pawn office in Vienna, set up in 1713 with funds donated by Charles VI.

In Russia the mint made loans on gold and silver plate from 1733 onward, and state mortgage banks were authorized in 1754 to lend on the security of pledges. The Spanish Netherlands (the future Belgium) had a tradition of interlinked public pawnshops in the main towns going back to 1618, making loans at 15% or less, not only for public assistance but also on a commercial basis, and receiving deposits at 6¼%. A local pawnshop in Paris in 1777 was converted by Louis XVI into a municipal institution on the strong recommendation of Jacques Necker, the minister of finance, who wanted an instrument for fighting social unrest.

Public pawnshops everywhere suffered a decline toward the late 18th century because to the liberal thought of the period limitation of interest represented restriction, and the use of public funds stood for state monopoly. Thus, it was thought, trade would be prevented from finding its own level through the operation of free competition. The armies of revolutionary France carried this doctrine into practice wherever they went. Not only was complete freedom of trade in pawnbroking introduced in France, but in Italy and the Spanish Netherlands Napoleon confiscated as enemy property both the capital and the stock of pledges found in public pawnshops. However, France itself in 1804, and most of the other states as soon as they had freed themselves from French domination, reverted to a system of public pawnshops, having found complete freedom in this business harmful to debtors. The only state which made an attempt at a later date to reintroduce unrestricted pawnbroking, subject neither to licence nor limitation of interest rates, was Prussia where this system prevailed from 1869 to 1879.

At mid-20th century the public pawnshop predominated in the majority of countries on the European continent, sometimes alone, sometimes side by side with private pawnbrokers. A typical example was the Paris Municipal pawnshop, an establishment with

4 main and 22 subsidiary offices, employing a staff appointed by the state from candidates proposed by the municipality. Working capital was obtained through deposits, for which interest was paid at rates varying from 1% to 3%. Its profits, like those of other French municipal pawnshops, were applied to charitable purposes. On a similar scale was the Vienna Municipal pawnshop (known as the Dorotheum), which acquired 18 branches all over Austria by absorbing a large number of other Austrian municipal pawnshops unable in the 20th century to continue on their own.

MODERN CONDITIONS AND REGULATIONS

In a public pawnshop the problem arises how, in the absence of a profit motive, the institution is to be safeguarded against losses arising from overvaluing of pledges or default by borrowers. The modern solution is usually an appraisal of articles offered as pawns by assessors acting under oath; in some countries, assessors are held personally liable for any difference which arises between the valuation price and the proceeds of an eventual sale by public auction. This practice leads to deliberate undervaluation by assessors anxious to avert compensation claims. The loans granted may not exceed 75% to 80% of the assessed value plus the interest expected to accrue.

Europe.—Modern developments provided pawnshops with new tasks, and many institutions adapted their business methods to new requirements. The Monti di Pietà in Rome and Milan established physical laboratories, using the most modern techniques of radiography and microphotography, for determining and certifying the precious metal content of plate and other articles, whether submitted as pledges or merely to provide owners with an authoritative statement of their value. French municipal pawnshops accepted in pawn new merchandise which could be sold after three months if the borrower made a special request to this effect. From 1891 onward the Paris Municipal pawnshop accepted as pledges recognized stocks and bonds (as did the State Loan office in Berlin at most times in the 20th century) and after 1918 motorcars, with the result that its premises had to be expanded to include a huge garage. So reasonable are the charges of the Paris establishment that many well-to-do people prefer pawning their silver when leaving town for the summer to hiring the necessary space in a safe deposit. The practice of depositing valuables with the pawnbroker for this purpose is also known in Great Britain.

Great Britain.—In English-speaking countries exclusively, and in many other countries at least to some extent, pawnbroking is carried on by private individuals as a trade licensed and supervised by the authorities. The nature of this trade and the basis on which it operates may be treated in terms of the kind of goods that are pawned, the type of customer it attracts and the typical size of loan that is made.

In Great Britain between 60% and 75% of the number of pawnshops are engaged in the industrial trade; *i.e.*, three-quarters or more of their lending is advanced on "napery and drapery." The characteristic loan, in common with other prices, became higher in nominal terms after World War II. It did not, however, often exceed £2 and the characteristic sum was in the range of 10*s.* to 15*s.* In the city trade the situation is very different and the average loan much higher. The industrial pawnbroker makes some loans on jewelry, usually of relatively low value, and on a wide range of personal effects. There are also pawnbrokers who engage in a mixed trade, with a substantial proportion of pawnbroking of the nonindustrial kind.

Historically, the person who was the backbone of profitability in industrial pawnbroking in Great Britain was the habitual borrower. The basis of the trade in its heyday, from about the middle of the 19th century until 1913–14, consisted of a very large volume of pledging, backed by a very high rate of redemption and turnover. It is still typical of this trade, although on a reduced scale, that the regular pawner should bring in goods on Monday and Tuesday and redeem them on Friday or Saturday. Many articles which are eventually redeemed remain in pledge for considerably longer periods, but there is a large substratum of weekly trade. At the beginning of the week funds are raised; at the end of the week, when wages are received, goods are redeemed. There are also seasonal fluctuations; a great deal of clothing, for example, is redeemed just before bank holidays and pawned again after them. Investigations of German pawnbroking revealed a similar weekly periodicity with increases in business activity during the summer holiday season, just before quarter days and after holidays. Much pledging takes place at the time of the year when families stock up with fruit, potatoes and coal, whereas the beginning of wintry weather serves as a signal for much redemption of wearing apparel.

The fundamental attractions of pawning as a means of borrowing money, apart from any consideration as to the rates of interest which may be charged, are that sums may be raised on personal effects which might be less suitable as security in other forms of borrowing, and that these may be constantly "turned over" without final sacrifice of the article. The charges allowed to be imposed are limited in Great Britain by statutory regulation, namely, the acts of 1872 and 1922. The latter introduced only a quite minor modification in permitted charges.

No pawnbroker in Great Britain, however, confines himself to the business of pawnbroking strictly defined. There is always a section of his activity which is concerned with straightforward retail trade. This, in turn, tends to be of different types. Part of it consists in the sale of secondhand articles represented by forfeited pledges from the same pawnshop or bought at public auction of forfeits. Some will be the sale of new goods. In the industrial trade these are usually clothing and rather cheap personal effects; in the city and mixed trades, there is jewelry and a heterogeneous collection ranging from umbrellas to binoculars. In many cases the pawnbroker's retail interests developed independently and extensively so that the pawnbroking establishment became a minor appendage of the business as a whole. Indeed, the two sections have become entirely separated in some cases.

Since the charges which a pawnbroker may make are regulated, the absolute amount of his gross profit is determined by the volume of lending. This will be governed by the average size of the loan and the rate of turnover of monies lent; *i.e.*, the rate at which goods are redeemed. This involves the related point of the profit or loss which may accrue on articles sold after forfeiture. It is precisely because charges and average loans in the industrial trade, taken together, yield small absolute profits, particularly with charges remaining fixed in a world of rising money incomes and prices, that the basis of high profits would have to be a large volume of pledging coupled with a high rate of redemption of goods. The Hamburg, Ger., pawnshop, a municipal institution, investigated over a period the actual rate of redemption of all pledges received. It discovered that between 70% and 80% of all pawns were redeemed within the statutory time, though many not by the original borrowers but by purchasers of pawn tickets. For 15% to 20% of the pledges, an extension of the contract was arranged by mutual agreement. Less than 4% of the total stock of pawns was forfeited and subsequently sold by the pawnshop.

Regulation.—Pawnbroking has been among the most stringently regulated of trades. This regulation has rarely been completely abandoned, even when the general climate of the economy has been freest from the atmosphere of restriction. Apart from the influence of general policies, special reasons have been adduced for controlling this particular trade. Licensing and control of pawnbroking owe their origin to the desire to legislate against usury as such, to the fear that the pawnbroker might be a receiver of stolen goods and to an attempt to control interest rates in a sector where the customer was thought to be peculiarly susceptible to exploitation by virtue of his ignorance and poverty. Pawnbrokers themselves were acutely interested in regulation of the trade, both as regards reform of the hostile provisions included in the acts relating to it in Great Britain until 1872, and also perhaps in order to prevent the trade from being associated by public opinion with the dolly shop and similar institutions.

The national and local associations of pawnbrokers in the 19th century engaged in vigorous campaigns to gain support for legislation more favourable to their trade. It is interesting to note, however, that there was a division of opinion among pawnbrokers

between those who favoured freedom of trade and those who adhered to the view that regulation of charges was advisable. Changing economic conditions induced pawnbrokers to seek authority to make higher charges than those permitted by the act of 1872. A relatively small additional charge was authorized by an act of 1922. There was a good deal of discussion in the trade about the advisability of seeking further changes in the law relating to charges, particularly among industrial pawnbrokers.

Some amendments to the principal act of 1872 were in fact introduced by the Pawnbrokers Act of 1960 dealing with both loans and charges. The key figures for permitted loans under section 10 of the act of 1872 were 40*s*. and £10. These were amended by the new act to £5 and £50 respectively. These increased figures apply not only to loans but also to other sections of the 1872 act, such as section 6 (designed to prevent evasion), section 24 (dealing with special contracts) and part I of the 4th schedule, regulating pawnbrokers' profits. These were various provisions in the act of 1872 relating to forfeiture of pledges not redeemed in time, depending upon whether the loans were over or under 10*s*. This figure has been increased to 40*s*. The charges allowed to a pawnbroker for a pawn ticket, a valuation fee, inspection of an entry of sale in the sale book and for a declaration were also increased, but the sums involved were minimal and almost nominal.

The number of pawnshops in England and Wales was about 650 at the beginning of the 19th century. In 1848–49 there were 1,837 in Great Britain (England, Scotland and Wales). These figures exclude very substantial numbers of unlicensed establishments. The number of licences issued in 1913–14 (one per pawnshop) was 5,087, but a steady decline followed. The major decline was in the industrial trade; pawnbroking with a substantial element of city trade fared quite differently. Indeed, the characteristic features of the trade in the years since the 1920s have been the growth in relative importance of straightforward retailing and the fall in the share of industrial pawnbroking in the trade as a whole. The volume of pledge trade has fallen much more than the money value of pledges. The latter has been cushioned by rises in the amount of individual loans. Nevertheless, both volume and value are very much smaller than in, say, the 40 years preceding World War I. The decrease in the importance of pawnbroking in Great Britain is attributable to changes in both demand and supply conditions.

Demand Conditions.—Certain types of social policy helped to reduce the demand for loans by mitigating the effects of temporary interruption of earning power. Old-age pensions have probably been relatively unimportant because many of the recipients had few articles to pawn and little means of redeeming them. Family allowances, since they enabled beneficiaries to carry on until payday, are more likely to be significant. Slum clearing which removed former borrowers some distance from the pawnshop impaired the appeal of convenience and at least reduced the frequency of their visits to the pawnshop. Full employment and high wages, enabling young people to grow up in an environment removed from memories of unemployment, helped to break the traditional connection between the pawnshop and the poor.

Multiple (chain) stores selling relatively cheap clothing and other consumer goods may have further reduced demand for loans by enlarging opportunities for the easy acquisition of durable and semidurable consumer goods. Installment buying may have contributed further, although credit trading of various kinds was known long before the decline set in. There has been a change in consumer attitude, expressed in a strong disinclination to become involved in traditional modes of living by habitual pawning.

Supply Conditions.—Pawnbroking in the smaller industrial establishments is an arduous occupation. A suitable staff is hard to obtain, the more so because the trade is unpopular. All expenses have risen, while interest charges are held at the old levels. Returns do not compare favourably with what might be earned in straightforward retailing.

Since the trade attracts practically no new recruits, retirement or death of a pawnbroker usually means the disappearance of a pawnshop. Some pawnbrokers allow their pledge business to lapse and concentrate wholly on pure retailing; sometimes individual branches of multiple pawnshops close down. Some pawnbrokers persevere, however, from habit and attachment or because they are too old to move from what may be a fairly comfortable living. This tendency is strengthened by the fact that they might find it extremely difficult to dispose of their rather specific assets for an acceptable sum. (A. L. M.; W. M. Sn.; X.)

United States.—Although pledge borrowing existed earlier, pawnbroking became a recognized business in the United States during the 18th century and increased thereafter. New York city had 10 pawnbrokers in 1819, Boston more than 50 in 1859, Minneapolis 25 in 1893. Pawnshops probably reached a maximum by 1914 when they were the main source of consumer credit.

Pawnbrokers were regulated by states and municipalities practically from the beginning. New York in 1803 became the first state to authorize the licensing of pawnbrokers, while Pennsylvania in 1823 instituted general statutory regulation. State laws varied widely; some contained detailed provisions while others merely authorized municipal regulation. City ordinances required annual licences and fees of pawnbrokers, and frequently also required bonding. Ordinances often set maximum interest rates, forbade or limited other charges, fixed loan and redemption periods and required auction sale of unredeemed pledges and return of any surplus to pledgers. The police were to receive regular reports upon goods pledged.

Public and charitable pawnshops were proposed but were never established in the United States. Semicharitable lending agencies were created to make low-cost consumer loans on pledges, chattel mortgages, or both. These were the so-called remedial loan societies, organized as limited-dividend corporations. The first was the Collateral Loan Company of Boston, founded in 1859 as the Pawner's Bank. The largest was the Provident Loan Society of New York. Established in 1894, it developed numerous branch offices, charged 1% interest per month and became the world's largest pawnshop. By the 1930s it made more than 500,000 pledge loans each year, and in the 1950s it did over one-half of New York city's pawnbroking business. There were 38 "remedials" in 1915 and 27 in 1932, several having been abandoned but none organized after 1917. The Russell Sage foundation's Department of Remedial Loans, created in 1909, promoted remedials, cooperative credit unions and the enactment of small-loan legislation. Many states enacted its "uniform small-loan law," initially drafted in 1916, to encourage the commercial small-loan business.

"Remedials" and private pawnshops were overshadowed during the ensuing revolution in consumer credit. The new small-loan giants were sales finance companies, personal loan departments of commercial banks and private finance companies. Industrial banks, credit unions, credit jewelers, second-hand dealers and unlicensed "loan sharks" offered further competition to pawnbrokers. After 1945 discount houses cut into pawnbrokers' loan and sales departments, forcing lower loan valuations on pledges and lower prices in their retail trade. Pawnbroking declined rapidly after 1945; several cities lost one-third of their pawnshops within ten years. Many closed when their proprietors retired or died; others accentuated the retailing aspect of their business, or shifted entirely to retailing. New consumer credit agencies, discount houses, rising personal incomes, increased public-welfare measures and changed attitudes toward "hock shops" caused a rapid decline of pawnbroking.

See also Moneylending. (F. G. H.)

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PAWNEE, an Indian tribe on the Platte River, Nebraska, from before the 16th to the latter part of the 19th century. They

spoke a language of the Caddoan stock, and lived by farming and hunting, raising corn, squash, and beans, and hunting grazing animals, principally the bison. In their permanent villages they lived in large earth-covered lodges, but on bison hunts they used skin tepees. For hunting, travel, and transport they used horses first obtained in the 17th and 18th centuries from Spanish settlements in the southwest. In the 19th century the Pawnee tribe was composed of relatively independent bands—the Kitkehahki, Chaui, Pitahauerat, and Skidi—each divided into more or less endogamous villages with hereditary chiefs and priests. They had a Crow (lineage) type of kinship system, matrilineal descent and matrilocal residence after marriage, which was contracted for a given couple by their maternal uncles. Class distinctions favoured chiefs, priests, and shamans. The Pawnee religion was elaborate, including star symbolism and human captive sacrifice. Pawnee culture was broken by the start of the 20th century and the population reduced from about 10,000 to about 600. There were about 670 Pawnee reported living on or near their Oklahoma reservation in the 1960s.

See G. B. Grinnell, *Pawnee Hero Stories and Folk Tales* (1963), *Pawnee, Blackfoot and Cheyenne* (1961). (G. I. Qv.)

PAWPAW (*Asimina triloba*), a North American shrub or low tree of the custard apple family (Annonaceae), native from western New York to Nebraska and southward to Florida and Texas. The West Indian pawpaw is the papaya (*q.v.*). On rich alluvial soil the pawpaw grows from 10 to 50 ft. high, with large leaves, sometimes 12 in. long and 6 in. wide, and brown to dark red flowers 1 to 2 in. across. The fleshy fruits, two to five inches long, mature in autumn. Those with orange-coloured pulp are edible and possess a flavour reminiscent of the banana, while in contrast the pale white or yellowish pulps are usually bitter and unpalatable. These two types of fruit are known to legions of American boys who seek the edible forms each fall, yet no botanical distinction between the plants bearing them is made by taxonomists.

PAWTUCKET, a city of Providence County, Rhode Island, U.S., on the Blackstone River (known there as the Pawtucket or the Seekonk), is 4 mi. N of Providence and adjoins Central Falls. Pop. (1960) 81,001; Providence-Pawtucket standard metropolitan statistical area (as enlarged in 1963; *see* PROVIDENCE) 821,101.

The city lies on both sides of the river, which in the heart of the business district makes a picturesque plunge of 50 ft. over a mass of rocks. The name, Pawtucket, is an Indian word meaning "fall of the waters." At one time the river provided power for textile mills. Textiles have been the leading manufactured product for over a century. Almost every branch of the narrow fabric textile industry is represented. There are also plants for dyeing, finishing, and spinning. Other manufactures include wire and cable products, machine tools, and textile machinery.

The river was continuously improved by the federal government after 1867; there is a 16-ft. channel all the way to Narragansett Bay. A six-lane highway bridge over the river at Pawtucket was completed in 1958.

The first settlement within the present city limits was made on the west side of the river about 1671 by Joseph Jencks, an ironworker. His manufactory, destroyed in 1676 during King Philip's War, was rebuilt and soon the village became a centre for skilled and inventive ironmongers. In 1790, Samuel Slater found there the mechanical skill and financial support necessary to reproduce the Arkwright machinery for the manufacture of cotton goods. His mill, the first successful factory of its kind in the United States, was preserved as a memorial to the introduction of cotton textile manufacture.

The part of Pawtucket east of the river was originally in Massachusetts and was transferred to Rhode Island in 1862; the section west of the river was annexed to Pawtucket from North Providence in 1874; and in 1885 the town was chartered as a city. For comparative population figures *see* table in RHODE ISLAND: *Population.* (G. H. Bs.)

PAX, Roman personification of peace, probably recognized as a deity for the first time by Augustus, in whose reign much was made of the establishment of political calm. An altar of Pax Augusta was dedicated in 9 B.C. and a great temple of Pax completed by Vespasian in A.D. 75 (Platner-Ashby, *Topographical Dictionary*, s.v. *Pax, Ara Pacis*). (R. B. Ld.)

PAXOS (PAXOÍ), one of the Ionian Islands (*q.v.*) of Greece, about 8 mi. S of the south end of Corfu (Kérkira), is a hilly mass of limestone 5 mi. long by 2 mi. broad, and not more than 800 ft. high. Pop. (1961) 2,599. It produces excellent olive oil. Paxoí (formerly Gáïos), the principal village, lies on the east coast and has a small harbour. Toward the centre, on an eminence, stands Papándi, the residence of the bishop, and there are many churches with picturesque belfries. On the west and southwest coasts are remarkable caverns. Ancient writers apply the plural form Paxi to Paxos and the smaller island now known as Antipaxos or Andípaxoi (Propaxos of the *Antonine Itinerary*). Paxos is the scene of the legend, in Plutarch's *De defectu oraculorum* ("On the Cessation of Oracles"), of the cry "Pan is dead." *See* PAN. (W. G. F.)

PAXTON, SIR JOSEPH (1801–1865), English landscape gardener and designer of hothouses, turned architect when he designed the Crystal Palace which housed the Great Exhibition of 1851 in Hyde Park, London. Born near Woburn, Bedfordshire, on Aug. 3, 1801, he was originally a gardener employed by the duke of Devonshire and rose to be his friend, factotum, and adviser. From 1826 he was superintendent of the gardens at Chatsworth (*q.v.*), the duke's Derbyshire estate, and built for him in iron and glass the famous conservatory there (1837–40) and the lily house for the duke's rare Victoria Regia (1850). In the same year, when a cumbersome design (chosen from among many by professional architects) had already been officially accepted by the exhibition's organizers, Paxton's inspired plan for a building of prefabricated elements of sheet glass and iron was substituted. Covering four times the area of St. Peter's, Rome, the grandeur of its conception was a challenge to mid-19th-century technology. Built within six months, it was at once recognized as marking a revolution in style. In 1854 its components were moved to Sydenham where they remained (re-erected in a different form from the original) until accidentally destroyed by fire in 1936. Paxton was member of parliament for Coventry from 1854 until his death at Sydenham on June 8, 1865.

See Violet R. Markham, *Paxton and the Bachelor Duke* (1935).

PAYA, a tribe of Indians living in northeastern Honduras (*q.v.*), numbering fewer than 600 in the 1960s and dwindling rapidly. The linguistic relationship of the Paya is judged by some authorities to be Chibchan (*q.v.*). They practise slash-and-burn agriculture to raise manioc, maize, and pineapple. Some Paya subgroups are reported to allow polygyny. *See* also MIDDLE AMERICA: *Lower Central America.*

See P. Kirchhoff, "The Caribbean Lowland Tribes: the Mosquito, Sumo, Paya, and Jicaque," in J. H. Steward (ed.), *Handbook of South American Indians,* vol. 4 (1948).

PA-YI (PAI-YI, P'O-YI, PAI-I, PAVI), an ethnic group that is part of the greater Thai cultural group (*see* THAI PEOPLES). The Pa-yi inhabit the hot river valleys of southwest Yünnan Province in China. Having a preference for wet-rice culture, which does best in valleys near streams (*see* CHUANG), they spread southward from their cultural centres in Szechwan and the Yangtze Valley two millennia ago, following the southern tributaries of the Yangtze River into the Yünnan Lake basins. Under subsequent pressure of the Han Chinese (*see* CHINA: *The People*) the Pa-yi moved farther southwest into the river basins of the China-Burma frontier region. Those that settled across the border in the Shan plateau are called the Shan (*q.v.*) tribes of Burma. Uncomfortable climate, malaria, and primitive living conditions long discouraged the Han Chinese from settling in Pa-yi territory. Thus, although the Pa-yi in Yünnan were compelled to acknowledge Chinese suzerainty, largely they were left to the rule of their own hereditary local chieftains. Many of these petty despots retained virtual autonomy in local affairs until after the Communist conquest of mainland China. Following this the Pa-yi were organized into a Thai Autonomous District (population about 470,000 in the 1960s) by the Communist regime. The social and economic systems of the Pa-yi also changed to conform with Communist ideology.

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(1954); H. Chen, *Frontier Land Systems in Southernmost China* (1949); C. Hu *et al.*, *China* (1960). (H. J. Ws.)

PAYMENT is the performance of an obligation to pay money. A person under such an obligation is called a debtor and a person to whom the obligation is owed is called a creditor. The obligation may arise in various ways, but most commonly as the result of a contract between the parties. In law, in order that payment may extinguish the obligation, it is necessary that it be made at a proper time and place, in a proper manner, and by and to a proper person.

England and Wales.—Payment may be made at any time of the day on which it falls due, except in the case of mercantile contracts, where payment must be made during the usual hours of mercantile business. In the absence of any agreement as to the place of payment, it is the duty of the debtor to take reasonable steps to seek out his creditor and to pay him the money, provided that the creditor is in England. A debtor is not, without agreement, entitled to any notice or demand from his creditor.

Payment must be made in lawful money, frequently referred to as legal tender. Gold is legal tender up to any amount, as are Bank of England notes. Silver or cupronickel is legal tender up to 40 shillings' worth and bronze up to one shilling's worth. A debtor has no right to demand change. The parties may, however, agree that payment shall be made in some other way; for example, by bill of exchange, by promissory note, or by check (all of which are commonly called negotiable instruments). Where payment is made by negotiable instrument, the general rule is that the acceptance of such instrument by the creditor operates only as a conditional payment. This means that if the instrument is subsequently dishonoured the debt revives, and the creditor may sue either on the instrument or on the original debt. The parties may however agree that acceptance of a negotiable instrument shall operate as an absolute payment, in which case, if the instrument is dishonoured, the creditor may sue on the instrument but not on the original debt. A payment may be made by the mere transfer of figures in an account without any money changing hands. If goods are accepted in satisfaction of a debt this constitutes payment.

When a debtor makes payment by post, and the money or instrument is lost in the post without fault on the part of the debtor, the debtor will have to bear the loss; unless the creditor directed payment by post, or unless payment by post was the usual way of business between the parties, in which cases the loss will be on the creditor. Payment may be made by a debtor personally or by a duly authorized agent on his behalf. Similarly, payment may be made to the creditor personally or to an agent of the creditor, provided that such agent has authority to receive payment. The general rule is that payment of a debt cannot be enforced after a lapse of six years.

A common way of proving payment is by the production of a signed receipt. But payment can be proved in other ways and, conversely, production of a receipt is not conclusive evidence of payment. The payee of money is liable to a penalty if, in any case where a receipt would be liable to duty, he refuses to give a receipt duly stamped and canceled.

Money paid under a mistake of fact can be recovered, but not money paid under a mistake of law.

(For appropriation of payments, *see* DEBTOR AND CREDITOR LAW. *See* also LIMITATION, STATUTES OF.)

Scotland.—The law of Scotland is substantially the same as that of England, differing therefrom only in the following respects. Bank notes issued by a bank of issue in Scotland are legal tender to any amount. The general rule is that payment of a debt cannot be enforced after 20 years, and it may be that money paid under a mistake of law is as much recoverable as money paid under a mistake of fact. The main point of difference between the two systems, however, is that in Scotland there are special rules relating to the manner in which a debt may be proved; and, in particular, there is a rule that if a document of debt is in the hands of the debtor there is a presumption that the debt has been paid.

United States.—In the United States the position is much the same as in the United Kingdom. The duty of the debtor to seek out his creditor obliges him to search only in the creditor's state of residence. If the creditor cannot be found therein there is no obligation upon the debtor to look further. In a few states money paid under a mistake of law can, in some circumstances, be recovered. The question of legal tender has been an important one in U.S. history. In 1862 and 1863 Congress passed acts making treasury notes legal tender (*see* GREENBACKS). After much litigation the Supreme Court decided in 1871 in favour of the constitutionality of these acts. These notes were held to be legal tender for all purposes except duties on imports and interest on the public debt. In 1933 all coins and currencies of the United States were made legal tender for all debts, public and private (including import duties and interest on the public debt). By the Constitution of the United States, "No State shall . . . make any Thing but gold and silver Coin a Tender in Payment of Debts" (Art. I, sec. 10). The law relating to limitation is complex and varies from state to state. (H. W. B.)

PAYNE, JOHN HOWARD (1791–1852), U.S. playwright and actor, one of the most notable of the school of American playwrights that followed the techniques and themes of the European romantic blank verse dramatists, was born in New York City, June 9, 1791. A precocious actor and writer, he wrote his first play, *Julia, or, The Wanderer*, when he was 15. The play was successful enough to cause him to be sent to Union College, Schenectady, N.Y., but family financial difficulties made it necessary for him to leave two years later. At the age of 18 he made his first stage appearance in the play traditional for such debuts, John Home's *Douglas*. Although his portrayal of Young Norval was successful, Payne encountered much opposition from established actors—chiefly George Frederick Cooke, a brilliant but eccentric star—and in 1813, at the height of the War of 1812, Payne sailed for England. At first interned as an enemy national, he was later released and triumphed at Drury Lane as Young Norval, repeating his success in other European capitals. In Paris, Payne met two men who were to have an important influence on his career: the actor Talma, who introduced him to French drama, from which many of his more than 60 plays were adapted; and Washington Irving, with whom he was to collaborate on two of his best plays.

Payne's finest play, *Brutus; or, The Fall of Tarquin*, was produced at Drury Lane on Dec. 3, 1818. Although Payne received only £183 for it, *Brutus* was on the boards for 70 years and served as a vehicle for three of the greatest tragedians of the 19th century: Edwin Booth, Edwin Forrest, and Edmund Kean. Other important plays were *Clari: or, The Maid of Milan*, which included Payne's famous song "Home, Sweet Home"; *Charles II* (1824), written with Irving; and *Thérèse* (1821), a French adaptation. Because of weak copyright laws, Payne received little return from his successful plays, and in 1842 he accepted a consular post in Tunis, where he died, April 9, 1852.

Although Payne was no innovator, his plays were strong, both in language and structure, and he exerted an important influence on later playwrights. Arthur Hobson Quinn suggests that *Brutus* may have been partially responsible for the emergence of the romantic drama in France under Hugo. (S. W. H.)

PAYNE, PETER (*c.* 1380–1456), English Lollard and Hussite diplomat who rendered great service to the Bohemian Hussite movement. Born at Hough near Grantham, he was a master of arts at Oxford by 1406, where he was principal of St. Edmund Hall during 1410–12, at about which time he joined the Lollard movement.

The Lollard Sir John Oldcastle's fall from power forced Payne, in 1413, to flee to Bohemia, where by 1415 he was defending Utraquism beside Jakoubek of Stribro. Huss's successor (*see* HUSSITES). During the subsequent revolution he was a leading figure in the consistory which governed the Hussite Church and was entrusted with several important missions. In 1420 he accompanied the Prague mission to the Polish court, and, respected alike by both the Taborite and "Orphan" Hussite sects, he was able to speak for the whole Hussite movement before King Sigismund at Bratislava in 1429, when he splendidly defended the Hussite program, the "Four Articles of Prague." After returning to Poland in 1431 he also gave notable service at the Council of

Basel in 1433, when he was entrusted with the defense of the expropriation of church property. Taken prisoner at the Battle of Lipany in 1434, he was soon freed, and took further part in the peace negotiations in the provincial Diet, but was expelled from Prague shortly after the signing of the peace and the return of Sigismund. He was arrested and imprisoned for two years by his enemies, but was ransomed by his friends from Tabor.

When negotiations began in 1441 for the unification of the Hussite Church under the elected archbishop, Jan Rokycana, Payne worked hard but unavailingly for agreement between Rokycana and the Taborites. Returning in 1448 to Prague, where the Rokycana Party was now established, he lived there till 1456, in the Na Slovanech monastery. Though he remained a foreigner in Prague, and never learned Czech, Payne gave the Hussites invaluable service both as diplomat and as theologian, and is gratefully remembered in the country of his exile.

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PAYSANDÚ, a department of western Uruguay, bordering the Uruguay River. Although the riverside and hinterland areas of Paysandú were developing agriculturally in the second half of the 20th century, ranching continued to be the department's major activity. Cattle and sheep are raised, and agricultural products include flax, wheat, sunflower seeds, corn, and forage crops. Surrounding farms supply vegetables and poultry to the departmental capital, Paysandú (*q.v.*). Several foreign agricultural colonies were notably successful, especially in southwest Paysandú. Area of the department 5,474 sq.mi. (17,959 sq.km.); pop. (1962 est.) 103,111. (M. I. V.)

PAYSANDÚ, a city and port of western Uruguay on the Uruguay River, is 300 mi. NW of Montevideo. Capital of the department of Paysandú (*q.v.*), it disputed with its rival to the north, Salto, the claim of being Uruguay's second largest city. One advantage of Paysandú (pop. [1962 est.] 56,080) over Salto, also a river port, is that oceangoing ships must transfer cargo at Paysandú to smaller craft because farther north the Uruguay River becomes too shallow for the draft of the larger vessels. Cereals, flax, and livestock products are loaded and merchandise for northwest Uruguay is unloaded at the port of Paysandú; it is built at various levels so that ships can dock despite changes in the level of the river. There are rail, road, and air connections to the north and southwest to Montevideo.

Paysandú has a relatively varied industrial economy with tanneries, textile factories, flour mills, distilleries, and breweries processing regionally produced raw materials. In the second half of the 20th century, modern buildings were changing Paysandú's once provincial aspect.

The city was founded in 1772 by Father Policarpo Sandú and 12 families of Christianized Indians. Indians translated the Spanish word *padre* ("father") into the Guarani Indian dialect word *pay*, from which stems the city's name. (M. I. V.)

PAZ ESTENSSORO, VÍCTOR (1907–), founder and principal leader of the Bolivian political party Movimiento Nacionalista Revolucionario (MNR), served as president of Bolivia from 1952 to 1956 and again after 1960. His administration marked the beginning of a process of revolutionary change in Bolivia's social, economic, and political structure.

Paz Estenssoro was born in Tarija in 1907. He obtained a university education, served in the army during the Chaco War with Paraguay (1932–35) and after the war became professor of economics at the University of San Andrés in La Paz. He was economic adviser to Pres. Germán Busch (1937–39) and in 1939 was elected to the Chamber of Deputies.

In 1941 Paz Estenssoro and others established the MNR, a left-wing nationalist party that sought to advance the interests of the Indians. After the party seized power in 1952 Paz Estenssoro became president. During his administration the right to vote was extended to the Indians, and the three largest tin companies were expropriated by the government. Most fundamental of all, an agrarian reform law began the process of transferring the arable land of the central plateau to the Indians.

During the administration of Hernán Siles Zuazo (1956–60) Paz Estenssoro served as ambassador to the United Kingdom. He again became the MNR candidate for president in 1960 and won a decisive victory. During his second administration his government reached an agreement with the U.S. government, the Inter-American Development Bank, and West German industrialists, providing for a reorganization of the tin-mining industry. He also stressed a program to stimulate colonization of eastern Bolivia by Indians from the highlands.

Over the protests of the opposition parties and some leaders of the MNR, Paz Estenssoro again ran for president in 1964. All other parties withdrew their candidates and urged the voters to boycott the election. About 70% of the eligible voters cast their ballots for Paz Estenssoro. Nevertheless, he was overthrown by a military *coup d'état*, headed by Vice President René Barrientos Ortuño in early November 1964 and went into exile in Peru.

(R. J. A.)

PAZ SOLDÁN, MARIANO FELIPE (1821–1886), Peruvian historian and geographer, was born at Arequipa, on Aug. 22, 1821. He studied law, and after holding some minor judicial offices, was minister to New Granada in 1853. In 1860 Castilla made him director of public works. In 1861 he published his great atlas of the republic of Peru, and in 1868 the first volume of his history of Peru after the acquisition of its independence. A second volume followed, and a third, bringing the history down to 1839, was published after his death by his son. In 1870 he was minister of justice and worship under President Balta, but shortly afterward retired from public life to devote himself to his great geographical dictionary of Peru, which was published in 1877. During the disastrous war with Chile he sought refuge at Buenos Aires, where he was made professor in the National College, and where he wrote and published a history of the war, *Historia de la Guerra del Pacifico* (1884).

He died at Lima on Dec. 31, 1886.

PEA, the common name for several species of herbaceous annuals of the family Leguminosae, grown for their edible seeds, borne in pods, or legumes. The favourite market and garden pea in North America, Europe, and parts of Asia is a variety of *Pisum sativum*. As is true of most food plants, the origin of the pea is prehistoric. It appears to have originated in Middle Asia, with secondary centres in the Near East, in Ethiopia, and in Mediterranean lands. Remains of the seeds have been found on the sites of Swiss lake-dwellings of the Bronze Age, dating back perhaps 5,000 years. The two main varieties of *P. sativum* are *humile* (or *hortense*), the choice dwarf garden pea (about two feet tall), and *arvense*, the taller (up to six feet) field pea. The dwarf pea, in its many horticultural forms, is widely grown for food; the field pea is grown chiefly for dried peas, forage, and green manure.

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GARDEN PEAS (PISUM SATIVUM)

The stems of the pea plant are hollow, and trailing or climbing. Leaves are pinnately compound, ending in tendrils that enable the plant to climb, and with large leafy stipules at their bases. The flowers are papilionaceous, or butterflylike, white or purple, about one inch across; each has nine united stamens and one free stamen; the single pistil has a bearded style. Flowers are self-pollinated, and nectar is secreted at the base of the stamens. The fruit is a characteristic legume, a one-celled, many-seeded pod, 2½–5 in. long, which splits into halves when ripe; the five to ten seeds are attached by short stalks to the halves of the pod. The seeds are more or less globular and smooth, dimpled, or wrinkled. Ripe seeds of white-flowered forms are cream, yellow, or light green; in purple-flowered forms they

are brown, gray, or flecked with dark colour. The cotyledons are large and roughly hemispherical. Upon germination and emergence of the seedling the cotyledons remain below the soil surface.

Some varieties, called sugar peas, produce pods that are edible; before the seeds enlarge appreciably the flat pods are tender, succulent, and sweet. This type of pea is popular in the Orient. Wrinkled seeded varieties are usually sweeter than smooth and dimpled varieties because they contain more sugar and less starch. Split peas for soup consist of only the cotyledons of smooth peas harvested mature dry.

The garden and field peas will tolerate a considerable range of climatic conditions but do not grow well in hot climates. Peas can be grown in the lower latitudes (such as the southern United States) only as late fall, winter, or early spring crops. The plants will tolerate some frost but not hard freezing.

Spring sowings in the United States are normally made about a month to six weeks before the average date of the last freeze and are finished before the frost-free date. Peas grow on a wide range of soils, but the soil preferably should be rich, well drained, well limed, well prepared and kept free of weeds. Inoculation of the seed with pure cultures of nitrogen-fixing bacteria is a generally profitable and common practice in certain parts of the U.S. and in northern Europe but is not normally necessary in Britain. In many pea-growing districts of the United States the soils have become so infested with a wilt fungus that only wilt-resistant varieties can be grown successfully. Under good farming practice, peas are not grown on the same land more than once in four years. In Great Britain early peas can be grown from November onward through the winter, but such methods are not used in America, where fall and winter sowings are made far enough south so that hard freezing rarely occurs.

For home garden and marketing fresh, either dwarf or tall-vined, large-podded sorts are sown in rows two to four feet apart, depending on the variety. One to two bushels of seed per acre are sown. When grown for home or fresh market, the tall varieties are usually supported on twigs or brush, or on light trellises of twine, but this is not done for a large commercial planting. Peas for canning or freezing are sown in rows six or seven inches apart, at the rate of about four bushels of seed per acre. Since they are not cultivated or hoed, the soil must be thoroughly prepared and comparatively free from weeds. These peas are sown with a grain drill and harvested with a mowing machine or special pea harvester, and the entire plants are then passed through a "viner"—a machine that removes the peas from the pods and separates them from all leaves and debris. The shelled peas are hauled to the processing plant and canned or frozen within a few hours. Field or harvest peas are for use dry and are also sown in rows six or seven inches apart. The entire plants are harvested before the seeds shatter from the dry pods, and they are allowed to dry in small shocks or windrows in the field; then threshed and cleaned —all by machinery.

The genus *Pisum* is very closely related to *Lathyrus*, which is distinguished botanically from *Pisum* by its flattened rather than tubular style. It is therefore not surprising that some species of *Lathyrus* are called peas. The fragrant ornamental sweet pea is *L. odoratus* and the Tangier pea is *L. tingitanus*. Many other legumes that are less closely related to *Pisum* also are called peas of various kinds, among them: the chick-pea, *garbanzo* or Spanish pea (*Cicer arietinum*), the cowpea (*Vigna sinensis; see* BEAN), and pigeon pea (*Cajanus indicus*).

Production.—In the United States, peas are no longer grown extensively for marketing in the pod because of the high cost of harvest by hand and competition from the quick-frozen and canned products. Dry peas and canned peas each account for over 35% of the acreage, while frozen peas account for over 20%. In Great Britain the acreage of peas marketed in the pod has rapidly declined and the acreage of peas harvested dry for processing is falling sharply. The growing acreage of peas raised for frozen-food manufacturers surpasses that for podded peas, though canned garden and canned process peas together account for the largest share of the pea market. In northern Europe canned garden peas, particularly the "petit pois" type, are the most popular, but quick-frozen peas are becoming more available. In southern Europe, peas are still widely grown for marketing in the pod. Green peas for processing, both canned and quick-frozen, are also grown in Australia and New Zealand. (V. R. B.; J. W. Bu.)

PEABODY, ELIZABETH PALMER (1804–1894), U.S. educationist and participant in the Transcendental movement, was born at Billerica, Mass., on May 16, 1804. Educated at a small private school by her gifted mother, as were her sisters Sophia (Mrs. Nathaniel Hawthorne) and Mary (Mrs. Horace Mann), she began her own teaching at 16. Later she was an assistant in A. Bronson Alcott's famous Temple School, of which she published a *Record* (1835). Although overshadowed by Margaret Fuller, she was one of the leading feminine figures in the Transcendental movement, her West Street bookshop becoming a sort of club. In 1860 Miss Peabody opened in Boston the first kindergarten in America. She went to Europe in 1867 to study Friedrich Froebel's methods at first hand, and thereafter through training classes, lectures, magazine contributions, and her editing of the *Kindergarten Messenger* (1873–77) she spread the new theories. Her writing reflects her dominant interests. She died at Jamaica Plain, Mass., on Jan. 3, 1894.

PEABODY, a city of Essex County, Mass., 13 mi. NE of Boston. The area that now constitutes Peabody was originally part of Salem (*q.v.*) then part of Danvers (*q.v.*) when that community was separated as a district from Salem in 1752. South Danvers became a town in 1855 and in 1868 adopted the name of Peabody to honour George Peabody, the philanthropist who was born and buried there. In 1882 part of Peabody was annexed to Salem. In 1916 Peabody was incorporated as a city. It is a manufacturing centre for leather, shoes, and cotton goods. In the early 1900s a number of immigrants, largely from Greece, Ireland, Russia, and Poland, settled there. For comparative population figures *see* table in MASSACHUSETTS: *Population.* (J. F. Co.)

PEACE, CHARLES FREDERICK (1832–1879), English murderer and cat burglar to whom legendary exploits have been ascribed, was born in Sheffield, Yorkshire, on May 14, 1832. After a successful career of robbery, he shot and killed a man named Arthur Dyson in the Sheffield suburb of Eccleshall in 1876 during a quarrel over Dyson's wife. He escaped the police by assuming another identity and for nearly two years lived, as "a gentleman of independent means," at Peckham in London; at night he committed widespread burglaries which entirely baffled the police. While attempting one of these in October 1878 he was arrested, almost by accident, in the London suburb of Blackheath. Only later was he charged with the murder of Dyson, for which he was executed at Leeds on Feb. 25, 1879.

See R. W. Postgate, *Murder, Piracy and Treason* (1925); W. T. Shore (ed.), *Trial of Charles Frederick Peace* (1926); D. Ward, *King of the Lags* (1963). (R. W. P.)

PEACE, INTERNATIONAL. Since the beginning of history, peace has been regarded as a blessing and its opposite, war, as a scourge. Yet it is only since the end of the Middle Ages that philosophers and statesmen have reflected systematically on the problem of peace. Attempts to put international peace on a secure basis on a worldwide scale through deliberate political action had to wait until the beginning of the 19th century.

Both movements, the speculative and the practical, were stimulated by political catastrophes that demonstrated the urgent need for making international peace secure. Men started to speculate about new forms of international organization after the rise of the territorial state had deprived the Holy Roman Empire of its political functions as the international organization of Christendom. Where could a substitute for this lost political unity, safeguarding at least a modicum of peace and order, be found? This question was posed by Erasmus in the 16th century, by Sully, Émeric Crucé, Hugo Grotius, and William Penn in the 17th, and by the Abbé de St. Pierre, Jean Jacques Rousseau, Jeremy Bentham, and Immanuel Kant in the 18th. Their answers were generally couched in terms of international law or of an international organization based upon international law.

The political measures of modern times to make international peace more secure had their starting point in the experience of

the Napoleonic Wars. That experience had a dual impact upon the international order of the modern world. The Napoleonic Wars destroyed the balance of power that had been the foundation of international peace and order since the end of the Middle Ages and threatened to replace it with a universal empire which, while it might assure peace temporarily, might destroy freedom forever. They also brought to victory the idea of nationalism that threatened to destroy the old dynastic order and to usher in an unending series of international crises and wars.

To these political factors that stimulated the search for a practical solution to the problem of international peace must be added three others: spiritual, moral, and intellectual.

From the time of the Stoics and the early Christians there has been present in Western civilization a feeling for the spiritual unity of the Western world which, in order to realize itself, is in need of a political organization commensurate with it. The Roman Empire was such a political organization of universal scope. It remained throughout the history of the Western world a symbol of its spiritual unity, which inspired Charlemagne no less than Napoleon and which provided throughout the Middle Ages the ultimate justification for the policies of the Holy Roman Empire and of the papacy. Thus it is not surprising that at the very moment the Holy Roman Empire was dissolved in 1806, Napoleon tried to revive it, and that only a decade later statesmen made attempts to find a substitute for the international order that the Holy Roman Empire had sought to provide.

The moral root of modern attempts to find a stable foundation for international peace must be sought in the increased humaneness and civilized conduct, of which the great political and social reforms of the 19th and 20th centuries are the outstanding practical realization. Religion, the philosophy of the Enlightenment, and the political theory of liberalism all postulate respect for human life and the promotion of human welfare. To extend the reign of law, peace, and order from the domestic to the international sphere was a logical conclusion from these postulates.

The intellectual factor underlying this development is to be found in the rise of the commercial and scientific spirit in the 18th and 19th centuries. To that spirit war is an irrational disturbance of the rational order of things. According to Kant "the commercial spirit cannot co-exist with war." Similarly, Herbert Spencer believed that war had become obsolete in an industrial society. Thus it was widely believed that permanent peace on the international scene could be established through the same concerted rational effort that seemed to have brought such spectacular benefits to mankind in other fields.

The convergence of these four factors at the beginning of the 19th century initiated the practical search for alternatives to war and sustained it thereafter. This search for permanent peace has been carried on through three different mediums: (1) limitation of the destructive and anarchical tendencies of international politics; (2) transformation of international politics by eliminating its destructive and anarchical tendencies altogether; and (3) accommodation of divergent interests by depriving the destructive and anarchical tendencies of international politics of their rational objectives.

To establish peace through limitation several devices have been used: disarmament, collective security, judicial agencies, peaceful change, international government. Peace through transformation has been sought through the establishment of a world state. Diplomacy has served the purposes of peace through accommodation.

Disarmament.—This term denotes the reduction or elimination of certain or all armaments for the purpose of stopping the armaments race. Disarmament must be distinguished from arms control, which seeks military stability through mutual deterrence in preparation for actual disarmament. Furthermore, general disarmament must be distinguished from local disarmament, and quantitative from qualitative disarmament. (*See* DISARMAMENT.)

General disarmament refers to a kind of disarmament in which all the nations concerned participate: examples are the Washington Treaty for the Limitation of Naval Armament of 1922, signed by all major naval powers, and the World Disarmament Conference of 1932 in which virtually all members of the community of nations participated. We speak of local disarmament when only a limited number of nations are involved; the Rush-Bagot Agreement of 1817 between the U.S. and Canada exemplifies this type.

Quantitative disarmament envisages an overall reduction of armaments of most or all types, as did the World Disarmament Conference of 1932. Qualitative disarmament aims at the reduction or abolition of certain types of armaments only, such as atomic weapons.

The first modern attempt at disarmament occurred in 1816 when the tsar of Russia proposed to the British government the "simultaneous reduction of the armed forces of every kind." Many similar proposals throughout the 19th century, especially by France, culminated in the Hague Peace Conferences of 1899 and 1907, both of which passed resolutions affirming the desirability of the restriction of armaments. It must be noted that most of the attempts at securing international peace through disarmament failed and that the two which succeeded, the Rush-Bagot Agreement of 1817 and the Washington Treaty for the Limitation of Naval Armaments of 1922, were an integral part of a political settlement which carried in itself the assurance of peace. In other words, as the armaments race is a symptom of political conflict which is likely to lead to war, so is disarmament the symptom of the disappearance of political tension which by itself gives assurance for the preservation of peace. Disarmament by itself, especially if it is of the local and qualitative type, gives no such assurance, for at best it would be able to alter the methods by which war is to be waged (but not the incidence of war itself).

Collective Security.—The concept of collective security assumes that nations generally increase their armaments and go to war either because they are in fear of aggression or because they trust that aggression will succeed without too great a risk. If the community of nations could provide its members with security through collective action, the main motive for war would disappear. In a system of collective security, security is the concern of all nations which will take care collectively of the security of each of them as though their own security were at stake. If nation A threatens nation B's security, C, D, E, F, and G will take measures on behalf of B and against A as though A threatened them, and vice versa.

The ability of a system of collective security to preserve peace rests on three assumptions: (1) the collective system must have at its disposal at all times sufficient strength to deter any potential aggressor; (2) the nations which dispose of such overwhelming strength must have the same interest in defending the status quo; (3) these nations must subordinate their conflicting political interests to the overriding concern for collective defense. The history of collective security, as it was provided for by the Covenant of the League of Nations and the Charter of the United Nations, shows that these three conditions are rarely present at the same time. First of all, history shows that aggression is generally threatened or committed not by one but several nations which, at least initially, are of approximately equal if not superior strength to those who are willing to resist aggression. The reason for this state of affairs must be sought in the fact that what is required for the security of one group of nations may be incompatible with, or actually threaten the security of, another group of nations. Finally, collective security presupposes a moral transformation which makes individual nations forego their national egotisms and the national policies serving them for the sake of collective policies serving the supranational purpose. (*See* also SANCTION AND GUARANTEE.)

Judicial Agencies.—Among other means that have been devised to preserve peace on the assumption that international conflicts have led to war because there were no facilities available to nations to settle their conflicts peaceably are judicial agencies. Nation A wants something of nation B which nation B is not willing to concede. Hence, A will try to get what it wants from B by force of arms. If there were a method, acceptable to A and B and fashioned after the model of national judicial agencies, of settling that conflict peaceably, war would become superfluous as the supreme arbiter among nations.

Thus during the second half of the 19th century the arbitration movement gained strong popular support for proposals to establish international arbitration courts with compulsory jurisdiction to settle all international conflicts. Many nations concluded treaties for the judicial settlement of at least certain types of disputes. The movement culminated in the establishment of the Permanent Court of Arbitration by the Hague Convention for the Pacific Settlement of International Disputes of 1899 and 1907, of the Permanent Court of International Justice in 1919, and of the International Court of Justice in 1946.

However, none of the disputes settled by these courts can be said to have carried the risk of war had it not been settled by an international tribunal. Furthermore, all nations likely to get involved in political disputes of a serious nature were careful to circumscribe strictly the type of dispute they were willing to submit to judicial settlement. Only nations which were unlikely to get involved with each other in disputes of this kind, such as Colombia and El Salvador, Denmark and Portugal, the Netherlands and China, Belgium and Sweden, agreed to submit all disputes to arise between them to judicial settlement without any qualification. Finally, and most importantly, while disputes between two individuals to be submitted to a national court concern the application or interpretation of the law as it is, disputes between states which are likely to lead to war typically have as their object the very survival of the legal order, which one state wants to change in opposition to another defending it. Issues of this kind, however, are of a legislative nature, and judicial agencies are unable to cope with them.

Peaceful Change.—The issue of peaceful change is raised by the inability of judicial agencies to settle peacefully disputes that concern not the application of the existing legal order, but its transformation. National societies, especially those of a democratic character, are continually engaged in processes of peaceful change. These processes are made possible by three factors: (1) the ability of different trends in public opinion to express themselves freely and compete with each other for maintenance or change of the status quo; (2) the ability of social and political institutions to absorb the pressures of public opinion and to translate them into legal measures and institutions; (3) the ability of the state to protect the result of these competing social pressures against violent change.

These factors are largely absent on the international scene. No free interplay of different trends in public opinion exists to the same extent between nations as it does within them. International social and political institutions are of a rudimentary character; more particularly, the operation of international legislative bodies, making majority decisions with binding effect upon the minority, is precluded by the principle of sovereignty, at least for matters of a political nature. For the same reason there can be no supranational organization of compulsion that is not based upon the voluntary cooperation of individual states.

In consequence, the institutional devices introduced into the Covenant of the League of Nations and the Charter of the United Nations in order to facilitate peaceful change proved to be ineffectual. Article 19 of the League Covenant reads: "The Assembly may from time to time advise the reconsideration by Members of the League of treaties which have become inapplicable and the consideration of international conditions whose continuance might endanger the peace of the world." Article 14 of the UN Charter refers in general to "the peaceful adjustment of any situation, regardless of origin, which it (the General Assembly) deems likely to impair the general welfare or friendly relations among nations." Article 19 of the Covenant was formally invoked only once, by Bolivia against Chile in 1920, but was not acted upon because Bolivia retracted its request. It was further weakened by authoritative interpretation of the assembly. The General Assembly of the United Nations made recommendations for peaceful change in a number of cases, such as the treatment of Indians in South Africa, the situations in Greece and Korea, the problems of Spain and Palestine, and the disposition of the former Italian colonies of Libya, Eritrea, and Somaliland. Of these attempts at peaceful change, only the latter two were genuine and successful. Yet the actual partition of Palestine was the result of a war between the Arab nations and the Israelis, a fact which the UN General Assembly had to recognize in succeeding recommendations.

Peaceful change administered by an international organization comes up against a basic fact of international life: national sovereignty. If the international organization respects national sovereignty and, hence, only recommends peaceful change, the effectiveness of the recommendation will depend upon the agreement of the parties concerned; yet if the parties concerned agree anyway, the recommendation is at best not a decisive factor and at worst superfluous. If the parties do not agree, change must then be imposed upon them by the international organization and will be peaceful only if it can be imposed under the ideal conditions—hardly attainable, as we have seen—of collective security.

International Government.—The above-mentioned devices to establish international peace are intended to provide specific remedies for particular problems. International government, on the other hand, recognizes that peace and order can be secure only in an integrated society existing under a common authority and a common conception of justice. International government, then, is the attempt to establish such an authority and to create such a conception of justice in a society of sovereign states. Such an attempt followed each of the three world wars of the 19th and first half of the 20th century. The Napoleonic Wars called into being the Holy Alliance; World War I the League of Nations; and World War II the United Nations. None of these international organizations was able to put international peace on a more secure basis for identical reasons, inherent in the nature of international government.

The Holy Alliance, the League of Nations, and the United Nations were conceived as international governments by the great powers; this is obvious from the membership of the Holy Alliance as well as from the membership and the functions of the council of the League of Nations and the Security Council of the United Nations. The ability of these international organizations to protect the peace of the world, then, depended upon the ability of the great powers to work in unison for the achievement of that objective. Yet in all three organizations the particular interests of individual great powers prevailed over the interest they were supposed to have in common: the preservation of peace.

All three organizations had as their basic political objective the maintenance of the status quo as it had been established by the preceding world war. However, not all the great nations had the same understanding as to what the maintenance of the status quo meant in view of their particular interests, nor were all of them equally interested in the maintenance of that status quo. Thus it came about that first the usefulness and then the very existence of the Holy Alliance was destroyed by the conflict between Great Britain and Russia, which lasted throughout the better part of the 19th century; that the ability of the League of Nations to become an effective instrument for the preservation of peace was jeopardized first by the political conflict between Great Britain and France, then between France and Germany, and finally between Great Britain and France on the one hand and the Soviet Union on the other; and that the United Nations as a peacemaker was paralyzed from the very beginning by the conflict between the Western world, under the leadership of the United States, and the Soviet bloc.

The attempts to secure peace by an international government of sovereign nations have all been the victims of a contradiction inherent in these very attempts. The establishment of an effective government of sovereign nations seems to be a contradiction in terms that can be eliminated only by a direct attack upon national sovereignty itself.

The World State.—A proposal that seems to many to offer a logical solution to the problem of international peace is the world state. In the same way, so it is argued, in which domestic peace has been made secure by the subjection of local and regional governments to a common authority, so international peace, to be secure, must be built upon the foundations of a government for all mankind to which national governments must yield their sovereignty.

Any world government, if it is not a tyrannical one, must rest on a triple foundation: supranational loyalties, expectation of justice, and overwhelming power. That is to say, whenever a conflict arises between loyalty to a particular nation and loyalty to the world government, the latter must be reasonably certain that the conflict will be resolved in its favour. Furthermore, the peoples of the world must be united in the reasonable expectation that the world government will at least approximate justice in its dealings with them. Finally, the world government must have at its disposal such overwhelming physical strength as will make unlikely from the outset physical resistance to its decisions on the part of any group subject to its rule.

To realize these three preconditions for a world state capable of preserving peace two methods have been suggested and partly put into practice: one constitutional and one functional. A number of organizations have worked out constitutions for a world state, generally on a federal basis. Once such a constitution has been ratified by the representatives of the nations of the earth, its actual operation is expected to call into being the three foundations upon which an effective world state must rest. On the other hand, there are those who believe that before a world state can be brought into being, humanity must experience its community of interests and develop the foundations for a world state through active cooperation for specific limited objectives. Once humanity has learned to cooperate, say, for the improvement of health or the increase in agricultural production regardless of national boundaries, its political unity will grow almost organically from common needs successfully met and the common interest in their continuing satisfaction. Hence, this functional approach puts its main reliance for preparing humanity for a world state upon the so-called specialized agencies of the United Nations and similar organizations; it points to the European communities, such as the European Coal and Steel Community, Euratom (European Atomic Energy Community), and the Common Market, as precedents.

Diplomacy.—The chief instrumentality through which states have actually attempted to preserve international peace by reconciling hostile interests that threaten to lead to war has continued to be diplomacy. It is the oldest and most natural method for the settlement of international disputes; for sovereign entities, such as nations, which by definition are not subject to a higher authority, must naturally try to settle their disputes peacefully by way of negotiation, that is, through diplomacy. The decisive factor in such diplomatic negotiations is the interest of the negotiating parties in the success of the negotiations. This interest generally takes two different forms. On the one hand, the negotiating parties expect from the peaceful settlement the protection and promotion of their vital interests, while both are willing to compromise on secondary issues, thus each giving up something and receiving something. On the other hand, the interest of the parties in concluding an agreement and, more particularly, in keeping it depends upon the political and military pressures which one side is able to exert upon the other in support of a peaceful settlement. This has been one of the traditional functions of competitive armaments, alliances, and the balance of power. Diplomacy as a method of preserving peace has been deprecated to the extent that the newer methods, mentioned above, have captured the popular imagination. That deprecation is based on moral as well as practical grounds. Yet, though diplomacy is defective on both counts, governments, while experimenting with the newer methods, have continued to put their main reliance upon the traditional methods of diplomacy. It is worthy of note to what extent, for instance, the United Nations, which was widely supposed to provide a substitute for the traditional methods of diplomacy, was transformed into an instrument of diplomacy, used by individual nations for the protection and promotion of their particular interests. However, the search for a more effective method of preserving peace than diplomacy can provide, which has occupied humanity to an ever increasing extent since the beginning of the 19th century, reflects the new and ever increasing urgency which the problem of peace has assumed. For political, technological, and moral revolutions have transformed war from the rational instrument of foreign policy that it once was into an instrument of universal destruction. And it became one of the great paradoxes of the 20th century that as the preservation of peace became a matter of survival for Western civilization the traditional instruments of preserving it had become less effective; and more effective ones had not yet been devised.

See also references under "Peace, International" in the Index.

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PEACE CONFERENCES. For conferences for the promotion of peace held before 1914 *see* HAGUE CONFERENCES. For conferences subsequent to World War I *see* relevant headings; *e.g.*, PARIS, CONFERENCE OF; VERSAILLES, TREATY OF; WASHINGTON CONFERENCE; WASHINGTON, TREATIES OF; LOCARNO, PACT OF, etc. *See* also CONFERENCE, INTERNATIONAL; WAR. For World War II peace conferences, *see* AUSTRIA: *History;* ITALY: *History;* JAPAN: *History*, etc. *See* also KOREAN WAR.

PEACE CORPS, an agency of the U.S. government established by Executive Order 10924 issued by Pres. John F. Kennedy on March 1, 1961. It became a permanent agency under the Department of State the following September when Congress approved the Peace Corps Act. Its first annual budget was $30,000,000. The Peace Corps, in the words of President Kennedy, was to be "a pool of trained American men and women sent overseas by the United States Government to help foreign countries meet their urgent needs for skilled manpower."

In the period following World War II, many European colonial possessions became independent nations. At the same time other developing countries began to build their own modern political and economic systems. The progress of many of these nations was impeded because their citizens lacked technological skills. The Peace Corps was formed to help solve this problem by enabling experienced Americans to share their knowledge in education, agriculture, health, trade, technology, and community development with nations trying to build their own pools of trained manpower.

Peace Corps volunteers must be U.S. citizens and must be at least 18 years old; there is no upper age limit. Married couples without dependent children are eligible if both husband and wife can do needed jobs. Each volunteer must answer a Peace Corps questionnaire and take a placement test, a one-hour general aptitude examination. On the basis of the candidate's skills, education, and experience he is assigned to a project that has been requested by one of the many countries in which the Peace Corps serves.

To prepare for this assignment, the volunteer studies for three months at a U.S. college or university. More than 90 colleges have conducted intensive instruction in the language, history, politics, and customs of various countries to which volunteers have been sent. During this training period the volunteer candidate also studies American history and policies and takes some training in the special skill that he brings to the program.

Once overseas, the volunteer functions as a good neighbour by working directly with the people of the host country, speaking their language, and sharing their lives. Each volunteer receives a living allowance comparable to that of his counterparts in the host country. The normal term of service is two years, at the end of which the volunteer receives a termination payment of $1,800 (less taxes). Peace Corps service does not exempt volunteers from military duty.

In 1961, the first year of the Peace Corps, 900 volunteers served in 16 different countries of Latin America, Asia, and Africa. The cost per volunteer for staff support, training, transportation, allowances, and equipment was $8,000. In 1964, because of increased requests from host countries, 10,000 volunteers were at work in 46 different countries and the Corps' budget was $104,100,000.

The Peace Corps maintained a headquarters staff in Washington, D.C., and a small staff in each host country to allocate the work

of the organization and to supervise individual projects. In its first years the Peace Corps was administered by R. Sargent Shriver, who held the title of director and was assisted by several associate directors. The largest division of the staff was that of Program Development and Operations. It was divided into four regional offices: (1) Latin America, (2) North Africa, Near East, and South Asia, (3) Far East, and (4) Africa, and was responsible for developing and administering the Peace Corps programs with the host countries. The other divisions were the Planning, Evaluation, and Research Division, which was concerned with the effectiveness of Peace Corps projects; the Public Affairs Division, which handled recruiting, congressional liaison, and public information; the Peace Corps Volunteers Division, which selected and trained the volunteers and provided support once they had been sent overseas; and the Management Services Division, which was responsible for the personnel section and the finances of the agency.

The overseas staff consisted of a Peace Corps director for each country, assisted by one or more associate directors and a medical doctor. They were responsible for the well-being and work performance of the volunteers; they also served as the channels of communication between Washington and the host country.

The record of the Peace Corps can be evaluated in several ways. Its popular appeal was indicated by the fact that more than 1,000 Americans applied for service each week in 1964. Every country that originally asked for volunteers doubled, tripled, and even quadrupled its first requests. One of the finest tributes to the Peace Corps was the 1963 Ramón Magsaysay Award, the $10,000 prize given to persons in Asia who "exemplify in spirit, integrity and devotion to liberty" the late president of the Philippines. This Asian equivalent to the Nobel Prize had never before been won by a non-Asian group. (S. Sr.)

PEACE PIPE: *see* Calumet; Pipe Smoking.

PEACE RIVER, a part of the great Mackenzie River (*q.v.*) system of western Canada, rises as the Finlay River in the Rocky Mountains of north central British Columbia. The length is 1,195 mi. Breaking through the mountains it flows northeast through Wood Buffalo National Park into the Slave River, near Lake Athabasca, in Alberta. The district between 55° and 60° N. and between 112° W and the Rocky Mountains, is commonly known as the Peace River country. Some parklike openings in the forests and a slightly longer growing season and better soil than the surrounding area attracted farming settlement to the Peace River country before World War I. In the latter half of the 20th century more than 4,000,000 ac. were in farms. The most important crop is barley; oats, wheat, and forage seeds are also grown. There are great deposits of coal, and after 1952 the region became a major producer of natural gas and petroleum. Pipelines connect the gas and oil fields to southern markets. Forest resources are also important. The Peace River country was connected by rail with Edmonton in 1914 and with Vancouver in 1958; the Alaska Highway begins at Dawson Creek, B.C., and crosses the Peace soon after. The Peace is navigable from Peace River, Alta., to the Slave, except for Vermillion Falls near Fort Vermillion, Alta. (Jn. H. W.)

PEACH, CHARLES WILLIAM (1800–1886), British naturalist and geologist who made valuable contributions to the knowledge of marine invertebrates and of fossil plants and fish, was born on Sept. 30, 1800, at Wansford in Northamptonshire. He received an elementary education at Wansford and at Folkingham in Lincolnshire, and for several years assisted his father in the operation of an inn and farm.

In 1824 the earl of Westmorland appointed him riding officer in the revenue coast guard at Weybourne in Norfolk. Seaweeds and other marine organisms attracted his attention, and he began to collect them. His duties during the next few years led him to move to several different places in Norfolk and in the course of his rambles he met the Rev. James Layton, curate at Catfield, who lent him books and assisted in laying the foundations for his future studies. He was finally sent to Gorran Haven in Cornwall where he continued to pursue his studies and supplied many specimens to the British naturalist G. Johnston, who was then preparing his *History of the British Zoophytes* (1838). It was there also that Peach found fossils in some of the older rocks previously regarded as unfossiliferous. This discovery proved the presence of Bala beds (Ordovician) in the neighbourhood.

In 1841 he read a paper before the British Association at Plymouth entitled "On the Fossil Organic Remains Found on the South-east Coast of Cornwall," and in 1843 he brought before the Royal Geological Society of Cornwall an account of his discovery of fish remains in the Devonian slates near Polperro.

Peach was appointed to a position in the customs at Fowey in 1845; and four years later he went to Scotland, first to Peterhead and in 1853 to Wick. He studied the Old Red Sandstone, the boulder clay of Caithness and the Carboniferous plants of Scotland. During a stay at Durness he first found fossils in the Cambrian limestone (1854). In the field of natural history his contributions included the discovery of many new species of sponges, coelenterates, and mollusks. He died at Edinburgh on Feb. 28, 1886.

PEACH (*Prunus persica*), a fruit tree grown throughout the warmer temperate regions of both the Northern and Southern Hemispheres. It belongs to the Prunoideae subfamily of the rose family (Rosaceae), which also includes the cherries, plums, and apricots, a group known as drupes or stone fruits.

History.—It was long thought that the peach originated in Persia as is suggested by the specific name *persica.* It is now reasonably certain that the original home of the peach was China and that it spread westward along the caravan routes through Asia to the Mediterranean countries and later to other parts of Europe. It has long been cultivated in China and reference to *Tao,* meaning "peach," has been found in Chinese writings of the 5th century B.C. The Greeks and Romans are believed to have had the peach shortly after the beginnings of the Christian era; it then was introduced to countries under their influence. The Spanish explorers brought the peach to the New World, and as early as 1600 the fruit was found in Mexico. Explorers, settlers, and Indians were responsible for the wide distribution of the fruit in the Western Hemisphere.

Plant Characteristics.—*Growth Form.*—The tree is small to medium sized, seldom reaching 25 ft. in height. Under cultivation, however, it is usually kept to between 10 and 12 ft. in height by pruning. The leaves are glossy green, lance-shaped, and long-pointed; they usually have glands at their bases, which secrete a fluid that attracts ants and other insects. The flowers

PEACH BLOSSOMS (PRUNUS PERSICA)

FRED BOND—PUBLIX

are borne in the leaf axils and are arranged singly or in groups of two or three at nodes along the shoots of the previous season's growth. The five petals, usually pink but occasionally white, five sepals, and three whorls of stamens are borne on the outer rim of the short tube that forms the base of the flower. The pistil consists of a single carpel with a relatively long style and an enlarged basal portion, the ovary, which becomes the fruit.

The Fruit and Its Composition.—While the skin of most ripe peaches is downy or fuzzy, there are some smooth-skinned peaches called nectarines, which are otherwise indistinguishable from ordinary peaches. The glabrous character of the nectarine is hereditary; peach seeds carrying this factor may give rise to nectarines. A branch bearing nectarines is occasionally produced as a sport or mutation on a peach tree (*see* NECTARINE).

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RIPE PEACH (PRUNUS PERSICA)

The peach develops from a single ovary that ripens into a fleshy, juicy exterior, making up the edible part of the fruit, and a hard interior called the stone or pit. Of the two ovules in the ovary usually only one becomes fertilized and develops into a seed, which is enclosed within the stone. This frequently results in one half of the fruit being slightly larger than the other, the two halves forming the slight longitudinal cleft typical of drupe fruits. The flesh may be white, yellow, or red. Varieties may be freestone types, which have stones that separate easily from the ripe flesh, or clingstones, which have flesh that adheres firmly to the stone.

The peach is about 87% water. It has fewer calories than either apples or pears; its protein and fat content are negligible. Yellow-fleshed types are especially rich in vitamin A, containing more than four times as much as an orange of the same size.

Cultivation.—For centuries the cultivation and the selection of new varieties was largely confined to the gardens of the nobility, and large-scale commercial peach growing did not begin until the beginning of the 19th century, in the United States. The early plantings were of seedling peaches, inevitably very variable and often of poor quality. The practice of budding superior sorts onto hardy seedling rootstocks, which came later in the century, led to the development of large commercial orchards. The most important limiting factor in peach production is cold injury to the wood and buds during the winter or frost injury at blossoming time. Peaches are intolerant of severe cold, and cannot be grown successfully where winter temperatures normally fall to −23° to −26° C (−10° to −15° F); only the most hardy varieties can withstand these temperatures. On the other hand, peaches do not grow satisfactorily where the winters are too mild. Most varieties require some winter chilling to induce them to burst into growth after the annual dormant period. If there is not sufficient cold to break this dormancy, the trees come into leaf slowly or not at all and the blossoms tend to drop off. In regions with warm winter climates, only those varieties with a low chilling requirement succeed.

The peach does well on various soil types, ranging from the coarse-textured sand or gravelly loams and shales to silt loam, but in general it grows best on well-drained sandy or gravelly loams. Fine-textured soils that have a tendency to waterlog or have poor subsoil drainage are unsatisfactory. In regions where low winter temperatures and spring frosts are hazards, the orchard site should be sufficiently elevated in relation to the surrounding land to permit cool air to drain away to lower levels. Large bodies of water may have a moderating effect in regulating temperatures and reducing frost hazard.

Peach trees should be pruned annually to prevent them from becoming too tall and leggy. Pruning back upright shoots to outgrowing laterals will help to produce a spreading tree and keep it open to sunlight. In general, peaches grow best when the soil around the tree is cultivated. Mulching with organic material will keep down competition of field grasses and conserve moisture. On most soils the peach responds well to nitrogen-rich fertilizers or manures, without which satisfactory growth cannot be obtained.

Most peach varieties produce more fruits than can be maintained and developed to full size. Some shedding of fruitlets takes place naturally, about a month to six weeks after full bloom, but the number remaining may have to be reduced further by hand thinning. This should be done as soon after the natural drop as possible.

Peach trees are relatively short-lived as compared with some other fruit trees. In some regions orchards are replanted after 8 to 10 years, while in others trees may produce satisfactorily for 20 to 25 years or more, depending upon their resistance to diseases, pests, and winter damage.

Varieties.—Thousands of varieties of the peach have been selected and in 1917 more than 2,000 varieties were described as being grown in the United States. Yellow-fleshed varieties are preferred in North America, and practically all the varieties grown commercially are of this type. In Italy, which represents European preference, 60% of the peaches grown are white-fleshed. Most of the varieties now grown commercially round the world are of American origin. The most widely known of all varieties is Elberta, produced in the United States in 1870 and still one of the most widely grown freestone peaches.

In most of the main peach-growing countries peaches are available for the four or five summer months. With the constant introduction of new varieties, lists of recommended sorts soon become out-of-date, but some well-tried varieties continue to be popular. Dixiered, an early producer among the early ripening yellow-fleshed freestones, is followed by Redhaven, Golden Jubilee, Triogem, Halehaven, Elberta, and J. H. Hale. The important firm-fleshed clingstones grown for canning include Halford, Gaume, Paloro, Peak, and Fortuna. Among the white-fleshed varieties favoured in Europe, Mayflower starts the season and is followed by Amsden, Bella di Roma Precoce, Charles Ingouf, Hales Early, and Belle of Georgia.

Pests and Diseases.—Peaches are attacked by many insects, nematodes, and fungus and bacterial diseases. Few fruits of good quality are obtained without the use of pesticides. Fortunately most of the pests and diseases can be controlled by chemical sprays and general orchard cleanliness. Mites, aphides, caterpillars, and scale insects (of which the San Jose scale is the worst) all attack the peach. Brown rot, due to species of the fungus *Sclerotinia*, causes rotting of the fruit on the tree and in storage; less seriously it causes blossom and twig blight and cankers. Peach leaf curl, which probably spread from Europe, is caused by the fungus *Taphrina deformans;* it is the most easily recognized disease, deforming the leaves and causing early defoliation. Peach scab (*Cladosporium carpophilum*) causes unsightly markings on the fruit. Peach blight or fruit spot, caused by *Coryneum beijerinckii,* attacks the blossom, leaves, and fruit and, like the others, is of almost worldwide distribution. Bacterial canker, silver leaf, and mildew are also troublesome. Virus diseases such as peach yellows, rosette, little peach, and peach mosaic are serious ailments that cannot be controlled by spraying. Most of these virus diseases are spread by insects or grafting. The best checks are to eradicate diseased trees, to control insect vectors, and to propagate only from virus-free trees. (*See* also FRUIT FARMING; HORTICULTURE.)

Production.—The peach is the third most important of the deciduous tree fruits, ranking after the apple and pear. The United States, where the peach ranks second to the apple in importance, produces almost half of the world's supply of this fruit; California leads among the states in the production of both freestone and clingstone peaches. In that state a large commercial industry has been developed in the production and canning of firm-fleshed clingstone varieties; freestone varieties are used chiefly for fresh fruit and for drying. In Europe, Italy, with a 1,000,000-ton annual crop, a quarter of the world's supply, is the leading peach producer, followed by France, Spain, and Greece. Elsewhere, Argentina, Japan, Turkey, Canada, South Africa, and Australia produce substantial crops.

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PEACHAM, HENRY (*c.* 1576–*c.*1643), English author best known for his *Compleat Gentleman* (1622), important in the tradition of courtesy books, was born at North Mimms, Hertfordshire, about 1576. He was educated at Trinity College, Cambridge, and was successively schoolmaster, traveling tutor, and author. Of his time as master of the free school at Wymondham, Norfolk, he wrote "whiles that it was free, Myselfe, the Maister, lost my libertie." His first book, *The Art of Drawing With the Pen, and Limning in Water Colours* (1606), dealt with a lifelong interest; his translation (1610) into Latin verse of King James's *Basilicon Doron* contained his own pen-and-ink drawings. *The Period of Mourning* (1613) honoured the memory of Prince Henry, and *Thalia's Banquet* (1620) proved Peacham's ability to turn an epigram. *The Truth of Our Times* (1638; ed. by R. Cawley, 1942) is full of acute observations on the London life he knew so well; he recalled seeing the acting of the great Richard Tarlton "when I was a Schoolboy in *London*." *The Worth of a Peny* (1647; in E. Arber's *English Garner*, vi, 1883) is Peacham's "complaint to his purse." But his chief work remained *The Compleat Gentleman* (ed. by G. S. Gordon, 1906). It was a full expression of his theories on education, and its table of contents exhibits the variety of his interests: cosmography, geometry, poetry, music, sculpture, drawing, painting, heraldry. Dr. Johnson drew the heraldic definitions for his *Dictionary* from the 1661 edition.

Peacham was royalist to a fault, writing in 1639 *The Duty of All True Subjects to Their King as Also to Their Native Countrey;* and he spoke proudly of having sketched the king's portrait as he sat at dinner. Though he attacked Puritans in *Thalia's Banquet*, he had some natural sympathy with them, deploring lavishness of every kind. He concludes *The Truth* with a quotation from Hippocrates: "All things moderately, and in measure."

See M. C. Pitman, "Studies in the Works of Henry Peacham," *Bulletin of Historical Research*, xi (1934). (R. R. Cy.)

PEACOCK, THOMAS LOVE (1785–1866), English poet and satirical novelist, in whose novels conversation is more important than character or plot, was born at Weymouth on Oct. 18, 1785. His father was a glass merchant, his mother a Devon woman with marked literary interests. Peacock was deeply attached to his mother, who lived to be nearly 80, and used to read his writings aloud for her criticisms. At ten he was already writing verse. He was not sent to a public school or university, but spent six and a half years at a private school and then seems to have gone straight into a business firm as a clerk. He was a self-educated man whose knowledge of the Greek and Latin classics was the result of his own study and enthusiasm. In 1804 he published *The Monks of St. Mark*, followed by other poems (*Palmyra, The Genius of the Thames*, and *The Philosophy of Melancholy*) between 1806 and 1812. In 1818 *Rhododaphne* appeared. Peacock is mainly remembered as a poet for the lyrics in his prose writings, but some of his other poems also contain fine passages. About 1810–11 he wrote *The Dilettanti* and *The Three Doctors*, farces which anticipate his later satires. In 1812 he met Shelley, whose close friend he soon became. The months that he spent near the Shelleys at Great Marlow in 1817 seem indeed to have been the main seminal period of his life, and the ideas that lie behind many of the witty dialogues in his books probably found their origin in the conversation of Shelley and his friends. A brief essay which he published in the first number of *Ollier's Literary Miscellany* (1820), "The Four Ages of Poetry," provoked Shelley to write his luminous *Defence of Poetry*. In the same year Peacock married Jane Gryffydh, a parson's daughter.

In his essay on "French Comic Romances" (*The London Review*, October 1835), Peacock distinguishes between comic romances in which "the characters are abstractions . . . and their opinions [are] the main matter of the work" and those in which "the characters are individuals, and the events and the actions those of actual life." Whereas most English novels fall into the latter category, Peacock's satiric tales belong to the former and should strictly not be described as novels at all. *Headlong Hall* (1816) was a foretaste of what was to come: the discussion of progress which begins in ch. i does not come to an end until the conclusion of his last novel, *Gryll Grange* (1860), while one need go no further than the second chapter to find the characters seated at table and embarked on the learned and philosophical discussion of food and drink which forms the leitmotiv of all his books. As in the most characteristic of the later books, there is little in the way of plot: a tenuous love story serves to hold the book together, but the main ingredients are satirical description, narrative, and above all dialogue in which many of the common opinions of the day are presented and criticized. The characters are "humours," no attempt being made to present them in the round. In *Melincourt* (1817), which is much longer and in which the action is set in the Lake District, there is the same basic structure. The idealistic lovers, Anthelia and Sylvan Forester (partly a representation of Shelley), stand in sharp contrast to most of the other characters, and the book as a whole is a passionate protest against the corruption, anti-jacobinism, and obscurantism that ran riot in the period of repression that followed Waterloo. As a satire on parliamentary corruption, an ape (Sir Oran Haut-ton) is elected M.P., while a definition of "the spirit of chivalry" is described by a friend of Southey as containing "all the ingredients of a rank Jacobin." Peacock's anticlericalism is particularly evident in this book: in ch. 39 Wordsworth and John Wilson Croker join Southey and George Canning in chanting "The church is in danger! The church is in danger!"

In *Nightmare Abbey* (1818) the reader is again presented with a house party and a number of "humours," but for once there is a plot with unforeseen incidents and a reversal of fortune. Scythrop is a representation of the young Shelley, with his passion for reforming the world: the outcome of his pursuit of two young women is that each of them marries another man. The atmosphere of the book is one of ironically described gloom: it is in fact a satire on romantic melancholy. Mr. Flosky is a satire on Coleridge and Mr. Cypress a satire on Byron. (His song "There is a fever of the spirit" is an admirable parody.) In *Maid Marian* (1822) and *The Misfortunes of Elphin* (1829) Peacock attempted to graft satire onto the historical romance, but in spite of some admirable passages neither is a successful whole. His greatest achievements are *Crotchet Castle* (1831) and *Gryll Grange* (1860), in which he returned to the pattern of *Headlong Hall*. Once again there is a host who loves conversation, a clerical gourmand, a pair of romantic young lovers, and a train of "humours." Dialogue is more prominent than ever. Like *Melincourt*, *Crotchet Castle* belongs to a particular period: the time when agitation about parliamentary reform was at its height. The main theme of the book is introduced when the Rev. Dr. Folliott bursts into the breakfast room and announces that he is "out of all patience with this march of mind." The troubles of the time lie rather heavily over this book, however, and it lacks the serenity that is one of the charms of *Gryll Grange*. Peacock's last book contains the same ingredients as its predecessors, but this time the mixture has "risen" to perfection. It dates hardly at all, partly because Peacock had ceased to worry about contemporary problems.

Almost the whole of Peacock's working life was spent in the service of the East India Company. He was an able administrator, and in 1836 he succeeded James Mill as chief examiner. In 1856 he retired on a pension. During the last years of his life he wrote his admirable *Memoirs of Percy Bysshe Shelley* as three articles in *Fraser's Magazine* (1858–62). He died at Lower Halliford on Jan. 23, 1866.

BIBLIOGRAPHY.—The best edition of the *Works* (with bibliographical notes) is the "Halliford Edition," ed. by H. F. B. Brett-Smith and C. E. Jones, 10 vol. (1924–34), vol. i of which contains the fullest biography. There is a useful one-vol. edition of the *Novels*, ed. by David Garnett (1948). *See* also J. B. Priestley, *T. L. Peacock* (1927); J.-J. Mayoux, *Un Épicurien anglais: T. L. Peacock* (1933). (I. J.)

PEACOCK, the male of the largest and most splendid of the pheasants, *Pavo cristatus*, a native of India and Ceylon. The female is the peahen; collectively, both are peafowl. The male has a crest and whitish bare areas on the sides of the head; the plumage is brilliant metallic green and blue. The upper tail coverts are

CLARENCE D. COOK FROM NATIONAL AUDUBON SOCIETY

PEACOCK (PAVO CRISTATUS) DISPLAYING

enormously elongated, forming the train of about six feet in length, bronzy-green and blue in colour and ornamented with brilliantly coloured eye spots, or ocelli. A white variety is common in captivity. In courtship display, the train is erected vertically above the bird's back, being supported by the tail feathers. At the climax of the display the tail feathers are vibrated, giving the feathers of the train a shimmering appearance and imparting a rustling sound.

Wild peafowl live in small flocks in open forest but roost in tall trees, which they begin to ascend, in gradual stages, in the afternoon. In captivity the bird often displays outside courtship periods, seemingly showing off, hence the saying, "proud as a peacock." The female is much more dully coloured and lacks the ornamental feathers. The peacock is polygamous, each male seeking to acquire a harem of four or five hens. During the breeding season the male utters a raucous, harsh cry. The hen lays from four to six whitish, sometimes spotted eggs in a hidden nest.

This beautiful bird, seen in almost every zoo and in some large estate gardens, has long been famous, especially since it adapts readily to domestication. The Phoenicians introduced it to the Pharaohs of Egypt, and Alexander the Great took it to Greece. The feathers were exported from India in quantities for ornamental use, although a superstition against the eye spots on the feathers as being evil somewhat lessened their popularity. In Rome and later in medieval Europe, peafowl were raised for the table. The emperor Charlemagne is said to have served thousands at a single state banquet. After the turkey was brought to Europe from Mexico, it quickly supplanted the peacock as a table bird.

A related species, the green peacock (*P. muticus*), inhabits Burma, Indochina, Malaya and Java. The name is also applied to other less closely related pheasants such as the Congo peacock (*Afropavo congensis*) and the peacock pheasant (*Polyplectron*). *See* PHEASANT.

See also W. Beebe, *Pheasants, Their Lives and Homes* (1936).

(DN. A.; X.)

PEAK DISTRICT, a heavily dissected plateau in north Derbyshire, Eng., forming the southern extremity of the Pennines. It includes an area of about 500 sq.mi. (1,295 sq.km.), mainly peaty moorland drained by tributaries of the Mersey and the Derwent. Kinder Scout, 2,088 ft. (6,346 m.), is the highest point, with summit areas of Millstone Grit. Many of the rivers, notably the Wye and the Dove, have cut through this to the underlying massive limestones and their gorgelike valleys are very picturesque. Caverns and potholes occur frequently. (*See* DERBYSHIRE.) In 1950–51 the Peak District National Park was formed, and in 1954 a warden service for patrolling the access land was inaugurated. The district is a popular walking and camping area.

PEALE, the name of a family of notable U.S. painters during the late 18th and early 19th centuries.

CHARLES WILLSON PEALE (1741–1827), whose portraits of the leading figures of the Revolutionary period are the most remembered of his remarkably diverse accomplishments, was born in Queen Annes county, Md., on April 15, 1741. His career in art began in 1763. John Hesselius, a successful Maryland painter, gave him lessons and John Singleton Copley advised and influenced him. From 1767 to 1769 he studied in London with Benjamin West, absorbing West's neoclassical style and the new ideals of social and political justice associated with neoclassicism. In an allegorical portrait of Pitt he sounded a warning to tyrants, and he refused to uncover when the coach of King George III passed in the streets.

On his return to America, Peale became at once the fashionable portrait painter of the middle colonies. He moved to Philadelphia in 1776, entered wholeheartedly into the Revolutionary movement and served with the city militia in the Trenton-Princeton campaign. From 1779 to 1780 he represented the "Furious Whig" party in the Pennsylvania assembly, an activity which damaged his professional career. In 1781 he opened a portrait gallery of Revolutionary heroes. In 1784 he founded the institution which became famous as Peale's museum, a pioncering venture in museum exposition and a new expression of his liberal philosophy, which was intended to illustrate nature and natural law. The first scientific expedition organized in the United States brought to it in 1801 the first complete skeleton of the American mastodon. The museum grew to vast proportions and was widely imitated by other museums of the period and later by P. T. Barnum.

In his long life, Peale painted about 1,100 portraits, including virtually all his great contemporaries. His seven life portraits of Washington of 1772, 1776, 1777, 1779, 1783, 1787 and 1795 were repeated many times by himself and other painters of his family. He died in Philadelphia, Feb. 22, 1827.

His brother, JAMES PEALE (1749–1831), became well known as a miniaturist and a painter of portraits, landscape and still life. He served as an officer of the Continental army, and painted a small group of Revolutionary battle scenes.

REMBRANDT PEALE (1778–1860), a son of Charles Willson Peale, was born in Bucks county, Pa., on Feb. 22, 1778. He studied first with his father, then at the Royal Academy in London in 1803 and between 1808 and 1810 in Paris, where he was offered the post of portrait painter to Napoleon's court. In 1814 he founded the Peale museum in Baltimore. Ambitious to rise above portrait work, he painted a number of formal subject pieces culminating in his huge "Court of Death" of 1819 (Detroit Institute of Arts), a picture whose exhibition brought the artist $19,000 in the first year.

In 1823, invoking both study and inspiration, he painted a head of George Washington, whom he had painted from life in 1795. This strong but idealized likeness enjoyed great popularity and was

PORTRAIT OF JAMES PEALE (THE "LAMPLIGHT PORTRAIT"). BY CHARLES WILLSON PEALE. IN THE DETROIT INSTITUTE OF ARTS, DETROIT, MICH.

BY COURTESY OF THE DETROIT INSTITUTE OF ARTS

repeated by him many times. He sold his museum in 1822 and thereafter devoted all his time to art, painting in New York, Boston, Philadelphia and other cities. His portraits include many distinguished figures, that of Thomas Jefferson being perhaps his masterpiece, as well as the best portrait of the president. His writings include *Notes on Italy* (1831), *Graphics* (1835), *Portfolio of an Artist* (1839) and reminiscences appearing in C. E. Lester's *Artists of America* (1846) and the *Crayon* (1855–57). He died in Philadelphia, Oct. 3, 1860.

Rembrandt's brother, RAPHAELLE PEALE (1774–1825), was a master of *trompe-l'oeil* and founder of the art of still-life painting in the United States.

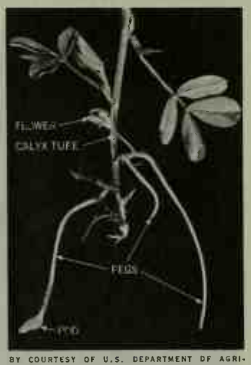
See Charles C. Sellers, *Charles Willson Peale,* 2 vol. (1947) and *Portraits and Miniatures* (1952). (C. C. Ss.)

PEANO, GIUSEPPE (1858–1932), Italian mathematician and logician, whose interests were concentrated on the foundations of mathematics and on the development of a formal logical language. Born at Cuneo, Aug. 27, 1858, he became professor of infinitesimal calculus at the University of Turin in 1890 and also at the Accademia Militare from 1887 to 1901. His *Formulaire de mathématique* (*Formulario Mathematico*), published from 1894 to 1908 with collaborators, sets forth the fundamental postulates of mathematics in Peano's notation, part of which was adopted by Bertrand Russell and Alfred N. Whitehead in their *Principia Mathematica* (*see* LOGIC, HISTORY OF). His name is particularly associated with the axioms for the integers (*see* NUMBER: *Ordinal or Inductive Definition*), and with the discovery of the Peano spaces (*see* TOPOLOGY, GENERAL).

He is known as the creator of an international language (*q.v.*), the *latino sine flexione,* based upon words most common in Western European languages. He compiled a *Vocabulario de interlingua* (1915) and was president of the Academia pro Interlingua. He died at Turin, April 20, 1932. (O. OE.)

PEANUT (GROUNDNUT, EARTHNUT, GOOBER), despite its several common names, is not a true nut but the pod, or legume, of *Arachis hypogaea* (family Leguminosae), which has the peculiar habit of ripening underground. It is a concentrated food: pound for pound peanuts have more protein, minerals, and vitamins than beef liver; more fat than heavy cream; and more food energy (calories) than sugar. Native to tropical South America, the peanut was at an early time introduced into the Old World tropics. India, China, West Africa, and the United States have become the largest commercial producers of peanuts. There are three major peanut-producing regions in the U.S.: Virginia-Carolina grows mainly the large Virginia type; Georgia-Florida-Alabama grows the Southeastern Runner, Virginia, and Spanish types; and Oklahoma-Texas grows mainly the Spanish type.

The plant is an annual ranging from an erect or bunch form 1½–2 ft. high, with short branches, to a spreading or runner form 1–1½ ft. high with branches up to 2 ft. long that lie close to the soil. The stems and branches are sturdy and hairy; leaves are pinnately compound with two pairs of leaflets. The flowers are borne in the axils of the leaves; what appears to be a flower stalk is a slender calyx tube up to 1½ in. long; the golden yellow petals are about ⅜ in. across. The pods are most commonly 1–2 in. long, two or three seeded, oblong, roughly cylindrical with rounded ends, contracted between the seeds, and have a thin, netted, spongy shell. The seeds vary from oblong to nearly round; seed coat colours range from whitish to dark purple, but mahogany red, rose, and salmon predominate.



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PEANUT PLANT SHOWING PEGS THAT PRODUCE PODS UNDERGROUND

After pollination and the withering of the flower, an unusual stalklike structure called a peg is thrust from the base of the flower toward the soil. In the pointed tip of this slender, sturdy peg the fertilized ovules are carried downward until the tip is well below the soil surface. Only then does the tip start to develop into the characteristic pod. The pegs sometimes reach down several inches before their tips can develop fruits. The fruits appear to function as roots to some degree, absorbing mineral nutrients directly from the soil. The pods may not develop properly unless the soil in which they lie is well supplied with available calcium, regardless of the nutrients available to the roots.

The peanut is grown mainly for its edible oil except in the United States, where it is produced for grinding into peanut butter (half the harvested crop); for roasted, salted nuts; and for use in candy and bakery products. A small percentage of the crop is crushed for oil. In the southern United States the peanut is used extensively as feed for livestock. The tops of the plants, after the pods are removed, usually are fed as hay, although the entire plant is sometimes so used.

Profitable growing of peanuts requires at least five months of warm weather with a growing-season rainfall (or irrigation equivalent) of 22–24 in. or more. In Asia the peanut is grown under irrigation. The best soils are well-drained sandy loams 1–1½ ft. deep, underlain by deep, friable loam subsoils. In the United States the shelled seeds are planted in rows 30–36 in. apart. Seeds of the small Spanish type are placed three–four inches apart; the larger varieties are seeded six–eight inches apart in the rows. The seeds are treated with a fungicide to control diseases during germination and seedling emergence. Dusting the plantlets with fungicides to control leaf diseases is usually necessary in humid areas. Careful weed control is essential.

Mechanical injury to the plants by weeding tools or by soil heaped upon them greatly increases the probability of infection and damage by certain soil-inhabiting fungi. Clean cultivation and the use of suitable chemical weed killers help minimize loss from diseases caused by these fungi.

The peanut is susceptible to leaf spot diseases of fungus origin and to insects that defoliate the plants, thereby reducing the yields and the quality of nuts. These blights are readily controlled by timely dusting or spraying with appropriate chemicals. Attacks by certain injurious insects and nematodes in the soil are less successfully controlled.

At harvest, the entire plant, except the deeper roots, is removed from the soil. The nuts are best cured by allowing the harvested plants to wilt for a day, then placing them for four to six weeks in stacks three–four feet in diameter and six feet high, each stack built around a sturdy stake driven upright into the soil. The pods are placed toward the inside of each stack to protect them from weather. Too rapid drying of the nuts impairs seed viability and eating quality. To an increasing extent in the United States, labour shortages necessitate curing the plants in windrows in the field, from which the pods are picked by mobile machines. For picking the pods from stacked plants the stacks are hauled short distances to stationary picking machines. The cured and picked pods are finally cleaned and graded at central establishments.

See also references under "Peanut" in the Index.

See T. K. Wolfe and M. S. Kipps, *Production of Field Crops,* 5th ed., pp. 357–370 (1959). (V. R. B.; X.)

PEAR, any of several species of *Pyrus,* especially *P. communis,* one of the most important fruit trees of the world, and one cultivated to some extent in all temperate-zone countries of both the Northern and Southern hemispheres. In these regions it is exceeded in importance only by the apple, to which it is related botanically; it surpasses in total production peaches, plums, and cherries. All of these fruits belong to the rose family (Rosaceae; *q.v.*). With the aid of hormones, hybrids between apples and pears have been produced but few have survived the first season's growth; likewise when grafted or budded one on the other, the union is usually short lived.

There are about 20 species of *Pyrus,* all originating in the area from Europe eastward through Asia to China and including North Africa. No species of pear is native in the New World or the Southern Hemisphere. The common pear (*P. communis*), a na-

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PEAR BLOSSOMS (PYRUS COMMUNIS)

tive of southeastern Europe and western Asia, is the species from which most of the high-quality varieties with juicy, melting flesh have been derived. Many of the varieties widely grown in Europe for the making of perry (*q.v.*), an alcoholic beverage prepared from fermented pears, are derived from the snow pear (*P. nivalis*). The Chinese sand pear (*P. pyrifolia*) is the parent of most Asiatic varieties, characterized by coarse-textured flesh and prominent stone cells. This species is included in the ancestry of some of the varieties most widely grown in the eastern United States. Sand pears and other Oriental species are generally more resistant to fire blight disease (*see* below) than varieties developed from *P. communis*. Oriental species like *P. ussuriensis*, *P. betulaefolia*, and *P. calleryana* have been used to breed varieties resistant to fire blight and to provide blight-resistant rootstocks.

History.—The common pear has been cultivated since long before the Christian era. Homer, nearly 10 centuries B.C., listed pears as one of the fruits in the garden of Alcinous, indicating that they were known to the Greeks of his day. Improved varieties propagated by grafting were known prior to the time of Christ. Thousands of varieties have been bred and named since that time in Europe alone. The pear was introduced into the New World by British and other north Europeans as soon as the Colonies were established. Also at an early date, the Mission Fathers from Spain took them to Mexico and California.

Plant Characteristics.—*Growth Form.*—The pear tree is broad-headed and up to 45 ft. high at maturity; it is taller and more upright than the apple tree. The roundish to oval, leathery leaves, somewhat wedge shaped at their bases, appear about the same time as the inch-wide, usually white flowers. The pear flower, similar to that of the apple, differs from the latter in having the bases of the five styles separated.

The Fruit and Its Composition.—Pears are generally sweeter and of softer texture than apples. The fruit is distinguished from the apple by the presence of hard cells in the flesh, the so-called grit or stone cells, which are absent in apples. In general, pear fruits are elongate, being narrow at the stem end and broader at the opposite end; some types, particularly among the Oriental pears, are apple shaped. Pears have slightly more protein (though it is an insignificant amount), more minerals, and more sugar than apples. They are, however, less rich in vitamins, containing about ⅛ the vitamin A of apples. Water content and caloric value are similar for pears and apples.

Varieties.—In most pear-growing countries of the world outside Asia, by far the most widely grown pear variety is Williams Bon Chrétien, often known simply as Williams. It was named after the nurseryman who introduced it on the market; on its introduction to America it was renamed after its importer, Bartlett. It is estimated that in the main pear-producing area of the western United States 75% and in Italy 25% of all the pears grown are of this variety. In the United States and Canada varieties such as Beurre Bosc, Beurre d'Anjou, and Winter Nelis are grown. The most popular variety in England and the Netherlands is Conference and in Italy, after Williams, are Curato, Coscia, and Passe Crassane, the last named being also popular in France. The pear acclaimed as having the finest flavour and texture is Doyenne du Comice, produced in France in 1849. In Asiatic countries, local varieties of native species are grown; they are considered low in quality by most Europeans and Americans.

Propagation and Cultivation.—The pear is propagated by budding or grafting a known scion variety onto a rootstock. Many are grafted on seedling pears, usually of *Pyrus communis* origin. In Europe the main rootstock used is vegetatively propagated quince, which produces a dwarfer tree that fruits at an earlier age than most of the trees on pear rootstocks. Some pear varieties—Williams is an example—are not satisfactory when grafted directly on quince and do not form good unions. In such cases a compatible variety is first grafted onto the quince rootstock and the incompatible variety is then grafted onto the compatible variety, a procedure known as double-working.

The pear on its own rootstock thrives best in well-drained, moderate-textured soils that permit deep rooting. It can be grown, however, on heavier and more poorly drained soils than can most other tree fruits. Pears grafted to quince rootstocks, which are more shallow rooted, do better in looser soil; they will not tolerate drought conditions as well as pears on pear rootstocks.

Pear trees are relatively long-lived (50 to 75 years) and may reach considerable size unless they are carefully trained and pruned. Within 4 to 7 years of setting out, the tree should begin to bear satisfactorily; at age 20 to 25 it should yield 25 to 45 bushels of fruit. The usual spacing for standard trees is 20 x 20 ft.; older orchards are more dense, with shorter trees spaced as close as 16 x 16 ft.; dwarf pears can be as close as 12 x 12 ft.

Pears are somewhat less resistant to winter cold than are apples. Most varieties do not survive where minimum temperatures are likely to reach −20° to −30° F (−29° to −35° C). Pears bloom earlier in spring than apples, hence are more subject to damage from spring frosts. Highest quality fruits are produced where summer temperatures are moderately high, and diseases are less serious where the summers are dry. Like other deciduous fruits, pears require a period of winter cold, and are not productive within 25° north or south of the equator, even at elevations where the year-round climate is cool.

Harvesting and Marketing.—Pears must be harvested at the correct stage of development otherwise they do not ripen or store in good condition. The fruits are cooled as quickly as possible after harvesting. The length of time the fruits can be stored depends on the variety and the type of storage. Fruits kept at 34° F (1° C) or slightly lower do not ripen, but proceed to do so when transferred to a temperature of 60° F (16° C). At tem-

RIPE PEAR (PYRUS COMMUNIS)

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peratures of 32° (0° C) to 34° F (1° C) Williams, or Bartlett can be held in store for six or seven weeks whereas Conference and Beurre Bosc can be kept for three months, then ripened at 60°–65° F (16°–18° C). Pears stored in refrigerated gas (carbon dioxide-oxygen mixture) give better quality fruit, with less wastage and a longer period of ripeness after removal from storage. Late-keeping varieties may be stored under natural conditions of air and temperature quite satisfactorily. Most pears are packed individually wrapped, in single layer trays or in half-bushel or bushel boxes.

Pests and Diseases.—*Pests.*—The codling moth, or apple worm, is a serious pest on pears wherever they are grown. Other insect pests that can be troublesome include the pear midge, the pear leaf blister mite, pear psylla or sucker, pear thrips, several species of scale, and a wide range of leaf-eating insects. Several species of red spider (mites) also do much injury to pear leaves. Where high quality, clean fruit is desired it is necessary to spray the orchard three to six times a year.

Fungus Diseases.—The pear is also subject to a number of fungus diseases controllable by spraying. Pear scab, caused by the fungus *Venturia pirina,* occurs in most areas where the pear is grown, but is of much greater importance in Europe than in North America. Pear leaf spot (*Mycosphaerella sentina*) and pear leaf blight (*Fabraea maculata*) are also fairly widespread in most pear-growing countries. These diseases attack the leaves, causing defoliation. Scab and leaf blight also attack the fruit, causing roughened, scabby spots on the fruit surface and deforming the fruit if it is infected early in its development.

Other fungus diseases that can cause serious trouble are brown rot (*Sclerotinia fructigena*), which attacks pear fruits on the trees, in storage, in transit, or in the market. Canker, caused by *Nectria galligena* or *N. ditissima,* is a problem particularly of trees on heavy soils. The cankers form on branches or on the trunk; if they girdle the stem they can kill the tree.

Fire Blight.—The most serious disease of pears in North America is fire blight, caused by a bacterium (*Erwinia amylovora*). The bacteria invade the bark and succulent tissues. When infection occurs in the main body of the tree, large branches or the whole tree may be killed. The roots are also subject to infection. In climates having warm, humid, rainy summers, the disease has not been successfully controlled on susceptible varieties. General orchard cleanliness and the use of the antibiotic streptomycin and copper-containing sprays applied during and following bloom are helpful in reducing infection. Fire blight has been reported from Japan, Italy, and some other European countries, but outside North America it is only in New Zealand that this disease has come to be of economic importance.

Virus Disease.—A virus disease called stony pit has been reported from many pear-growing countries. This disease, as its name suggests, produces hard, stony pits in the fruit. It appears to be transmitted only by grafting. Control is by propagating only from virus-free trees and rootstocks. Not all varieties are affected, and some appear to be able to carry the disease without showing the characteristic symptoms.

Production and Uses.—As stated earlier the pear is, commercially, the second most important of the world's deciduous fruit trees, exceeded only by the apple. In the United States and Italy, two of the greatest fruit-producing countries, however, the pear ranks third after the apple and peach. In Europe table varieties of pears achieve one-third of apple production and in the United States about one-quarter.

World production of table or dessert pears, excluding those used for perry, is about 5,000,000 tons annually, about half of which is produced in Europe. Italy is the world's leading pear producer. The United States is the second largest producer, the three Pacific Coast states of California, Oregon, and Washington accounting for about 90% of the crop. Other countries having important pear production are China, Japan, Turkey, Argentina, Australia, and South Africa.

In the United States, Canada, and Australia the quantity of fresh fruit used by canners amounts to about half of the total commercial crop; in South Africa canning accounts for 30%. In Europe canning is of relatively minor importance. In France about one-third of the total production of pears is used for making perry; in Germany, half; in Austria, three-quarters; and in Switzerland, as much as four-fifths. *See* also FRUIT FARMING.

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PEARL, RAYMOND (1879–1940), U.S. biologist and pioneer expositor of the statistical approach to biology and medicine (biometry). He was born at Farmington, N.H., on June 3, 1879, and studied at the University of Michigan, Ann Arbor, and in Leipzig, Naples, and London. In London, studying with Karl Pearson (*q.v.*), Pearl began his contributions to biometry with investigations on morphologic variations and correlations in man and animals. These studies were continued at the Maine Agricultural Experiment Station, where he was biologist and head of the department of biology from 1907 to 1918. In this period he conducted fundamental studies on the physiology of reproduction in domestic fowl. From 1917 to 1919, he was chief of the statistical division of the U.S. Food Administration.

In 1918 Pearl was invited to organize the department of medical statistics and biometry at the new School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md. In 1925 he was appointed director of the school's Institute of Biological Research. His investigations centred on fertility and population growth, human longevity and the relationship of physique to health and disease. He founded two journals: *Quarterly Review of Biology* in 1926 and *Human Biology* in 1929. Pearl's record of publication was prodigious; his bibliography lists about 700 articles and books. Of the books, the most important and lasting are: *Introduction to Medical Biometry and Statistics* (1923), considered a model for such textbooks; *Studies in Human Biology* (1924), a summary of Pearl's investigations on public health problems and a guide for biostatistical research; *Alcohol and Longevity* (1926), a critical review of the reported findings regarding alcohol on the biological system and a clear description of its noxious and beneficial effects; *The Natural History of Population* (1939), in which he discussed the population problem and laid solid biological foundations for later population studies.

Pearl died at Hershey, Pa., Nov. 17, 1940. (A. Co.)

See Thomas Park's biography of Raymond Pearl in the *Dictionary of American Biography,* vol. XXII, suppl. 2 (1958).

PEARL. A pearl is a concretion formed by a mollusk; it consists of the same material (nacre, or mother-of-pearl) as the mollusk's shell. Every mollusk endowed with a shell can produce pearls. Pearllike chitinous formations also have been found in insects and horny ones occur in horn-bearing mammals. Thus a

NACRE, OR MOTHER-OF-PEARL, IN THE SHELL OF THE GREEN TURBAN (TURBO MARMORATUS)

RUTHERFORD PLATT

pearl might be defined broadly as a concretion of organic origin.

In common usage, however, pearls are understood to be the concretions of mollusks. The characteristics that make such pearls desirable and often highly prized as jewelry are their iridescence and translucence. The more perfect the shape (symmetrical ball- or droplike) and the deeper the pearly lustre, the greater the pearl is esteemed. Only those pearls found in mollusks whose shells are lined with nacre are really fine pearls. Pearls from other mollusks are either reddish or whitish, porcelaneous or lacking in pearly lustre.

An unblemished pearl is one of the most ancient symbols of perfection. Pearls were so highly esteemed in classical Rome that only persons of a specified rank were permitted to wear them. Pliny speaks of pearls as "the richest merchandise of all, and the most sovereign commodity in the whole world." The trade in pearls was conducted by a special corporation whose members were known as *margaritarii*.

In spite of the modern development of the cultured-pearl industry, the demand for naturally occurring pearls of high quality has continued, and fine specimens still command prices amounting to thousands of dollars. However, the peak prices that prevailed in 1928 and 1929 had not been reached again by the early 1960s.

The chief component of the nacre that constitutes the pearl is aragonite, a calcium carbonate distinguished by its orthorhombic crystalline system, its hardness and its lustre. Occasionally a pearl may contain calcite, also a calcium carbonate but differing from aragonite in crystalline structure and other physical characteristics. Nacre contains a small amount of conchiolin, the albuminoid that is the main constituent of the mollusk's outer shell.

The mollusk's shell-secreting cells are located in the mantle, or epithelium, of its body; when a foreign particle penetrates the mantle, shell-building cells attach to the particle and build up layers of pearl around the invading material. If the foreign substance penetrates deeply enough into the mantle or other soft body part, a sac or cyst of tissue is first formed around it; the pearl building takes place within this sac. The cyst process begins as an indentation in the mantle or body tissue and proceeds in a pouch formation with an ultimate closure at the neck. When the sac is located in the mollusk's body so as not to be subjected to any deforming pressure, it tends to be globular or pear-shaped and the pearl that develops inside it consequently assumes either a spherical or a pearlike form. The nacreous layers that comprise a round pearl of good quality are generally built up concentrically.

Pearl formation does not always occur in soft tissue areas where the expanding pearl sac encounters no appreciable resistance. Pearl cysts lodged in muscular tissue, for example, are unable to overcome the resistance of tough muscle fibres and assume irregular shapes. The pearls produced are consequently oddly formed and are termed baroque pearls. If the depth of penetration of the foreign body is not great and the particle lodges between the shell and the mantle, the shell-secreting cells deposit a sacless pearl formation that is attached to the shell. A pearl-bearing sac situated close to the outer surface of the mantle may come in contact with the shell and also become attached to it. Shell-attached pearls that grow into half spheres flat on one side are called blister pearls.

Although the term pearl is somewhat loosely applied to the calcareous concretions found in various types of mollusks, the appellation true pearl is used only to describe the cyst pearl composed predominantly of nacre and formed free within the mollusk's body without attachment to its shell. The true pearl is characterized by its lustre and by a delicate play of surface colour called its orient.

True pearl-bearing mollusks, of which there are both salt-water and fresh-water varieties, are popularly called pearl oysters, which is something of a misnomer, since these mollusks are not of the Ostreidae family of bivalves that includes the *Ostrea edulis*, or edible oyster. Concretions found in the common edible oyster are generally black or purple in colour, sometimes with an admixture of white, and almost never exhibit lustre. They are not true pearls.

The salt-water mollusks most important in natural pearl production belong to the genus *Meleagrina* (or *Pinctada*), formerly and perhaps better known as *Margaritifera*, which belong to the family Aviculidae or Pteriidae. The *Meleagrina* alone yields the most highly prized of all true pearls, the oriental pearl.

BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

ORIENTAL PEARL OYSTER (MELEAGRINA) WITH ATTACHED BLISTER PEARL

True pearls are formed of nacre secreted by mollusks in layers around a particle of foreign matter that has become lodged in the fleshy mantle

Sources of Natural Pearls. —Ranking first among oriental pearls for superior form, lustre and orient are those produced by the *Mohar*, a variety of the *Meleagrina vulgaris* species of mollusk found in the Persian gulf. The richest pearl harvest of the gulf is taken from the waters of the great bight that curves from the peninsula of Oman to that of Qatar, where the pearl banks lie at depths of 8 to 20 fathoms (48 to 120 ft.). Pearls of fine quality are also fished from the pearl banks of the Island of Bahrain.

The Persian gulf pearling fleet is, for the most part, based on the Trucial coast, and fishing is carried on from May through the early part of September. The pearl divers work in pairs, one man remaining at the surface to attend the two lines used; one line, to which is attached a stone weighing about 40 lb., carries the diver downward with baskets to contain the mollusks he gathers, while the second line serves as a signal cord. A diver remains below for 60 to 80 seconds before signaling to be drawn to the surface with his catch. The great pearl market of the Persian gulf has long been the Iranian port city of Lingeh, whose name has become synonymous with the finest of Persian gulf pearls. (*See* also PERSIAN GULF.)

Another important source of oriental pearls produced by the *Meleagrina vulgaris* is the Bay of Bengal in the neighbourhood of Ceylon, particularly in the Gulf of Mannar. These pearls are marketed in the Indian city of Madras, which confers its name on the pearls marketed there. Also marketed in Madras are numbers of African pearls that are taken chiefly from the pearl banks that lie in the coastal waters of east Africa from the Island of Zanzibar to Inhambane in Mozambique. Since the days of the Ptolemies, pearls have also been fished in the Red sea, though the industry there has dwindled to insignificant proportions.

In southeast Asia, the pearls of the Celebes are noted for their lovely colouring, while Australian waters yield pearls of a beautiful silvery white that are produced by *Meleagrina margaritifera* and *Meleagrina maxima*. The islands of the South Pacific also produce fine pearls, and the islanders are noted for their skill and daring as pearl divers. They use no sinkstone and both men and women take part in the fishing. In the Americas, salt-water pearls greater in size than oriental pearls, though less finely formed, have been fished in the Caribbean. The Gulf of California, the Gulf of Mexico and the waters of Mexico's Pacific coast have yielded dark-hued pearls with a metallic sheen, as well as white pearls of good quality.

Fresh-water mussels, notably the species known as *Unio margaritifera*, which inhabit the rivers and streams of the temperate zone of the northern hemisphere, have produced pearls of great value. The fresh-water pearls of the United States have come principally from the Mississippi river and its tributaries, although rivers in other parts of the country have been rich sources also. The most famous of all American fresh-water pearls, the pink "queen pearl," which weighed 93 pearl grains (23¼ carats), was found in Notch brook near Paterson, N.J., in 1857. It was purchased by the jeweler C. L. Tiffany, from whom it passed to a French gem dealer and was sold to the empress Eugénie.

Although pearling has declined greatly in Great Britain, pearls from the rivers of Scotland, particularly the Spey and the Tay, and those from the river Conway in northern Wales were once in great demand. Pearling is still a profitable and carefully fostered industry in central Europe, however, and the forest streams of Bavaria,

in particular, are the source of choice fresh-water pearls.

In China, fresh-water pearling is an ancient industry. As long ago as 2000 B.C., the pearl was a reckoned item in the collection of taxes or tribute, and it is listed in *Rh'y*, a dictionary believed to have been compiled earlier than 1000 B.C., as a product of the western part of the empire.

Cultured Pearls.—To the Chinese belongs the distinction of having been the first producers of cultured pearls. The discovery that pearl production in the fresh-water mussel could be stimulated by introducing a foreign object inside the creature's shell is said to have been made by Ye-jin-yang, a native of Hoochow, in the 13th century A.D. Certainly the Chinese have been adept for hundreds of years at cultivating pearls by opening the mussel's shell and inserting into it small pellets of mud, or tiny bosses of wood, bone or metal, and returning the mussel to its bed for about three years to await the maturation of a pearl formation. Curious pearl-encased statues of the seated Buddha have been produced by placing tiny metal statues of Gautama inside the shells of mussels. The cultured pearls of China have been almost exclusively blister pearls that required the addition of a half sphere of mother-of-pearl to achieve the joined round pearl form known as the doublet.

The production of whole cultured pearls was perfected by the Japanese; the research that led to the establishment of the industry was started in the 1890s by K. Mikimoto. After long experimentation, Mikimoto concluded that a very small mother-of-pearl bead introduced into the mollusk's tissue was the most successful stimulant to pearl production. It possessed the added virtue of providing a pearl entirely of nacreous content.

Cultured pearls closely approximate natural pearls. However, if the covering of nacre is too thin it will deteriorate upon prolonged contact with the human body and eventually will reveal the mother-of-pearl matrix. Japan has more than 300 sea farms devoted to production of cultured pearls. The largest of these extends for 20 nautical miles in Ago bay.

Examinations.—Numerous scientific instruments are available for ascertaining the nature and quality of a pearl. The core of a pearl can be observed in the strong light of the nacrescope, or pearl illuminator. Another instrument, the endoscope, provides an enlarged image of the hole drilled through the pearl for stringing. When the illuminator is used with the endoscope, the beam of light, which is first directed on the walls of the drill hole and then follows a path through the pearl, reveals the structure of the pearl from its heart out. The genuine pearl is of concentric construction, while the cultured pearl is shown to be composed of parallel layers of nacre upon its mother-of-pearl matrix. In the case of undrilled pearls, X-ray photographs aid the gem expert in determining the nature of the pearl structure.

Properties.—The colour of pearls varies with the mollusk and its environment. Colours range from black to white, with the rose of Indian pearls being valued most highly. Other colours are cream, gray, blue, yellow, lavender, green and mauve. All occur in delicate shades.

The size range also is wide. Pearls weighing less than one-quarter grain are called seed pearls; as many as 9,000 seed pearls may together weigh one ounce. The largest naturally occurring pearls are the baroques; Henry Thomas Hope owned a baroque weighing 1,860 gr.

Special care must be accorded pearls since they are comparatively soft and easily damaged by acids. On Mohs' scale of hardness, pearls are ranked as 3½ to 4, compared with 1 for talc and 10 for diamonds. This ranking indicates pearls can be scratched with a pin, coin or knife. Consequently they are worn almost exclusively in protected positions, such as in earrings and as necklaces. Pearls also can be damaged by friction; to avoid enlarging the drill holes, pearl necklaces should be restrung regularly and knotted between pearls to keep them from sliding on the string. Since pearls are composed mainly of calcium carbonate, they should not be placed in contact with acid; small amounts of weak acid occur in perspiration, hence pearls should be wiped off after being worn. Small amounts of acid may cause pearls to change colour; large amounts may cause them to decompose. Pearls also are adversely affected by heat.

The surface of a pearl is rough to the touch. A common method for distinguishing between natural or cultured and imitation (man-made) pearls is to pull a string of them across the teeth. The natural or cultured pearls feel rough; the imitation pearls feel smooth. Imitation pearls, which were first made in France in the 17th century, are manufactured by dipping alabaster glass beads in a pearl solution of fish-scale essence and lacquer and repeating until the desired qualities are attained.

History.—The history of the pearl is a long one. It is mentioned in the literature of ancient India as well as that of China (see *Sources of Natural Pearls* above). In Vedic literature the pearl is mentioned as being known in India before the influx of the Aryans (*c.* 1500 B.C.). Archaic Greek and Etruscan jewelry (*c.* 400 B.C.) featured borders of pearls surrounding a central setting of coloured gem stones. Fine pearls were fished in the Persian gulf when Macedonia was a power, and pearls were prized gems in imperial Rome. Oriental pearls were not widely known in medieval Europe until trade with the east was restored by the maritime city-states of Italy, when they became increasingly popular with Europeans. Both river and oriental pearls were used profusely for personal adornment. During the Renaissance, airily light earrings were made by suspending pearls from fine gold wires, and brooches were fashioned with pendant pearls. Portraits of the period show ropes of pearls encircling the neck and winding around the shoulders of the wearer. The goldsmith of the Renaissance found beauty in the baroque pearl. His imagination saw in it not the misshapen product of a sea mollusk but rather an animal form from nature, or the body of a hero or a god from the pages of classical mythology. He broke with the ancient tradition that demanded of the pearl the classic regularity of the sphere and skilfully incorporated the baroque into the individualistic freedom of his design.

With the advent of the modern era, pearls lost none of their popularity. The age turned to the safety of symmetry, however, and the regularity of the globed jewel was again preferred to the eccentricity of the baroque.

Pearls noted for their size, beauty and historical associations are ranked among the famous jewels of the world. La Reine des Perles, a 27.5-carat oriental pearl, was among the crown jewels of France stolen in 1792, while La Regente, an oval pearl weighing 34 carats, once was owned by the French imperial court. A beautiful Caribbean pearl presented to Philip II of Spain in 1570 is presumed to have been destroyed by fire in the Escorial in 1734.

See JEWELRY; *see* also references under "Pearl" in the Index.

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(E. L. Y.)

PEARL HARBOR ATTACK. The Japanese attack on Pearl Harbor, Hawaii, on Dec. 7, 1941, was the culmination of worsening relations between the United States and Japan extending over a decade. U.S. policy in the far east was closely tied to friendship with China and to dislike of Japanese aggression against that state. As early as 1931 the Tokyo government had extended its sway over the Chinese province of Manchuria. By 1937 it had entered upon formal warfare with the Chinese Nationalists. In 1938 the United States government extended its first loan to China; in 1939 it denounced the commercial treaty of 1911 with Japan; in the summer of 1940 it began to restrict the export to Japan of materials useful in war. Between June 1940 and the fateful crisis of Dec. 1941, the tension constantly mounted. In July 1941, by which time the Japanese had occupied all of Indochina and had entered into an alliance with Germany and Italy, the U.S. government severed all commercial and financial relations with Japan. The militarists in the Tokyo government were steadily gaining in influence; they bitterly resented U.S. aid to China, which had by this time been stepped up; and they saw in the German invasion of the U.S.S.R. an unrivaled opportunity to pursue a policy of aggression in the orient without danger of an attack upon their rear by the forces at the disposal of the Kremlin. Nonetheless, negotiations looking to some kind of understanding between the United States and Japan took place

through the autumn of 1941, and not until near the end of November did it become clear that no agreement was possible. By this time the Japanese government had decided that upon failure of the negotiations, it would attack the United States without first declaring war; the plan for a surprise assault on Pearl Harbor had already been worked out. The order for this assault was issued on Nov. 5; on Nov. 16 the task force of about 30 ships, including 6 aircraft carriers, under Vice-Adm. Chuichi Nagumo, began its rendezvous in the Kuril Islands; and on Nov. 26 it sailed on its mission. It was instructed, however, that it might be recalled in case of a favourable outcome of the negotiations in Washington, D.C.

Warnings and Responses.—The U.S. Pacific force had been stationed at Pearl Harbor since April 1940. In addition to nearly 100 naval vessels, including 8 battleships, were substantial military and air forces at this key U.S. base. As the tension mounted, Adm. Husband E. Kimmel and Lt. Gen. Walter C. Short, in command at Pearl Harbor, were warned of the possibility of war, specifically on Oct. 16 and on Nov. 24 and 27. The dispatch of Nov. 27, to Admiral Kimmel, beginning, "This dispatch is to be considered a war warning," went on to say that "negotiations have ceased," and directed the admiral to "execute an appropriate defensive deployment." Kimmel was also ordered to "undertake such reconnaissance and other measures as you deem necessary." The communication of the same day to General Short declared that "hostile action is possible at any moment," and, like its naval counterpart, urged "measures of reconnaissance."

In response to these warnings, the measures taken by the army and navy commanders were, as the event proved, far from adequate. General Short ordered an alert against sabotage and concentrated most of his fighter planes at the base on Wheeler field in order more effectively to prevent damage to them. He also gave orders to operate five of the mobile radar sets that had been set up in the island from 4 A.M. to 7 A.M., considered to be the most dangerous period. (Radar training, however, was in a far from advanced stage.) Admiral Kimmel, despite the fact that his intelligence had not been able to locate substantial elements in the Japanese fleet, especially the first-line ships in carrier division 1 and 2, did not expand his reconnaissance activities to the northwest, the logical point for an attack. He moored the entire fleet (save that part which was at sea) in harbour, and permitted a part of his personnel to go on shore leave. Neither of these officers suspected that the base at Pearl Harbor would be subjected to attack. Nor, for that matter, is there any indication that their superiors in Washington were in any way conscious of the approaching danger. In the ten days between the war warning of Nov. 27 and the Japanese attack itself no additional action was taken by Washington.

Early on Sunday morning, Dec. 7, Washington learned that the Japanese ambassadors had been instructed to ask for an interview with the secretary of state at 1 P.M. (7:30 A.M. Pearl Harbor time). This was a clear indication that war was at hand. The message took some time to decode. It was not in the hands of the chief of naval operations till about 10:30. It was delivered at the war department between 9 and 10 A.M. General Marshall, the chief of staff, was out horseback riding and did not see the dispatch till arriving at his office about 11:15 A.M. The chief of naval operations, Admiral Stark, even then, did not think that the communication called for any additional instructions to Kimmel. However, General Marshall *did* decide to send a new warning, and gave orders to the military command to communicate also with the navy. He did not telephone, fearing that his words might be intercepted. He sent his dispatch by telegram. There was a mix-up in communication, and the warning did not reach Hawaii till after the attack had begun. It is important to note that it had not been filed until noon, only an hour before the Japanese planes moved in on the great base.

At Pearl Harbor itself, there were incidents that, properly interpreted, might have given a brief warning. Four hours before the decisive moment a Japanese submarine was sighted by the destroyer U.S.S. "Ward". No report was made. About two and a half hours later, the commander of the U.S.S. "Ward" sent a message saying that he "had attacked, fired upon and dropped depth charges upon submarine operating in defensive sea area." While Admiral Kimmel waited for "confirmation" of this report, the Japanese opened hostilities. In these same morning hours, an army private, practising on the radar set after its normal closing time, noticed a large flight of planes on the screen. When he telephoned his lieutenant, he was told to forget it, for a flight of B-17s from the United States was expected at that time. Once again, an opportunity was missed.

The Attack.—It was at 7:55 A.M. (local time) that the first dive bomber from the Japanese aircraft carrier arrived over Pearl Harbor. It was followed by a massive group of nearly 200 aircraft, including torpedo planes, bombers and fighters. Within a quarter of an hour the various airfields at the base were subjected to savage attack. At Wheeler field, in particular, where General Short had drawn up his planes, the destruction was fearful. Of the 126 planes on the ground, 42 were totally destroyed, 41 were damaged, and only 43 were left fit for service. Only six U.S. planes got into the air to repel the attackers on this first assault. At the same time a massive movement was directed against Admiral Kimmel's fleet, so conveniently moored at the base. The battleship U.S.S. "Arizona" blew up with a tremendous explosion.

U.S. NAVY PHOTO FROM U.P.I. COMPIX

BATTLESHIPS DURING ATTACK BY THE JAPANESE

(Left) U.S.S. "West Virginia"; (centre) U.S.S. "Tennessee"; (right) U.S.S. "Arizona." The "Arizona" and the "West Virginia" sank in the harbour with large loss of life

The U.S.S. "West Virginia" was riddled with bombs and torpedoes, and settled on an even keel on the bottom of the harbour. The old U.S.S. "Oklahoma," hit by four torpedoes within five minutes, rolled completely over, with her bottom and propeller rising above the waters of the harbour. The old target ship U.S.S. "Utah" was sunk. Hardly a vessel escaped damage. The antiaircraft crews on the various vessels were fairly prompt in getting into action; the army fired away with what it had; but the force of the attack was in no serious way blunted.

At 8:50 A.M. the second wave of the attack began. Less successful than the first, it none the less succeeded in inflicting heavy damage. The battleship U.S.S. "Nevada" was hit by seven or eight bombs and was grounded at the head of the channel. The battleship U.S.S. "Pennsylvania" was hit and the two destroyers moored near her reduced to wrecks. The destroyer U.S.S. "Shaw" was split in two by a great explosion. Shortly after 9 A.M. the Japanese withdrew.

No one could doubt that the Japanese had gained a great success. They had inflicted on the U.S. navy casualties to the number of 2,718, of which over 2,000 were fatalities. Army casualties exceeded 600 men, of whom more than 200 were killed. The attack had resulted in the total destruction of three battleships, in the capsizing of a fourth, in heavy damage to a fifth, and in lighter damage to three others. Two light cruisers were heavily damaged, and a third suffered less severe hurt. Three destroyers were put out of action, a repair ship badly punished, and a mine-

layer sunk. Heavy damage was inflicted on both army and navy planes on the ground. To accomplish these results the Japanese had sacrificed less than 100 men, 29 planes and five midget submarines. Their task force escaped without being attacked.

There was, however, one consoling feature to the tragedy. As a result of the dispositions made by Admiral Kimmel, two aircraft carriers were not in the harbour; they were engaged in reinforcing other stations, notably Midway and Wake islands. In connection with this same operation, seven heavy cruisers and a division of destroyers were at sea. Of cardinal importance was the absence of the carriers. They were the only two vessels of this type in the area, and were to play a highly important role in future battles.

Investigations and Interpretations.—The great disaster at Pearl Harbor led to numerous investigations. Almost immediately after the assault, the president appointed a commission headed by Justice Owen J. Roberts of the supreme court to examine the facts and to fix responsibility for the disaster. At a later date both army and navy boards reviewed the problem. In 1946 a full-scale congressional investigation took place. Probably no episode in U.S. military history has been so thoroughly examined, and on none has a wider divergence of opinion been expressed.

The most extreme view of the disaster is not to be found in any of the numerous investigations, but was disseminated long after the tragedy by Rear Adm. Robert A. Theobald of the U.S. navy in *The Final Secret of Pearl Harbor*. This view is that President Roosevelt "by unrelenting diplomatic pressure" "enticed" Japan "to initiate hostilities with a surprise attack by holding the Pacific fleet in Hawaiian waters as an invitation to that attack." Such a position is not taken by any responsible historian. It involves judgments as to motives which simply cannot be substantiated.

The president did indeed pursue a policy of support to Nationalist China which acted as a substantial irritant to the Tokyo government, and did much to provoke it to action. But at the same time there is substantial evidence that he sought to postpone a clash, rather than to incite one, and even in the closing days of the negotiations he made an appeal to the Japanese emperor, which, if listened to, might have had that effect.

The success of the attack on Pearl Harbor was primarily due to a false estimate of the enemy's capabilities and intentions. The authorities in Washington knew that the Japanese forces were moving southward into the Gulf of Siam. They did not believe that coincident with this move they could or would mount an attack on the Hawaiian base. It seemed logical, too, that the Japanese would avoid such action because it would inevitably bring the United States into the war; operations in the far east directed against the British and the Dutch might not have this effect. True, the possibility of an air attack on Pearl Harbor had been frequently discussed in the course of the year. But, as matters came to a crisis, for the reasons mentioned above, it fell into the background.

It is a difficult matter (and one on which divergent opinions will long be held) to apportion responsibility between Washington and the commanders on the spot. The Roberts commission, the body appointed by the president on Dec. 17, 1941, in a report presented only a few weeks later, placed the principal blame for the disaster upon Admiral Kimmel and General Short. The army and navy commissions which later examined the problem took a contrary view, throwing the blame on the war and navy departments. The majority report of a congressional committee, rendered in 1946, while not avoiding criticism of the chief of naval operations and the army chief of staff, laid stress on the lack of preparation in Hawaii. Two members of this committee strongly dissented, severely blaming the authorities in Washington, and a third took a kind of middle ground.

Those who defend the position of the Hawaiian commanders make the following points. General Short replied to Marshall's warning of Nov. 27, "Department alerted to prevent sabotage." When this reply passed over the chief of staff's desk, he neglected to notice that it mentioned only this one kind of preparation (as did Gen. Leonard T. Gerow, his subordinate). At no time in the next ten days was this neglect repaired. As for Admiral Kimmel, the point has been made that he was inadequately informed as to the seriousness of the crisis. In the months before Pearl Harbor the armed services, through the breaking of the Japanese code, were able to get much information as to Japanese purposes. Not a small part of this related to the position of the naval forces in Hawaii. Kimmel himself has claimed that had he been put in possession of this material he would have taken far stronger measures than he actually did. In defense of his failure to undertake more vigorous measures of reconnaissance, he urged the importance of his training program, and the limited nature of his resources.

The critics of Washington also asserted that by the evening of Dec. 6 the president had clear evidence that war was impending, and that he should have taken prompt measures to alert the war and navy departments. This view attached little importance to the warnings of Nov. 27.

Those who were critical of the commanders on the spot took the view that the warnings given were sufficient, and that a deplorable lack of imagination was shown in acting on them. Everyone who read the papers knew that war was imminent. Why was not the possibility of an air attack taken into account? Why were Short's airplanes drawn up in such fashion as to be most exposed to enemy attack? Why was the radar training program not more advanced? Why did Admiral Kimmel so handle his schedule that the Japanese could count on all the battleships being in port on Sunday? Why were normal week-end leaves and liberties granted? Why was not some attempt made to improve reconnaissance? Why was not the report on the Japanese submarine taken more seriously? Those who emphasize the responsibility of Kimmel and Short also call attention to the fact that the war warnings of Nov. 27 brought much more vigorous action on the part of the commanders in the Canal Zone and the Philippines.

Whatever judgment may be rendered on this matter, more important than the question of responsibility is the question of the historical significance of Pearl Harbor. And here the verdict is easier to come at. Great as was the Japanese success in the short run, great as was the humiliation inflicted on the United States, the "sneak attack," in the longer perspective, was a monstrous error on the part of the government in Tokyo. Even from the tactical point of view it was a blunder. For in their purpose of destroying the fleet, the Japanese neglected the great oil supplies on Hawaii, the destruction of which would have immobilized the United States for months to come. But, more important, the Japanese attack brought the U.S. government into the war, unified the American people, and made the ultimate defeat of the Japanese militarists inevitable. There was much antiwar sentiment in the United States in the fall of 1941. Had the Japanese commanders directed their attention against the British and Dutch, it must have been at least doubtful whether President Roosevelt could have led the American people into the war in the Pacific. As in so many other instances in the history of the 20th century, in spite of the weaknesses of the democracies, the autocratic states made errors even more vital than the errors of the democracies. Pearl Harbor was atoned for in four and a half years of war; but the blunders of the Tokyo militarists resulted in utter and total defeat. This is the most memorable fact of all with regard to the "sneak attack" of Dec. 7, 1941.

BIBLIOGRAPHY.—The most voluminous source of material on the Pearl Harbor attack is the hearings of the Joint Committee on the Investigation of the Pearl Harbor Attack, 79th Cong., 1st. Sess. (39 vols.) followed by the report of the committee itself, 79th Cong. 2nd. Sess. Doc. 244. There are to be found the report of the Roberts Commission, the Army Pearl Harbor Board, the Naval Court of Inquiry, and the Hewett Inquiry, with masses of testimony as to the attack itself. Of secondary materials the following may be mentioned. Walter Millis, *This is Pearl! the United States and Japan, 1941* (1947); Walter Lord, *Day of Infamy* (1957); Rear Admiral Robert A. Theobald, *The Final Secret of Pearl Harbor* (1944); Admiral Husband E. Kimmel, *Admiral Kimmel's Story* (1955); George E. Morgenstern, *Pearl Harbor: The Story of the Secret War* (1947); Charles A. Beard, *President Roosevelt and the Coming of the War, 1941* (1948); R. Wohlstetter, *Pearl Harbor: Warning and Decision* (1962). An admirable brief analysis is to be found in Samuel Eliot Morison, *The Rising Sun in the Pacific* in vol. 3 of his History of United States Naval Operations in World

War II (1948); and in Mark S. Watson, *Chief of Staff: Prewar Plans and Preparations*, pp. 494–520 (1950). The three volumes by Theobald, Kimmel and Morgenstern are distinctly polemical, and should be used with caution. Charles A. Beard's account is also slanted, but contains much material of great interest on the various hearings. (D. Ps.)

PEARL RIVER, a river of the southeastern United States, rises in east-central Mississippi, near Louisville, and flows southwest, south, and then slightly southeast to the head of its delta, south of Bogalusa, La. From there the East Pearl river continues southward for 34 mi. (55 km.) and passes into Mississippi sound near Grand Island. West Pearl river parallels East Pearl in the delta, several miles to the west, and enters the Rigolets, a tidal channel connecting Lake Pontchartrain with Lake Borgne. The two mouths of the Pearl are interconnected by a maze of channels.

The Pearl is approximately 490 mi. (789 km.) long and has a drainage basin of about 7,600 sq.mi. (19,684 sq.km.). Chief tributaries are the Yokahockany and Strong rivers and the Bogue Chitto. Three locks on the West Pearl, completed in 1953, provide a 7-ft. channel from the mouth to Bogalusa, 58 mi. (93 km.) upstream. Navigation on the East Pearl and on the Pearl above Bogalusa is no longer important. Until the early 20th century, however, the river below Jackson, Miss., was a main route for transporting lumber. Columbia, Monticello and Jackson, Miss., and Bogalusa, La., are the chief river cities. Jackson obtains its water supply from the Pearl. In 1958, the Mississippi legislature approved the issuing of revenue bonds for a 21-mi.-long (34 km.) reservoir north of Jackson, to provide water, flood and pollution control and recreational facilities for the Pearl River valley.

The lower course of the Pearl, and the East Pearl, form the boundary between Mississippi and Louisiana. Prior to 1812, when Louisiana was granted statehood, the Pearl was the eastern boundary of the province of West Florida. Honey Island swamp lies in the mid-delta area of the Pearl River valley, southwest of Picayune, Miss. This heavily forested swamp, criss-crossed by a maze of channels, is noted for its wildlife and fishing. (M. W. M.)

PEARSE, PATRICK HENRY (1879–1916), Irish revolutionary nationalist and poet, and a leader of the Easter rising in Dublin in 1916, was born in Dublin on Nov. 10, 1879, the eldest son of James Pearse, an English monumental sculptor, and of his Irish wife Margaret Brady. Educated at the Christian Brothers' Schools, Dublin, and the Royal University of Ireland, Pearse joined the Gaelic League, becoming an energetic member of its executive, and was editor of its weekly publication *An Claidheamh Soluis* from 1903 to 1909. He wrote later that the Gaelic League "will be recognized in history as the most revolutionary influence that has ever come into Ireland." Pearse wanted an Ireland free from foreign domination and influences. He published tales from Irish manuscripts and in 1914 a celebrated collection of poems in the modern Irish idiom. Deeply interested in education, he toured Belgium to study bilingual methods and he approved of Augustine Birrell's Irish educational policy, since it gave Ireland control over its own educational system. He founded St. Enda's College at Cullenswood, Dublin, in 1908, as a bilingual college with its teaching based on Irish traditions and culture. In 1910 it was moved to the Hermitage, Rathfarnham. Pearse outlined his ideas on education in an essay, "The Time Machine" (1912), and in *The Story of a Success . . . a Record of St. Enda's College* (1917).

On the formation of the Irish volunteers in November 1913 (*see* IRELAND: *History*), Pearse became a member of the provisional committee and in July 1914 was made a member of the supreme council of the Irish Republican brotherhood. He wrote poems and articles for *The Irish Volunteer*, the official paper of the volunteers, as well as pamphlets designed to stir the minds of the people and to prepare them for a national uprising. After the Irish volunteer movement split in September 1914 he became director of organization of the more extreme Nationalist section, which opposed any support for Great Britain in World War I. He was moved most of all by a burning conviction that Ireland might be freed only by the blood of martyrs and his oration in August 1915 at the graveside of O'Donovan Rossa, the veteran Fenian, was a classic of romantic revolutionary eloquence on this theme. Commander in chief of the Irish forces at the rising in Dublin on Easter Monday, April 24, 1916, Pearse proclaimed the provisional government of the Irish Republic, of which he was the first president, from the steps of the general post office. He surrendered on April 29, 1916, and after a military court martial was executed by a firing squad at Kilmainham Prison, Dublin, on May 3, 1916. More than any other man, Pearse was responsible for establishing the republican tradition in Ireland. His *Collected Works* were published in three volumes (1917–22) and in five volumes (1924); his *Political Writings and Speeches* were published in 1952.

See L. N. Le Roux, *Patrick H. Pearse*, Eng. trans. by D. Ryan (1932). (P. N. S. M.)

PEARSON, KARL (1857–1936), British mathematician, one of the founders of modern statistics, was born in London, March 27, 1857, and educated at University College School, London, and Kings College, Cambridge. He practised law from 1881 to 1884, when he received an appointment as professor of applied mathematics and mechanics at University College, London. There he taught until his retirement in 1933, becoming lecturer in geometry (1891), head of the department of applied mathematics (1907), and professor of eugenics (1911). Pearson was the founder and editor (1902–36) of the statistical journal *Biometrika*, editor of *The Annals of Eugenics* (1925–36), and director of the Biometric and Francis Galton Eugenics laboratories.

Pearson's early lectures were published as *The Grammar of Science* (1892), one of the classics in the philosophy of science. Beginning in 1890 his interests began to shift to the application of statistics to biological problems of heredity and evolution; his greatest contribution was the methodology he developed for the handling of certain types of problems in the biological and social sciences. From 1893 to 1912 he wrote a series of 18 papers entitled *Mathematical Contributions to the Theory of Evolution*, which contained much of his most valuable work, including the chi-square test of statistical significance. He died on April 27, 1936, in London.

Among his other works were *The Ethic of Free Thought* (1888); *The Chances of Death and Other Studies in Evolution* (1897); *The Life, Letters and Labours of Francis Galton* (1914, 1930); *Tables for Statisticians and Biometricians* (1914, 1931); *Tables of the Incomplete Gamma Function* (1922); and *Tables of the Incomplete Beta Function* (1934).

See also E. S. Pearson, *Karl Pearson* (1939); H. M. Walker, "Contributions of Karl Pearson," *American Statistical Association Journal*, vol. 53 (March 1958). (S. S. W.; X.)

PEARSON, LESTER BOWLES (1897–), Canadian statesman, Liberal Party leader and prime minister, who won the Nobel Peace Prize in 1957. He was born at Toronto, Ont., on April 23, 1897. He was educated in the public schools of Peterborough and Hamilton, and served in World War I in the Royal Flying Corps. Invalided home, he entered the University of Toronto (B.A., 1919) and earned B.A. and M.A. degrees at Oxford University (1923, 1925). He was a lecturer (1924–26) and assistant professor (1926–28) of history at the University of Toronto before becoming a first secretary in Canada's newly formed Department of External Affairs. After a series of diplomatic posts and service on loan as secretary to two royal commissions, he became secretary (later counsellor) of the Canadian High Commissioner's Office in London. Canada's ambassador to the United States, 1945–46, and undersecretary of state for external affairs, 1946–48, he was often spokesman for Canada at the United Nations. He served in 1947 as chairman of the UN Political and Security Committee of the UN General Assembly. In 1947 he was instrumental in securing UN passage of the Palestine partition resolution.

He entered politics in 1948, becoming secretary of state for external affairs in the Liberal government of Louis St. Laurent and member of Parliament for Algoma East. Reelected three times, he became a private member of the House of Commons in opposition when his party was defeated in June 1957. He was awarded the Nobel Prize for his efforts at resolving the 1956 Suez crisis. In 1958 he succeeded St. Laurent as leader of the Liberal Party and in April 1963 became prime minister. (W. D. A. O'H.)

PEARY, ROBERT EDWIN (1856–1920), U.S. Arctic explorer who reached the North Pole in 1909, was born at Cresson,

Pa., on May 6, 1856. He was graduated from Bowdoin College, Brunswick, Me., then joined the civil-engineering branch of the U.S. Navy and took part in the survey of the Nicaragua canal route from 1885 to 1887. In 1886, with one companion, he journeyed inland from Disko Bay over the Greenland ice sheet for about 100 mi., reaching 7,500 ft. above sea level. He returned in 1891 with seven companions, including his wife and F. A. Cook. After wintering in Hvalsund, he sledged for 1,200 mi. to the northeast of Greenland, discovering Independence Fjord and evidence of the insularity of Greenland. The "Arctic Highlanders," an isolated tribe of Eskimo, were befriended and studied; they were of the greatest assistance to Peary on later expeditions. He returned to Hvalsund in 1893 with a larger party, and sledging journeys were made to northeast Greenland again in 1894. Summer trips in 1896 and 1897 were mainly occupied in transporting three masses of meteoric iron from Greenland to the United States. In 1898 he announced his intention of reaching the North Pole, and from 1898 to 1902 he reconnoitred routes from bases at Etah in Inglefield Land and Fort Conger on Ellesmere Island. Meanwhile, the Peary Arctic Club of New York was formed to raise funds for the support of his further expeditions, thus relieving Peary of financial worries. A ship, the "Roosevelt," was built to his specifications and carried his next expedition, early in 1905, through Smith Sound to Cape Sheridan, Ellesmere Island. The sledging season was unsuccessful owing to adverse weather and ice conditions and the party only reached latitude 87° 6′ N. Peary returned to Ellesmere Island in 1908 and early the following March left Cape Columbia on his successful journey to the North Pole. He was accompanied on the last stage of the journey by Matthew Henson, his Negro aid, and four Eskimos, one of whom was drowned during the return. F. A. Cook's claims to have forestalled him by a year, though generally discredited, marred the enjoyment of Peary's triumph. He died on Feb. 20, 1920, in Washington, D.C. Peary's published works include *Northward over the "Great Ice"* (1898), *Nearest to the Pole* (1907), *The North Pole* (1910), and *Secrets of Polar Travel* (1917). (L. M. Fs.)

PEASANT MOVEMENT. World War I and, paradoxically, the Russian Revolution gave a strong impetus to the political consciousness of a class which had seemed to be falling into insignificance. Through the centuries the peasants had occasionally played a forceful part in social convulsions, but since the Industrial Revolution western political life was dominated by leaders in commerce and industry; and that trend was only sharpened by the rise of the workers' movement. Eastern Europe had little industry: the bulk of its people were peasants, who had little share of material wealth and little influence in public life. And so it was natural that the stirrings of 1917 in that region should raise a peasant movement, with a social and political philosophy all its own.

Political Traditions of the Peasantry.—Between the French Revolution and 1848 the peasants of western and central Europe were gradually freed from all feudal servitudes. But the peasants derived only an indirect benefit from reforms achieved mainly by the urban middle classes, who needed freedom of action for the new capitalist enterprise.

The growing division between town and country was widened into a gulf by the rise of "scientific" socialism. The viewpoint of socialist economics was essentially the same as that of capitalist liberalism, except that the socialists wanted production to be planned, organized and controlled upon the largest scale. Marx gave credit to capitalism for having at least rescued considerable sections from the "idiocy of rural life"; he and his disciples placed the nationalization of the land and collectivised farming in the forefront of their program. This gave rise to the organization of many conservative agrarian groups in central and western Europe, which found in the peasants credulous recruits. The electoral effects gradually led to a watering down of socialist agrarian programs.

Populism.—The economic and political incentives which had interested the western bourgeoisie in rural emancipation had little meaning in the eastern half of the continent. Politically, that region was still in the autocratic stage. Its economic life rested on primitive agriculture and artisan manufacture. But the social incentive stirred up reformers in the east perhaps more deeply than in the west.

The younger intellectuals, imbued with 18th century humanitarian philosophy, centred all their ideals on freeing the peasants. But what for western liberals had been an end in itself, for the Russian reformers was merely a steppingstone to a free and full village life. Marxism was essentially a policy for transforming industrial society; in the east, socialism was for the peasants. Hence eastern socialists were forced to work out alternative ideas and programs suited to the problem of their own peasant populations. "Populism" became the expression of that trend. (*See* RUSSIA: *History.*)

The kernel of populism was the rejection of Marxist economic determinism. Marxism looked upon capitalist concentration of production as only a stage on the way to a socialist society. The Russian Populists put their faith in the existence of the village community (*mir*). They contended that a capitalist-proletarian phase was neither necessary nor possible in a backward agrarian country, as it would merely ruin the peasants, the only customers for industrial products. Above all, they believed that a rural democracy offered the masses the promise of a better life than industrial society. All they needed was more "land and liberty," and the backbone of the Populist program was a plea for the equal distribution of land among the peasants.

The later exponents of this program were the Social-Revolutionaries, the strongest party of the left up to the Bolshevik revolution. That the Populist doctrine had its roots in the natural conditions of the region is proved by the way it spread to the other agrarian countries of eastern Europe. It was perhaps natural that Serbia and Bulgaria should come under its influence, for both stood intellectually in close dependence on Russia. The decisive test is supplied by Rumania, a Latin country, strongly averse to Slav influence, yet there also the new doctrine engendered a strong rural current that joined with the others in denouncing Marxism.

The Peasant Renascence.—The Populist movement had remained largely theoretical because the peasants were restrained by a rigid political and social tutelage. Political activity and claims for the distribution of land were treated as revolutionary activity. The only outlet for their grievances were occasional uprisings, like those of 1905 in Russia and 1907 in Rumania, which were mercilessly repressed. But World War I and the Russian Revolution completed in the east the change begun by the French Revolution in the west. Sweeping reforms transferred the bulk of the land to the peasants, thus holding out to them the hope of economic independence. At the same time the peasants secured political rights, and were roused to a consciousness of their interests and their power as a class. Their movement was still loose and vague: its possibilities lay in the fact that more than half the population of the globe lived under a typically peasant "family economy," and that even in Europe there were more peasants than industrial workers.

In India the Congress party was led to take over the program of the Kisan Sabhas which had come into being after the 1930s; in China the strength of the Communist movement derived largely from its support of the peasants. There were stirrings in other far eastern countries, and also in South America and the middle east.

Doctrine and Program.—Unlike socialism, which had a fully developed doctrine before it had an organized following, the peasant movement sprang up separately in the various countries, though out of similar convulsive events. Hence its sociology was still in the making, and the programs of the several parties showed substantial variations. Its philosophy and policy were taken over and adapted to its own use elements from all the main political creeds. It can be summed up as a cross between liberalism and socialism: it stands firmly for democratic government and it holds tightly to the small family holding, which to the peasant is not merely a means of living but a way of life. For the rest, it generally accepts state control of public services and of primary and other big industries, though it wants small

industries scattered about the country to combine work on the land and in the factory according to seasonal needs. It is generally anticapitalist, but would eliminate bankers and middlemen gradually by setting up co-operatives either for specific purposes or embracing the whole life of a village community. It believes in a rural society based on an educated, land-owning peasantry; and combining through a network of co-operative undertakings the virtues of small property with the means of large-scale enterprise.

The radicalism of the eastern peasant movement came from the peculiar conditions of the region. In the west, agrarian parties were a mixture of all rural classes, with big landowners to the fore, as in the German *Landbund;* the eastern parties were exclusively peasant. Secondly, oppression in the east had prevented the growth of a peasant middle class, so the movement was supported by a more uniform mass of small peasants. Thirdly, peasant antagonism toward town and capitalism had different effects in the two halves of Europe. In the west, finance and industry had entered a phase of international organization by means of cartels, trusts, etc., and the outlook of the towns was cosmopolitan; as a reaction the countryside was conservative and nationalist. In the east, industry and finance were bound up with local nationalism, and the peasant who paid the bill of protectionism favoured a liberal and even a radical policy in all respects.

The Peasant Parties.—The peasant movement that sprang up after 1918 was peculiar to the eastern half of Europe. In the industrial countries of the west, even in the Netherlands and Denmark, the peasants had been drawn into conservative agrarian parties because of a general antagonism to industry and finance, partly through clerical influence, and largely by the fear of the socialist demand for land nationalization. But just as western socialism had stirred up industrial groups in the east and shaped their outlook, so the eastern peasant movement caused stirrings in the west. In France a peasant party was founded four weeks before the elections of 1928; in Germany, also before that year's elections, the left wing of the old *Landbund* formed a new Christian National Peasant party, and at the same time the Bavarian *Bauernbund* changed itself into a German Peasant party which dominated the parliamentary situation in Bavaria. Attempts to establish peasant parties were made in the Netherlands and elsewhere.

Some of the eastern peasant parties were founded before World War I, but became important only after it. The Bulgarian Agrarian union, founded in 1899 as a professional body, became political in 1901: it polled 14.45% of the votes in 1911, 31% in 1919, 38.16% in 1920, 52.0% in 1923. In June 1923 a military coup led to the murder of Aleksandr Stamboliski and other party leaders. While in power, the party carried through broad co-operative measures and a law for compulsory civic service (*see* International Labour organization pamphlet, *Legislative Series,* 1920).

The Czechoslovak Republican Party of Farmers and Small Peasants, founded in 1896, at first conservative, veered leftward, led by Antonin Svahla, Rudolf Beran, and Milan Hodza. Czechoslovakia took the lead in adopting an 8-hour day for agriculture and working out practical ties between peasant producers' co-operatives and urban consumers' co-operatives. Alone of the eastern countries, it included members of the national minorities in the cabinet. All these steps were due to the party's initiative.

Poland had several peasant parties, reflecting its unsettled political outlook. The Polish Populist party, known as *Piast* (significantly the name of the first Polish royal dynasty, which was of peasant origin) was led by Wincenty Witos. Twice premier, he was rather conservative, admitted land reform only with compensation, and was open to clerical influence. The Liberation party, led by Stanislaw Thugutt, was radical, demanded land reform without indemnity, favoured regional autonomy for the minorities, and was anticlerical. A similar program was supported by the Peasant party led by Jan Dabski, representing chiefly the small peasants.

It is noteworthy that while the political movement was divided by regional, clerical and personal influences, the peasants worked together in their co-operative affairs, brought to high achievement by Stanislaw Mikolajczyk. The Rumanian National Peasant party, formed by the fusion of several groups, was the only substantial opposition; in Nov. 1928 it formed the first truly parliamentary government in Rumania, led by Iuliu Maniu, Nicholas Lupu, Ion Michalache, and the economist Virgil Madgearu.

In Yugoslavia the Croat Peasant party, founded in 1904, dominated Croatia after World War I and gained strength in Bosnia and Dalmatia. Stjepan Radić, Pavle Radić, Dr. Vladimir Maček and other leaders held office in various coalition governments. Remarkable for its organization and comprehensive activities, and especially for its spiritual cohesion, it was built upon a clear rural creed rather than upon agrarian interests.

There were also rising peasant parties in Finland, the Baltic states and elsewhere.

International Organization.—A number of international agrarian bodies had existed before, but they had not been limited to peasant groups nor had they been set up for political action. Soon after World War I an attempt was made by Bavarian and Austrian farmers to unite the peasant groups of central Europe, the Bavarian Georg Heim being one of the initiators. The movement was conservative and anticommunist and, while some of the leaders kept neutral, others had a strong clerical bias. The attempt came to nothing. Though no peasant party existed in Russia, the Communists encouraged some of the refugees living in Moscow to set up there a Peasant International. Formed in 1923, it held its first congress in 1925, but made no visible impression on the peasant movement. On the initiative of the Bulgarian Stamboliski, an international bureau for research and information was set up in Prague in 1921, the Czech, Bulgarian, Polish and Serbian parties being members. In May 1928, the bureau was joined by the Croat, Rumanian and other parties, including the newly-formed French and Dutch parties. At the same time, eight parties of central and eastern Europe formed a regional group within the bureau itself with a joint executive, to work for the solution of political and social problems in the peasant interest; and to resist jointly any attempt at dictatorship, from the left or from the right.

The Interwar Period.—The potential strength of the eastern peasant movement was attested less by the actual power it enjoyed than by the strong efforts made to check it. As noted above, Stamboliski and other Bulgarian leaders were murdered in 1923 and the party broken up. The Croat leaders were repeatedly imprisoned, and ultimately Stjepan Radić died of wounds, and his nephew Pavle Radić and others were killed outright. The Rumanian leaders were persecuted and the party was denied the power to which its electoral strength entitled it.

In Poland, Witos was imprisoned for a short time and then had to flee the country. All these parties and leaders had stood firmly for democratic government and social reform. Their persecution everywhere ended in dictatorship, because the peasant groups also had to face the competitive antagonism of socialist parties. In Bulgaria, Rumania and Yugoslavia these were insignificant, but they were strong in Poland and Czechoslovakia. The division between the two sections of the working mass paved the way for reaction.

War and Aftermath.—World War II and the Nazi occupation found the peasants united with others in resistance; there was no defection among their groups and leaders. But after victory the movement again became the target of violent reaction, this time from the Communist left, backed by Russian military power. Against all Marxist teaching and Soviet policy, the new regimes in the eastern countries, including the Soviet zone of Germany, handed over the land to the mass of poorer peasants, in tiny uneconomic holdings, to undermine the solidarity of the peasant class. At the same time, all the peasant parties were suppressed, their leaders killed, imprisoned or driven into exile. The latter group revived in Washington, D.C., the activities of the International Peasant union in 1947. Significantly, in Poland, Bulgaria, Rumania, Hungary and Czechoslovakia, the Communist regimes found it expedient to set up new peasant parties under their own patronage.

Up to 1948 these regimes sought to keep the peasants quiet and at work by denying any intention to collectivise farming. But after 1948 collectivisation was pressed forward ruthlessly in all the "peoples' democracies." It was later pushed forward in China, where in 1948 the Communists had ridden to victory on the back of a discontented peasantry.

After Stalin.—This trend was sharply reversed after the death of Stalin. Nikita Khrushchev, who had formerly invented a scheme for the extreme concentration of farming in "agro-towns," took the initiative in lowering taxes, reducing the compulsory deliveries, and giving higher prices for produce taken from the peasants by the state. Admitting that central planning had proved "wrong and inefficient," a decree in March 1955 also gave collective farms more power to run their own affairs. In China, also, in March 1957 peasants were given some ease, but later, new oppressive measures sought to end peasant resistance.

The Soviet reversal set off a more thorough retreat in the satellite countries. Apart from concessions to the peasants in the form of lower prices and reduced taxes in Yugoslavia, Rumania, Hungary and Poland, the very policy of collectivisation was eased or virtually abandoned. In Poland, two thirds of collectivised farms were said to have been broken up and returned to individual holdings. In Indonesia and in Indochina the Communist leaders formally disclaimed any idea of nationalizing agriculture and promised to distribute land to the peasants.

The simple fact is that wherever the Communists gained power the Marxist agrarian idea had to be imposed by force and had to rely on force for its survival; western socialists who wanted to remain democratic in every instance had to abandon it. Whatever else the Soviet and other Communist regimes may have achieved, the agrarian problem has defeated them.

The peasants have not been allowed to revive their own parties, and no peasant has held office in the Soviet Politburo. But even in collectivised areas the peasants are still a class.

In the first general election of 1952 in India the Communists gained in depressed agricultural areas, not in cities. India began to experiment widely with a middle-of-the-way system of "community development." Side by side with essential heavy industries she encouraged cottage and village industries, and promoted agricultural improvement, with the village as a relatively self-contained economic and administrative (*panchayat*) unit. This policy followed closely the ideas of Gandhi, but it was also strikingly close to the outlook and program developed independently by the peasant movement in eastern Europe. It revealed how essentially peasant qualities are rooted in the peculiar conditions of rural work and life. As the peasant revival of the 1920s showed, the peasants of eastern Europe, and other continents, were more closely linked by common peasant traits than they were divided by national differences.

See David Mitrany, *Marx Against the Peasant* (1952). (D. Mi.)

PEASANTS' REVOLT. The Peasants' Revolt of 1381 was the first great popular rebellion in English history. The main causes of the rising were the collection of a poll tax at a rate of one shilling per head, and agrarian discontent that had existed since the time of the Black Death. Artisan support for the rebels was important in many places; probably the main grievance of agricultural labourers and the working classes in the towns was the attempt made in the Statute of Labourers, first enacted in 1351, to prevent increases in wages. The most serious disorders occurred in southeast England and in East Anglia, but there were widespread disturbances affecting many other counties, including Cambridgeshire, Hampshire, Somerset, and West Riding of Yorkshire. In some towns local conditions were decisive; at St. Albans and Bury St. Edmunds the townsfolk rose to end the rule of the abbot and to secure municipal freedom.

The rising took the government by surprise. At the end of May the outbreak, which began in Essex, soon spread to Kent and the ineffectiveness of the ministers ruling on behalf of the young Richard II enabled the Kentish rebels to enter London on Thursday, June 13. There they massacred some Flemish merchants and other aliens and destroyed the Savoy palace, the property of the king's uncle, John of Gaunt. The government was compelled to negotiate and in an interview with the men of Essex at Mile End on June 14 Richard II promised the abolition of serfdom and compulsory labour services, the leasing of bond land at a rent of 4*d.* per acre, and freedom of trade throughout the realm. During the king's absence at Mile End the Tower of London was surrendered to the mob; the chancellor, Archbishop Simon of Sudbury, and the treasurer, Sir Robert Hales, who were held responsible for the exaction of the poll tax, were both beheaded. The confiscation of church lands was among the demands made by the Kentish rebels at Smithfield on Saturday, June 15, but the insurgents dispersed after their leader, Wat Tyler (*q.v.*), had been struck down in the king's presence. Richard II's promises, which had persuaded many of the rebels to go home, were not kept after the collapse of the movement. The rising lasted less than a month and the crisis in London was over before the troubles in the provinces reached their climax. In East Anglia, where the leader was a dyer, Geoffrey Litster, the rebellion was crushed by the militant bishop of Norwich, Henry le Despenser, probably on June 25.

The rising was not a movement of men made desperate by destitution; among the rebels were many well-to-do villeins. Insofar as it aimed at social revolution, the insurrection was a failure and manorial discontent continued to find expression in local riots. As a protest against taxation of the poorer classes, the rebellion was successful, because it prevented any further attempt to levy the poll tax, first instituted in 1377. *See* also English History: *The 14th Century*.

Bibliography.—*The Anonimalle Chronicle, 1333–1381,* ed. by V. H. Galbraith (1927) contains the most valuable contemporary account of the revolt. *See* also A. Steel, *Richard II* (1941); C. W. C. Oman, *The Great Revolt of 1381* (1906); G. M. Trevelyan, *England in the Age of Wycliffe*, 4th ed. (1909); A. Réville, *Le Soulèvement des travailleurs d'Angleterre en 1381* (1898); C. E. Petit-Dutaillis, *Studies and Notes Supplementary to Stubbs' Constitutional History*, vol. ii (1914); E. Powell, *The Rising in East Anglia in 1381* (1896). (T. B. P.)

PEAT: *see* Fuels: *Peat*.

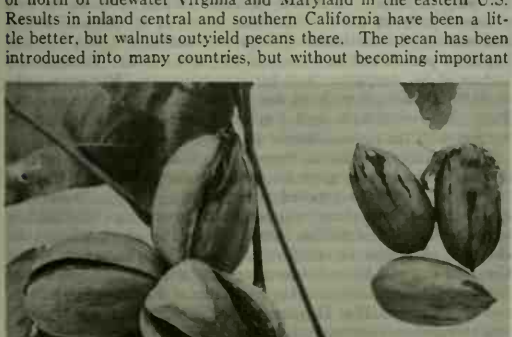
PEĆ (formerly Ipek; ancient Pescium), a town of Kosovo i Metohija (Kosmet), Socialist Republic of Serbia, Yugos., lies in the foothills of the Prokletije (North Albanian Alps) Mountains, 389 km. (242 mi.) S of Belgrade by road. Pop. (1961) 28,297 including a large proportion of Albanians. A small stream, the Bistrica (Bistritza), flows through the town which, with its narrow streets and mosques, presents an oriental appearance. It is the terminus of a railway from Nis and a commercial centre for fruit and tobacco. Peć was formerly the chief see of the Serb Orthodox Church, the archbishopric having been raised to the patriarchate by Stephen Dushan (1331–55). This was suppressed in 1459, restored in 1557, and abolished again by the Turks in 1766. After the Turkish occupation the Serbs continued to emigrate from this region to the north, the greatest exodus taking place in 1690, led by the patriarch. The title of archbishop of Peć is still retained by the patriarch of Belgrade. In 1918 the town was incorporated in the Kingdom of the Serbs, Croats, and Slovenes (called Yugoslavia from 1929). The patriarchal buildings just outside Peć on the west include churches with fine 13th- and 14th-century frescoes. (V. De.)

PECAN, one of the finest nuts in flavour and texture, with the highest fat content of any vegetable product and a caloric value close to that of butter. Its production is the basis of a considerable industry in the southeastern United States. The pecan tree (*Carya illinoensis*, or *C. pecan*), a member of the walnut family (Juglandaceae), is the most important nut producer of the *Carya*, the hickory genus. It is the most important orchard species native to temperate North America, though a sizable portion of the industry is still in wild trees, some of them supporting grafts of selected varieties. The tree is the largest of its genus; in deep, fertile soils it occasionally reaches a height of about 160 ft. and a trunk diameter of 6 ft. It has a deeply furrowed bark; compound leaves with 9–17 finely toothed edge leaflets, arranged in feather fashion. The male (staminate) flowers form pendant catkins; the female (pistillate) flowers are arranged in tight clusters at the ends of shoots. At maturity the fleshy hulls of the short-clustered fruits dry, split along suture lines, and separate into four approximately equal sections, thus gradually freeing the nuts. The nuts have

brown, mottled shells, varying greatly in thickness; size varies from 45 to 200 per pound, and shape from long-cylindrical with pointed apex, to short and roundish, or intermediate. Harvesting begins in late September, but may continue until late winter in southern orchards.

The original range of the pecan tree may not have extended into the northern Mexican highlands before men took nuts there from Texas. Native trees have been found from near the Rio Grande in southwest Texas, north and east to extreme southeast Nebraska, eastern Iowa, west-central and southern Indiana, and occasionally up the Tennessee River to near Muscle Shoals in Alabama. Limited cultivation of grafted varieties had begun in Louisiana by 1847; some important varieties were introduced before 1890, and thereafter the crop assumed increasing commercial importance from the Carolinas to New Mexico and Mexico. Georgia, Alabama, and Mississippi soon became the most important producers of grafted pecan nuts, exceeding the total annual production of the states of Texas and Oklahoma, which have the greatest numbers of native seedling trees. Canada has been the principal importer of U.S. pecans.

For good kernel development, even the earliest maturing pecans need high summer temperatures both day and night, so nuts are seldom matured on trees in northern California, northern Indiana, or north of tidewater Virginia and Maryland in the eastern U.S. Results in inland central and southern California have been a little better, but walnuts outyield pecans there. The pecan has been introduced into many countries, but without becoming important



J. HORACE MCFARLAND CO.

(LEFT) BRANCH OF A PECAN TREE SHOWING NUTS ENCLOSED IN HUSKS. (RIGHT) MATURE PECANS

in production outside the U.S. and northern Mexico. It is cultivated to a limited extent in Australia (New South Wales) and South Africa (Natal).

Pecan varieties are suited, for reasons of climatic requirement, to particular zones within the U.S. Important southeastern varieties are Brooks, Candy, Curtis, Desirable, Elliott, Farley, Mahan, Moore, Stuart, and Success. In the central Texas group are Barton, Burkett, Clark, San Saba Improved, Squirrel, Texhan, and Western. Clarksville, Giles, Greenriver, Hirschi, Major, Peruque, Posey, Starking, and Witte ripen in midwestern orchards. Duvall and Sweeney were introduced from Maryland. For culture somewhat north of pecan limits, there are hicans (pecan-hickory hybrids) of which Burton, Des Moines, Henke, and Jay Underwood are among the fruitful varieties, and McCallister, a useful pollinator.

See also HICKORY; NUT.

See W. H. Chandler, *Deciduous Orchards*, 3rd ed., pp. 438–448 (1957). (J. C. McD.; X.)

PECCARY, the New World counterpart of the swine, forming the family Tayassuidae. Peccaries resemble small pigs and are about 2½ to 3 ft. long, with small erect ears and no tails. They are hunted for their hides and for their meat, which is much esteemed. Although ferocious when hunting in packs, they are sometimes tamed by South American Indians and then become practically domesticated.

WILLIS PETERSON

COLLARED PECCARY (TAYASSU TAJACU), NATIVE FROM EXTREME SOUTHWESTERN U.S. TO PARAGUAY

Peccaries differ from true pigs in having only three toes on their hind feet, and upper canine teeth that are directed downward. They possess a scent gland under the skin opening on the ridge of the back; from this derives the old traveler's tale that they have two navels, one above and one below. Peccaries live in herds of 10 to 100 and are not restricted in home range but travel over considerable tracts of territory, undeterred by thick bush, rivers, or other obstacles. They are distributed over nearly all the Americas southward from Texas to Patagonia. They entered the southern continent in comparatively late geological times. Peccaries give a barklike alarm call and when disturbed make a rattling sound by chattering their teeth.

Little is known of their breeding habits. Those of Panama probably breed in June, with a gestation period of 120–125 days. One or two young are produced at birth, very rarely three; the female has only two teats.

There are two species: the collared peccary (*Tayassu tajacu*), dark gray with a white band across the chest from shoulder to shoulder, and the white-lipped peccary (*Tayassu pecari*), slightly larger and darker in colour, with a light area around the mouth. Both species are widely distributed in South America, but the white-lipped peccary does not extend so far to the north or south as the collared peccary. *See* also ARTIODACTYL. (L. H. M.)

PECHENEG, the name of a Turkic people (in Byzantine sources called *Patzinakoi*, in Latin *Bisseni*, in Hungarian *Besenyö*), which between the 6th and the 12th centuries A.D. played an important role in the history of the steppes north of the Black Sea. Their name first occurs in the Arabic work of Ibn Rusta (*c.* 912), who relies on earlier information from Jayhani's lost work. According to the Byzantine emperor Constantine VII Porphyrogenitus, whose *De administrando imperio* is the main source on Pecheneg history, three of the eight tribes constituting the Pecheneg nation were also called Kangar. This name, however, occurs as early as in the 6th century in Syriac sources, where the people that it designates are said to have lived south of the Caucasus.

According to Marvazi, whose work, written *c.* 1120, incorporates much earlier information,

> the Pechenegs are a wandering people, following the rainfalls and the pasturage. Their territory extends a distance of 30 days in either direction, and they are bordered on all sides by many peoples; to the north are the Kipchaks, to the southwest the Khazars, to the east the Oghuz, and to the west the Slavs.

This seems to tally with Constantine, who puts the original seat of the Pechenegs between the rivers Volga and Yaik (now Ural). Around 889 the Pechenegs were driven away from there by a simultaneous attack of the Khazars and the Oghuz. Moving westward, they ousted the Hungarians from the country called Levedia, situated somewhere between the lower Don and the Dnieper. The Hungarians moved farther west, into the so-called Etelköz, where in 896 they were again attacked by the Pechenegs, acting as allies of the Bulgarian tsar Simeon. This Pecheneg victory had a lasting effect on eastern European history: the defeated Hungarians set out to conquer the Carpathian Basin, the country in which they were to stay. Thus in the first half of the 10th century the Pechenegs were in command of the lands between the Don and lower Danube and were constituting a serious menace to the Byzantines.

The military importance of the Pechenegs was such that Constantine Porphyrogenitus considered the maintenance of friendly relations with them to be one of the foremost duties of the em-

peror. This was difficult to achieve, and during the 10th century the Pechenegs repeatedly invaded Thrace. With the Byzantine conquest of Bulgaria the Pechenegs became immediate neighbours of Byzantium, and in the course of the 11th century their raids grew both in frequency and intensity. Constantine IX Monomachus settled some of the Pechenegs on former Bulgarian territory, but these federates were unable and perhaps also reluctant to resist the tremendous pressure of their kinsmen remaining beyond the pale, whose raids led them in the winter of 1090–91 to the very gates of Constantinople. But the Pechenegs' finest hour was almost their last. In his desperate need the emperor Alexius I obtained the aid of the Kumans, and on April 29, 1091, the Pecheneg army was annihilated. Though their last attack on Byzantine territory was in 1122, the defeat of 1091 marks the end of their real power.

The Pechenegs were a menace not only for Byzantium but also for the Russian principalities and Hungary. They were, however, successfully kept at bay by Yaroslav I the Great of Kiev and by László I of Hungary. At a later date, probably after the great reverses suffered at Byzantine and Kuman hands, important Pecheneg settlements were established in Hungary.

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(Ds. Sr.)

PECHENGA (formerly the Finnish Petsamo), a town in Murmansk *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., stands at the head of Pechenga Fjord of the Barents Sea. An ice-free port and the northern terminus of the Arctic Highway from the Gulf of Bothnia, the town had to be ceded to the U.S.S.R. by Finland after the Winter War in 1940. Although reoccupied during World War II by the Finns and Germans, it was recaptured by the Russians in 1944 and its cession was confirmed in 1945. The centre of an important nickel and copper mining area, it has an ore refinery and is the base for a large herring fleet operating in the fjord. (R. A. F.)

PECHORA, a river in the U.S.S.R., is 1,814 km. (1,127 mi.) long and drains an area of 327,000 sq.km. (126,255 sq.mi.). The greater part of its basin lies in the Komi Autonomous Soviet Socialist Republic, U.S.S.R., but the lowest reaches and the delta are in Archangel *oblast*. The Pechora rises at a height of 675 m. (2,214 ft.) in the Ural Mountains, 19 km. (12 mi.) NE of Mt. Koyp. At first a mountain stream flowing south in a narrow, deep valley, the river swings west and north, receiving its tributaries, the Ilych, Shchugor, and Usa (itself more than 677 km. [421 mi.] long). The river and its flood plain both widen steadily. After the Usa confluence the Pechora swings to the southwest and, having joined the Izhma, Pizhma, and Tsilma, turns north once more to its delta on Pechora Bay of the Pechora Sea (the southeastern corner of the Barents Sea). Below the Usa confluence the river varies from 503 to 1,509 m. (550 to 1,650 yd.) in width. Its average annual discharge is 144,800 cu.ft. a second. Almost half the yearly flow occurs in spring, when a maximum of 1,221,900 cusecs. has been recorded. The period during which ice forms is lengthy, but the river is frozen hard by early November. The thaw comes in late April in the upper course and in the first half of May in the lower, thus causing severe ice jams and flooding. Navigation is possible in the open season as far as Ust-Unya for small craft. There is much timber rafting to the sawmills of Naryan-Mar at the head of the delta. In the basin are important mineral deposits: coal in the upper Usa Valley around Vorkuta, petroleum and natural gas near Pechora town and Ukhta. (R. A. F.)

PECKHAM, RUFUS WHEELER (1838–1909), associate justice of the United States Supreme Court from 1896 to 1909, is chiefly remembered as the author of the majority opinion (*Lochner v. New York*, 198 U.S. 45 [1905]) which evoked one of the sharpest dissents by Justice Oliver Wendell Holmes (*q.v.*). Peckham held that the 14th Amendment prevented the states from curtailing a man's liberty to engage in or contract concerning economic activity—in the Lochner case, the liberty of a baker to contract for working hours longer than ten per day. Holmes replied in dissent that the "Fourteenth Amendment did not enact Mr. Herbert Spencer's *Social Statics*." Peckham is representative of the school of constitutional jurisprudence that felt it was the court's function to scrutinize carefully and form its own conclusion as to the reasonableness of a state regulation (*see* Supreme Court of the United States, The: *Role in American Life: Self-Limitation*). This judicial approach in cases involving economic regulation did not disappear until the 1930s, when the Holmes point of view became the almost unanimous opinion and such legislation as the minimum-wage law was held to be constitutional.

Peckham, a member of a distinguished New York judicial and legal family, was born in Albany, N.Y., on Nov. 8, 1838, and was educated in Albany and Philadelphia. In 1859 he was admitted to the bar and began practising law in Albany; in 1883 he was appointed a justice of the New York State Supreme Court and in 1886 became a member of the Court of Appeals of New York, the highest court in the state. Nominated to the U.S. Supreme Court by Pres. Grover Cleveland after the nomination of his brother, Wheeler Hazard Peckham, failed of Senate confirmation, he took office on Jan. 6, 1896. Peckham died at Altamont, near Albany, on Oct. 24, 1909. (A. Dm.)

PECOCK, REGINALD (d. *c.* 1460), bishop of St. Asaph and then of Chichester, a polemicist against the Lollards who was himself convicted of heresy, was born between 1390 and 1395, probably in Wales. A fellow of Oriel College, Oxford, he was ordained priest in 1421 and became rector of St. Michael Royal and master of Whittington College in London in 1431; he soon began to preach and to write against the Lollards. Consecrated bishop of St. Asaph in 1444, his translation to Chichester early in 1450 seems to have been due to the favour of William de la Pole, duke of Suffolk, and further strengthened Pecock's connection with the doomed house of Lancaster.

In attacking the Lollards, Pecock himself advanced some heterodox views, and these gave his political enemies of the Yorkist faction an excuse to proceed against him. Thomas Bourchier, archbishop of Canterbury, was persuaded to order an examination of his books and at a trial on Nov. 28, 1457, Pecock was offered the choice of abjuration or burning; he publicly recanted at St. Paul's Cross on Dec. 4. His subsequent appeal to Rome was favourably received by Pope Calixtus III; but Calixtus died in August 1458, and his successor, Pius II, gave ear to Pecock's enemies. Pecock was confined to Thorney Abbey, Cambridgeshire, where he was to have "no books to look on . . . nothing to write with; no stuff to write upon." He died there in about 1460–61.

Pecock wrote in English, attempting to present philosophical and theological argument in terms that could be grasped by laymen. He had an immense faith in the authority of reason and the power of syllogistic argument. His chief work, the *Repressor of Overmuch Blaming of the Clergy*, issued about 1455, has an exceptional interest for the striking style of the English in which it is written, which fittingly matches the strength of the thought.

Bibliography.—For Pecock's works, see *The Repressor of Overmuch Blaming of the Clergy*, ed. by C. Babington (1860); *The Book of Faith*, ed. by J. L. Morison (1909); *The Reule of Chrysten Religioun*, ed. by W. C. Greet (1927), *The Donet* and *The Folewer to the Donet*, ed. by E. V. Hitchcock (1921, 1924), all for the Early English Text Society. *See* also V. H. H. Green, *Bishop Reginald Pecock* (1945).

PECOS, a river in the southwestern United States, rises in Mora county in north-central New Mexico in the high peaks of the Sangre de Cristo Range. It is about 735 mi. (1,183 km.) long and drains about 38,300 sq.mi. (99,197 sq.km.) of wild and rugged land which in places is devoid of population and communications. The Pecos flows south-southeast through eastern New Mexico and west Texas, emptying into the Rio Grande as it leaves Pecos canyon 40 mi. (64 km.) N.W. of Del Rio, Tex. After leaving the mountains, the Pecos flows over land of desert character and the stream channel is dry much of the year. A valley 1,000 ft. (305 m.) deep and from 5 to 30 mi. (8 to 48 km.) wide extends almost to Roswell, N.M.

Near Roswell, the river widens into a basin which closes somewhat to a broad, shallow valley at the Texas-New Mexico border. Below this valley and in the last 125 mi. (201 km.) of its course, the Pecos has cut a narrow canyon over 1,000 ft. deep into the

Edwards and Stockton plateaus. As the stream emerges from this canyon it empties into the Rio Grande. Flow of the Pecos is regulated by two reservoirs. The Alamogordo at Fort Sumner, with storage capacity of 122,100 ac.ft., was completed in 1938. McMillan dam near Lakewood, N.M., stores 38,660 ac.ft. and was completed in 1906. About 150,000 ac. are irrigated from these units. Pecos tributaries include the Hondo, Gallinas, Felix, and Black rivers, all in New Mexico. Santa Rosa, Fort Sumner, Roswell, and Carlsbad, N.M., and Pecos, Tex., are important towns on or near the river. (M. J. L.)

PÉCS (Ger. FÜNFKIRCHEN), one of the oldest and most interesting towns of Hungary and capital of Baranya *megye* (county), lies on the southern edge of the Mecsek Mountains, about 137 mi. (220 km.) SSW of Budapest by rail. Pop. (1960) 114,713. The earliest occupation of this site was by the Illyrians and by the Celtic tribes known as Pannonians. The Romans had a settlement there called Sopianae. In the early Middle Ages the town became known as Quinque Ecclesiae ("five churches"), and in 1009 Stephen I made it a bishopric. The town has a well-marked rectangular core of medieval origin surrounded by suburbs. The Romanesque cathedral dates from the 11th century although it was much restored in 1881–91. The Turks held Pécs from 1543 to 1686; traces of their rule remain; *e.g.*, in the parish and "hospital" churches, once mosques. The 14th-century university, the earliest in Hungary, perished with the Turkish conquest, but was newly founded in 1922. In the 18th century German colonists entered the city and German miners came to work the coal seams. The rapid rise of population in the 20th century (10,000 in 1920) was mainly due, however, to a big intake of Hungarian peasants. The economic importance of Pécs comes from the proximity of the biggest and richest coal mines in Hungary. Local industries include the making of leather goods and majolica, and the surrounding vineyards are some of the best in Hungary. The town has good rail and road connections. (H. G. S.)

PECTIN, the commercially concentrated extract of a group of pectic substances found in the cell walls and intercellular layers of certain plant tissues. Chief use of commercial pectin is in the preparation of jellies, jams, and marmalades but its property of forming thick solutions gives it numerous uses in the food, confectionery, pharmaceutical, and textile industries.

Pectic substances consist of an associated group of three polysaccharides: an araban, which on acid hydrolysis yields L-arabinose; a galactan, giving D-galactose on hydrolysis; and, most significantly for the physical properties of these substances, a pectic acid whose carboxyl groups are in part esterified with methanol and in part neutralized as salts of calcium and magnesium. Pectic acid is a polysaccharide in which units of D-galacturonic acid are joined in α-D-(1 → 4) linkages (*see* CARBOHYDRATES). The calcium salt of pectic acid is water insoluble and in the maturation of tissues, as in the ripening of fruits, complex enzymic changes occur in which the calcium salts are converted, in part, to methyl ester groups. The pectic substances are extractable with warm aqueous solutions of dilute acids. The extract may then be concentrated and sold as a liquid or converted to a powder. The product is known as pectin. The chief sources of commercial pectin are citrus waste and apple pomace. Sugar beet cossette (chip) pulp is employable and makes a usable product after suitable modification to remove an acetate ester group present.

Pectin forms a viscous aqueous solution and in the presence of acids, such as those of fruits, and added sugar, this solution will produce a jelly. Very small amounts (less than 1%) of pectin will suffice. It has been found that if the methyl ester (methoxyl) content is decreased, less sugar is required to give a gel which is formed by the addition of calcium ions.

See also FOOD PRESERVATION (IN THE HOME): *Jams and Jellies.*

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PEDERSEN, CHRISTIERN (*c.* 1480–1554), Danish humanist, one of the first to rediscover Denmark's national literary and historical heritage and to encourage the development of a vernacular style. Born near Helsinki (Helsingfors), he studied at Greifswald and took orders in 1505. In 1508 he went to Paris and there produced the first edition (now lost) of Saxo Grammaticus' *Gesta Danorum*, under the title *Historia danica* (1514). He also edited Peder Laale's proverbs and published a Latin-Danish lexicon. Returning to Denmark, he supported the Reformation and became secretary to Christian II, following him into exile in 1525. In Holland he translated, from the Vulgate, part of the New Testament (1529) and the Psalms (1531) and also adapted some of Luther's tracts. In 1532 he set up as a printer at Malmö, publishing Danish versions of French romances and the legends of Charlemagne. He had a share in the translation of the Bible published in 1550 as "Christian III's Bible," and based on Luther's translation, which marked an important stage in the development of Danish literature as well as in the progress of the Reformation. He died on Jan. 16, 1554, in Helsinge.

See Pedersen's *Danske Skrifter*, ed. by C. J. Brandt and B. T. Fenger, 5 vol. (1850–56).

PEDERSEN, HOLGER (1867–1953), Danish linguist of exceptional competence in a number of fields, especially Celtic, was born at Gjelballe, near Lunderskov, on April 7, 1867. After receiving his doctorate in 1897 with a masterly dissertation (*Aspirationen i Irsk*) he proceeded, while professor at Copenhagen, to enrich linguistic scholarship with an incredible number of articles and books, all highly original. Nurtured in the exacting methodology of the 19th century neogrammarian (*q.v.*) movement, he went far beyond its limits and was either participant in, or critic of, most succeeding schools of linguistic thought; he even anticipated some new trends, but conscientiously avoided frills and fads.

The results of Pedersen's Celtic researches are contained in numerous articles and in his monumental *Vergleichende Grammatik der keltischen Sprachen*, (2 vol., 1909–13), also his *Concise Comparative Celtic Grammar* (with Henry Lewis, 1937). About 30 books in four languages (Danish, English, French, German) treat authoritatively Albanian, Armenian, Russian, Indo-European dialects, Lithuanian, Hittite, Tocharian, Czech, Turkish phonology, the relations between Indo-European and Semitic, between Indo-European and Finno-Ugric, the origin of runes, and the history of linguistic science. Holder of honorary degrees in nine countries and recipient of countless other scholarly honours, Pedersen closed a long and fruitful career in Copenhagen, where he died on Oct. 25, 1953. (R. A. Fs.)

PEDERSEN, JOHANNES PEDER EJLER (1883–), Danish Old Testament scholar and Semitic philologist, important for his conception of Israelite culture and modes of thought based on religio-historical and sociological studies, was born on Nov. 7, 1883, at Illebolle on the island of Langeland. He matriculated at the University of Copenhagen in 1902 as a student of divinity. The Old Testament in particular aroused his interest, and he studied Semitic languages under Frants Buhl. A graduate in divinity (1908), he went abroad for three years, studying under Heinrich Zimmern, August Fischer, Christiaan Snouck Hurgronje, and Ignaz Goldziher. He was appointed docent in Old Testament exegesis at Copenhagen (1916–22) and then professor of Semitic philology (1922–50) in succession to Buhl. His doctoral thesis (1912) showed him to be an eminent philologist with an exceptional ability to enter into the spirit of the ancient Oriental trains of thought.

These qualities are even more pronounced in his chief work, *Israel: Its Life and Culture*, in four volumes (1920–34; Eng. trans. 1926–40). These studies of ancient Israel marked a new departure in Scandinavian Old Testament research. Pedersen's conception of the importance of the cult led in many aspects to a break with Julius Wellhausen and his school, especially in his estimation of the narratives and the laws in the Pentateuch as sources for the history of Israel. (E. HB.)

PEDIATRICS: *see* CHILDREN, DISEASES OF; INFANTS, CARE OF.

PEDIMENT, in architecture, is a triangular gable end treated in classical style and crowned with a raking cornice; or a similar

form used decoratively. The pediment was the crowning feature of the Greek temple front, the entablature over the columns being carried completely through, horizontally under the pediment, and the tympanum or triangular wall surface between this horizontal cornice and the raking cornice above being often decorated with sculpture. (*See* GREEK ARCHITECTURE and, for pedimental sculpture, GREEK ART.) The Romans further adopted the pediment as a purely decorative form to crown doors, windows, and especially niches, and frequently made pediments occurring in a row alternately triangular and segmental in shape; this was copied in the High Renaissance in Italy.

Following certain late Roman precedents, in which the line of the raking cornice is broken back in the centre, the designers of the Baroque period developed all sorts of fantastic broken, scrolled, and reverse curved pediments; in some cases they even reversed the direction, so that the high part of the broken or sectional pediment was toward the outside of the composition rather than toward the centre, and in the Churrigueresque, or late Renaissance of Spain, little sections of pediment were used to indicate line patterning.

PEDIMENT, in geology, a low-angle slope of ½°–7°, and of slightly concave form, found at the base of hills in regions where the rainfall comes in heavy storms. There is frequently a sharp break of slope between the pediment and the steeper hillside above it. There may or may not be a soil cover. Water passes across the pediment by laminar sheet flow, but if this is disturbed the flow becomes turbulent and gullies develop. Many tropical towns sited on pediments (which offer easier building sites than the steep hillsides above or the river marshes below) show severe gullying where the water flow has been concentrated between walls and buildings.

The pediment is the most important element in the tropical landscape, both for building and farming; under natural conditions it is the most permanent part of the landscape, but it is also the part most easily destroyed by human interference.

(J. C. PH.)

PEDODONTICS is the practice of dentistry for children; it is the dental counterpart to pediatrics in medicine. Seven qualifications for a pedodontist have been listed by the American Board of Pedodontics: the pedodontist should be able to manage the behaviour of a very young patient and control his relations with the child's parent; he should be a master of the operative and restorative procedures that are practised for the deciduous (first) teeth and the immature permanent teeth; he should possess a thorough knowledge of the physical and chemical properties of the materials employed in all types of dental treatment and utilize them with skill; he should be able to remove children's teeth skillfully and perform the minor oral surgery that may be required; he should be able to provide root canal treatment for infected teeth and confirm bacteriologically the removal of infecting microorganisms; he should be able to diagnose and treat any juvenile dental problem of growth, development, or health; and he should be able to instruct the family in proper dental health practices and to institute measures for the prevention of defects of the teeth or the mouth.

During the years when dentistry was developing from a mechanical trade, learned by apprenticeship, to a health profession, the teeth of young children were neglected consistently. The "baby" teeth, it was thought, would be replaced promptly by the adult or permanent teeth, hence the first set of teeth was unworthy of the expenditure of the dentist's time and the family's resources. From 1840, when the first dental school in the world was established in Baltimore, Md., until 1916, when teaching in dental schools in the United States was reorganized to include the human biologic sciences, children's teeth generally were treated by removal whenever they ached. The teaching of scientific techniques in dental schools for the comprehensive treatment of the teeth and mouths of children came even later.

On the child's first visit, which should take place when the child is 2½ to 3 years old, many pedodontists introduce the child to the equipment and instruments of the dental office; secure a sample of saliva to be used in obtaining a count of acid-producing microorganisms; complete the cleansing and polishing of the teeth, much as in an adult's dental prophylaxis; and instruct the child in proper toothbrushing. In those geographical regions in which the water supply is deficient in fluorine, a series of applications of a fluoride solution to the dried surfaces of the teeth sometimes is instituted. Such a series, begun at three years of age, has been shown to cause a 40% reduction in the number of cavities. A comprehensive examination, including dental X-rays and a check of the child's occlusion (bite), also may be made during the initial visit.

At a later visit, for the benefit of the child whose salivary examination indicates the presence of a large number of lactobacilli, the entire family may be placed on a diet low in sugar for a few weeks to change the bacterial flora of the mouth. The process of dental caries generally can be halted by periodic dietary restrictions of this type.

See also DENTISTRY; ORTHODONTICS. (KH. A. E.)

PEDRARIAS DÁVILA: *see* ARIAS DE ÁVILA, PEDRO.

PEDRELL, FELIPE (1841–1922), Spanish composer and musical scholar who devoted his life to the development of a Spanish school of music founded on its national folk songs and its own great musical heritage from the past, was born at Tortosa, Feb. 19, 1841. As a choirboy his imagination was first fired by contact with early Spanish church music. Though largely self-taught he composed several operas, mostly on national subjects. The first, *El último Abencerraje*, founded on a text by Chateaubriand, was produced in an Italian version in Barcelona in 1874. In 1891 he published his manifesto *Por nuestra musica*, which attracted much attention, though it was misunderstood as advocating Wagnerian reforms. Following his theories, he set a practical example by publishing an invaluable four-volume collection of folk songs and editing, for the first time, a vast quantity of early Spanish church, stage, and organ music, including the keyboard works of Antonio de Cabezón and the complete works of Tomás Luis de Victoria. At the same time he was working on an operatic trilogy, the first part of which, *Els Pirineus* (to a Catalan libretto), was produced in an Italian version in 1902. The second part, *La Celestina*, though it contained some of his finest music, remained unperformed. He died at Barcelona on Aug. 19, 1922. As a composer Pedrell was, to a certain extent, hampered by technical shortcomings. His influence on later Spanish composers, however, particularly through his pupil Manuel de Falla, was incalculable, and his editions of early Spanish music laid the foundations of Spanish musicology. (L. SA.)

PEDRO I (1798–1834), founder of the Brazilian empire and first emperor of Brazil, 1822–1831. Pedro was born in Lisbon, Port., on Oct. 12, 1798, the son of King John VI of Portugal. When the French conquered Portugal in 1807, Pedro accompanied the royal family in its flight to Brazil. He remained there as regent when King John returned to Portugal at the behest of parliament in 1821. According to legend, King John, aware of the mounting sentiment for separation from Portugal, advised Pedro to assume leadership of the independence movement, if necessary, so that Brazil and Portugal might remain united under the Braganza dynasty. Pedro surrounded himself with ministers who counseled independence. When the Portuguese parliament demanded that he return to Lisbon "to complete his political education," he refused; when it sought to curb his authority, he declared Brazil independent in the *grito do Ipiranga* (*q.v.*) on Sept. 7, 1822. Brazil was established as an empire with Pedro as its first ruler. However, his initial popularity soon waned in the face of widespread resentment against the Portuguese nobility that influenced his court. In the constituent assembly of 1823 an attempt was made to draft a liberal constitution reducing the emperor's powers and curtailing the rights of the Portuguese in Brazil. Pedro dissolved the assembly and exiled its leaders. In 1824 he issued the basic charter that governed Brazil for the next 65 years. Pedro's autocratic manner, his continued interest in Portuguese affairs, and the failure of his military forces to uphold Brazil's claims to Uruguay combined to alienate his subjects. His reign was marked by a series of local uprisings, some reflecting republican ideals. In 1831 he abdicated in favor of his son, Pedro II, then five years

old, and returned to Portugal. He died in Lisbon on Sept. 24, 1834, fighting to secure his daughter's rights to the Portuguese throne. (R. E. P.)

PEDRO II (Dom Pedro de Alcántara) (1825–1891), second and last emperor of Brazil, was born in Rio de Janeiro on Dec. 2, 1825, and died an exile in Europe in 1891. On April 7, 1831, when he was as yet not six years old, his father, Pedro I, abdicated in his favour, and for nine years Brazil was governed by a regency. Statesmen declared Pedro of age in July 1840 and crowned him emperor on July 18, 1841. Disturbances in the provinces, which had plagued the regency, continued for the next five years; however, by that time the young emperor's intellectual curiosity and profound concern for his subjects were recognized by his subjects and a vast majority of them gave him almost unqualified support for the next 40 years. He considered himself the arbiter of Brazil's political life, and he used the "moderative power" given him by the constitution to regulate the antagonistic groups that sought to dominate the country. Pedro is supposed to have said, "Were I not a monarch I should be a Republican." A president of Argentina called his rule a "crowned Democracy." When a dictator-president of Venezuela learned of Pedro's overthrow in 1889, he exclaimed, "The only Republic in South America is ended—the Empire of Brazil." It is true nonetheless that Pedro ruled in the interests of a narrow social and economic elite.

The slave trade and slavery, both of which were officially sanctioned in Brazil, had caused seriously strained relations between Brazil and Great Britain before Pedro established his leadership of the country. Once in control, he gave his full support to ending the African slave trade, achieved in 1850, and to the abolition of slavery, ratified in 1888. Approximately 700,000 slaves were freed and no provision was made for compensation to the owners. Pedro strongly insisted upon the government's power to regulate the Roman Catholic Church, but that institution was not submitted to the bitter attacks it experienced in most of the Spanish-American republics.

Pedro was an ardent believer in commercial expansion and technological progress. He supported the founding of banks, and extended special privileges to would-be industrialists. Under his guidance Brazil made significant gains in railroad, telegraph, and cable construction.

The monarch's interest in language, religion, education, and science encouraged him to travel abroad. He made trips to Europe in 1871, 1876, and 1887, and to the United States, in 1876, where he attended the Centennial Exposition.

Pedro's government intervened in Uruguay and in 1852 Brazil's troops were instrumental in the defeat of the Argentine dictator Juan Manuel de Rosas (*q.v.*). Brazilian forces joined with those of Argentina and Uruguay to defeat the Paraguayan dictator Francisco Solano Lopez in the Paraguayan War (1864–70).

Illness prevented Pedro from giving adequate attention to the dissension that arose over the slavery issue and, on Nov. 16, 1889, he was forced to abdicate by military leaders who were convinced that monarchy was an anachronism in the New World. The royal family went into exile in Europe where Pedro died, Dec. 5, 1891. His remains and those of his wife were returned to Brazil in 1920 and placed in a chapel in the city of Petropolis, named in his honour.

See Mary W. Williams, *Dom Pedro the Magnanimous, Second Emperor of Brazil* (1937). (J. J. J.)

PEDRO, kings of Aragon: *see* Peter, kings of Aragon.

PEDRO the Cruel (1334–1369), king of Castile from 1350 to 1369, was born at Burgos on Aug. 30, 1334, the son of King Alfonso XI. Though the contemporary English poet Chaucer praised him, a stronger historical tradition, working from narratives written by his enemies, has, without enquiring into motives, depicted him as a monster of cruelty. Pedro was, in fact, a courageous, energetic, conventionally pious man and a competent general. He was also passionate, entirely uninterested in the chivalric doctrines of his age, impatient of political maneuvering, and overready to kill high-ranking traitors—or merely suspected traitors—without trial. Two forces determined the pattern of his reign. Abroad, John II of France thought the accession of a 15-year-old king provided a long-awaited chance to force Castile into a military alliance against England. The alliance was concluded (1352) and Pedro was forced to marry (1353) Blanche, daughter of Pierre, duc de Bourbon, though he was already passionately in love with the beautiful María de Padilla—who was to remain his mistress, and perhaps his legal wife, until her death (1361). He abandoned Blanche immediately after the marriage. This act ruptured the Franco-Castilian alliance.

At home Pedro was at once confronted by a row of bastard half brothers, led by Henry of Trastamara (later Henry II), who, to win support for his undefined ambitions, proclaimed himself defender of the magnates' privileges against the growing power of the crown. After leading several revolts which Pedro crushed with energy, Henry, who failed to win any popular sympathy, escaped to France (1356) and offered to serve the French crown against his brother. From 1356 to 1366 Pedro was engaged in a bitter war with Aragon, whose king, Peter IV, supported Henry's cause and had ambitions to seize Murcia and eastern Castile. Pedro, for his part, had territorial ambitions in western Aragon. Hostilities had been provoked by an Aragonese admiral acting, apparently, on French orders. During the war Pedro won many successes against Aragon while Trastamaran propaganda failed to undermine Castilian loyalty toward him. In 1365, therefore, the French king Charles V, Pope Urban V, and Peter IV—to save Aragon from being overrun—paid the veteran French mercenaries, the *compagnies,* led by Bertrand du Guesclin, to go to Spain and overthrow Pedro, replacing him by Henry. This was done. Pedro fled to Gascony and requested English help under the Anglo-Castilian alliance, concluded on June 22, 1362. The Trastamarans and their French allies were routed at Nájera (April 3, 1367) by Edward the Black Prince, and Pedro resumed his reign without significant opposition.

After the victory, however, the prince showed complete misunderstanding of the political situation in Castile and—having quarreled with Pedro about finance and chivalry—retired to Gascony, where he pondered plans for making himself king of Castile. Charles V sent Henry back to Spain with more French troops and a long civil war ensued. Eventually Pedro was defeated at Montiel and assassinated there by his brother's own hand (March 23, 1369), though strong loyalist resistance continued for several years. It is clear that Pedro's overthrow was brought about almost entirely by French military intervention and, in its final stages, by the Black Prince's political incompetence.

See P. E. Russell, *The English Intervention in Spain and Portugal in the Time of Edward III and Richard II* (1955). (P. E. R.)

PEDRO, the name of five kings of Portugal.

Pedro I (1320–1367), king from 1357, was born at Coimbra on April 8, 1320, the son of Afonso IV of Portugal and his consort Beatriz of Castile. He was married in 1336 to Constanza, daughter of Don Juan Manuel (*q.v.*); but she died in 1345, and Pedro is chiefly remembered for his tragic amour with Inês de Castro (*q.v.*), whose death he savagely avenged after his accession to the throne. Even so, some of his acts, designed to curb abuses and to enhance the royal power, were of great importance: he reformed the administration of justice (1361) and did much to make the Portuguese Church a national one by insisting on the *beneplácito régio,* that is, the royal approbation of all papal bulls or letters before they could be published in the kingdom. Though before he became king of Portugal he had advanced a claim to the Castilian throne (1354), he later helped Castile against Aragon (1358 and 1360). From 1363, however, he pursued a neutral policy. He died on Jan. 18, 1367, leaving his throne to his son Ferdinand I. (V. R. R.)

Pedro II (1648–1706), king from 1683, was born in Lisbon on April 26, 1648, a son of John IV of Portugal. In November 1667, when his elder brother, Afonso VI (*q.v.*), was sent into lifelong captivity, Pedro became regent of Portugal; and in April 1668 he married his brother's former consort, Marie Françoise Élisabeth de Savoie-Nemours (d. 1683). His first international act was to make peace with Spain (Feb. 13, 1668), forgoing the advantages which might have been expected from Afonso's victories of 1663–65. When Afonso died (Sept. 12, 1683), Pedro became king.

Pedro II's reign was marked by a consolidation of royal absolutism: the *Cortes* never met. For Portugal's commerce, however, Pedro in December 1703 obtained the valuable Methuen Treaty, whereby England reduced customs duties on Portuguese wines in return for Portugal's favourable treatment of English woolen goods. This treaty was largely a consequence of Pedro's having finally adhered (May 1703) to the Anglo-Austrian side in the War of the Spanish Succession, though in June 1701 he had allied himself with France. A Franco-Spanish invasion of Portugal was repelled (1704), and Portuguese troops invaded Spain, but their capture of Madrid (July 1706) was a fruitless victory. Pedro II died on Dec. 9, 1706, leaving his throne to John V, his son by his second wife, Maria Elizabeth of Palatinate-Neuburg, whom he had married in 1687.

PEDRO III (1717–1786), king-consort from 1777, was born in Lisbon on July 5, 1717, the younger son of John V of Portugal. He was married in July 1760 to the daughter of his elder brother, King Joseph I. When she became queen as Maria I (February 1777), Pedro became nominally king. He devoted himself entirely to religious practices. He died on May 25, 1786.

For PEDRO IV of Portugal, *see* PEDRO I, emperor of Brazil.

PEDRO V (1837–1861), king from 1853, was born in Lisbon on Sept. 16, 1837, the eldest son of Queen Maria II. Succeeding his mother on Nov. 15, 1853, he had his father, Ferdinand of Saxe-Coburg, as regent for him till he came of age to rule on his 18th birthday. Meanwhile he went on a long tour of the more progressive states of Europe; in England he formed a close understanding with the prince-consort Albert (his father's first cousin), with whom he later maintained a regular correspondence.

Earnest and enlightened, Pedro V devoted himself to his country's problems. In external affairs, he was concerned with the occupation of Cabinda, Molembo, and Ambriz, in northern Angola (1855); with the final abolition of slavery (1856); with the convention (1857) whereby the Holy See restored the effect of the Portuguese patronate over dioceses in India and the Far East, after having practically abolished it in 1838; and with the detention of the French slave-ship "Charles et Georges" off the coast of Mozambique (1857), which led to conflict with the French government (1858–59). In Portugal itself he had to face successive epidemics of cholera and yellow fever (1854–57). He founded the Curso Superior de Letras (1859) for teaching literature, philosophy, and history at university level.

Pedro V married Stephanie of Hohenzollern-Sigmaringen in 1858, but she died in 1859. Pedro died childless on Nov. 11, 1861. (DA. A. P.)

PEEBLES (TWEEDDALE), an inland county of southern Scotland (area 347.3 sq.mi.), forms an eastward-pointing triangle between the counties of Midlothian, Selkirk, Dumfries, and Lanark.

Physical Features.—The county occupies the upper third of the Tweed Basin, with a northerly extension which includes the southern end of the Pentland Hills. There, lavas and sandstones of Old Red Sandstone Age form broad moorlands at about 1,700 ft., clothed in matgrass, heather, and an association of sheep's fescue and purple moor grass. The moorlands are drained southward by the Lyne Water, whose valley opens out into a basin at 700 ft. around West Linton, before crossing the geological boundary of the Southern Uplands fault into a gorge cut into swelling hills of Silurian rocks. These, cut by the steep-sided, flat-floored valleys of the Tweed itself and its tributaries, the Manor, Leithen, and Eddleston waters, comprise the bulk of the county. South of the Tweed are large stretches of high plateau matgrass moorland at 1,800–2,000 ft., swelling to 2,754 ft. in Broad Law, which are given over to hill sheep farming.

The inland position of the county and its altitude give a severe climate—West Linton, with a January temperature of 0° C (32° F) and a July temperature of 13° C (55° F), averages 40 snowy mornings a year; rainfall exceeds 60 in. in the southwest, 35–45 in. elsewhere, with a winter maximum and a dry spring.

There are several Forestry Commission plantations on the edges of the high plateau; the two largest are Glenbreck (6,517 ac.) and Elibank and Traquair (5,594 ac.), the latter crossing into Selkirk county.

History.—Occupation in the Early Iron Age is indicated by the remains of numerous hill forts around the burgh of Peebles, and there are standing stones near the confluence of Lyne Water and the Tweed. The Romans left traces of their military rule in the camp at Lyne, locally known as Randal's Walls. In medieval times a series of peel towers were erected; the best preserved is that of Neidpath Castle, a 15th-century stronghold of the Frasers just outside the royal burgh of Peebles.

The county is closely associated with the legend of Merlin (*q.v.*) and has provided background and other material for Sir Walter Scott, James Hogg, John Buchan, and other writers. The royal burgh of Peebles (*q.v.*) has interesting links with Mungo Park (*q.v.*) and the Chambers brothers (*see* CHAMBERS, ROBERT). The rebuilt cottage of the Black Dwarf (David Ritchie) lies southwest of Peebles, and Scott's novel *St. Ronan's Well* is generally thought to have been inspired by the mineral springs at Innerleithen (*q.v.*). Other places of historical interest include Traquair House, one of the oldest inhabited Scottish mansions, where William the Lion lived and held court in 1209 and where Mary, queen of Scots, and Lord Darnley stayed in 1566; St. Gordian's Cross at Manor; Cross Kirk, dating from 1261, at Peebles burgh; Drochil Castle, left unfinished by the regent Morton when he was executed in 1581 (*see* MORTON, JAMES DOUGLAS, 4th earl of); and Stobo Kirk, dating from Norman times.

Population and Administration.—The population in 1961 was 14,156, showing a decrease of 7% since 1951. The royal burgh of Peebles (pop. [1961] 5,548), and the burgh of Innerleithen (2,299), also show decreases. The county is combined with Roxburgh and Selkirk to form a joint constituency, returning one member to Parliament. It forms a sheriffdom with the Lothians; there is a sheriff-substitute at Peebles.

The Economy.—Less than one-fifth of the total area is improved land and of this more than a third is under permanent grass; oats occupy half the cropped area, with turnips and rape also important. Cultivation is confined largely to loams of glacial origin bordering the gravel and alluvium of the "haughs," or flat valley floors, which are mainly under grass except where drainage and flood protection make them valuable crop land. Livestock farming predominates, with black-faced sheep on the hills and Cheviot sheep and beef cattle along with the arable on the lower land. High quality tweeds and knitwear are made in Peebles, Innerleithen, and Walkerburn.

The scenery is a valuable asset which has led to increased tourism. There is good trout and salmon fishing in the Tweed and easy access to the hills.

See J. W. Buchan and Rev. Henry Paton (eds.), *A History of Peeblesshire*, 3 vol. (1925–27); Land Utilisation Survey of Britain, *The Land of Britain, Peebles and Selkirk* by D. L. Linton and C. P. Snodgrass (1946); *Third Statistical Account of Scotland for the Counties of Peebles and Selkirk* (1964). (W. GE.; A. T. A. L.)

PEEBLES, a royal and small burgh and the county town of Peebles, Scot., at the junction of Eddleston water with the Tweed, 23 mi. S. of Edinburgh by road. Pop. (1961) 5,548. The burgh consists of the new town, on the south of the Eddleston, and the old on the north. Portions of the town walls still exist, and there are cellars constructed in the 16th and 17th centuries as hiding places against border freebooters. The old market cross stands in High street. The Chambers institution incorporates the mansion where the notorious "Degenerate Douglas," or "Old Q." 4th duke of Queensberry (1724–1810), was born. Of St. Andrew's church, founded in 1195, nothing remains but the tower, restored by William Chambers, the publisher, who was buried beside it in 1883. Cross kirk was erected by Alexander III. in 1261, to contain a supposed remnant of the true cross discovered there. The building remained till 1784, when it was nearly demolished to provide stones for a new parish church. Peebles was a favourite residence of the Scots kings when they went to hunt in Ettrick forest. It was created a royal burgh in 1367 and was the scene of the poem of *Peblis to the Play*, ascribed to James I of Scotland. Peebles lost its importance after the union of the crowns. There are several large woollen mills, and the town is an agricultural centre. The Buchan family (Lord Tweedsmuir) is associated with Peebles, and Mungo Park practised medicine there (1801–03). In June

the "Beltane queen" is crowned, this being a survival of the ancient religion.

On the north bank of the Tweed stands Neidpath castle, of which the ancient peel tower dates probably from the 13th century. Its first owners were Tweeddale Frasers, from whom it passed to the earls of Tweeddale. It was besieged and taken by Cromwell in 1650. The 3rd earl of Tweeddale (1645–1713) sold it to the duke of Queensberry in 1686. The earl of Wemyss succeeded to the Neidpath property in 1810.

PEE DEE-YADKIN, a river system originating as the Yadkin River in northwestern North Carolina, U.S., on the southeastern slopes of the Blue Ridge Mountains. The Yadkin flows northeastward past Wilkesboro and Elkin, N.C., and then turns south. After 202 mi. it joins the Uharie River and continues southward into South Carolina. The combined stream is known thence to the Atlantic as the Pee Dee River. The Pee Dee is named for the eastern Siouan Pedee Indian tribe, which resided along its course in southern North Carolina when that area was first settled. The Pee Dee-Yadkin flows through coastal plain and piedmont areas where it is hemmed in by fairly high hills that serve well in the erection of dams. There are several artificial lakes along the Yadkin. High Rock Lake, formed by a hydroelectric dam, furnishes power for aluminum production at Badin, N.C. Several early settlements on the central North Carolina Piedmont were founded by pioneers who poled boats up the stream. The river is navigable 91 mi. (146 km.) inland from Georgetown, S.C., on the Atlantic, where the Pee Dee meets the Waccamaw, Sampit, and Black rivers. Former rice plantations, now devoted to cattle, vegetables, timber, and hunting activities, line its banks for a score of miles inland from Georgetown.

(M. C. P.)

PEEKSKILL, a city of Westchester county, N.Y., U.S., on the east bank of the Hudson river, 41 mi. (66 km.) above New York City. Peekskill is the shopping centre for northern Westchester and Putnam counties. Its name was derived from that of the adjacent creek, or "kill," on which Jan Peek, an early Dutch settler, conducted an Indian trading post from 1667 to 1677. The village was strategically important during the American Revolution, and large sections of it were burned by the British on March 23, 1777. It became a city in 1940.

For comparative population figures *see* table in NEW YORK: *Population.* (M. H. LE.)

PEEL, SIR ROBERT (1788–1850), British home secretary from 1822 to 1827 and from 1828 to 1830, prime minister from 1834 to 1835 and from 1841 to 1846. The leader of the Conservative Party that emerged after the Reform Act of 1832, a free trade reformer, and the repealer of the Corn Laws in 1846, Peel was one of the outstanding British statesmen and administrators of the 19th century. His policy did much to ease Britain's difficult social and economic transition from an agricultural and mercantile to a primarily industrial society in the 50 years following the close of the Napoleonic Wars in 1815. He was born on Feb. 5, 1788, at Bury in Lancashire. His grandfather was a small yeoman farmer, who became one of the pioneers of the Lancashire cotton industry. His father, Sir Robert Peel, was a shrewd and ambitious businessman who built up a large cotton-manufacturing interest, purchased a landed estate at Drayton, near Tamworth, Staffordshire, entered the House of Commons (1790) and was made a baronet by the younger Pitt in 1800. Robert Peel, his eldest son, was educated at Harrow School (1800–04) and Christ Church, Oxford (1805–09), where he was the first to achieve a double first in classics and mathematics in the new degree examination. With his father's money and government influence a parliamentary seat was found for him as soon as he came of age and in April 1809 he was returned as M.P. for Cashel city, County Tipperary.

BY COURTESY OF THE NATIONAL PORTRAIT GALLERY, LONDON

MARBLE BUST OF SIR ROBERT PEEL BY MATTHEW NOBLE. IN THE NATIONAL PORTRAIT GALLERY, LONDON

Secretary for Ireland (1812–18).—Like his father Peel was from the start a government supporter and received an early appointment as undersecretary for war and the colonies in 1810. Two years later he accepted the difficult post of chief secretary for Ireland. During his six years in this office he made his reputation as an able and incorruptible administrator. With the war on the continent still in a critical phase, he was faced in Ireland with the first serious Catholic agitation since Pitt's Act of Union in 1800. In 1814 he was largely responsible for the suppression of the Catholic board, the semi-illegal central committee of the movement, and thus effectively checked the course of Irish agitation for another nine years. Increasingly, however, he was impressed by the endemic anarchy of Irish society and the economic poverty and disorganization from which it derived. To deal with the problem of crime and disorder he carried through the Peace Preservation Act of 1814, which made possible the formation of a body of national police later known as the Royal Irish Constabulary, popularly called "Peelers." In 1817 came the first serious Irish famine of the century, but Peel's energy and practical sense in raising relief funds and supervising the distribution of food carried the country through the crisis without serious disorder. When Peel's Irish secretaryship ended the following year he was already marked out for early promotion. At the same time, partly because of family tradition and early education, partly because of his role in the House of Commons as spokesman for the Irish government, he had distinguished himself as the ablest of the "Protestant" party which resisted the recurrent efforts to pass Catholic emancipation. This issue, which divided the Cabinet as well as ordinary political parties, was primarily concerned with the admittance of Roman Catholics to membership of Parliament and high offices of state from which they were still legally barred. Peel's brilliant speech in the emancipation debates of 1817 was widely held to be decisive in defeating the proposed measure and was instrumental in securing his election to the coveted honour of member of Parliament for Oxford University later the same year.

In 1820 Peel married Julia, the beautiful younger daughter of Gen. Sir John Floyd, a veteran of the wars in India and second-in-command of the forces in Ireland when Peel first went there. The marriage was ideally successful and for the rest of his life Peel enjoyed a serene family life. Following his marriage Peel built an elegant house in Whitehall Gardens and began the collection of paintings, mainly of the Dutch, Flemish, and contemporary English schools, for which he became famous among art connoisseurs. When on his father's death in 1830 Peel succeeded to the baronetcy and estate, he made his home at Drayton. A magnificent manor house was built on the site of the old, and he administered his estate with zeal and knowledge, developing the property and encouraging scientific methods of drainage, fertilizers, and stock breeding among his tenants.

After his departure from Ireland in 1818 Peel twice declined minor appointments though he remained an active government supporter. In 1819 he was made chairman of the important currency committee which brought about the return of the gold standard. Though expert opinion was generally in favour of ending the wartime system of paper currency, the deflationary policy carried through under the act of 1819 became a major controversial issue. By his subsequent defense of this measure Peel became identified with the gold standard policy to which his opponents attributed much of the industrial and agricultural distress of the 1820s.

Home Secretary (1822–27, 1828–30).—In the reconstruction of 1822 by which the earl of Liverpool endeavoured to strengthen his unpopular ministry, Peel accepted the post of secretary of state for the home department and a seat in the cabinet. His first task was to meet the long-standing demands in Parliament, made

by the Whig legal reformers, Sir Samuel Romilly and Sir James Mackintosh, for a radical change in the criminal laws. In a series of five acts in 1823 Peel carried out most of the reforms suggested by Mackintosh's 1819 committee. He then proceeded to a comprehensive reorganization of the criminal code. Between 1825 and 1830 he effected a fundamental work of consolidation and reform, covering three-quarters of all criminal offenses. Though accompanied by a progressive reduction in the severity of punishment, the main object of Peel's work was to repeal obsolete legislation, simplify judicial procedure, and reduce the mass of old and confused penal laws to a small number of short, intelligible statutes. On the controversial issue of capital punishment he preferred to move more slowly, retaining a wide degree of administrative discretion while waiting to see the effect of his initial measures. The rising statistics of crime convinced him that legal reform should be accompanied by improved methods of crime prevention and detection. In 1829 he carried through the Metropolitan Police Act, which set up the first disciplined police force for the whole London area (excluding the City); its headquarters were at Scotland Yard. The nickname of "Bobby" for its members was a popular tribute to the founder of the force. In the general administration of the country the main task of the home office was to preserve order in the periodic disturbances arising from unemployment and agitation in the industrial districts. Though concerned at the increasing activity of the trade unions, following the removal of the restrictive Combination Acts in 1824–25, Peel observed a policy of nonintervention in industrial disputes and tried to induce both masters and men to conform with the law. He used pressure on local magistrates to see that cotton mills were properly inspected, and by calling for returns on conditions of child labour helped to repair the widespread neglect by magistrates and mill owners. In the bad year of 1826, when there was extensive industrial rioting in the north and west of England, he was able to restore order without recourse to emergency legislation; then, and in the less serious disturbances of 1829, he ensured that relief funds were available to the distressed areas.

Catholic Emancipation.—When George Canning succeeded Liverpool in April 1827, Peel resigned on the issue of Catholic emancipation though in other respects he and Canning both belonged to the more liberal wing of Liverpool's old Cabinet. After Canning's death (August 1827) and the collapse of the Goderich ministry early in 1828, he returned to office under Wellington as home secretary and leader of the House of Commons. He endeavoured to reunite the old Liverpool party by including William Huskisson and other followers of Canning in the new administration; personal and political differences between Huskisson and Wellington led to the resignation of the Huskisson group after four months in office. The secession considerably weakened the government, which had substantially less support in the House of Commons than Liverpool's Cabinet. A Whig motion for the repeal of the Test and Corporation Acts, which debarred Dissenters and Roman Catholics from municipal and public office, was carried against the government in February 1828 and this first successful attack on the supremacy of the Anglican Church was followed by the Catholic crisis of 1828–29. The Irish movement for emancipation had been renewed in 1823 with the formation of the Catholic Association by Daniel O'Connell. Its growing strength, demonstrated in the general election of 1826, culminated two years later in O'Connell's victory at a by-election for County Clare (July 1828). A month earlier, in May 1828, the House of Commons had carried a motion in favour of emancipation. Convinced that further resistance was useless, Peel proffered his resignation and though the simultaneous defection of the Huskissonites made his immediate retirement difficult, he made it clear that it could only be delayed. Meanwhile he urged the prime minister to prepare for a final settlement of the dispute and promised to give it independent support. Faced with considerable royal and episcopal opposition, Wellington finally persuaded Peel in January 1829 to remain in office and introduce the bill as the only means of carrying through the policy on which they both agreed. When the measure was debated Peel argued that while he was not converted to the principle of emancipation, the threatening state of Ireland and the long-standing divisions in Parliament and Cabinet on the issue left the government with no choice but concession. He suffered bitter personal attacks for his sudden change of front. When on conscientious grounds he resigned his seat for Oxford University, he was defeated at the ensuing by-election; many of the ultra-Protestant supporters of the administration were left angry and hostile. In the following session support for the government was weaker than ever and the general election of 1830 consequent on the death of George IV made no fundamental difference to the political situation. Wellington failed to obtain fresh recruits for his Cabinet, and his declaration against parliamentary reform at the opening of the new session in November 1830 brought about the fall of his government.

Parliamentary Reform: First Ministry (November 1834–April 1835): Conservative Leader.—In the reform crisis that followed, Peel's position was difficult and ambiguous. Though not opposed to moderate parliamentary reform, he was shocked by the sweeping measure introduced by Earl Grey's ministry in March 1831, and by their subsequent appeal to the electorate and the forces of public agitation. Convinced that reform could not be prevented, he tried to mitigate its effects and used his influence to stiffen the opposition in the House of Lords as a warning to future radical reformers. The divisions in his party made leadership impossible; he made no effort to conciliate the ultra-Tories; his refusal to join Wellington in office and pass a Tory reform bill in 1832 forced the king back on the Whigs and further weakened Peel's standing with his former followers. Nevertheless, he was already looking to the growth of a more durable conservative opinion in the country, and his studied moderation in the first two sessions of the Reformed Parliament (1833–34) did much to restore his political status. The unexpected dismissal of Viscount Melbourne's ministry in November 1834 and Peel's appointment as prime minister gave him an impossible task; though the immediate dissolution of Parliament enabled him to make in the so-called Tamworth manifesto an important statement of conservative reforming principles. At the general election the Conservative Party, though still in a minority, gained 100 seats and for the first time came under his acknowledged leadership. Peel resigned office in April 1835 when beaten by a combination of Whigs, Radicals, and Irish nationalists. During the next six years, aided by his astute and cautious leadership in the Commons and by the careful electoral organization of his subordinates, the Conservative Party steadily increased in numbers and confidence. The hard-fought election of 1837 that followed the death of William IV brought the two main parties to a position of near equality; though a clash with the youthful and whiggish Queen Victoria over the replacement of some of the ladies of her bedchamber caused Peel to abandon taking office in 1839, he was able to carry a vote of no confidence against the government in June 1841. At the succeeding dissolution the Conservatives for the third time running increased their numbers and on Aug. 30, 1841, Peel took office with a working majority of about 70 in the House of Commons. In its achievements and membership the administration he now formed was one of the most outstanding of the century. It included six past or future prime ministers, four future governors of India, and several able young men, notably W. E. Gladstone, Henry Pelham-Clinton, earl of Lincoln (afterward duke of Newcastle), Edward Cardwell, and Sidney Herbert, who later formed the group of "Peelites" which played a formative role in later Victorian politics.

Peel's Second Ministry (1841–46).—At the outset of his ministry, Peel was faced with war in China, the threat of war in India, strained relations with France and the United States, severe commercial distress at home, Chartist agitation among the working classes, the powerful organization of the Anti-Corn Law League, O'Connell's campaign for the repeal of the union, and a five-year accumulation of budgetary deficits. His policy aimed at peace and better trade relations abroad, a reduction in the cost of living for the working classes, and encouragement to trade and industry by progressive tariff reductions and a more stable financial system. One immediate issue was the Corn Laws. The free trade proposals of the outgoing Whig ministry, though widely held to be an elec-

tion maneuver, had ensured that cheap bread was one of the election cries in 1841. Peel defended protection for agriculture on grounds of expediency but had refrained from any pledges and explicitly reserved his right to formulate policy when in office according to his view of national needs. Early in 1842 he brought forward a new Corn bill which reduced the protective duties by about a half but retained a sliding scale (as against the Whig proposal of a fixed duty of 8*s.* a quarter) designed to eliminate sudden price fluctuations. The 1828 Corn Law had not worked satisfactorily and most leading agriculturalists accepted the new bill as a necessary compromise of opposing interests. During the same session Peel restored the financial position of the government by the reintroduction of the wartime income tax for a period of three years. This enabled him not only to meet a deficit of about £2,500,000 but to make a sweeping reduction of duties on about 750 articles of import, mainly food, raw materials, and semimanufactured goods. In 1844 the Bank Charter Act completed the foundations of the Victorian banking and currency system. Designed primarily to put the currency system on a sound basis, it separated the banking and note issue functions of the Bank of England; related the volume of note issue to the amount of bullion reserves; and provided for the gradual extinction of note issue by provincial banks. Though the act was perhaps unduly rigid, as was demonstrated in the commercial panic of 1847, Peel's convictions of the dangers of unsound currency made him prefer a tight system, with possible recourse to emergency measures in time of crisis, to one which provided any loophole for credit inflation. The success of his tariff changes and the buoyancy of the revenue led in 1845 to Peel's second great reforming budget. The income tax was renewed for another three years and the resultant surplus of over £3,000,000 used for an even more drastic free trade experiment, though one made in more favourable circumstances than in 1842. A large reduction was made in the sugar duties, and the excise on glass, all remaining export duties, and import duties on about 430 articles were entirely removed.

Under the impact of Peel's early measures, aided by the stimulus of expenditure on the new railroads, the years 1843–45 saw a return of prosperity under which Chartist agitation tended to die down. The Anti-Corn Law League, which in the hard times of 1842–43 had shown signs of exploiting social disorders to bring pressure on the government, turned to more constitutional electoral methods and began to prepare for the next general election. In foreign affairs relations with France improved under the conciliatory policy of the foreign secretary, the earl of Aberdeen, though important measures were put in hand during 1845 to strengthen the naval and coastal defenses of the country. With the United States the disputed boundary between Maine and New Brunswick was settled by Lord Ashburton's mission in 1842, and four years later, after a show of stiffness by both sides, the Oregon Treaty of 1846 extended the line of the 49th parallel to the Pacific with deviations which allowed Britain to retain Vancouver Island. Like Aberdeen, Peel's desire was for peace but he invariably showed a firmer attitude in foreign policy than his patient and charitable colleague. The same combination of firmness and conciliation was exhibited toward Ireland. O'Connell's movement to obtain the repeal of the Act of Union was checked in 1843 by large military reinforcements for Ireland and by the banning of the mass meeting arranged at Clontarf (October), followed by O'Connell's trial for conspiracy. Though the verdict was subsequently quashed, it proved in fact the end of O'Connell's active career. Meanwhile the royal commission under the earl of Devon was set up to enquire into landlord and tenant relations in Ireland; the Charitable Bequests Act of 1844 brought Catholic bishops into the administration of charitable funds in Ireland; and in 1845 a wider scheme of Irish education passed through Parliament. Three university colleges were set up; and despite fierce Protestant opposition a greatly increased grant was made to the Catholic seminary at Maynooth.

The development of Peel's Irish policy was cut short by the Irish famine years of 1845–48. It is clear that Peel already had in mind a further reduction in the corn tariff, but the Irish potato disease in 1845 combined with a partial failure of the corn harvest in England made suspension of the Corn Laws for an indefinite period an immediate necessity. He came to the conclusion that it was impossible to maintain them any longer. His cabinet split on the issue in December 1845 but Lord John Russell was unable to form a government. Peel returned to office and managed to carry through his repeal measure. He believed the attempt to preserve the Corn Laws in the changing social conditions of Britain would imperil the political ascendancy of the aristocracy and that the salvation of British agriculture lay not in protection but in scientific farming. Nevertheless, he had strained the loyalty of his party on various issues; many of his followers were under pressure from farmers and agricultural protection societies in their constituencies; and as soon as Parliament met, a bitter personal challenge to his leadership developed under Lord George Bentinck and Disraeli. The bill to repeal the Corn Laws was passed at the third reading in the House of Commons on June 25, 1846, by a composite majority of Whigs, Radicals, and a minority of the Conservative Party; the same day Peel was defeated on an Irish Coercion Bill by a purely tactical combination of Whigs and protectionists. He resigned on June 29. He was never again in office, though he remained a great national figure in Parliament, dedicating himself to the support of free trade principles and the maintenance of a Whig ministry as the only safeguard against a protectionist government. Despite the pleas of some of his followers, he abstained from any attempt to organize a party, and was frequently called upon by members of Russell's ministry for assistance and advice. Though he delivered the last great speech of his career on June 28, 1850, in condemnation of Palmerston's policy in the Don Pacifico incident, he was relieved at the government's avoidance of defeat. Next day, as he rode down Constitution Hill, he was thrown from his horse, breaking his collarbone and several ribs. He died on the evening of July 2, 1850, at his house in Whitehall Gardens.

Character and Political Significance.—In appearance Peel was a tall, handsome, well-built man with reddish hair and blue eyes, and was something of a dandy in his dress. He was fond of sport, an excellent shot, and capable of great physical exertion. But this solid exterior concealed a complex and self-conscious personality. A proud, shy person of scrupulous integrity and with a prickly sense of honour, he was both ambitious and idealistic in his pursuit of politics. Though trained by early experience to habitual caution and reserve, he was by nature quick-tempered, stubborn, and courageous. Ill at ease with strangers, impatient with fools and bores, he often gave an impression of aloofness and frigidity; yet with intimate friends he was lively and affectionate, and to those in trouble unusually generous and warmhearted. Endowed with a first-class intellect, an exact memory, and an immense capacity for work, he was a superb administrator and as prime minister supervised every aspect of departmental policy. In the Commons his practical knowledge, political sagacity, and persuasive debating skill made him the greatest parliamentarian of his time. Yet his stiff public manner and lack of aptitude for the lesser arts of management made it difficult for him to win the real loyalty of his followers. Subsequent criticism that he lacked foresight and "chose the wrong party," overlooked the fact that his public outlook was formed in an older and more aristocratic period of politics. Though recognizing the need after the Reform Act for government to be based on organized parties, he still held that ministers of the crown were servants of the state and not the mouthpieces of sectional interests. With those beliefs he made a more important and permanent contribution to the structure of the Victorian state than any other statesman of the period. At the same time, by insisting on fundamental changes in the national interest, he did much to preserve the continuity of aristocratic parliamentary rule in an age of social distress and class conflict. Though sometimes obstinate, his mind never lost its flexibility and imagination; the last decade of his life was coloured by his intense concern for the "condition of England" problem (*see* ENGLISH HISTORY: *The Victorian Age*). The repeal of the Corn Laws in 1846, involving him in the sacrifice of power and party, gave him a prestige with the middle and working classes that no previous minister had ever possessed; his dra-

matic death in 1850 occasioned unprecedented scenes of national sorrow. *See* also references under "Peel, Sir Robert," in the Index.

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(N. G.)

PEEL, a seaport and seaside town on the west coast of the Isle of Man, lies 10 mi. NW of Douglas by road and on the Isle of Man railway. Pop. (1961) 2,487. It is situated on Peel Bay at the mouth of the River Neb, which forms the harbour. The old town consists of narrow streets and lanes, but a modern residential quarter has grown up to the east. On the west side of the river mouth St. Patrick's Isle, connected with the mainland by a causeway, is occupied almost wholly by ruins surrounded by a 16th-century wall. The ruins include the keep and guardroom of Peel Castle and, close by, the remains of the Cathedral of St. German, including a transitional Norman choir with an early crypt beneath, and a nave with an Early English triplet at the west end. There are also remains of the bishops' palace and of the palace of the lords of Man. In 1397 Richard II condemned the Earl of Warwick to imprisonment in Peel Castle, and in 1444 Eleanor, duchess of Gloucester, received a similar sentence. Also on the island St. Patrick is said to have founded the first church in Man, and a small chapel dedicated to him appears to date from the 8th or 10th century. There is an ancient round tower.

Peel has a long-established fishing industry. It was called by the Northmen Holen ("island"; *i.e.*, St. Patrick's Isle); the existing name is Celtic, meaning "fort."

PEELE, GEORGE (1556–1596), English dramatist, predecessor of Shakespeare, who experimented in many forms of theatrical art: pastoral, history, melodrama, tragedy, folk play, and pageant. His *The Arraignment of Paris* is one of the earliest mythological pastorals, and his *Device of the Pageant Borne Before Woolstone Dixi* is the earliest surviving complete lord mayor's show, the annual pageant produced for the inaugural ceremonies of the lord mayor of London.

Peele was born in London, the eldest son of a middle-class urban family. His father, James, was an accountant and teacher who himself wrote pageants, as well as two treatises explaining double-entry bookkeeping. Shortly after George's birth James was appointed head bookkeeper of Christ's Hospital, at that time a home and school for London orphans. There the dramatist lived and studied until he went to Oxford in 1572.

What is known of Peele's career at Broadgates Hall (later Pembroke College) and Christ Church, Oxford, indicates that he began his varied literary career by translating into English one of the plays of Euripides. William Gager, the celebrated Latin dramatist, wrote two commendatory poems to the young student, praising him for his literary skill; and Anthony à Wood records that Peele was "esteemed a most noted Poet in the University."

In 1579 Peele made two trips to London. His second visit was cut short at the request of the hospital governors, who seem to have felt that the added burden of a student able to shift for himself was too distracting for the now-ailing father. Peele returned to Christ Church, where he married Anne Cooke and settled down in the university community. During this period he probably wrote the first of his surviving works, a 485-line verse epitome of the *Iliad*, titled *The Tale of Troy* (published 1589).

In 1581 he moved to London but during the next two years returned to Oxford many times to cope with litigation over property his wife had inherited. Pleasanter business necessitated his return in 1583, when Christ Church presented two spectacular plays by Gager, and Peele was hired as one of the technical directors.

About this time Peele had joined a group of Oxonians living just outside the London city wall and had begun to experiment with poetry in various metres. From this association with the so-called "university wits" comes a blank verse commendatory poem to the poet Thomas Watson and two mythological pastorals: *The Arraignment of Paris* (1584) and *The Hunting of Cupid*. This sort of gentleman's writing probably brought Peele less money than praise, for shortly afterward he produced *The Device of the Pageant Borne Before Woolstone Dixi* (1585). It was followed by other pageants for the city, of which only *Descensus Astraeae* (1591) survives.

The Arraignment of Paris was produced for the courtiers, but the rest of Peele's life was devoted to writing for the popular stage. Of the many playhouse dramas he must have had a hand in, only four can be certainly ascribed to him: *The Battle of Alcazar* (1594), *The Old Wives Tale* (1595; ed. by R. L. Blair, 1936), *Edward I* (1593), and *The Love of King David and Fair Bethsabe* (1599). To supplement a meagre income, Peele turned out poems commemorative of noteworthy events: *A Farewell* (1589), to John Norris and Francis Drake on their departure with a counterarmada to fight the Spanish; *An Eglogue Gratulatorie* (1589), to the earl of Essex on his return home from this expedition; *Polyhymnia* (1590), celebrating an important tilting match; *The Honour of the Garter* (1593), commemorating the earl of Northumberland's installation as knight of the Garter; and *Anglorum Feriae* (1595), another memorial of a noteworthy tilt. The only other work which can with any certainty be ascribed to Peele is a poem, "The Praise of Chastity," which appeared in *The Phoenix Nest* (1593), an anthology of Oxford poets.

It used to be customary to describe Peele as dissipated, depraved and desperate, but the evidence on which such an estimate of his character was largely based—an anonymous jestbook that made free use of his name—is valueless in this respect. He lived and died a varied life fraught with the perils of poverty; shortly before his death he sent his eldest daughter to Lord Burghley with a request for money, describing himself as enfeebled by long sickness. His contemporaries praised him highly. Modern critics accord him a place, along with Robert Greene, Thomas Kyd, and Thomas Nashe, as an important early playwright with considerable technical skill.

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(D. H. H.)

PEEL RIVER, in northwest Canada, 425 mi. in length, rises in the Ogilvie Mountains, Yukon Territory. With its tributaries the Blackstone, Hart, Wind, Bonnet Plume, and Snake, it drains a large area of northern Yukon to the Mackenzie River which it joins near Fort McPherson. Its upper course through Peel Plateau is characterized by canyons up to 1,000 ft. deep; its lower valley, much of which is in nature reserve and game sanctuary, is wide, with braided channels, gravel bars, and small wooded islands. It was named after Sir Robert Peel. (B. V. G.)

PEERAGE (medieval Lat. *paragium*, Fr. *pairie*), the quality or status of a peer, that is, originally, in the kingdom of the British Isles and in France, of a member of the nobility entitled to a measure of personal and direct participation in the legislative or judicial deliberations of his sovereign. Though examples can be found of the word peer (Lat. *par*, Fr. *pair*) used for an immediate vassal of some lesser lord than a king (*e.g.*, of a duke or of a count) when his relation to that lord is in question, here the discussion will be concerned only with the peers of kingdoms.

THE BRITISH ISLES

Origins and History of British Peerages

The origins of the peerages of England, Scotland, and Ireland are connected in varying degrees with the development of Parliament in the three countries, the early identification of the English peerage with the history of the House of Lords being particularly striking. From the abolition of the Scottish parliament in 1707, until 1963 only 16 Scottish peers had the right to sit at Westminster, and from 1800 only 28 Irish peers were lords of Parliament. Moreover, after the establishment of the Irish Free State (now the Republic of Ireland) in 1922, no more Irish representative peers were elected; the last Irish peer to sit at Westminster died in 1961.

England.—Etymologically, peers (Lat. *pares*) are "equals," and in the Anglo-Norman period the word was invariably employed to indicate parity before the law. This early usage is illustrated in clause 39 of Magna Carta (1215), in which King John promised that "no freeman shall be taken or imprisoned, or disseised, or outlawed . . . except by the lawful judgment of his peers (*judicium pariun*)." The feudal tenants in chief of the crown were all the peers of one another, as the tenants of any lesser lord were each others' equals. Tenants owed suit of court to their lord, whoever he might be, and the tenants in chief were bound to attend the king's great council (*magnum* or *commune concilium*) when summoned. The Norman kings followed the Anglo-Saxon practice of holding such councils thrice yearly, at Easter, Whitsuntide, and Christmas; they could, of course, be held also at other times. The Norman great councils also retained some of the characteristics of the Anglo-Saxon Witan (*q.v.*), in that the kings could summon to them whom they would. But by far the greater element in the Anglo-Norman *magnum concilium* was the body of tenants in chief, among whom were numbered the earls (*q.v.*), in origin great royal officials whose titles were based on territorial possessions.

The size of the holdings of different tenants in chief varied greatly. Some great landowners held honours comprising the equivalent of two or three counties, while others held only small fiefs, perhaps granted to them or their ancestors as a reward for quite humble services. The gap between the greater and the lesser tenants in chief gradually widened (*see* BARON); Magna Carta recognized this clearly in the arrangements it made (clause 14) for the summoning of the *commune concilium*. It distinguished between archbishops, bishops, abbots, earls, and greater barons (*majores barones*), who were to be summoned individually, by writ, and "all those who hold of us in chief," who were to be summoned through the sheriffs. The greater barons became the ancestors of the peers of later days, while the rest of the tenants in chief became merged with the ordinary manorial owners; their representatives were the knights of the shire of the early medieval Parliaments who, after some hesitation, joined forces with the city and burgher representatives to form the House of Commons.

An examination of the early writs issued to individuals shows that those thus summoned to Parliament were indeed the archbishops, bishops, abbots, priors, earls, and greater barons. While the archbishops and bishops received their writs with regularity (during the vacancies caused by death, deprivation, or translation, the writs were issued to the "guardian of the spiritualities"), the summonses to heads of religious houses and to the barons were intermittent. Bishops had often begun their careers as royal clerks and their services were of great value to the crown; but heads of religious houses, on the other hand, were primarily concerned with the welfare of their order, while the influence of individual magnates was bound to vary. It seems, therefore, that the issue of writs of summons was at first entirely at the pleasure of the crown, and that in practice the decision was made in accordance with the personal and tenurial importance of the magnate concerned.

It was thus only gradually that the hereditary principle of the peerage was established. Throughout the reigns (1272–1377) of the first three Edwards, summonses were not always issued to the same baron for successive Parliaments, and it seems certain that these kings never considered that the issue of one writ to an individual bound the crown to its repetition for the rest of his life, much less to his heirs in perpetuity. But the fact that primogeniture had long been established as the normal rule of inheritance naturally affected the principle of summons. Primogeniture tended to secure estates in strict family succession; thus, if extent of possession had originally extracted a personal summons from the crown, it was likely that as successive heirs received the inheritance, they too would be similarly summoned. Gradually the free and indiscriminate choice of the crown became fettered by the principle that once a summons had been issued to an individual to sit in Parliament and he had obeyed that summons, he thereby acquired a right of summons for the rest of his lifetime; and in later years, when the doctrine of nobility of blood became established, his heirs were held to have acquired the same privilege by hereditary right.

Thus far the "peerage" depended entirely upon tenure of land and summons to a council or to Parliament by individual writ. But in 1387 Richard II introduced the practice of creating peerages by letters patent. John Beauchamp, steward of the king's household, was created "Lord de Beauchamp, Baron of Kidderminster, to hold to him and the heirs of his body." These letters patent were not founded on any right by tenure of land possessed by Beauchamp; Richard made him "for his good services . . . and for his noble descent, and his abilities and discretion, one of the peers and barons of the kingdom of England. . . ." The grant rested wholly on the grace and favour of the crown, and was a personal reward for services rendered. A hereditary barony was created which was entirely a personal dignity, quite unconnected with the tenure of land. From Richard's reign to the present day, baronies (and, indeed, all other peerage honours) have continued to be conferred by patent. The custom of summons by writ was not in any way interfered with, the patent operating merely to declare the dignity and to define its devolution. Summons alone continued for many generations side by side with summons founded on patent; but after the reign (1509–47) of Henry VIII the former method fell into disuse and since the 17th century there have been no new creations by writ of summons alone. So, from the late 14th century, barons were of two classes; the older, and more ancient in lineage, summoned by writ alone, the honours descending to heirs general; and the newer, created by letters patent, the terms of which governed the issue of the summons and prescribed the devolution of the peerage in a line usually of the direct male descendants of the person first ennobled.

It was long believed that originally there had existed peerages by tenure alone, and that such could devolve by right of tenure independent of descent. But in the Berkeley case (1858–61), when Sir Maurice Frederick FitzHardinge Berkeley unsuccessfully claimed the barony by virtue of his seisin of Berkeley Castle, it was finally determined that bare tenure could not be regarded as a means of establishing a peerage right. The main attribute of a peerage is that hereditary and inalienable quality which ennobles the blood of the holder and his heirs, or, as Sir John Doderidge put it in the case of the earldom of Oxford and the office of lord great chamberlain (1625–26), "he cannot alien or give away this inheritance, because it is a personal dignity annexed to the posterity and fixed in the blood."

Until the reign of Edward III, the peerage consisted only of prelates, earls, and barons. The earls were barons with their special name of dignity added, and their names always appear on the rolls before those of the barons. In 1337 King Edward created his son, Edward the Black Prince, duke of Cornwall, giving him precedence over the rest of the peerage. Subsequently several members of the royal family were created dukes, but no subject received such an honour until 1386, when Richard II created his favourite Robert de Vere, earl of Oxford, duke of Ireland (for life). The original intention may have been to confine the dignity to the blood royal, since, with the exception of de Vere, it was some years before a dukedom was again conferred on a subject.

Richard had previously (1385) created de Vere marquess of Dublin, thus importing into the English peerage a title hitherto unknown in that country. The grant was, however, for life only, and was in fact resumed by the crown in 1386, when de Vere was created duke of Ireland. Yet another order was added in 1440, when Henry VI created John, Baron Beaumont, Viscount Beaumont, giving him precedence next above the barons. None of these three new titles ever carried with them any official position; they were conferred as additional honours on men who were already members of the peerage.

The application of the hereditary principle to temporal peerages early differentiated their holders from the spiritual peers. Both spiritual and temporal peers were equally lords of Parliament, but the temporal peers, stressing their doctrine of "ennobled blood," gradually came to consider that they were superior to all other lords of Parliament. Eventually they arrogated to themselves the exclusive right to be called peers, and as such the

only persons entitled to the privileges of peerage. The prelates were hindered in their struggle to retain peerage privileges by the success obtained by the church in establishing certain rights, such as exemption from trial in the secular courts (*see* CLERGY, BENEFIT OF). Thus they never claimed the privilege of trial by peers, and when arraigned alleged that they were altogether beyond secular authority. The standing orders of the House of Lords for 1628 contain the statement that "bishops are only lords of Parliament, but not peers."

The reign of Henry VIII brought about far-reaching changes in the position of the peerage. At Henry's accession the hereditary element was in a decided minority, but the balance was rapidly redressed by new creations, while the dissolution of the monasteries removed from the House of Lords the heads of religious houses. The numbers of the House increased steadily throughout the Tudor and Stuart periods and from the time of William III there were recruited to the Lords a steady stream of men who had served their country well in various capacities, mainly as statesmen, judges, sailors, and soldiers.

Scotland.—The Scottish peerage, like that of England, owes its origin to feudalism. Tenants in chief of the crown owed suit of court, but only the more important were summoned personally. Generally, those so summoned were earls and barons, the "barons" being those tenants in chief who themselves were entitled to hold a court. In 1426, however, legislation of James I resulted in the appointment of "lords of Parliament" who received individual writs and were therefore distinguished from other barons. The lords of Parliament became hereditary, though the title generally passed with the land. During the 15th century other barons still attended Parliament, although it was the intention that they should be represented by commissioners of shires, and this was enforced after 1587.

When the Scottish earls and barons attended Parliament, however, they did not separate themselves from the Commons' representatives, it being the custom for the estates of Scotland to deliberate together. The territorial strength of the nobles inevitably led them to regard the honour as belonging to and inseparable from their land, and until comparatively late in Scottish history there is no record of the conferment of a personal dignity unattached to land such as that conferred in England on John Beauchamp by Richard II. This explains the frequent surrenders and altered grants which are so common in Scottish peerage and history and which, in sharp distinction to the English rule of law, are there regarded as perfectly legal.

Ireland.—The Anglo-Normans who conquered Ireland in the 12th century carried with them the laws and the system of tenure to which they were accustomed in England. Consequently the growth of the Anglo-Irish baronage and the development of Parliament in Ireland proceeded in much the same way as in England. But the Irish Parliament was rarely attended by Irish chiefs; and although intermarriage occurred, the Irish peers in Parliament were almost always representative only of the conquerors. After the Reformation had been forced upon Ireland, the abbots disappeared. The bishops became Anglican and from the 17th century onward the Irish peerage was swamped by numbers of English Protestant creations. Early in the 18th century penal laws debarred Catholics from Parliament, thus dividing the peerage. The Irish Lords, moreover, had no tradition of privilege such as that developed among their English fellows; Irish nobles could not claim trial by their peers.

The United Kingdom.—The acts of union with Scotland (1707) and with Ireland (1800) respectively abolished the Parliaments of these countries, providing instead for their representation in the Parliament, first of Great Britain, and then of the United Kingdom. But whereas before the union the lords of Parliament in Scotland and all the peers in Ireland had a right to attend their Parliament, after the union only a certain number went to Westminster. The Scottish act gave to the Scottish peers the right to elect 16 of their number to represent them in the House of Lords. Further creations in the Scottish peerage were no longer to be made. The effect of the act was to leave most of the Scottish peers outside the House of Lords. By the Irish Act of Union 28 Irish peers were to be elected for life by the other peers, to represent them at Westminster. One archbishop and three bishops were also chosen to represent the Protestant Church of Ireland, but when that church was disestablished in 1869, the spiritual lords lost their seats.

The merger of the three kingdoms had an important effect on their peerages. The English peer (and, as the Acts of Union were passed, the peer of Great Britain and the peer of the United Kingdom) continued by hereditary right a lord of Parliament. But the Scottish and Irish peers were henceforth lords of Parliament only when elected by their fellow peers. They retained every other privilege of the peerage, however, and the 1963 Peerage Act admitted all peers of Scotland (no longer just the 16 elected) to be members of the House of Lords.

The establishment in 1922 of the Irish Free State, which became the Republic of Ireland in 1949, indirectly but vitally affected the status of the Irish peerage. This peerage belonged to the old united Ireland and could not arbitrarily be divided between its two halves. The Irish Free State Constitution Act of 1922, together with various other acts dependent thereon, destroyed the procedure by which Irish representative peers were elected; whether intentionally or by accident is not known. Existing representative peers, having been elected for life, remained in the House of Lords until their deaths, but no vacancies could be filled. The Irish peerage thus disappeared from Parliament after the death of the last representative peer in 1961. The peerage itself, like that of Scotland, will also slowly diminish as existing peerages become extinct, and no new Irish creations are made.

THE PEERAGE IN THE MID-20TH CENTURY

The modern meaning of the term "peerage" can now be more clearly defined. It will be noted that there have always been separate peerages of England, Ireland, and Scotland. After the union of England with Scotland new creations became of the peerage of Great Britain, and after the union of Great Britain with Ireland, of the United Kingdom of Great Britain and Ireland. After 1922 it was correct to speak of "the United Kingdom of Great Britain and Northern Ireland." Many members of the House of Lords hold peerages in several of these groups, but they use publicly only the title which is first in point of precedence. Every peerage descends according to the limitations prescribed in its patent of creation or its charter, and, where these are nonexistent (as in the case of baronies by writ), to heirs general (*see* ABEYANCE).

There is no limit on the crown as to the number of United Kingdom peerages which may be created. Since party government became the rule, new peerages have usually been created on the recommendation of the prime minister of the day, though the crown, especially in considering the claims of royal blood, is believed in some instances to take its own course. By far the greater number of peerage honours granted since the beginning of the 18th century have been rewards for political services. Until the Parliament Acts of 1911 and 1949 reduced the power of the House of Lords, the threat of mass creations was the only way to force the Lords to pass certain bills. This was done in the case of the 1832 Reform Bill and for the passage of the Parliament Act of 1911.

The House of Lords in the 1960s consists of about 900 lords spiritual and temporal. The former are the archbishops of Canterbury and York, the bishops of London, Durham, and Winchester, and the 21 senior bishops from the other dioceses. The temporal peers are the peers of England, of Scotland, of Great Britain, and of the United Kingdom, peeresses in their own right (since 1963), the 9 lords of appeal in ordinary (who are life peers), and (since 1958) life peers and life peeresses.

Life Peers.—Life peers were sometimes created during the later Middle Ages, but such grants were usually in the form of further honours given to persons already members of the peerage. The creations of Robert de Vere, earl of Oxford, as marquess of Dublin and duke of Ireland were for life only. But such creations were infrequent and the attempt made in 1856 (the Wensleydale Peerage Case) to create one of the judges a life peer was rejected by the House of Lords. But in 1876 legislation was passed creating two lords of appeal (with power to appoint two more) with a right

to sit and vote during their tenure of office only. In 1887 further legislation conferred life peerages on all lords of appeal and former lords of appeal. The number of lords of appeal in ordinary who may hold office at any time is now fixed at between 8 and 11. The Life Peerages Act of 1958 permitted the creation of life peerages for men and for women, carrying the right to sit and vote in the House of Lords. Although by this act women were allowed to sit in the Lords, the bar against peeresses in their own right remained until the Peerage Act of 1963. In the mid-1960s an average of about nine life peerages were created each year.

Privileges of the Peerage.—Many privileges once keenly asserted have now fallen out of use or been forgotten. The most important privilege now remaining is a seat in the House of Lords. Lords of Parliament have freedom of speech in Parliament. Peers also have a right of personal access to the sovereign and are exempt from jury service. Until the Criminal Justice Act of 1948, in cases of treason and felony, they had the right of being tried by their peers only. The last trial of a peer by his fellow peers was that of Lord de Clifford in 1935. As late as 1962, however, a peer successfully claimed his privilege of immunity from attachment, *i.e.*, arrest in a civil case.

Termination of Peerages.—Peerages can be terminated by surrender or by attainder and corruption of blood. The application of the doctrine of corruption of blood to peerages arises out of their close connection with the tenure of land. Conviction of any kind of felony—and treason originally was a form of felony—was always followed by attainder (*q.v.*). This resulted in the immediate corruption of the blood of the offender; its capacity for inheritance was lost forever and could only be restored by act of Parliament. This stringent rule of forfeiture was to some extent mitigated by the promulgation in 1285 of the statute *De Donis Conditionalibus* (*see* ENTAIL), making possible the creation of estates tail, and when a tenant in tail was attainted, forfeiture extended only to his life interest. The statute was soon applied by judges to such dignities as were entailed (*i.e.*, dignities conferred by patent with limitations in tail), but it never affected baronies by writ which were not estates in tail but in the nature of estates in fee simple descending to heirs general. An act of 1534 brought estates tail within the law of forfeiture, but for high treason only. The position then became that peerages of any kind were forfeitable by attainder following high treason, while baronies by writ remained, as before, forfeitable for attainder following on felony. An act of 1708 determined that, on the death of James Edward, the Old Pretender, and three years after Queen Anne's death, the effects of corruption of blood consequent on attainder for high treason were to be abolished and the offender alone punished (7 Anne, cap. 21, sec. 10). Because of the 1745 rebellion the operation of this act was postponed until the decease not only of the Pretender but also of all his sons (17 Geo. II, cap. 39, sec. 3). In 1814 forfeiture for every crime other than high and petty treason and murder was restricted to the lifetime of the offender (54 Geo. III, cap. 145). Finally, in 1870, forfeiture, except upon outlawry, was altogether abolished, and it was provided that "no . . . judgment of or for any treason or felony . . . shall cause any attainder or corruption of blood, or any forfeiture or escheat . . ." (33 and 34 Vict., cap. 23).

In many cases, from the 15th to the 18th century, special parliamentary acts of attainder and forfeiture were passed and these operated apart from the general law. In any case, attainder and forfeiture of a dignity, whether resulting from the rules of common law or from special or general acts of Parliament, can be reversed only by act of Parliament.

From the doctrine of nobility of blood is derived the rule of law that no peerage (apart from a Scots peerage, Scots law admitting surrender) can be surrendered or extinguished unless the blood be corrupted. Nevertheless, in medieval times many surrenders were made. By a decision (1906) of the Committee for Privileges, any heirs of line of those who thus got rid of their peerages have, if their pedigrees be provable and no attainders bar the way, a fair chance of reviving the titles. By the Peerage Act of 1963 existing peers were allowed to surrender their peerage for life only, provided they did this within six months of the passage of the act. Persons succeeding to a peerage were to be allowed one year in which to make the decision. Peerages which are thus surrendered remain dormant until the decision of the next heir whether or not also to surrender.

Claims to Peerages.—Claims to peerages are of two kinds, of right and of grace. In theory the crown, as the fountain of honour, might settle any claim without reference to the House of Lords and issue a writ of summons to its petitioner. This would not in any way prevent the House of Lords from examining the patent and writ of summons when the petitioner or his heir came to take his seat. If of the opinion that the patent was illegal, the House might refuse admission, as it did in the Wensleydale Case. In the case of a petitioner who has persuaded the crown to terminate in his favour as a coheir the abeyance of an ancient barony, and who has received a writ of summons, the matter is more difficult. The House cannot refuse to admit any person properly summoned by the crown, as the prerogative of creation is unlimited in point of numbers; but it can take into account the precedence of the newcomer. The crown, therefore, rarely terminates an abeyance without referring the matter to the House of Lords and invariably refers to it all claims which are disputed or involve any question of law.

The Committee for Privileges, which for peerage claims is usually constituted of three or more of the law lords and any other lords interested in peerage history, sits as an ordinary court of justice and follows the usual rules of law and evidence. The attorney general attends as adviser to the committee and to watch the interests of the crown. According to the nature of the case, the committee reports to the House, and the House to the crown, that the petitioner (if successful) has made out his claim and is entitled to a writ of summons, or has proved his coheirship to an existing peerage and has also proved the descent of all coheirs that can reasonably be traced. In the first case the writ of summons is issued forthwith; but the second, being one of abeyance, is a matter for the pleasure of the crown which need not be exercised at all, but, if exercised, may terminate the abeyance in favour of any one of the coheirs. In 1926 the House of Lords appointed a select committee to examine the history of abeyant peerages and to report on the advisability of limiting future claims. After debate on the report, the House resolved (1927) that such claims ought not to be considered where the abeyance had existed for longer than a century, and where the claimants possessed only a small fraction of the original heirship. The resolution was duly reported to the crown and although such recommendations cannot in law affect the crown's prerogative to terminate any abeyance, they would have some weight.

In addition to those peerages which have fallen into abeyance between coheirs, there are dormant peerages which are in a state of suspense. Such titles have not become extinct, but no person has been able to prove succession. The expression, therefore, should be taken to indicate that the title is one to which it is thought that an heir exists, but his whereabouts is unknown; or that there are persons living who are undoubtedly in the line of succession, but through lack of evidence cannot prove the extinction of senior lines; or that the claim of some individual has not been accepted because proof of his legitimate descent has not been produced.

Precedence.—Dukes come first in the order of precedence among peers, followed by marquesses, earls, viscounts, and barons. In each order seniority is determined by the original date of creation. The premier duke of England is the duke of Norfolk (created 1483), of Ireland the duke of Leinster (1766), and of Scotland the duke of Hamilton (1643). The premier marquess of England is the marquess of Winchester (1551), and of Scotland the marquess of Huntly (1599). The earl of Shrewsbury (1442) and of Waterford (1446) is the premier earl of both England and Ireland; the premier earl of Scotland is the earl of Mar (1404). The premier viscount of England is Viscount Hereford (1550), and of Ireland Viscount Gormanston (1478). The premier barony of England (now held by a woman) is de Ros (1264); the premier baron of Ireland is Baron Kingsale (*c.* 1340), and of Scotland Baron Forbes (1424).

The children of peers are commoners. The eldest son of a peer of the rank of earl (and above) is usually known socially by the name of his father's next peerage, but the courtesy nature of such title is clearly indicated on every public or legal document, the phraseology employed being (*e.g.*) "John Smith, Esq., commonly known as Viscount Blackacre." Several cases are on record in which peers' eldest sons have actually borne courtesy titles not possessed as peerage honours by their fathers, but inasmuch as such are only accorded by courtesy, no question of peerage privilege arises. The younger sons of dukes and marquesses by custom use the prefix "lord" before one of their Christian names, and all the daughters of earls as well as of dukes and marquesses are entitled similarly to style themselves "lady," on the principle that all the daughters are equal in rank and in precedence. The younger sons of earls and all the children of viscounts and barons, including lords of appeal and life barons and baronesses, use the prefix "honourable" before one of their Christian names, but this style is one of written address and reference only. Usually, when the direct heir of a peer dies, his children are given by the crown, on the death of the peer, the courtesy titles and precedence they would have enjoyed had their father actually succeeded to the peerage. (C. F. J. H.)

FRANCE

The Peerage of the Old Monarchy.—The peerage of France does not become clearly defined as an institution till the 14th century, and its origins are still problematic.

In feudal society, one of the meanings borne by the word *pares* (Fr. *pairs*) was that of vassals of the same lord (*see* FEUDALISM). It could thus be applied to all those immediate vassals of the king who might attend his court of government, the *curia regis*, to assist him there, *inter alia*, in his function as supreme administrator of justice and so to take cognizance of cases concerning any one of their number. It is in this sense that the word must be understood where it occurs in the letter of *c.* 1022–23 addressed by Eudes II, count of Blois and of Chartres, to King Robert II (this letter was most probably composed by the bishop of Chartres, Fulbert).

At the same time the word *pares* was likewise used to denote those vassals of the counts of Flanders, of Hainaut, and of Champagne who particularly assisted the counts or their chatelains in dispensing justice; and here these *pares* are most often found to be 12 in number. This number is best regarded as preserving a tradition from the Carolingian period, when counts had 12 *scabini* (local magistrates) to assist them; and in fact this tradition survived in another form in the *échevinage* (*see* COMMUNE [MEDIEVAL]) in some of the towns of the same area.

Such was the way in which the word *pares* was being used by the beginning of the 12th century, that is to say at the time of the composition of the *Chanson de Roland*, which is the earliest text to refer to "the 12 peers" of the Frankish kingdom, meaning the principal companions of Charlemagne. In documents of the same period, however, the expression *majores pares* ("greater peers"), combining the notion of superiority with that of equality, is applied to the principal vassals of the king. Yet there is no mention of peers of France in the earliest extant account of a French king's *sacre* or coronation, namely Philip I's (1059); and the role eventually assigned to the peers at coronations was a later development, representing moreover their duty of homage, not any privilege. This role was not defined till the coronation of Philip V (1317).

It was during the 13th century that the peerage began to take shape as an institution, albeit within narrow limits. The old story that Philip II Augustus took a formal verdict from a judicially constituted "court of peers" before he deprived the English king John of his French fiefs in 1202 is now quite discredited (Philip merely consulted his barons before starting war against John); and there is no substance in the story of a trial of John by a similar court for the murder of Arthur of Brittany in 1203. The first authentic mention of the peers of France dates from July 1216, when on the occasion of the lawsuit between Blanche, countess of Champagne, and Erard of Brienne, the title "peers of our realm" is used to describe the archbishop of Reims, the bishops of Langres, Châlons, Beauvais, and Noyon, and the duke of Burgundy.

It is not till 1275 that there is any official listing of the 12 peers of France, when an ordinance of Philip III on mortmain dues exempts (1) the six ecclesiastical peers, the archbishop-duke of Reims, the bishops-dukes of Laon and Langres, and the bishops-counts of Beauvais, Châlons, and Noyon; and (2) the six lay peers, the dukes of Aquitaine, Burgundy, and Normandy and the counts of Champagne, Flanders, and Toulouse. This list, however, merely echoes an enumeration made in the middle of Louis IX's reign by the chronicler Matthew Paris without any known authority from the king, obviously in an attempt to establish a symmetrical correspondence between peerages and titles. By 1275 the list was already out of date, since both Normandy and Toulouse had been reunited to the French crown. When Philip IV in 1297 recognized the duke of Brittany and the counts of Anjou and Artois as peers it is not at all likely that he was concerned about restoring a fixed total of 12 peerages (though the old list was by that time even more remote from reality, in view of the contumacy of the king's vassals in Aquitaine and in Flanders).

It is certain that some of the major vassals of the kingdom sought to assert a right to be tried only by a court composed of their equals exclusively; but successive kings steadfastly refused to allow this privilege. Philip V did however admit, during the trial of Robert III of Artois (1316), that "to take cognizance . . . of the cases of peers of France, the court of *parlement* should be reinforced by peers of France" (*paribus Francie munita*); and thereafter *"la cour garnie de pairs"* was the only formula acknowledged (*see* PARLEMENT).

Peerage was thereafter an honorific distinction only, without political significance; and from 1327 the kings bestowed this supreme dignity without any regard to limiting the number of peers, so that creations, extinctions, and revivals intermingle chronologically. At first peerage was bestowed only on princes of the Capetian blood royal, but later it was extended to foreign princes who held fiefs in France and finally to lesser French nobles whom the kings wanted to elevate. There was only one addition, however, to the ecclesiastical peerages, the archbishop-duke of Paris (1674). By the beginning of the 16th century it was usual for new peerages to be associated with duchies (*see* DUKE), though occasionally a peerage might be granted with the revived title of some particularly venerable countship, such as Toulouse. The 16th and the 17th centuries were the most prolific in peerages.

The 19th Century.—The French Revolution abolished the old peerage. The Chamber of Peers, established at the first Restoration by the constitutional charter of 1814 as the upper house of a bicameral legislature, introduced a peerage of a very different sort. Apart from the princes of the blood royal, its members were nominated by the king; their number was theoretically unlimited; their peerages could be either hereditary or for life only, as the king wished; and the majority of the members nominated by Louis XVIII in fact came from the Napoleonic Senate of the Empire. The chamber's deliberations were secret; and it could be empowered by the king to sit as the Court of Peers to try cases of high treason or crimes against state security, as well as charges brought against a peer.

During the Hundred Days a Chamber of Peers was instituted by Napoleon's *Acte additionnel* (1815), with hereditary peerage for its members. The second Restoration brought back the Chamber of Peers of 1814, with the difference that peerage was made hereditary (August 1815). Under the July Monarchy the principle of hereditability was abolished (December 1831). After the revolution of 1848 the Second Republic abolished the Chamber of Peers.

See further BARON; COUNT; DUKE; EARL; MARQUESS; VISCOUNT; ADDRESS, FORMS OF; PROTOCOL AND PRECEDENCE.

(MI. F.)

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PEERSON, MARTIN (*c.* 1572–1650), English composer of vocal and instrumental music, born in Cambridge about 1572. In 1613 he took the bachelor of music degree at Oxford University; it is probable that he was then master of the choristers at St. Paul's Cathedral, London, a post he apparently held until his death in London in December 1650.

Peerson published two volumes of his own works: *Private Musicke* (1620), a collection of airs for voices and instruments; and *Mottects or Grave Chamber Musique* (1630), for voices and instruments and including a figured bass part. His work surviving in manuscript includes sacred vocal music to English and Latin texts; secular vocal music; several pieces for viol consort; and four keyboard pieces in the *Fitzwilliam Virginal Book*.

PEGASUS, the winged horse of Greek mythology, sprung from the blood of Medusa as she was beheaded by Perseus. With Athena's (or Poseidon's) help Bellerophon captured Pegasus drinking at the Corinthian spring Pirene, and rode him in his fight with the Chimera, and while taking vengeance on Stheneboea (alias Anteia; *see* BELLEROPHON). Subsequently Bellerophon attempted to fly with Pegasus to heaven but was unseated and killed, the winged horse becoming a constellation in the sky and the servant of Zeus. Hippocrene, on Mt. Helicon, was the most famous of the springs which rose where Pegasus' hoof had struck the earth. Corinth, whose early coinage regularly bears the device of Pegasus, has numerous points of contact with his story, and was probably the intermediary by which it was transmitted from the Middle East to Greece, in whose art and literature it became a favourite theme. Pegasus' soaring flight was interpreted as an allegory of the soul's immortality in late antiquity; it has been regarded as a symbol of poetic inspiration in modern times. (D. E. W. W.)

PEGASUS (THE WINGED HORSE), in astronomy, a constellation that appears in the south during autumn evenings for observers in the middle northern latitudes. Named for the winged horse of Greek mythology, its conspicuous geometrical figure is the "Great Square of Pegasus," which has at its corners three bright stars of this constellation and one of Andromeda. The vernal equinox, the sun's location when spring begins, is not far south of the square. To locate features of this area, it may be convenient to imagine that the square is the bowl of a large dipper, having as its handle the line formed by three bright stars of Andromeda and a fourth star in Perseus.

PEGMATITE, a name originally given by French mineralogist René Haüy (1743–1822) to masses of granite characterized by coarse crystals of alkali feldspars with regular intergrowths of quartz, giving an appearance suggesting cuneiform characters (graphic granite). Later usage of the term has been much broadened to include almost any wholly crystalline igneous or metamorphic rock that is at least in part very coarse grained, whose major constituents include minerals typically found in ordinary igneous rocks, and in which extreme textural variations, especially in grain size, are characteristic. Giant crystals, with dimensions measured in feet or yards, occur in some pegmatites, but the average grain size of all such rocks is only three or four inches.

Pegmatites are little different from the common igneous rocks in major elements of bulk composition, and they range from acid to basic. Granitic and syenitic types are most abundant. Quartz and alkali feldspars are the essential constituents; the most common varietal and accessory minerals are muscovite, biotite, apatite, garnet, and tourmaline. Many granitic pegmatites contain various minerals that bespeak unusual concentrations of the less abundant elements, *e.g.*, beryllium in beryl, chrysoberyl, phenacite; boron in tourmaline, axinite; fluorine in apatite, micas, topaz, tourmaline; lithium in lepidolite, spodumene, several phosphate minerals; rare alkalies in pollucite, beryl, feldspars, micas; tin in cassiterite; tungsten in wolframite; zirconium in zircon; and tantalum, niobium, uranium, thorium, and rare earths in many oxide and phosphate minerals (*see* GEOCHEMISTRY: *Residual Melts and Solutions*).

Most bodies of pegmatite are tabular, podlike or irregular in form, and range in size from single crystals of feldspar to dikes hundreds of feet thick and nearly a mile long. Many are intimately associated with masses of fine-grained aplite (*q.v.*). They are found in terranes of igneous and metamorphic rocks in all parts of the world, and are most abundant in rocks of relatively great geologic age. Some are segregations within much larger bodies of intrusive igneous rocks, others are distributed satellitically in the rocks that surround such bodies, and still others are not recognizably associated with igneous rocks.

Granitic and syenitic pegmatite deposits are the chief source of commercial feldspar, sheet mica and beryllium, tantalum-niobium, and lithium minerals. They also yield significant quantities of cassiterite, gem minerals, scrap mica, molybdenite, tungsten minerals, rare-earth minerals, zircon, and certain types of kaolin, either directly or as the sources of placer deposits. Economic lode concentrations generally occur in zoned pegmatite bodies; *i.e.*, those within which two or more different rock types are systematically disposed.

Three contrasting mechanisms together account for the origin of most pegmatites: (1) replacement of preexisting nonpegmatitic rocks through the action of various fluids; (2) crystallization of silicate melts derived by partial fusion of preexisting rocks; and (3) crystallization of residual fluids developed during late stages in the consolidation of intrusive magmas. The first process is essentially metamorphic, the others mainly igneous. The presence of water and other volatile substances seems necessary, and probably is common to all three processes; such constituents depress the temperature range of crystallization, participate directly in the formation of many minerals and lower the viscosity of igneous melts, thereby promoting formation of large crystals. Experimental evidence indicates that the presence of a separate vapour phase is necessary for development of the giant crystals found in pegmatites.

Features indicating replacement of one mineral by another are widespread within many bodies of pegmatite. Most are attributable to attack of earlier-formed minerals either by residual liquid, by vapour separated from the liquid, or by liquid condensed from such vapour. The end stages of some pegmatite crystallization are marked by development of well-faced transparent crystals, commonly as linings and partial fillings of cavities. Such occurrences have yielded handsome mineral specimens, as well as apatite, beryl, chrysoberyl, corundum, feldspars, garnets, phenacite, quartz, scapolite, spinels, spodumene, topaz, tourmaline, and zircon of gem quality.

Ore minerals, chiefly sulfides and oxides, are widespread in pegmatites, but rarely are abundant. The origin and behaviour of ore-forming fluids derived from magmas (*see* ORE DEPOSITS) probably are intimately related to the processes responsible for development of pegmatites. For discussion of replacement and other mechanisms referred to above *see* METASOMATISM; MINERALOGY; PETROLOGY. (R. H. J.)

PEGOLOTTI, FRANCESCO BALDUCCI (*fl.* 1315–40), Florentine merchant and writer whose *Pratica* gives an excellent picture of contemporary trade and travel, was a factor in the service of the mercantile house of the Bardi. In this capacity he was at Antwerp from 1315 (or earlier) to 1317; in London in 1317; in Cyprus from 1324 to 1327, and also in 1335, when he obtained from the king of Little Armenia (*i.e.*, medieval Cilicia, etc.) a grant of privileges for Florentine trade. Between 1335 and 1343, he compiled his *Libro di divisamenti di paesi e di misuri di mercatanzie e d'altre cose bisognevoli di sapere a' mercatanti*, commonly known as the *Pratica della mercatura*. Beginning with a sort of glossary of foreign terms then in use for all kinds of taxes or payments on merchandise as well as for "every kind of place where goods might be bought or sold in cities," the *Pratica* next describes some of the chief trade routes of the 14th century, and many of the principal markets then known to Italian merchants; the imports and exports of important commercial regions; the business customs prevalent in those regions; and the comparative value of the leading moneys, weights and measures.

There is only one manuscript of the *Pratica*, in the Riccardian

Library at Florence, and one edition of the text, in volume iii of Gian Francesco Pagnini's *Della Decima e delle altre gravezze imposte dal comune di Firenze* (Lisbon and Lucca—really Florence—1766); Sir Henry Yule, *Cathay and the Way Thither*, ii, 279–308, translated into English the most interesting sections of Pegolotti (Hakluyt Society, 1866).

See also C. R. Beazley, *Dawn of Modern Geography*, vol. iii (1906). (A. M. F.)

PEGU, a town and former capital of Lower Burma, giving its name to a district and a division. The town is situated on a river of the same name, 47 mi. (76 km.) NE of Rangoon by rail. Pop. (1953) 47,378. It is still surrounded by the ruins of its old wall and moat, which formed a quadrilateral, each side a mile and a half long. Its ancient Mon pagoda, the Shwemawdaw, 288 ft. (88 m.) high, was severely damaged by an earthquake in 1930, but its restoration was completed in April 1954. West of the modern town is a colossal reclining figure (Shwethalyaung) of Gautama Buddha, 181 ft. (55 m.) long, and near it the famous Kalyani Sima or "hall of ordination" founded by the Mon king Dammazedi (1472–92), from which spread one of the greatest reform movements in Burmese-Buddhist history. Its story is related in ten stone inscriptions erected by the king close to the Sima.

The most likely date of its foundation as the capital of a Mon kingdom is A.D. 825. The earliest mention of the kingdom was by the Arab geographer Ibn Khurdadhbih shortly before 850; he called it Raman'n'adesa (the *Rmen* or Mon land). Thaton, about 80 mi. (129 km.) SE on the far side of the Sittang estuary, was the Mon capital when the kingdom was conquered by the Burmese of Pagan in 1056. Little is heard of Pegu until after the fall of Pagan to the Mongols in 1287, when the Mons recovered their independence. In 1369 King Binnya U made it his capital, and from then until its capture by the Burmese king Tabinshwehti in 1539 Pegu was famous both for its Buddhist culture and for its extensive commerce. The kings of the Burmese Toungoo dynasty made it their capital from 1539 to 1599 and again from 1613 to 1634 and used it as a base from which to invade Thailand. Of the many Europeans who visited it during that period the Venetian Caesar Frederick (1569) and the Englishman Ralph Fitch (1587–88) described it in detail and stressed its magnificence. When the Burmese capital was moved up to Ava in 1634 Pegu was for a century a mere provincial capital. In 1740, however, a successful revolt made it again the capital of a Mon kingdom, but in 1757 the Burmese king Alaungpaya captured it, destroyed everything except its religious buildings, and wiped out the last vestiges of the Mon independence. In 1852 the British annexed the province of Pegu, and in 1862 the province of British Burma (later Lower Burma) was formed with Sir Arthur Phayre, the historian of Burma, as chief commissioner, the capital being moved from Pegu to Rangoon.

PEGU DISTRICT, formed in 1883, consists of a portion of the forested Pegu Yomas and an alluvial tract between the Pegu Yoma range and the Sittang River. Area, 4,824 sq.mi. (12,494 sq.km.). Pop. (1962 est.) 897,395. Almost the only crop grown is rice, which is exported in large quantities to Rangoon. The district is traversed by the railway, and also crossed by the Pegu-Sittang canal, navigable for 85 mi. (137 km.) with locks.

PEGU DIVISION comprises the districts of Rangoon town, Hanthawaddy, Insein, Tharrawaddy, Pegu, and Prome, lying east of the Irrawaddy. Area 19,423 sq.mi. (50,306 sq.km.); pop. (1962 est.) 4,650,300. (D. G. E. H.)

PÉGUY, CHARLES (1873–1914), French poet and philosopher who was an outstanding member of the brilliant generation of 1890, to which Claudel, Gide, Proust, and Valéry also belonged. His writings were intimately bound up with his personality and his life and work both exemplify the writer deeply involved in the life of his times, and illustrate the French intelligence at grips with the social and spiritual problems of the years before World War I.

Charles Péguy was born at Orléans on Jan. 7, 1873. His parents were poor; his father died young and his mother made a living as a chairmender. He was strictly brought up, both by his schoolmasters, with their stern, secular morality, and by the parish priests from whom he received religious education (*cf.* the autobiographical pages in *Pierre*, 1898, and *L'Argent*, 1913). The legacy from this upbringing was a love of hard work, of the land, of purity, of France (an essential strand in his development was that Orléans was a centre of devotion to Joan of Arc), of the republic, of truth, and a distrust of every manifestation of spiritual oppression and political tyranny. A scholarship to the *lycée* opened his mind to the riches of humanist culture—to the Greek poets and philosophers as well as to Ronsard, Corneille, and Hugo, who were to become his masters in poetic composition.

After military service (1892–93), in 1894 he entered the École Normale Supérieure at Paris, intending to become a teacher of philosophy. This he conceived as his primary vocation and, in spite of appearances to the contrary, he remained faithful to it; his last books were devoted to Descartes and Henri Bergson.

But at this point in his life two crucial events intervened. First, in 1895, he turned, with all the force of a conversion, to Socialism as the sole means by which poverty and destitution in the modern world could be overcome. The social and political outlook of the Catholic Church, as well as acute intellectual difficulties with such doctrines as that of Hell, caused him to abandon religious practice and even, as he then thought, religious faith. It was at this point that, with an enthusiasm religious in its fervour, he wrote his "first" *Jeanne d'Arc* (1897), a dramatic trilogy dedicated to those who desired to labour "for the advancement of a universal socialist republic." This vast work, utterly unsuited to the stage though brimming over with treasures of thought and expression, was an affirmation of principles he was never to deny. He also wrote, at the same period, two theoretical expositions of his Socialism: *De la Cité socialiste* (1897) and *Marcel, premier dialogue de la cité harmonieuse* (1898). In October 1897 he married Charlotte Baudouin; significantly, it was a civil marriage. She brought him a dowry which enabled him to found the Librairie Socialiste, and he gave up his ambition of a university career.

The second event which greatly affected him was the *"Affaire Dreyfus"* (*see* DREYFUS, ALFRED) which became a matter of impassioned public controversy at the beginning of 1898. Péguy threw himself unreservedly into the battle for Dreyfus' innocence and, despite strong opposition from the Socialist leaders, ranged his party on the same side. He explained his position in *Notre Jeunesse* (1910), maintaining that he had engaged himself in the *"immortelle affaire"* as a Socialist, a patriot and a Christian. This book, although not published until long after the controversy, was completely in line with the articles written between 1895 and 1899, and is one of the keys to Péguy's mind. The antagonism of the party leaders, particularly Jules Guesde, brought about a dramatic split, at the end of 1889, between Péguy and the party. When accused of anarchism he replied that he was the servant of truth and claimed the right to witness to truth as he saw it. This was the first appearance in the political and literary history of France of the *"homme libre en face du Parti."* Péguy's first act at this juncture was to found the *Cahiers de la Quinzaine* (vol. i, January 1900) which, though never reaching a wide public, exercised a profound influence on the intellectual life of France for 15 years. All the famous writers of the time contributed to it: Anatole France, Henri Bergson, Jean Jaurès, Romain Rolland, the brothers Tharaud, etc. Péguy himself published in it a large number of polemical articles, which still retain a lively interest; his style has a strength, vivacity, and imaginative and percussive power which transcends contemporary controversy. Péguy and those who supported him fought for truth, justice, and liberty. He attacked imperialism and colonialism, the anti-Catholic persecution known as *"combisme,"* the deceits and compromises of parliamentary socialists and demagogues, the anti-militarists who refused to acknowledge *"maîtresse realité"* (*cf. Notre Patrie*, 1905), and the *"parti intellectuel"* which he accused of seeking a domination both temporal and spiritual (*cf.* the four essays published as *Situations* and *L'Esprit de système*, 1906–08).

During these years he was also developing and deepening his own philosophical thought, in which Bergson's philosophy played a determinant role. He discovered—or rediscovered—a reality at the centre of which was the "natural" mystery of "incarnation." This was the only path by which he could rediscover the profound truth of the Christian religion to which he had never really ceased

to adhere, and which is itself founded on a supernatural Incarnation.

This development in Péguy's thought is illuminated in his later books: *Clio I* (1909, published 1955), *Un Nouveau Théologien* (M. Fernand Laudet) (1911), *Clio II* (1912), and the unfinished *Note conjointe sur M. Descartes et la philosophie cartésienne* (1924). And from 1910 onward the writing of poems accompanied these essays and the constant labour entailed in editing the *Cahiers;* this return to poetry was a return to his first literary vocation, and in these poems he began a new career. They were: *Le Mystère de la charité de Jeanne d'Arc*, a mystical meditation which enlarges upon some of the first scenes in the *Jeanne d'Arc* of 1897; *Le Porche du mystère de la deuxième vertu* (1911); the *Mystère des Saints Innocents* (1912); the *Tapisseries de Sainte-Geneviève et de Notre-Dame* (1912–13) which includes the well-known "La Présentation de la Beauce à N. Dame de Chartres," and, finally, *Eve* (1913), resembling in structure and scope some vast cathedral, in which, in 4,000 alexandrines, Péguy sees the human condition in the perspective of the Christian revelation.

It is impossible to entertain doubts of the authenticity and orthodoxy of Péguy's thought and religious feeling. Yet for personal reasons and chiefly because his wife remained an unbeliever he refused to have his marriage blessed or his children baptized, and this was a great grief to him in his last years. This grief was aggravated by the incomprehension with which Catholics regarded his poems, disconcerted as they were by the novelty of his poetic style—his use of *vers libre* or the *verset* and his idiosyncratic technique of verbal repetition. He also aroused their hostility by his refusal to be annexed by politicians both secular and religious, Charles Maurras and Albert Sorel for example, of the extreme right wing (*cf. Notre Jeunesse* and, more particularly, *Un Nouveau Théologien*). His unequivocal reply to his fellow-Catholics was: "I will never deny a single atom of my past." Thus, little by little, he became imprisoned in solitude, even at the time when he was writing his finest work. This was all the more serious because during the same period he felt constrained to fight, with growing intensity, his adversaries of the left on the question of the German peril; against them, and against Jean Jaurès (*q.v.*) in particular, he wrote the most savage of his pamphlets: *L'Argent suite* (1913).

In the midst of these trials Péguy the man had to suffer a further ordeal, and one of such emotional and spiritual conflict that he touched the frontiers of despair. He loved, and was loved by, a young girl, but he refused to make her either his wife or his mistress. This personal drama, of which the details are unknown, gave a new and quieter accent, like that of the tender light of dawn, to the *Mystère des Saints Innocents* and the *Deuxième Vertu* which celebrate an *"espérance espérée,"* and to the *Ballade du coeur qui a tant battu*, a long sequence of quatrains that remained unpublished until 1942. This personal grief is also reflected in *Clio II* where certain pages, written with wry self-knowledge, evoke the *"secret des hommes de 40 ans,"* but above all it shines through the "Prières dans la Cathédrale" where, at last in full possession of Hope, he sings the ineffable joys of the *"Résidence,"* of Peace restored.

Charles Péguy, serving with the French Army, was killed on Sept. 5, 1914, in the Battle of the Marne.

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PEI-HAI, known as PAKHOI in Cantonese, a fishing port of Kwangtung Province, south China, on the Gulf of Tonkin, 483 km. (300 mi.) WSW of Canton. The port was opened to foreign trade by the Chefoo Convention of 1876, and in the succeeding period a considerable traffic was developed by coolies and transport animals between Pei-hai and the Hsi Chiang Valley of Kwangsi Province. As additional treaty ports were opened at Meng-tzu in 1889 and Wuchow in 1897, more convenient routes became available to the interior and Pei-hai declined. It serves mainly as a fishing and local trade centre. The population in 1953 was estimated at between 50,000 and 100,000. (T. Sd.)

PEINE, a town of West Germany in the *Land* (state) of Lower Saxony (Niedersachsen), Federal Republic of Germany, lies 24 km. (15 mi.) WNW of Brunswick by road. Pop. (1961) 29,836. Peine has few buildings of interest except the new town hall (1959). It is on the main railway and trunk road from Hanover to Berlin, on the Mittelland Canal, and near the Berlin-Ruhr Motorway. Eddesse Airport is nearby. Iron and steel form the chief industry; machinery and boots are made, and there is weaving, brewing, and sugar refining. Founded 1223 by Count Gunzelin of Wolfenbüttel, Peine belonged in turn to the Duchy of Brunswick, the Bishopric of Hildesheim, and the Kingdom of Hanover, passing to Prussia in 1866. (D. Wi.)

PEINE FORTE ET DURE, the term in English law for a torture inflicted on those who, arraigned of felony, refused to plead and stood silent; or who challenged more than 20 prospective jurors, which was deemed a contumacy equivalent to a refusal to plead. (Before he can be tried, a prisoner has to plead "guilty" or "not guilty.") By the Statute of Westminster, 1275, the *peine* was "strong and hard imprisonment," but in 1406 pressing to death by heavy weights was substituted. This was abolished in 1772, when "standing mute" was made equivalent to conviction. By an act of 1827 a plea of "not guilty" was to be entered against any prisoner refusing to plead, and that has remained the rule. *See* TORTURE.

PEIPING: *see* PEKING.

PEIPUS, LAKE (Estonian PEIPSI JÄRV; Russian CHUDSKOYE OZERO), in the U.S.S.R., lies between the Russian Soviet Federated Socialist Republic and the Estonian Soviet Socialist Republic. It is 48 ft. (15 m.) at its deepest, with an average of 25 ft. (7.5 m.), with mostly low, marshy shores; 96 km. (60 mi.) from north to south, and 50 km. (31 mi.) from east to west, excluding the smaller southerly extension of Lake Pskov. It is fed by the Velikaya River from the south, via Lakes Pskov and Teploye, and drains northward through the Narva River into the Gulf of Finland. With extensions its area is approximately 3,600 sq.km. (1,390 sq.mi.), but varies periodically when adjoining lowlands are flooded, highest water being in May or July–August. The north shore has sand dunes, while low cliffs reach the western shore. Water close to the shore usually freezes during December–April, the central surface for a shorter period. In summer, because of its shallowness, the water reaches a high temperature. The lake is suitable for navigation, and about 30 varieties of fish are caught, principally the European smelt. In April 1242 the Russians under Alexander Nevski defeated the Teutonic knights on the ice of Lake Peipus.

(J. P. Co.)

PEIRCE, CHARLES (SANTIAGO) SANDERS (1839–1914), U.S. logician and philosopher who originated American pragmatism and made important contributions in formal logic and in the logical analysis of mathematics. He was born in Cambridge, Mass., on Sept. 10, 1839, the son of the Harvard mathematician Benjamin Peirce (1809–1880), and prior to entering college in 1855 was educated largely by his father. Graduating from Harvard in 1859, he ranked, despite his brilliance, 79th in a class of 91. From 1861 to 1891 he was associated with the U.S. Coast and Geodetic Survey. He lectured at Harvard, Johns Hopkins University (1879–84), and elsewhere, for eight years altogether, but was not a popular teacher. His meticulous insistence upon clarity and precision and his technical vocabulary made his lectures difficult, and his academic career was also doubtlessly hampered by his distinctive, not to say eccentric, personality, and by domestic difficulties—in 1883 he divorced his first wife, from whom he had long been separated, and remarried shortly thereafter. His last years were spent in serious illness and in abject poverty relieved only by aid from such friends as William James—in whose

honour Peirce added "Santiago" (St. James") as his middle name. This was nevertheless a period of tireless writing and rewriting; in fact, some of his best work was done between 1906 and 1909. He died in Milford, Pa., on April 19, 1914.

Peirce's fundamental contributions in logic are summarized in LOGIC, HISTORY OF: *Modern Logic: Peirce.*

Although Kant had introduced the term *pragmatisch* almost a century earlier, Peirce is credited with creating the philosophy of American pragmatism and with first using the term in English in his paper "How to Make Our Ideas Clear" in the *Popular Science Monthly* for January 1878, where he states the pragmatic principle as follows: "Consider what effects, that conceivably might have practical bearings, we conceive the object of our conception to have. Then our conception of these effects is the whole of our conception of the object." Displeased with James's use of the term, in 1905 he invented "pragmaticism" for his own type of philosophy, saying that this word was "ugly enough to be safe" from misuse by the uninitiated. (For Peirce's formulations and his disagreements with James, *see,* further, PRAGMATISM.)

The specialized nature of Peirce's work made it difficult for him to find a publisher, and, except for professional papers, he published during his lifetime only *Photometric Researches* (1878), containing the results of his astronomical research at the Harvard Observatory. *Chance, Love and Logic* (1923) is a collection of his philosophical essays, edited by M. R. Cohen. *The Collected Papers of Charles Sanders Peirce* were edited by Charles Hartshorne and Paul Weiss (vol. 1–6, 1931–35), and Arthur W. Burks (vol. 7 and 8, 1958). (P. A. Sc.)

PEIRESC, NICOLAS CLAUDE FABRI DE (1580–1637), French antiquary, influential patron of learning, and discoverer of the Orion nebula (*q.v.*), was born at Beaugentier, Provence, on Dec. 1, 1580. Travels in Italy (1599–1602), studies at Padua, and acquaintance there with Galileo stimulated Peiresc's antiquarian interests. Returning to Aix, he took his legal degree (1604) and the next year became a senator in the Aix *parlement.* He was appointed lay abbot of the monastery of Guîtres in 1618. No published works by Peiresc are known, so that his name has tended to lapse into undeserved obscurity. Only records of his correspondence with such men as Peter Paul Rubens, and associations with British and French scholars indicate the catholicity of his interests. Peiresc was largely responsible for the publication of John Barclay's *Argenis* (1621) and he also encouraged Hugo Grotius' legal studies. One of the first to emphasize numismatics in historical research, an epigraphist, and collector of antiquities, Peiresc was first to verify William Harvey's discovery of the circulation of the blood and his work on optics was utilized by Sir Isaac Newton. He introduced into France such plants as ginger, jasmine, and the tulip. Peiresc died at Aix on June 24, 1637.

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(J. M. Wi.)

PEITHO, in Greek mythology, a goddess who is essentially a personification of the act of persuading (the name means "persuasion"). In literature she is often mentioned only figuratively, though as early as Hesiod she is curiously described as the daughter of Ocean. In both art and poetry she is introduced as an attendant on Aphrodite. She received worship at Athens, where her priestess had a seat in the theatre of Dionysus.

See Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft,* vol. 19, col. 194–217 (1937).
(H. W. Pa.)

PEKALONGAN, capital of the *kabupaten* (regency) of the same name in the province of Central Java, Indonesia, is situated on the northern coastal plain, 338 km. (210 mi.) ESE of Jakarta. Pop. (1961 census) 102,380, of whom many are Chinese or Arabs. There is a fort built in 1753, and a small harbour is used by coastal and fishing vessels. Pekalongan is the main trading and distributing centre for the area. It exports sugar, which is refined in the town, but by the mid-1960s the sugar industry had still not fully recovered from the devastation caused by fighting during and after World War II. Textiles form an important cottage industry and the town is one of the main centres of the batik industry (*see* TEXTILES: *Printed Textiles*), producing distinctive designs. The town lies on the main coastal road and railway linking Tjirebon and Semarang.

Pekalongan regency (pop. [1961] 851,224) has an area of 2,176 sq.mi. It was granted to the Dutch in 1746 by the Sultan of Surakarta. Bordering the Java Sea in the north, it includes the Kembang and Slamet mountains and part of the Dijeng Plateau in the south. The chief rivers are the Tjomal and the Pemali, flowing north. The river valleys and the coastal plain are very fertile, growing sugar, rice, kapok, cinchona trees, indigo, and maize (corn). Besides the capital, the chief towns are Tegal, Pemalang, and Tjomal, and Batang (Pa-an) is a fishing centre.

PEKIN, the seat of Tazewell County, Illinois, U.S., is an important port on the Illinois River, 10 mi. below Peoria in the central part of the state. A shipping centre for grain, cattle, and coal, Pekin is served by several railroads and is on the Lakes-to-Gulf Waterway. Its manufactures include corn products, alcohol, liquor, malt, steel tanks, barrels, burial vaults, and copper, brass, iron, and aluminum castings.

The first settler was Jacob Tharp in 1824; the town was laid out in 1829 and in 1830 was named Pekin, the "new Celestial City," by Mrs. Nathan Cromwell, wife of a founder. The dragon and other Chinese symbols are still used. An outpost for Indian warfare, its first schoolhouse (Snell School) was fortified during the Black Hawk War as Fort Doolittle. Incorporated as a city in 1849, Pekin for many years remained a rough river port, characterized by much violence. Abraham Lincoln argued cases in its old courthouse. Early settlers were Anglo-Americans from Virginia, Kentucky, and Tennessee and also from the northeast. German immigration began in the 1840s and grew after the Civil War; until World War I the German language was used in schools, churches and in business. Italians and Irish also settled there.

Good hunting and fishing in the vicinity make Pekin a favourite spot for sportsmen. Its large Mineral Springs Park has excellent swimming and other recreation facilities. Pekin's older streets are named Ann Eliza, Cynthiana, Henrietta, Matilda, etc., for friends of Mrs. Cromwell. For comparative population figures *see* table in ILLINOIS: *Population.* (M. Ws.)

PEKING (PEIPING), the capital of China, situated in Hopeh province. The name Peiping, which means "northern peace," was used in the Nationalist period, 1928–1949, while the nation's capital was at Nanking ("southern capital"). The name Peking (Peiching) meaning "northern capital," was used while the city was the capital of China, from 1421 to 1928, and again under the Communist regime after 1949. Peking is situated in lat. 39° 54′ N. and long. 116° 28′ E. at the northern apex of the alluvial north China plain. Its area is the point of convergence of routes from Manchuria via Shan-hai-kuan (the "gate between mountains and the sea"), and the easiest routes from the Mongolian plateau via the valley of the Yung-ting Ho and Nankow pass.

Only 35 mi. northeast of the city at its nearest point, the Great Wall of China, following the crests of the scarpland belt at an elevation of 4,000 ft., marks the historic frontier defense of the agricultural plain against the pastoral nomads of the interior plateaus. The narrow apex of the plain is thus the crucial region in the relations of China, Mongolia and Manchuria, and is historically the border zone between two strongly contrasted types of social organization.

History.—The earliest city of which there is authentic record was that of Ch'i, the capital of Yen, the most northerly of the feudal states which acknowledged the authority of the Chou dynasty in the twelfth century B.C. Thus early was the site of Peking within the Chinese culture area, but Yen was clearly a buffer state, intended to keep back the Tatar hordes, and is significantly mentioned in records of the 6th century B.C. as possessing great numbers of horses. Ch'ien Lung, the famous scholar-emperor of the Manchu dynasty, made extensive researches into the exact site of Ch'i and located it slightly to the north of the present city.

The city was destroyed by Shih Huang Ti, the "First Emperor" and founder of the Ch'in dynasty (221 B.C.), who unified China and completed the frontier defenses of the Great Wall. Yen was one of the districts which made up his empire. Under the Han dynasty a new city arose close to the site of Ch'i and was known first as Yen and later as Yu-chow. It remained a definitely Chinese city until the end of the Han dynasty, but in the ensuing period of anarchy and disintegration was for two centuries under Tatar control. The T'ang dynasty (7th to 10th centuries), like the Han, maintained the frontier defenses of the empire intact, and Yu-chow was the headquarters of a military governor. But early in the 10th century it came into the hands of the K'itans, one of the most famous of the Tatar groups prior to the rise of the Mongols, who successfully resisted the attempts of the Sung emperors to recover it for China. The K'itans under the Liao dynasty (sometimes called the Iron dynasty) rechristened the city Nanching, signifying southern capital, and later (986) rebuilt it on imperial lines with walls said to have been 13 miles in length and 30 feet high.

From early in the 11th century it was known as Yenching but the K'itans of the Iron dynasty continued to hold it until 1122 when it was captured by the chief of the Tatars of the Golden Horde from the northern steppes of Manchuria, who greatly enlarged and beautified it and made it one of the three capitals of his large empire, that of the Kin or Chin (Gold) dynasty. The other two capitals were Pien-ching (now Kai-feng) in Honan and Shen-yang (Mukden) in the north, so the future Peking was known at this period as Chung-tu or the "middle capital." This phase lasted until early in the 13th century when the greatest of all the steppeland powers arose, the Mongol empire.

The City Under Kublai Khan.—Kublai Khan took the decisive step of making it the metropolitan city of the immense Mongol empire, which now stretched from the Pacific to beyond the Black sea. But although this was the technical status of the city after Kublai had moved his headquarters there from Karakorum in 1267, it was as the new capital of China that the choice was of the greatest ultimate significance. Kublai was indeed the "Great Khan who ruled in China" but his descendants were primarily emperors of China.

Under Kublai the city was once again rebuilt and on a more magnificent scale than ever before. It was named Khanbaliq, "city of the Khan," but the Chinese knew it as Ta-tu, "great capital." Through the reports of Marco Polo, who visited China at that time, Khanbaliq became known in medieval Europe as Cambaluc. This was often, as by Longfellow, inaccurately spelled Cambalu. Marco Polo described the magnificence of the capital in glowing terms. Cambaluc was laid out on a rectangular plan and had a circuit of 24 mi. Its walls, 50 ft. high and on top 15 ft. thick, were each pierced by three gates, the roadways connecting them running straight across the city.

Marco Polo was followed by the Pope's envoy, Giovanni di Monte Corvino, who was well received by Kublai and made archbishop of Khanbaliq in 1307.

The Ming and Manchu Dynasties.—Later under the Ming and early Manchu dynasties the Jesuits were in favour at the capital, and were encouraged to practise western mathematics and astronomy. The communications of Khanbaliq with the rest of China were actively developed by the construction of radial roads on which well-organized courier services were maintained, and by extending the Grand Canal from the Yellow river to Tientsin and connecting it by the Pai Ho and a small canal, the capital was brought into direct water-communication with the lower Yangtze valley.

Khanbaliq continued to be the capital of China throughout the Yuan dynasty but the city temporarily lost its imperial status when in 1368 Chu Yuan-chang (Hung Wu) headed the successful revolt against the Mongols and established the native Ming dynasty. After being under the control of foreign steppeland powers for about 450 years the region was once again under direct Chinese rule and Khanbaliq, now known as Peiping, served, as in the days of the Han and T'ang dynasties, the function of a border garrison town, subordinate to the capital city of Nanking. This phase lasted until 1421, when the third Ming emperor, Yung Lo, transferred his court to the north and Peiping was given the name of Peking.

The reason for this decisive step was undoubtedly strategic, for the Mongols were still troublesome and the Manchurian tribes were becoming increasingly strong and restless. Peking was the only frontier capital which could guard both the vulnerable flanks. The menace from the north, increased by internal revolts, culminated in the Manchu conquest of 1644 and China once again came under Tatar domination. The new Manchu (or Ch'ing) dynasty transferred their court from Mukden to Peking and administered their newly won empire from a capital which, while it lay within the Chinese culture area, was in close contact with their own recruiting ground.

The Modern Period.—Two and a half centuries later the rule of the decadent Manchus was ended by the revolution of 1911 and the imperial office was abolished. Peking continued to function as the capital of the new republic. But the disintegrating effects of the civil war and the rise of the nationalist movement, focused in the south, meant that the rule of the Peking government was increasingly ineffective and nominal. The final northward advance of the nationalist armies in the spring of 1928 was quickly followed by the proclamation of Nanking as the capital of the new China and by autumn 1928 the northern city had lost its metropolitan status and was known once more as Peiping, the name which it bore under the early Ming emperors. So, too, the province, in the centre of which it lies, reverted to the ancient name of Hopeh ("north of the river," *i.e.*, the Yellow river) in place of Chihli ("direct rule").

After the Tangku truce of 1933 which ended the Manchurian invasion, the Japanese endeavoured to separate Peiping and north China from the rest of China. The Chinese government was forced to approve the establishment in Peiping of a Hopeh-Chahar politi-

EASTFOTO

THE NATIONAL PALACE OF CULTURE IN PEKING, COMPLETED 1959, COMBINES MODERN ARCHITECTURAL TECHNIQUE WITH TRADITIONAL CHINESE STYLING

EASTFOTO

CHUAN-LUN-TSANG, ONE OF THE BUILDINGS IN THE MANCHU EMPERORS' SUMMER PALACE, PEKING

cal council under the chairmanship of Gen. Sung Chih-yuan, commander of the 29th army. By the Ho-Umetsu agreement of 1935 all Chinese troops and Kuomintang organizations were excluded from north China. In spite of strong Japanese pressure, Sung remained loyal to the Chinese government. On July 7, 1937, the Japanese during maneuvers attacked the Marco Polo bridge (Lu-kou-ch'iao) across the Yung-ting Ho southwest of Peiping to sever the last railroad link with the rest of China. The Chinese garrison resisted and thus began the war with Japan which merged in 1941 with World War II. The city was taken by the Japanese in July 1937 and remained occupied until the end of World War II in 1945, when it reverted to Nationalist control. In 1949, Peiping fell to the Chinese Communists, who made it once more the capital of China under its historic name of Peking. (*See* also CHINA: *History*.)

Description.—Peking consists essentially of two walled cities, the northern Inner city and the southern Outer city. The Inner city, also known as the Tatar city, lies approximately on the site of Khanbaliq of the Mongol dynasty. It is in the form of a square with walls nearly 15 mi. in length.

The Outer city, also known as the Chinese city, was added during the reign of the emperor Chia Ching (1522–66) of the Ming dynasty. It is in the form of an oblong adjoining the Inner city, with walls 14 mi. in length, including 4 mi. of the southern wall of the Inner city.

Within the Inner city was the Imperial city, also in the form of a square and with red-plastered walls six and one-half miles in length, of which only the southern wall and a part of the western wall remain. And within the Imperial city was the moated Forbidden city, with walls two and one-quarter miles long, plastered with a violet-coloured mortar, whence comes the popular name of the Purple city. The Forbidden city contained the Imperial palaces, which have been converted into a museum. The palaces, symmetrically arranged, consist of outer throne halls, an inner court, and the palace buildings.

The entrance to the Forbidden city is through the Wu Men (Meridian gate). Ancient works of art are found in T'ai-ho-tien (Hall of Supreme Harmony) and Pao-ho-tien (Hall of Preserving Harmony), two of the outer throne halls. Works of art of different dynasties, ranging from the Shang (1600–1100 B.C.) to the Ming, are found in halls on the east side of the inner court. In halls on the west side of the inner court are works of art of the Manchu dynasty.

In side halls on both sides of the courtyard in front of the Wu Men is the historical museum, exhibiting historical objects from primitive times, through the Hsia (2100–1600 B.C.), Shang and Chou dynasties to the Sui (A.D. 581–618) and T'ang dynasties. In the main hall above the Wu Men are objects of China's modern history after the Opium war of 1840.

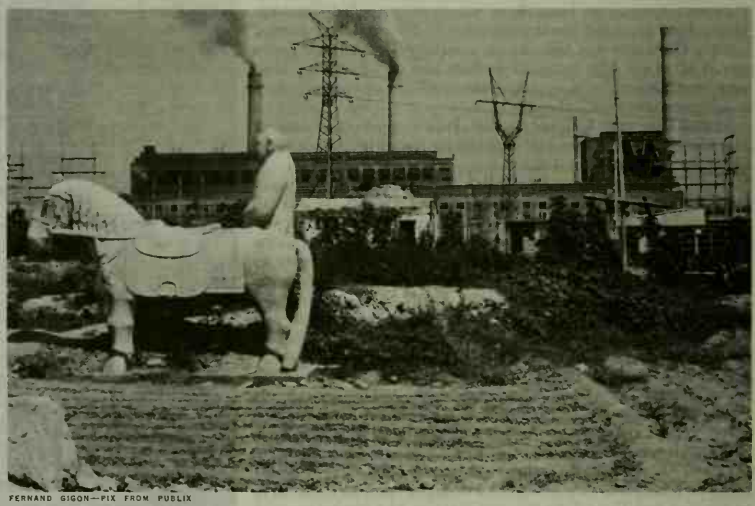
South of the Palace museum, the former imperial roadway separates two parks that have been converted into public recreation areas under the Communist regime. On the west side is Sun Yat-sen park, surrounding the former Altar of Land and Grain, and on the east side is the Working People's Palace of Culture, which was the Imperial Ancestral temple, in which tablets of emperors were displayed and worshiped.

Adjoining the parks on the south is part of the remaining southern wall of the former Imperial city. The wall is pierced by T'ien-an Men (Gate of Heavenly Peace), on which China's Communist leaders gather on ceremonial occasions to review military and civilian parades in the square adjoining the gate.

Adjoining the Forbidden city on the east, in the southeast quadrant of the Inner city, is the old legation quarter, where foreign representatives had their residences. The legation quarter contains many hotels, department stores, theatres and cinemas.

In the northeast quadrant of the Inner city stand some of the most historic buildings of China, including the Lama temple and the simple but beautiful Temple of Confucius. Nearby is the Bell tower, where the curfew was sounded nightly in imperial times.

Extending in an irregular chain from the north wall of the Inner city are six artificial lakes supplied from a moat outside the walls of the city. The shores of Pei Hai (North lake), just



FERNAND GIGON—PIX FROM PUBLIX

MODERN ELECTRICAL PLANT OUTSIDE PEKING. IN CONTRAST IS THE 18TH-CENTURY STATUARY IN THE FOREGROUND, A MONUMENT ERECTED UNDER EMPEROR CH'IEN-LUNG, CH'ING DYNASTY. AT THE BASE OF THE MONUMENT IS A VEGETABLE GARDEN OF THE WORKERS AT THE PLANT

northwest of the Palace museum, have been converted into a park. The National library stands on the southwest shore. Grouped around Chung Hai (Middle lake) and Nan Hai (South lake), just west of the Palace muscum, are the government buildings of the Chinese Communist regime.

The northern part of the Outer city is a busy commercial and shopping area adjoining the city's main railroad terminal at the Ch'ien Men, the main gate connecting the Inner city and the Outer city. In the southern portion are the grounds of the Temple of Heaven and of the Temple of Agriculture.

In modern times, and especially after 1949, Peking has expanded far beyond the two walled cities that constitute its core. Residential suburbs and educational centres have risen to the west and northwest. Extending along a road going northwest to the former Summer palace and its lakes and parks are many of China's important universities: Peking (former Yenching university), Tsinghua university, People's university and many specialized institutions of higher learning, such as the Central Institute of Nationalities, and schools in the fields of iron and steel, geology, aeronautics and other engineering disciplines. Outside the northwestern gate, Hsi-chih Men, are the city's zoo and permanent exhibition grounds.

Industry.—While the city's educational and cultural institutions are being expanded largely in the western and northwestern suburbs, Peking's growing industries are concentrated east of the city. In connection with the city's growth as China's political and cultural centre under the Communist regime, attention was also given to the expansion of industry.

Manufacturing was traditionally restricted to light industry (flour mills, textiles, garments). After 1949, several heavy industrial enterprises were added, including a machine-tool plant, a printing machinery factory and a synthetic fibres mill. An auto parts factory was expanded into a small automobile plant, and a farm-machine factory was converted into a tractor plant. Other industrial suburbs, southwest of the city, include Feng-t'ai, with railroad marshalling yards, bridge-construction, concrete railroad ties and asbestos-pipe factories, and Ch'ang-hsin-tien, with locomotive and rolling-stock shops.

The iron and steel plant of Shih-ching-shan is situated on the Yung-ting Ho, 14 mi. west of the city centre. This plant, first opened in 1920, was completed in 1937 and produced 80,000 tons of pig iron at its peak under Japanese rule. The plant was greatly expanded by the Communists, and annual production increased to more than five times its previous capacity. Beyond Shih-ching-shan, at the end of a rail spur, 20 mi. west of the city centre, are the coal mines of Men-t'ou-kou.

Peking is a transportation hub with rail connections to Hankow, Canton, Kalgan, Pao-t'ou, Tientsin, Mukden, Tungchow and Ch'eng Te. It is also linked to the Soviet Union via Manchuria and via Outer Mongolia.

Administration.—Under the Nationalist regime, Peking's municipal area covered more than 300 sq.mi. Under the Communists, the city limits were greatly expanded. As a result of annexations in 1953, the municipal district was extended to the Great Wall, 35 mi. from the city centre.

Within this expanded area of 1,750 sq.mi., the 1953 census reported a population of 2,768,149, of whom about 830,000 lived in the walled Inner city, 220,000 in the Outer city, and 1,700,000 in suburbs outside the walls. By the early 1960s, the population of Peking was estimated to be more than 4,000,000 as a result of the in-migration of people attracted by the city's growing importance as the nation's political, educational and economic centre. In March 1958, a second expansion of the municipal area took place, nearly doubling its territory from 1,750 sq.mi. to 3,386 sq.mi. This time Peking absorbed the towns of T'ung-chou (Tungchow) and Shun-yi on the east, Ta-hsing on the southeast, and Fang-shan and Liang-hsiang on the southwest. The new municipal area had an estimated population of 6,800,000, of whom more than 2,000,000 were rural farmers.

Peking is administered directly by the central government, and is outside the jurisdiction of Hopeh province. The municipal district itself is divided into five suburban districts (*hsien*) and eight boroughs (*ch'u*). The latter are Hsi-ch'eng and Tung-ch'eng in the Inner city; Ch'ung-wen and Hsuan-wu in the Outer city; and the suburban *ch'u* of Hai-tien, with the city's educational institutions; Men-t'ou-kou, with the coal mines; Feng-t'ai and Ch'ao-yang.

The *hsien* consist of Ch'ang-p'ing with the Ming tombs north of the city, Fang-shan where the remains of Peking Man were found southwest of the city, Ta-hsing, T'ung and Shun-yi.

See also references under "Peking" in the Index. (T. Sd.)

PELAGIA, SAINT (?–*c.* 311), a 15-year-old Christian girl of Antioch who, probably during Diocletian's persecution, threw herself from a housetop to avoid outrage, and died on the spot. Her feast day is June 9.

The memory of this historical Pelagia helped to give rise to two legends of fictitious Pelagias: namely, Pelagia the Penitent (also called Margarito), a prostitute of Antioch who experienced sudden conversion and lived the rest of her days in a cave at Jerusalem, disguised as a man; and Pelagia of Tarsus, who refused to marry the emperor Diocletian and was punished by being roasted to death. Both are named in some calendars.

The origin of the first of these two legends was the repentance of a notorious Antiochene woman, of whom John Chrysostom speaks without mentioning her name.

Both legends are connected with that of St. Margaret (*q.v.*).

See H. Delehaye, *The Legends of the Saints* (1907). (D. Ar.)

PELAGIUS, the name of two popes.

Pelagius I (d. 561), pope from 556 to 561, was a noble born at Rome, date unknown. Under Popes Agapetus I, Silverius and Vigilius his ecclesiastical roles were highly important. He was elected to succeed Vigilius in 555 and consecrated on April 16, 556. At first opposed to Vigilius' condemnation of the "Three Chapters" (554; *see* Papacy) Pelagius upheld it as pope, winning thereby hostility in the west, especially in northern Italy, where long schism developed. He died on March 4, 561.

Pelagius II (d. 590), pope from 579 to 590, was born at Rome, date unknown, of Gothic descent. During his pontificate, which began on Nov. 26, 579, Lombard barbarians pressed more deeply into Italy. Schism arising out of the "Three Chapters" controversy resisted his conciliatory efforts in northern Italy. Pelagius protested when the bishop of Constantinople assumed the title "ecumenical patriarch." He died on Feb. 7, 590.

(Jn. F. B.)

PELAGIUS (fl. 405–418), proponent of a doctrine, condemned as heresy by the Christian Church, which was thought to minimize the role of divine grace in man's salvation. Pelagianism was a cause of discord in the church for more than a century.

Little is known about the circumstances of Pelagius' early life. He was born in Britain, and attempts to argue that he was of Irish origin and to see his name as a hellenized form of the Irish *Muirchu* ("son of the sea") or the Welsh *Morgan* have no foundation. He was a layman, often styled a monk by his contemporaries, well educated in the Latin classics, and familiar with the Bible, the Latin Fathers, and a certain amount of Greek theology in translation. According to St. Augustine, he long resided at Rome, and the familiarity with legal matters displayed in his writings and his taste for clear-cut definition suggest that he may originally have come there as a law student, abandoning his secular studies after his baptism, perhaps in the last years of the pontificate of Pope Damasus (d. 384). During the next two decades, Pelagius lived at Rome and wrote his most important works, including a treatise on the Trinity, now lost, and his commentary on the Epistles of St. Paul.

In his writings, he attacked the Arians and the Manichaeans, asserting against the former Christ's full divinity and against the latter his full humanity (*see* Arianism; Manichaeism). Pelagius' anti-Manichaean polemic led him to lay stress upon the essential goodness of human nature and the freedom of the human will, and this dogmatic emphasis was intensified by a desire to recall his contemporaries to stricter observance of Christian conduct. His outlook is well illustrated by the famous episode which occurred about 405, when he rebuked a bishop who quoted St. Augustine's famous prayer from the *Confessions:* "Give what thou commandest

and command what thou wilt," which seemed to Pelagius to provide an excuse for indolence and lethargy (*see* Augustine, *De dono perseverantiae*, xx, 53). Clearly, to some persons, such an outburst could imply a denial of the need for grace, but Pelagius' reforming views found much support at Rome. His disciples included Celestius and Julian, the future bishop of Eclanum in southern Italy, and he had many followers among the pious ladies of the Roman aristocracy.

About 409, when the Goths menaced Rome, Pelagius and Celestius removed, first to Sicily and thence to North Africa. After the Conference of Carthage of 411, Pelagius departed to Palestine, leaving Celestius behind. The latter appears to have obtained considerable influence among the Carthaginian Christians, when he was charged with heresy by Paulinus, a deacon of Milan then visiting Africa, and accused of denying that Adam's sin had any effect upon his descendants, so that infants are born in the condition of Adam before the Fall. Celestius was tried before Aurelius, bishop of Carthage, and excommunicated. He considered appealing to Rome, decided otherwise, and left for Ephesus.

Meanwhile Pelagius had arrived at Jerusalem, where he found many friends and one bitter enemy, St. Jerome, then living at Bethlehem. The writings of Pelagius and the propaganda of Celestius were having their effect and making many converts. St. Augustine saw in Pelagius' views a denial of the need for prevenient grace (*i.e.*, grace that is antecedent to every good action) and from 412 onward was constantly writing and preaching against Pelagian doctrines, although he spoke of Pelagius personally with respect (*see* Augustine, Saint, of Hippo). In 415 the Spanish priest Paulus Orosius (*q.v.*) arrived at Bethlehem, bearing letters from Augustine to Jerome. Orosius accused Pelagius of heresy at a diocesan synod held before Bishop John of Jerusalem, but failed to secure Pelagius' condemnation. The matter was referred to a provincial synod, held at Diospolis (Lydda) before Eulogius of Caesarea, the primate of Palestine, on Dec. 20, 415. Here Pelagius gave satisfactory (his enemies thought hypocritical) answers to the charges brought against him and was exonerated. He was, however, subsequently discredited by an assault by his sympathizers on St. Jerome's monastery at Bethlehem and shortly afterward (Jan. 27, 417) was excommunicated by Pope Innocent I. The force behind this excommunication was an appeal from the African episcopate to the pope in the second half of 416 inspired by reports from Orosius of the events in Palestine. Innocent died on March 12, 417, and was succeeded by Pope Zosimus, who showed himself more favourable to the Pelagians than his predecessor had.

Zosimus was visited by Celestius, was impressed by him, and, after receiving a profession of faith from Pelagius, sent a strongly worded letter to the African bishops on Sept. 21, 417, accusing them of having acted precipitately in condemning Pelagius and Celestius. The Africans, however, maintained that the case had already been settled by the judgment of Innocent. Outbreaks of violence by the Pelagian party at Rome stirred the imperial authorities to action, and on April 30, 418, the emperor Honorius issued a rescript condemning Pelagianism and exiling Pelagius (who was assumed to be at Rome) and Celestius from Italy. Next day, May 1, 418, an African council held at Carthage passed a series of nine canons against Pelagianism. Meanwhile Zosimus, who had already begun to entertain doubts about the Pelagian case, now read Pelagius' commentary on Romans. He was shocked by its doctrine and commanded Celestius to appear before him for examination. Celestius ignored the summons and fled from Rome, thereby appearing self-condemned. Zosimus then issued a lengthy document, which survives only in fragments, the *Epistola tractoria*, in which he excommunicated Pelagius and Celestius and condemned their doctrine. Subscription to the *Tractoria* was enforced in Italy by imperial authority, but 18 bishops, including Julian of Eclanum, refused to sign. Julian demanded a general council to discuss the matter, but his appeal was rejected and he was deposed. Pelagius, horrified by his excommunication, now affirmed that grace was necessary, not only for every hour or moment but for each individual action of our lives. His confession was not accepted. He was expelled from Jerusalem and departed, probably for Egypt. His subsequent fate is unknown.

The controversy, however, was far from ended. Julian of Eclanum continued to assert the Pelagian view and engaged Augustine in literary polemic until the latter's death in 430. Julian himself was finally condemned, with Celestius and the rest of the Pelagian party, at the Council of Ephesus in 431. Meanwhile the vehemence with which Augustine defended his own doctrine of original sin and predestination aroused opposition among many Christians who had no sympathy with Pelagius—the so-called Semi-Pelagians of southern Gaul who might better perhaps be called Anti-Augustinians. These included the saintly John Cassian, abbot of Saint-Victor at Marseilles (*see* Cassianus, Johannes), and Euladius, bishop of Arles. Augustinian doctrine was defended in Gaul by St. Prosper (*q.v.*) of Aquitaine, and the dispute, which was very bitter, was not finally settled until nearly a century after St. Augustine's death, at the Council of Orange of 529. (*See* Semi-Pelagianism.)

The theology of Pelagius was not, as the scholar Adolf von Harnack held, basically godless, and its affinities with Stoicism have been exaggerated. Pelagius never crudely affirmed that man could be good without God. His thought was inspired by the Bible, and he stood in a direct line from earlier theological writers, notably Ambrosiaster and Origen, whom he knew from the translation of Rufinus. He never doubted that his system was anything other than Christian orthodoxy. He did not seek publicity and undoubtedly suffered through the excesses of his disciples. The weakness of his position lay precisely in the zeal with which he sought to refute Manichaean determinism and to rebuke the laxity of professing Christians. Pelagius admitted divine grace in man's natural endowments; in the revelation of the Old and New Testaments; and, above all, in the remission of sins in Christian baptism, whose necessity he affirmed for every age and condition of man, while rejecting the Augustinian view of the physical transmission of Adam's sin to his descendants. His great defect lay in an inadequate comprehension of the weakening of human nature resulting from the Fall and of the complexity of the numerous conflicting impulses which constitute the human will. It was here that Augustine, despite some unlovely harshness in his doctrine, had a better understanding of sin and grace than Pelagius.

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PELARGONIUM, a genus of plants belonging to the geranium family (Geraniaceae, *q.v.*) and including most of the cultivated ornamentals known as "geraniums." *See* Geranium.

PELASGIANS, an ancient people of the Aegean, equated by classical Greek ethnological theory with the pre-Hellenic inhabitants generally (*see* Leleges). In the *Iliad* of Homer they are mentioned among Trojan allies (ii, 840–843), standing in the list, which is generally in geographical order, between Thracians and inhabitants of Hellespontine towns. Their "far-off" city of Larisa (*Iliad*, xvii, 301) is therefore probably imagined to be in southeastern Thrace and is not identical with any of the numerous places called Larisa in historic times. In northern Greece they seem already to be remembered as displaced by Achaeans; Achilles' Myrmidons inhabit "Pelasgian Argos" (*Iliad*, ii, 691 ff.; *see* Argos), and Achilles prays to the "Pelasgian Zeus" of northwestern Dodona (*q.v.*; *Iliad*, xvi, 223). In the *Odyssey* (xix, 177) they are mentioned among the many peoples, native and immigrant, of Crete. In classical times Herodotus (i, 57) mentions them as "having occupied Plakia and Skylake" on the Sea of Marmara (towns identified by later geographers on its south coast, east of Cyzicus) and as "holding the city of Kreston, beyond the Tyrsenoi." This is puzzling, since Tyrsenoi (Tyrrhenians) elsewhere in Herodotus means the Etruscans of Italy; but Thucydides (iv, 109, 4) seems to identify the "Krestonians" with the "bilingual barbarians" (speakers of Greek and a native vernacular) of a group of settle-

ments, mostly with Greek names, on the Mt. Athos peninsula. Herodotus adds the important observation that the two groups spoke a common language, which was not Greek. They may well, therefore, have been remnants of a people once more widely spread but in his time elsewhere overlaid by Greeks or Thracians.

The "Pelasgian Theory."—But Herodotus quotes these details in connection with the above-mentioned theory, which identified the Pelasgians with the pre-Hellenic (modern theory would say "pre-Indo-European") population of Greece in general (Herodotus, i, 56). This theory was correct in distinguishing two chief strains in the Greek population, one immigrant, the bringers of the Indo-European Greek language, and the other aboriginal, Mediterranean as we should say, or old Aegean; but Herodotus oversimplifies in identifying the former exclusively with the Dorians (*q.v.*), whose invasion of southern Greece was remembered as an epoch-making event. Greek tradition, its oldest surviving documents being the Homeric epics, preserved no clear memory of the ages before the Trojan War, nor of the earlier migrations which must, it would seem, have brought in the pre-Dorian Greek dialects (*see* GREECE: *Ancient History*). Herodotus, therefore, had difficulties in placing the aboriginal ("autochthonous") Athenians and other speakers of kindred dialects (Ionians; *q.v.*) in terms of his theory, and supposes them to be "Pelasgians" who had learned their Greek from contact with the Hellenes proper. The name Pelasgians thus acquired its later literary use as an equivalent for "aborigines," a usage no more historically justified than that of "Iberians" for early inhabitants of Britain. Neither the usage nor the theory was first invented by Herodotus; the eponymous hero Pelasgus was claimed as their ancestor by the mountaineers of Arcadia, equally "autochthonous" and speaking an archaic Greek dialect, a claim traceable as early as the Ionian epic poet Asius (7th century?), quoted by Pausanias (viii, 1); and Aeschylus in *The Suppliants* (250 ff.) makes Pelasgus a king of primeval Argos, with an empire stretching to the Strymon (thus taking in the Mt. Athos peninsula) and to "the mountains of Dodona."

Whether any ancient people actually called themselves Pelasgians, otherwise than in the terms of this literary convention, is uncertain; it may, like "Phoenicians," have been originally a name bestowed by the Greeks; for the suggested derivation from *pelagos*, "sea," by way of a hypothetical original form *Pelag-skoi*, is thought by philologists to be linguistically possible. And such a north Aegean "sea people" could possibly have been connected with the Tyrrhenians or Etruscans, that element in the population of early historic Etruria which, according to a persistent tradition, had come by sea from the East. Some elements in Etruscan culture do suggest Eastern affinities (*see* ETRUSCANS); and possible connecting links may be found in the archaeology of Lemnos, an island which also had, until the Athenian conquest about 500 B.C., a non-Greek population called by Herodotus (iv, 145; vi, 137) Pelasgians.

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(A. R. BU.)

PELAVICINO (PALLAVICINO), **OBERTO** (1197–1269), Lombard statesman powerful in northern Italy, was born at Polesine, near Cremona, of a feudal family with lands in the territories of Parma, Piacenza, and Cremona. The Holy Roman emperor Frederick II (*q.v.*) appointed him vicar of the Lunigiana and Pontremoli in 1239; vicar-general of the Lunigiana, Versilia, and Garfagnana from 1243 to 1245; *podestà* of Reggio (Nell' Emilia) in 1246; and, after the capture of King Enzio by the Bolognese in 1249, vicar-general "from Pavia downward" (*i.e.*, southward to Tuscany).

Elected *podestà* of Cremona in 1249, Oberto used his local influence after Frederick's death (1250) to build up an extensive dominion in Lombardy. Appointed vicar-general in Lombardy for King Conrad IV (1253), he could by October 1254 style himself "lord for life of Cremona, Piacenza, Pavia, and Vercelli." In 1259, having defeated his former ally Ezzelino (*q.v.*) da Romano, he also acquired Brescia; Milan elected him as its lord for five years.

Milan's defection in 1264 marked the beginning of Oberto's decline; his power collapsed when, after the victory of Charles of Anjou in 1266, the Guelph party prevailed in Lombardy. Oberto died at Pontremoli on May 8, 1269.

See Z. Schiffer, *Markgraf Hubert Pallavicini* (1910). (N. R.)

PELAYO (d. ?737), traditionally recognized as the first of the Asturian kings, ruled from *c.* 718 to *c.* 737. His existence is attested by Arabic as well as Christian chroniclers but, since the earliest accounts of him belong to the late 9th century, his historical personality is overshadowed by legend. As far as can be ascertained he was a page, or possibly a member of the royal bodyguard, of the Visigothic king Roderick, and may have been of royal blood. He survived the defeat (711) of the Visigoths by the Moors at the Battle of Guadalete near Medina Sidonia and reached his native Asturias, where he led a revolt of Asturians and Visigothic refugees against the Moorish governor Munuza. He was captured and sent to Córdoba as a hostage, but escaped (717) and again assumed leadership of the Asturian rebellion. The rebels, though driven into the uplands of the Picos de Europa, were able to survive massive attacks by Moorish armies, especially at the Battle of Monte Auseba, and, eventually, Pelayo—accepted as their ruler—was able to set up a tiny kingdom with its capital at Cangas de Onís. The stories and relics of Pelayo associated with the nearby shrine of Covadonga belong to legend rather than to fact; it was, however, in this legendary guise that he became an important symbol of Christian resistance in medieval Spanish history.

(P. E. R.)

PELECYPODA, a name, synonymous with Lamellibranchia, for the bivalve (*q.v.*) mollusks.

PELEUS, in Greek mythology king of the Myrmidons (*q.v.*) of Phthia in Thessaly, and most famous as the husband of Thetis and father of Achilles, whom he survived. When he and his brother Telamon were banished from their father Aeacus' kingdom of Aegina because they had conspired to murder their half brother Phocus (*q.v.*), he went to Phthia to be purified by his uncle, King Eurytion. There he married Eurytion's daughter Antigone and received a third of Eurytion's kingdom. Later he took part in the voyage of the Argonauts and the Calydonian boar hunt, during which he accidentally killed Eurytion. He then went to Iolcus to be purified by King Acastus, whose wife, Astydameia, made advances to him. When he refused her she told Antigone he wanted to marry her daughter, so Antigone hanged herself. Astydameia further accused Peleus to Acastus of attempting to seduce her. Acastus thereupon tried to betray Peleus unarmed to the Centaurs, but the gods rescued him. He won Thetis (*q.v.*) by capture and all the gods came to the wedding (*see* ERIS), but after bearing Achilles (*q.v.*) to him she returned to the depths of the sea. In the end, however, she fetched him to dwell with her.

See A. Lesky in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, col. 271–308 (1937). (H. W. PA.)

PELHAM, the name of an English family, derived from Pelham in northeastern Hertfordshire. The family dignities have included the baronies of Pelham of Laughton (1706–68) and Pelham of Stanmer (from 1762), the earldoms of Clare (1714–68), Chichester (from 1801), and Yarborough (from 1837), and the dukedoms of Newcastle upon Tyne (1715–68) and Newcastle-under-Lyme (from 1756).

In the late 13th century a certain WALTER DE PELHAM acquired lands in Sussex, where in future the family's great estates were held. SIR JOHN PELHAM (*c.* 1355–1429) was appointed constable of Pevensey by Henry IV and was given the rape of Pevensey, a feudal castlery or demesne which ran inland across Ashdown Forest as far as East Grinstead. His son SIR JOHN II (*c.* 1400–71) was chamberlain to Catherine, queen of Henry V. The direct male line was continued through THOMAS (d. *c.* 1517), third son of John II. His son SIR WILLIAM (1486–1538), was twice married. By his first wife Mary, daughter of Sir Richard Carew, he was ancestor of the Barons Pelham of Laughton, of the dukes of Newcastle, the earls of Chichester, and of the Pelhams of Catsfield Place, Sussex. By his second wife Mary, daughter of William, Lord Sandys of the Vine, Sir William Pelham was ancestor of the Pelhams of Brocklesby, Lincolnshire, who became earls of Yarborough. The 6th earl of Yarborough is MARCUS HERBERT PELHAM (1893–).

Sir Thomas Pelham (d. 1624), grandson of Sir William and of Mary Carew, was created a baronet in 1611. His great-grandson, Sir Thomas (d. 1712), the 4th baronet, was created Baron Pelham of Laughton in 1706. The 1st baron's two sons, Thomas Pelham Holles (1693–1768), duke of Newcastle upon Tyne (*see* Newcastle, Dukes of), and Henry Pelham (*q.v.*; 1696–1754), both held the office of prime minister. When Newcastle died without issue, his dukedom of Newcastle upon Tyne, his earldom of Clare, and the barony of Pelham of Laughton became extinct. But the dukedom of Newcastle-under-Lyme had been granted him in 1756, with special remainder to the son of his sister Lucy, Henry Fiennes Clinton, afterward Pelham-Clinton (1720–94), 9th earl of Lincoln. From him is descended the present duke, Henry Edward Hugh Pelham-Clinton-Hope (1907–). The barony of Pelham of Stanmer, conferred on the 1st duke in 1762, had remainder to his cousin Thomas Pelham (d. 1805), great-nephew of the 1st Baron Pelham of Laughton.

Anthony Pelham (d. 1566), second son of Thomas (d. *c.* 1517), was ancestor of the Pelhams of New England and of the Pelhams of Compton Valence in Dorset. Anthony's son Herbert (*c.* 1546–1620) was twice married. His first wife was Katherine Thatcher and among their grandchildren were Herbert III (*c.* 1600–74), treasurer of Harvard College, and Penelope (1619–1702), who married Richard Bellingham (1592–1672), governor of Massachusetts. Herbert III's daughter Penelope married Josiah Winslow, governor of Plymouth colony from 1673 to 1680. As his second wife, Herbert (*c.* 1546–1620) married Elizabeth West of Compton Valence, where their issue subsequently resided.

See M. A. Lower, *Historical Notices of the Pelham Family* (1873); E. G. Pelham and D. McLean, *Some Early Pelhams* (1931).

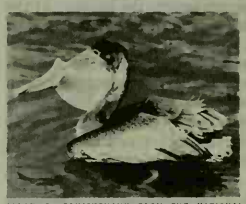
PELHAM, HENRY (1696–1754), prime minister of England from 1743 to 1754, was the son of Thomas, 1st Lord Pelham, and Lady Grace Holles, daughter of the 3rd earl of Clare. He was educated at Westminster School and Hart Hall (later Hertford College), Oxford, and then served briefly in the Army, taking part in the defeat of the Jacobites at Preston (November 1715). Pelham was elected to Parliament for Seaford in 1717 and then for the county of Sussex in 1722, a seat he held for the remainder of his life. In Parliament he was a consistent supporter of Robert Walpole and through this devotion and his family connections soon gained office. Starting as a lord of the treasury in 1721, he became secretary for war (1724) and paymaster to the forces in 1730. He supported Walpole during the excise crisis in 1733 and was one of his staunchest defenders in 1742 after Walpole had lost office and was threatened with impeachment.

After a year's uneasy combination of Whig factions under Lord Wilmington, Pelham became prime minister and chancellor of the exchequer in 1743. He managed to survive two initial threats of disruption and led a relatively stable Whig ministry until his death in 1754. Much of his success depended on the brilliant borough-mongering and parliamentary personnel management of his brother Thomas, the duke of Newcastle (*see* Newcastle, Dukes of). Relations between the brothers, however, were at times strained, and there were several open disputes. Pelham was able to get rid of John Carteret, earl Granville, in 1744, a favourite of George II, who advocated a more vigorous prosecution of the War of the Austrian Succession. The administration was remodeled and became known as the "Broadbottom Administration" since it had given office to groups of dissident Whigs. By a mass resignation of the cabinet in 1746 (the first recorded example in English history) Pelham forced George II to abandon Lord Bath and Granville as leaders of an alternative ministry and even accept people in office like William Pitt, who were personally obnoxious to the king. He concluded the treaty of Aix-la-Chapelle in 1748 and made serious attempts to reduce the national debt and remodel the finances. He died in London on March 6, 1754. *See* also English History; *The First Hanoverians (1714–60)*.

PELIAS, in Greek mythology, a king of Thessaly, who imposed on his step-nephew Jason (*q.v.*) the task of bearing off the golden fleece (*see* Argonauts). According to Homer, Pelias and Neleus (*q.v.*) were twin sons of Tyro by Poseidon, who came to her disguised as the river-god Enipeus, whom she loved; Tyro afterward became the wife of Cretheus, to whom she bore Aeson, Jason's father. Later legend relates that on Jason's return with the fleece his wife, Medea (*q.v.*), the enchantress, persuaded Pelias' daughters, except for Alcestis, to cut up and boil their father in the mistaken belief that he would thereby recover his youth.

(H. W. Pa.)

PELICAN, the large water bird famous for its enormous beak, from the lower half of which is suspended a somewhat elastic pouch. About six species of *Pelecanus* comprise the family Pelecanidae, related to the cormorants and gannets. All pelicans breed in colonies; some nest on the ground on islands, others build nests of sticks in bushes or trees. They live on fish which are caught, but not stored, in the pouch. The pouch also acts as a cooling device in the young by providing a large surface for water evaporation. Ungainly on land, pelicans soar impressively in formation at great elevations. All members of the family seem to be voiceless or nearly so.



ALLAN G. CRUICKSHANK FROM THE NATIONAL AUDUBON SOCIETY

BROWN PELICAN (PELECANUS OCCIDENTALIS), ONE OF TWO AMERICAN SPECIES WITH SKIN-POUCH PARTIALLY EXTENDED BY FOOD

One species, the brown pelican (*P. occidentalis*), captures fish by a spectacular plunge from the air; the others swim in formation, driving small schools of fish into shoal water where they are scooped up by the birds. The three or four eggs, white with a rough, chalky shell, require about a month to hatch. The young are naked and black when hatched. As they become larger, they push their bills so deeply into the pouch of the parent while feeding on regurgitated fish as to give rise to the myth that they are feeding on blood from the breast of the parent; this is the basis for the use of the pelican in Christian symbolism to typify the atonement.

The white pelican (*P. erythrorhynchos*) nests on islands of lakes in the Great Basin of North America north to Great Slave Lake and south to the coast of Texas; this species winters on the seacoasts. The brown pelican, with brown and silver-gray plumage, is a coastal bird, ranging from Florida to California and southward on the western coast of South America, where it breeds in enormous colonies, contributing to one of the important depositories of bird fertilizer, or guano. The white or roseate pelican (*P. onocrotalus*) of Eurasia and Africa is similar to the American white pelican except that the plumage is suffused with a delicate pink. Perhaps the most attractively coloured species is the black and white Australian pelican (*P. conspicillatus*).

(Dn. A.)

PELION (modern Gr. Pílion), a mountain in Thessaly, Greece, in the *nomos* (department) of Magnesia (Magnisía), between the town of Vólos and the east coast; highest point 1,601 m. (5,253 ft.), Pílion peak 1,547 m. (5,075 ft.). Its western flank is the more sheltered, and is well wooded. On that side it overlooks the Bay of Vólos or Pagasitikós Kólpos where there were several ancient ports (Iolcos, Pagasae). In Greek mythology the giants piled it on Ossa (*q.v.*), another mountain in Thessaly, to scale Olympus, the abode of the gods. It was the home of the centaurs, especially of Chiron (*q.v.*) who educated many heroes in a cave near its summit. The ship "Argo" of the Argonauts was built from wood from trees on Pelion. At an altar of Zeus Actaeus on its summit a festival was held in the dog days.

PÉLISSIER, AIMABLE JEAN JACQUES, Duc de Malakoff (1794–1864), French army officer, one of the conquerors of Algeria and the last French commander in chief in the Crimean War, was born at Maromme (Seine-Inférieure) on Nov. 6, 1794. With commissioned rank from 1815, he took part in the expeditions to Spain (1823) and to the Peloponnese (1828–29). After his first brief service in Algeria (1830), he returned there in 1839, with the rank of lieutenant-colonel, having meanwhile learned some Arabic. Chief of staff of a division, he campaigned against Abd-el-Kader, but shocked European opinion by smoking to death the Ouled-Riah tribe when it took shelter in caves near Mostaganem (June 1845). Bugeaud, however, protected him; and

Pélissier, promoted general in 1846, was commander of the Oran Province from 1848 to 1851. His furious temper and his sarcasm became notorious.

During the Crimean War (*q.v.*) when Gen. F. C. Canrobert failed to take Sevastopol, Pélissier was first given command of an army corps (Jan. 1855), then appointed commander in chief (May 16). His attack of June 18 on the fort of Malakhov (Malakoff) was unsuccessful, but he defeated a counterattack on the Traktir bridge over the Chernaya River on Aug. 16, and both Malakhov and Sevastopol itself fell on Sept. 8. On Sept. 12, 1855, Pélissier was made marshal of France. On July 5, 1858, he was created duc de Malakoff.

From March 1858 to April 1859 Pélissier was French ambassador to London. During the war of 1858 against Austria (*see* ITALIAN INDEPENDENCE, WARS OF) he commanded the army of the Rhine. In November 1860 he was appointed governor of Algeria. He died in Algiers on May 22, 1864. His savage character could not detract from his martial ability or from his gift of leadership.

See V. E. Derrécagaix, *Le Maréchal Pélissier* (1911). (L. G.)

PELLA, ancient capital of Macedonia, situated in northern Greece about 24 mi. NW of Salonika. The original name was Bounomos, which may have been applied to the island of Phakos where prehistoric remains have been found, and which in classical times was a stronghold where the royal treasury was located. In the 5th century B.C. Pella occupied a narrow strip of land along the sea. By early Roman times this arm of the sea had so far silted up that there was a great marsh in front of Pella, and the town was accessible from the sea only by a channel 15 mi. long. The marsh has been drained, and a fertile plain stretches to the sea 20 mi. away.

Pella first came into prominence when King Archelaus moved the capital there from Aegae (modern Edessa) at the end of the 5th century B.C. It developed rapidly under Philip II. Alexander the Great was born there. After the defeat of the last Macedonian king by the Romans (168 B.C.) Pella sank to a small provincial town.

The site of Pella has long been known, and tumuli on the outskirts of the city marked its approximate limits. Excavations by the Greek Archaeological Service begun in 1957 have revealed large, well-built houses with colonnaded courts and rooms with mosaic floors which have figured panels portraying such scenes as a lion hunt and Dionysus riding a panther. These mosaics are made with small natural pebbles of various colours, carefully matched and laid, and are masterpieces of their kind. Their date is late 4th century B.C. The town was laid out on a rectangular grid plan with streets over 30 ft. wide. Under the streets are terra-cotta pipes for distributing fresh water.

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PELLAGRA, a dietary deficiency disease, noncontagious, and occurring in persons of any age, of either sex, of any race, and in any stratum of society. Until rather recently it was considered by many to be merely a disease of the skin, the Italian term *pelle agra* meaning "rough skin." For more than 200 years it was associated especially with maize-eating areas of the world—maize being notably deficient in niacin (*see* below). However, pellagra may result from inadequate diet under many circumstances, prominently including alcoholism.

Some of the early symptoms are weakness, apathy, loss of appetite, indigestion, and neurasthenia. In the late stages of the disease appear the classical four D's: dermatitis, diarrhea, dementia, and death. The symptoms vary greatly in each case. If dermatitis is present it begins as an erythema resembling sunburn that becomes reddish brown, roughened, and scaly. Lesions may appear on any portion of the body, but the commonest sites are the hands, wrists, elbows, under the breasts, knees, feet, and perineal regions. A sharp line of demarcation separates the lesion from the healthy skin. Glossitis and stomatitis are common symptoms. The tongue becomes red and thickened and the mucous membrane is reddened. Severe watery diarrhea often is present in the acute stage. Nervousness, insomnia, headache, and dizziness may be present, and pellagrins are subject to periods of depression and apprehension. Unless early and adequate treatment is administered, confusion, hallucinations, and complete disorientation as to time, place, and person develop. Death inevitably occurs unless the afflicted person receives prompt and intensive treatment.

The pellagrin is relieved of his disease when niacin (a member of the B group of vitamins) and substances that act similarly are given in adequate amounts. The diet of the pellagrin is deficient not only in niacin but also in thiamine (vitamin B_1), riboflavin (vitamin B_2), and folic acid (folacin), as well as many other essential nutrients. (*See* VITAMINS.) Physicians remedy all these deficiencies at the same time and call the tablets or capsules they use "mixed vitamin therapy." Persons who develop symptoms of pellagra, beriberi (*q.v.*), riboflavin deficiency, or folic acid deficiency not only should receive mixed vitamin therapy but they should have a diet rich in lean meat, eggs, milk, fruit, and vegetables. Dried brewers' yeast powder and crude liver extracts contain these vitamins and many other useful nutrients.

(T. D. Ss.; X.)

PELLICO, SILVIO (1789–1854), Italian patriot, dramatist, and author of *Le mie prigioni* (1832; *My Prisons*), an account of his sufferings as a political prisoner regarded as more damaging to the Austrians than the loss of a battle, which inspired widespread sympathy for the Risorgimento (*see* ITALY). He was born at Saluzzo, Piedmont, on June 25, 1789, and educated at Turin, later spending four years in France, returning in 1809 to Milan, where he began his career as poet and playwright. His romantic tragedy *Francesca da Rimini* (published 1818) was an immediate success on its first performance (1815), and was followed by several others. He had already become one of the circle of Romantic revolutionaries including Monti, Foscolo, Berchet, and Manzoni, and in 1818 he collaborated with Count Luigi Porro Lambertenghi and Count Federico Confalonieri in founding a liberal and patriotic newspaper, *Il Conciliatore,* of which he became editor. After its suppression by the Austrian police (1819) and a disappointment in love, he joined the Carbonari, and in October 1820, was arrested for treason. In 1822 he was sentenced to death, but the sentence was commuted to 15 years' imprisonment in the Spielberg fortress in Brünn (Brno), where he remained until 1830. The rest of his life was spent at Turin, where from 1838 he lived with the Marchese Carlo Tancredi di Barolo and his wife. He died there on Jan. 31, 1854. He had continued to write plays, poetry, and prose works, notably the didactic treatise *I dovere degli uomini* (1834), but *Le mie prigioni* is his only work still widely read and translated. It has become a classic for its simple, direct style and for its revelation of spiritual experience and Christian piety.

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PELLITORY, any small annual or perennial herb of the genus *Parietaria* of the nettle family (Urticaceae), but without the stinging hairs. There are about four species in North America, the chief one being the annual *P. pennsylvanica,* a weedy plant of the southern and north central U.S., about 1½ ft. high, with unisexual, greenish, inconspicuous flowers. The Eurasian *P. officinalis,* a perennial with a woody rootstock, has a stem 1–2 ft. high, bearing slender leafy branches; it is common throughout most of the British Isles. Spanish pellitory is the drug derived from the root of the North African *Anacyclus pyrethrum,* a composite plant; it has been used to promote the flow of saliva. (N. TR.)

PELLOUTIER, FERNAND (1867–1901), a leading organizer and theoretician of the French labour movement who deeply influenced the philosophy and methods of French anarcho-syndicalist labour unionism, was born in Paris on Oct. 1, 1867. As a young journalist in Saint Nazaire, he became a member of the Parti Ouvrier Français, which was inspired by the ideas of Jules

Guesde; but he turned his back on all political parties when the Guesdists rejected the idea of the general strike, which he and Aristide Briand advocated. Becoming an anarchist, Pelloutier was named secretary of the Fédération Nationale des Bourses du Travail in 1895. The *bourses du travail* were a distinctive French institution combining the functions of workers' clubs, employment exchanges, and local labour union federations. They were the most vital element in the growing French trade union movement of the time.

Pelloutier was one of the rare French labour leaders who, while preaching social revolution, nevertheless paid scrupulous attention to the practical details of trade-union organizing and "housekeeping," and to the need for immediate gains in workers' conditions. Desperately ill, poor, and overworked, he managed, in a short lifetime, to strengthen the *bourses* and their federation, to write extensively on working-class life and problems, and to set forth his own ideals of labour action in his *Histoire des Bourses du travail* (1901). He died in a Paris suburb on March 13, 1901.

See M. Pelloutier, *Fernand Pelloutier, sa vie—son oeuvre* (1911); Lewis L. Lorwin, *Syndicalism in France,* 2nd ed. (1914). (V. R. L.)

PELOPIDAS (d. 364 B.C.), Theban statesman and general, was responsible with his friend Epaminondas (*q.v.*) for the brief Theban hegemony in mainland Greece (371–362 B.C.). In 385 he served in a Theban contingent sent to the support of the Spartans at Mantinea, where he was saved, when dangerously wounded, by Epaminondas. Upon the seizure of the Theban citadel by the Spartans (382) he fled to Athens, and took the lead in a conspiracy to liberate Thebes. In 379 his party surprised and killed their chief political opponents and roused the people against the Spartan garrison, which surrendered. In this and subsequent years he was elected boeotarch, and in 375 he routed a much larger Spartan force at Tegyra (near Orchomenos). This victory he owed mainly to the valour of the Sacred Band, a picked body of 300 infantry which also distinguished itself under Pelopidas at the Battle of Leuctra (371). In 370 he accompanied Epaminondas as boeotarch into the Peloponnese. On their return both generals were unsuccessfully accused of having retained their command beyond the legal term. In 369, in response to a petition of the Thessalians, Pelopidas was sent with an army against Alexander, tyrant of Pherae. After driving Alexander out, he passed into Macedonia and arbitrated between the Macedonian king Alexander II and his rival Ptolemaeus. Next year Pelopidas was again called upon to interfere in Macedonia, but on his return through Thessaly he was seized by Alexander of Pherae and two expeditions from Thebes were needed to secure his release. On one or other of his expeditions Pelopidas brought back to Thebes numerous Macedonian hostages, including the future king Philip II. In 367 he went on an embassy to the Persian king Artaxerxes II and induced him to prescribe a settlement of Greece according to the wishes of the Thebans. In 364 he received another appeal from the Thessalian towns against Alexander of Pherae. He overthrew the tyrant's far superior force on the ridge of Cynoscephalae; but wishing to kill Alexander with his own hand, he was cut down by the tyrant's guards.

See also THEBES (Greece).

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PELOPONNESE (PELOPONNESUS; ancient Greek PELOPONNESOS, modern Greek PELOPÓNNISOS), the part of the Greek peninsula south of the Isthmus of Corinth. The ancient Greeks interpreted the name as *Pelopos nesos,* "island of Pelops" (*q.v.*). The word does not appear in Homer, who seems occasionally to use "Argos" to mean the whole peninsula, as being under the hegemony of Agamemnon of Argos. The name Peloponnesos is usually assumed to derive from this hegemony of the Pelopidae ("Pelops' descendants").

By the 14th century A.D. the Peloponnese was known as "Morea," the Greek for "mulberry"; this word is first found in the 12th century applied to Elis, a mulberry-growing district, being later extended to cover the whole of the peninsula. *See* GREECE; *see* also references under "Peloponnese (Peloponnesus)" in the Index.

See A. Philippson, *Die griechische Landschaften,* vol. iii (1959).

PELOPONNESIAN WAR. The Peloponnesian War (431–404 B.C.), between Sparta and Athens, was recorded by the most penetrating and important historian of military and political events in antiquity, Thucydides of Athens, whose mature years coincided with the war. Himself a combatant and a general, exiled in 424, he had access to both sides. As his sources of information were immediate, personal, and numerous, he sifted them himself and presented his own narrative, which we have not the evidence to disprove nor in general the desire to challenge because the whole tenor of the work supports his claim to have been meticulously accurate and unbiased (*see* THUCYDIDES). In terms of power and politics, as Thucydides foresaw, the war was decisive. He laid less emphasis on the economic and social consequences for Greek civilization (to which modern writers attach importance), because he was concerned with the interplay of human psychology and of circumstance in the sphere of war and politics.

The Antecedents of the War.—The Thirty Years' Treaty of 445 was a pact of nonaggression between the two leading blocs of power in Greece: Athens and its empire, which comprised most of the islands and maritime states on the northern and eastern coasts of the Aegean basin, and the Greek states of the Propontis and Black seas; and Sparta and its allies, among whom most of the leading land powers in the Peloponnese and central Greece were counted, and also Corinth, the leading sea power in the western seas, which extended to Sicily. So long as neither bloc trespassed on the other's sphere of influence, the peace was likely to last, because the balance between them was in equipoise and the outside powers were neutral. But in 433 Athens made a defensive alliance with a recalcitrant colony of Corinth, Corcyra, which held a strategic position in the western seas and possessed a large fleet of 120 triremes. This alliance infringed the principle but not the letter of the Thirty Years' Treaty and resulted in a clash between Athenian and Corinthian ships when Corinth and its allies attacked Corcyra. In the ensuing winter Athens not only banned one of these allies, Megara, from access to the eastern seas, which had been guaranteed under the Thirty Years' Treaty, but also ordered one of its own allies, Potidaea, which was a colony of Corinth, to break off relations with its founder city and dismantle its seaward walls. These were no idle threats, because the fleet of Athens dominated the Aegean basin. Nevertheless, Potidaea refused. "Volunteers" from Corinth and its Peloponnesian allies reached Potidaea and enabled it to beat off an Athenian attack.

Corinth, Megara, and other states now maintained that Athens had committed aggression and had thus infringed the terms of the Thirty Years' Treaty. They complained, therefore, to Sparta. The Spartans' local interests were not involved. Yet their position at the head of the Spartan alliance was endangered by Athens' moves against two of its members, Corinth and Megara. The executive authorities at Sparta had already made a secret agreement to help Potidaea, but this fact was not known to the Spartan citizens when they met in the assembly to decide their attitude. A large majority found Athens guilty of aggression. The allies of Sparta, meeting in a formal congress, confirmed Sparta's verdict. The two components of the Spartan alliance or, as it is commonly called, the Peloponnesian League, declared themselves ready to go to war if the Athenians proved unwilling to withdraw their ban on Megara and their order to Potidaea.

The decision lay with Athens. The people were swayed by their leading statesman, Pericles (*q.v.*), who had himself proposed the alliance with Corcyra and the ban on Megara. He warned the assembly against yielding to any demands made by the Peloponnesians. The majority accepted his advice. The demands of Sparta were rejected. A diplomatic deadlock ensued. The Athenians offered to accept arbitration on the points under dispute. The Spartans refused arbitration. In spring 431 an ally of Sparta, Thebes, made a treacherous attack on an ally of Athens, Plataea. The Thirty Years' Treaty was flagrantly broken, and both blocs of power went to war. As Thucydides rightly observed, the fundamental cause of the war was the interaction of two forces, the growing power of Athens and the growing apprehension of Sparta.

The First Part of the War ("The Archidamian War," 431–421 B.C.).—The armies of Sparta and its allies were far stronger

than those of Athens. But they could be deployed for only a few months each year, because the Spartans had to keep their serfs, the helots, under control, and the allied soldiers were needed on their farms. The Spartans hoped to force a decisive battle on land. Otherwise there was little hope of success, for Sparta and its allies had relatively small fleets and no financial resources for building large numbers of warships. On the other hand, the fleet of Athens, even without the squadrons of Lesbos, Chios, and Corcyra, was unrivaled; and the Athenians had large financial reserves and access to shipbuilding materials. Their infantry, though outmatched by the combined forces of their enemies, included a striking force of 13,000 men, free to operate at any time and capable of damaging their neighbours individually, and a reserve force of 16,000 men, able to hold the massive walls which circled Athens and the Piraeus and linked the city with its port.

Sparta's lines of communication with its allies beyond the isthmus —Boeotia, Phocis, and Locris—ran through the narrow corridor of northern Megaris which separates Attica from the Corinthian Gulf. This corridor was threatened from the east by Athens and from the west by Athens' ally Plataea. In their desire to control the corridor the Thebans attacked Plataea in March 431. The attack failed. Athens evacuated the noncombatants from Plataea and sent troops to reinforce the garrison. In May the Spartan king Archidamus led the allied armies slowly into Attica and ravaged part of the plain north of Athens, hoping to provoke an engagement. But on the orders of Pericles the Athenian population and the Athenian army were concentrated behind the walls of the city. Although the troops wanted to attack, Pericles held them back. He had no intention of offering battle then or later to the superior army of the enemy. He proposed to conserve his forces for a war of attrition during which the Athenian fleet would guard the empire and Athens' supplies and wear down the enemy by seaborne raids. In June, therefore, before the Spartans left Attica, a fleet of 150 triremes set off from the Piraeus. It raided the coasts of the Peloponnese and closed the mouth of the Corinthian Gulf by winning over Cephallenia (Cephalonia), an island off the entrance to the gulf, as a base. Meanwhile a fleet of 30 triremes ravaged the coast of Locris and garrisoned the island of Atalante in the Euboean Channel, through which convoys passed to an Athenian army blockading Potidaea. The people of Aegina were expelled, and the Athenians occupied the island, which held the entry to the Saronic Gulf. Thus the net of naval blockade was closing round the enemies of Athens and its own sea-lanes were secure.

The policy of Pericles was a wise one in the opinion of Thucydides. It safeguarded the city, the fleet, and the empire—the sources from which Athens drew its financial and naval strength. Even if it meant the loss of property in Attica, which was relatively unimportant, it involved no risks for the Athenian army; and Pericles was confident that he could maintain the morale of the people. In 431 and subsequent years the army ravaged the Megarid. In March 430 Pericles proclaimed his faith in Athens when he delivered a funeral speech in honour of the Athenian dead. But shortly afterward, when the Peloponnesian army was ravaging Attica for the second time, an unexpected blow fell on the crowded city of Athens—a terrible plague which within three years killed one-third of its best troops and maimed many others, apart from its toll among the civilian population. Pericles himself was one of the casualties. The power and the morale of the Athenians were seriously undermined, but they fought on with grim determination in Chalcidice, capturing Potidaea and instigating an extensive raid on Chalcidice and Macedonia by their ally, the Thracian king Sitalces, in 429.

While the plague raged at Athens, the initiative lay with the Spartans. They tried to oust the Athenians from their bases in the western area—Zacynthus, Cephallenia, Acarnania and Amphilochian Argos, Corcyra, and, in the Gulf of Corinth, Naupactus—and thus to regain contact with Italy and Sicily, where they had allies and sources of supply. In 430, attacks on Zacynthus and Amphilochian Argos failed. In 429 a large army of Peloponnesians, Ambraciots, and light-armed levies from the tribes of Epirus invaded Acarnania but suffered defeat at Stratus. A Peloponnesian fleet of 47 warships and smaller troop-carrying vessels, which had intended to join the attack on Acarnania, was intercepted as it sailed out of the Corinthian Gulf by an Athenian squadron of 20 warships based at Naupactus. When the Peloponnesian warships formed a circle, facing outward to protect the smaller vessels at the centre, the Athenian commander Phormion ordered his warships to row round the outside of the circle, which contracted and fell into confusion. Phormion then attacked and gained a remarkable victory. The Peloponnesian fleet then threatened Naupactus. But Phormion won another victory, and reinforcements from Athens soon reached Naupactus. Later in the year the Peloponnesians set out to raid the Piraeus by sea; but their courage deserted them and they raided the island of Salamis instead. The other objective of Sparta in 429 was Plataea. When diplomacy failed, the Spartans built a double wall round the town and imposed a blockade which was destined to last into 427.

In 428 the Peloponnesians made no further move in the western area, but an important opportunity arose for intervention in Aegean waters. Lesbos, one of the two allies of Athens which had a fleet, was planning to revolt and allied itself in August with the Spartans, who undertook to invade Attica that autumn and to send help overseas to Lesbos. But the Athenians moved first, blockading the leader of the revolt, the city of Mytilene, with a squadron of 40 ships, and ravaging the east coast of the Peloponnese with an army transported on 100 ships. The Peloponnesians failed to invade Attica or to send help to Mytilene. During the winter Mytilene was hard pressed by the Athenians. The oligarchs in the town who had organized the revolt found themselves threatened by the democratic party, and they surrendered to the Athenian commander on condition that the Athenian people should make a final settlement. A week later a Peloponnesian squadron of 42 ships crossed the Aegean Sea, learned of the surrender, and sailed ignominiously home. The only success that Sparta gained during the years of the plague was the capture in 427 of Plataea, from which half the garrison had made a brilliant escape at night. The remainder surrendered, entrusting their fate to Spartan courts.

The strain of war lowered the standard of humanity on both sides. The Athenians, incited by a violent orator, Cleon, ordered the execution of all adult males at Mytilene and the enslavement of the rest. Next day the assembly repented. The order was countermanded just in time, but even so a thousand ringleaders were executed. The Spartans condemned and executed the captured garrison of Plataea and the town was demolished by the Thebans. In Corcyra a terrible civil war, fanned by the intervention of a Peloponnesian squadron and later of an Athenian squadron, caused much loss of life and degenerated into guerrilla warfare, which lasted until 425. Supplies were now short in the Peloponnese. At Athens financial reserves were running low, and bitter animosity developed between the extreme democrats, led by Cleon, and the moderate party with which Thucydides and Aristophanes sympathized.

In 427–424 the Athenians abandoned the cautious strategy of Pericles and engaged in a series of offensives. An attack on Melos failed (426). A squadron of 20 ships started operations in 427 against Syracuse in Sicily, where Athens had allies, and gained control of the Strait of Messina; 40 more ships were sent in 425, but the Sicilian states made peace among themselves in 424 and so ended Athenian intervention. An enterprising general, Demosthenes, tried to extend Athens' power in western Greece by attacking Leukas and invading Aetolia, where he suffered defeat. In 426 the Spartans retaliated. Campaigning along the northern coast of the Corinthian Gulf and then joining the Ambraciots in an attack on Amphilochian Argos, they hoped to reduce Acarnania and control the northwestern mainland. But Demosthenes came up with 20 Athenian ships, took command of the Acarnanians and Amphilochians, and inflicted a double defeat on Sparta and Ambracia. His success was so great that the Acarnanians were alarmed and made a separate alliance with Ambracia. From this Athens derived no advantage.

In 425, when the reinforcements were sailing to Sicily, Demosthenes fortified Pylos, a rocky promontory on the west coast of Messenia, and stayed there with a small force. A Peloponnesian

fleet of 60 ships, which had been operating at Corcyra, hastened south to Pylos and landed 420 Spartans on an island, Sphacteria, hoping to blockade the promontory. The Athenian fleet returned suddenly, defeated the Peloponnesian fleet by surprise and isolated the Spartans on Sphacteria. Sparta then negotiated an armistice at Pylos, during which the Athenians were given possession of the Peloponnesian fleet as a guarantee of good faith. Sparta offered peace and alliance to Athens. Cleon persuaded the assembly to reject the offer in the hope of winning some decisive victory, and later in the year he was sent out to take command with Demosthenes at Pylos. There the Athenians, alleging a technical breach of the armistice, had refused to return the Peloponnesian ships but failed to land on Sphacteria. Cleon and Demosthenes, encouraged by a fire which burned the woods on the island, made a landing, fought the Spartans to a standstill, and obtained the surrender of 120 Spartiates.

Stripped of its fleet, shaken in morale, and threatened by helot risings in Messenia, Sparta was now at its lowest ebb. Athens tried to press home its advantage. During the voyage to Sicily the fleet from Pylos connived at a massacre of oligarchs at Corcyra. Nicias led successful raids by sea on the coasts of Corinth and Epidaurus and occupied Methana. In 424 he captured and garrisoned Cythera as a base for raiding Laconia. Demosthenes and Hippocrates came within an ace of capturing Megara and thus cutting the Peloponnese off from Boeotia. In the summer a triple attack was launched on Boeotia, but a failure in the timing and the slowness of the main force under Hippocrates at Delium enabled a Boeotian army of 7,000 hoplites and 1,000 cavalry to force a battle, in which Hippocrates and 1,000 Athenian hoplites were killed. This disaster brought the Athenian offensive to an end.

Meanwhile the Spartans broke out of the net in which the Athenians sought to enclose them. An able Spartan officer, Brasidas, having saved Megara from capture by Demosthenes and Hippocrates, led an army of Peloponnesian troops and freed helots into Chalcidice, an area neglected by Athens since the fall of Potidaea. There he raised city after city in revolt from Athens and in December 424 captured Amphipolis, Athens' chief base in the northwest Aegean. Athens tried to stop the landslide by concluding a year's armistice with Sparta, but it proved ineffective in Chalcidice, where Brasidas continued to detach states from the Athenian empire. Afraid of more widespread revolt, the Athenians sent an army under Cleon's command to recapture Amphipolis in 422. It was decisively defeated; Cleon was killed, but so was Brasidas. Nicias, Cleon's rival, now persuaded the assembly to accept the overtures for peace that Sparta had been making since 425. A treaty of peace was accepted in 421 by Athens and Sparta, but not by four of Sparta's leading allies (Boeotia, Corinth, Elis, and Megara). Soon afterward Athens and Sparta entered into a defensive alliance, not of goodwill but of convenience.

The Ineffective Peace, 421–415 B.C.—These years gave the Athenians an opportunity to seduce Sparta's allies and isolate Sparta by diplomacy. They failed to use it because they were split internally by the rival policies of appeasement, led by Nicias, and of aggression, led by Alcibiades. The other states now distrusted both Athens and Sparta, but a breakaway group of Argos, Corinth, Elis, and Mantinea was too weak to withstand either great power. In the atmosphere of general mistrust the terms of the so-called Peace of Nicias were never implemented. Sparta managed to make an alliance with Boeotia, and Athens won over Argos, Elis, and Mantinea, but not Corinth, in 420. Sparta took military action in 418. The Spartan army of 6,000 hoplites and the levies of Boeotia, Megara, Corinth, Tegea, and lesser allies outmaneuvered the forces of Argos (numbering 6,000 hoplites), Elis, Mantinea, and some lesser states and imposed an armistice on Argos. Sparta's allies had gone home when Argos received 1,000 hoplites and 300 cavalry from its ally Athens and reopened hostilities. At Mantinea the army of Sparta, aided by Tegea alone, inflicted a decisive defeat on Argos, Mantinea, and Athens, and rapidly reestablished the Spartan alliance as it had been in 431. The feeble intervention of Athens in the Peloponnese with a mere 1,000 hoplites had lost the chance of diplomatic or military success on land. Meanwhile in the north, Amphipolis and Chalcidice remained independent and hostile. The war party at Athens now favoured adventure at sea. In 416 Athens attacked Melos, which refused to renounce neutrality and accept Athens' rule. When Melos capitulated, Athens massacred the adult males, enslaved the rest, and gave the island to 500 Athenian settlers. In 415 the Athenians sent out a great armada to conquer Sicily. These acts showed that their methods were unscrupulous and their ambitions were unlimited. They heralded the end of the Peace of Nicias.

The Second Part of the War, 415–404 B.C.—This was decided at Syracuse and at sea. On this element the Athenians began with complete supremacy. In all they committed 200 warships to the gamble in Sicily, and left their home fleet dangerously weak. The expeditionary force in Sicily was commanded by three incompatible generals, Alcibiades, Lamachus, and Nicias. Alcibiades was soon recalled on a charge of sacrilege; he escaped and transferred his services to Sparta. Lamachus was killed in action. Nicias was soon affected by illness. In 414 the first attempt was made to circumvallate and blockade Syracuse by land (for Athens held command at sea); it failed, mainly because a Spartan, Gylippus, with nearly 3,000 troops slipped through the Athenian lines and enabled the Syracusans to defeat the Athenian land forces, which had had only a small margin of superiority. Nicias then concentrated his army in defense of the naval base by the great harbour and advised Athens to recall the expedition. He was told to await reinforcements.

In July 413, when Nicias had lost his naval base and been defeated at sea, Demosthenes arrived with a large force. It was essential to establish military superiority at once. Demosthenes therefore launched a night attack, suffered a severe defeat, and wished to sail home. Nicias now refused to go. A month later Nicias agreed to sail; but an eclipse of the moon occurring on Aug. 27, 413, Nicias accepted his soothsayers' advice to stay "thrice nine days." While he stayed, the fate of the expedition was decided in the Great Harbour; the morale of the Athenian navy was broken by a single defeat and the whole force attempted to escape overland. It suffered complete destruction. Mismanagement, indecision, and panic thus cost Athens more than 200 warships with crews totaling about 35,000 men, a fine army including 4,000 Athenians, and much material and treasure.

The Spartans and their allies declared war in 414. On the advice of Alcibiades, they established a fortified post at Decelea in northern Attica which denied the Athenians the use of Attica and made them import all foodstuffs by sea at great expense. The Athenian disaster in Sicily gave Sparta hope of winning at sea. With Alcibiades' help the Spartans entered into alliance with the king of Persia, who could provide bases and money; they were joined by Chios, Miletus, and other states which revolted from Athens; and a small Peloponnesian fleet established itself at Miletus. The Athenians showed great energy; they built ships quickly, secured Samos as their main base, and covered their chief line of supply through the Hellespont. In 411 Abydos in the Hellespont revolted with the help of a Spartan force and Persia. At this stage the Persian king adopted a waiting game on the advice of Alcibiades, who suggested that he let the Greeks wear one another down and use his wealth to end the war at his pleasure. Alcibiades engineered his own recall to the Athenian fleet at Samos. He began by promoting an oligarchic revolution which developed partly from the hypothesis that as an oligarchic leader he could obtain aid from Persia. Oligarchy at Samos was short-lived but the succeeding democratic leaders appointed Alcibiades general of the fleet. Meanwhile at Athens an oligarchy seized power, ruled despotically, and negotiated with Sparta for terms of peace. It was overthrown by a popular rising, and a moderate government, known as "the five thousand," took its place and cooperated with the democratic fleet at Samos. The slowness of Sparta and the deliberate inaction of Persia gave Athens the chance to ride out the storms of disaster in Sicily and of revolution at home. Late in 411 the Athenians won their first victory against the Peloponnesian navy at Cynossema in the Hellespont. Two more victories followed. They put the main enemy fleet out of action for three years, and merged the two governments at Samos and Athens in a restored democracy.

The democratic leaders, especially Cleophon, pushed the war

to the finish by rejecting the terms which Sparta repeatedly offered and by attacking those who advocated negotiation as oligarchs. Neither side had the money to outdo the other. Alcibiades came home in triumph in 407, but Persia chose to subsidize the Spartan admiral, Lysander, who equipped 90 ships and defeated an Athenian fleet. Alcibiades was held responsible by the Athenians; he fled into exile in 406. By tremendous efforts the Athenians survived further defeats at sea, manned 150 ships, and won a battle at Arginusae in which about 20,000 Greek lives were lost. The Persian policy of attrition was now coming to an end. In 405 the Persian prince Cyrus enabled Lysander to man 200 ships. He entered the Hellespont, drew the Athenian fleet of 180 ships after him, and caught them ashore in a sudden attack at Aegospotami. Only eight ships escaped. The Athenian navy was no more. The relentless advance of Lysander to the Piraeus and the blockade imposed from Decelea starved the Athenians into final submission, but only after Cleophon had been executed and the way had been prepared for an oligarchic government. In April 404 Lysander's troops began to demolish the walls of the Piraeus. Athens was to be stripped bare of empire, fleet, and fortifications, so that it should never try again to enslave the Greek states.

The Spartans owed their victory to the tenacity of their government, their excellent infantry, and their power of leadership, but also to the fighting quality of the Syracusans and to the gold of Persia, for which Sparta promised to sacrifice the liberty of the Greeks in Asia. The Athenians owed their failure to instability in government and temperament, mistaken policy, incompetent generalship, and declining morale. Although the principle of national independence was strikingly vindicated by the outcome, the general strength of the Greek states was fatally weakened and the most progressive and civilized state was reduced to impotence.

See also references under "Peloponnesian War" in the Index.

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PELOPS, legendary founder of the Pelopid dynasty at Mycenae in the Greek Peloponnese (Peloponnesus), which was thought to take its name from him. He was the grandson of Zeus, son of Tantalus, and brother of Niobe. Thucydides speaks of him as an Asian who won influence in Greece by his wealth. He was said to have a shoulder of ivory, because his father, Tantalus, on terms of intimacy with the gods, had served his son up to them at a banquet; though only Demeter—distracted by grief at the loss of her daughter Persephone—ate of the dish, the gods needed to replace the shoulder when they brought Pelops back to life.

Pindar (*Olympian* i) refuses to believe this story and offers an elaborate alternative, showing how free poets felt to change traditional accounts. Poseidon loved Pelops and took him up to heaven. The ghastly feast was merely malicious gossip to account for his disappearance. Unlike Ganymede, however, Pelops had to return to mortal life because his father abused the favour of heaven by feeding nectar and ambrosia, of which only gods partake, to mere mortals (*see* TANTALUS). Nothing daunted, Pelops strove for the hand of Hippodamia, daughter of King Oenomaus of Pisa in Elis. Oenomaus used to challenge his daughter's suitors to a chariot race, with Hippodamia the prize of victory and death the price of defeat. Oenomaus had already won on at least 12 occasions, since his team and chariot were the gift of his father, Ares. Pelops, however, had a chariot from Poseidon, won the bride and killed Oenomaus. Thus far Pindar.

In more hostile versions, Pelops bribed Oenomaus' charioteer, Myrtilus, to replace Oenomaus' linchpins with wax dummies, and then after his victory threw Myrtilus into the "Myrtoan" sea near Geraestus in Euboea to avoid paying what he had promised—in some versions the favours of Hippodamia. Myrtilus—or Oenomaus—was said by some to have uttered the curse that dogged the Pelopid house of Atreus. (For the history of this house, *see* ATREUS; AGAMEMNON.) Pelops was sacrificed to as a hero at Olympia as part of the festival of the games, with which he and his charioteering are obviously connected. His tomb was shown there. (G. E. DK.)

PELOTA: *see* JAI-ALAI.

PELOTAS, a port in the state of Rio Grande do Sul, Braz., located on the left bank of the Canal de São Gonçalo, the river that connects Lagoa Mirim with Lagoa dos Patos. The population in 1960 was 121,280. Pelotas was founded in 1830 and became a city in 1835. Together with the port of Rio Grande, 32 km. (20 mi.) SSE, it serves as the transfer point between lake and ocean shipping. Ocean steamers, after crossing the bar at the outlet of Lagoa dos Patos, can reach both Rio Grande and Pelotas but cannot reach Pôrto Alegre fully loaded. Pelotas also serves as the chief port for the cattle-ranching area of southern Rio Grande do Sul. It is Brazil's largest producer of *xarque*, or jerked beef, and has meat-packing plants, flour mills, tanneries, and factories producing lard, soap, candles, shoes, and furniture. Wool, hides, dairy products, rice, and timber are exported from Pelotas. The city is connected by rail and highway with Rio Grande, with Bagé, and with the Uruguayan border at Jaguarão. It is reached by lake steamer from Pôrto Alegre and is served by Brazilian and international airlines. (P. E. J.)

PELTIER, JEAN CHARLES ATHANASE (1785–1845), French physicist, whose discovery (1834) that an electric current produces, according to direction, either heat or cold at the junction of two dissimilar metals in a circuit is called the Peltier effect. Peltier is also remembered for introducing the concept of electrostatic induction. He was born at Ham (Somme), France, on Feb. 22, 1785, and became a clockmaker. He died in Paris on Oct. 27, 1845. *See* ELECTRICITY, ATMOSPHERIC: *History;* HEAT: *Radiation: Absolute Radiometers.* (D. MCK.)

PELUSIUM, an ancient Egyptian city on the most easterly (now silted) mouth of the Nile, probably called by the Egyptians Sa'inu and also Per-Amun, "House of Amon," whence perhaps the modern name of the site, Tell Farama, about 32 km. (20 mi.) SE of Port Said. In the late period of pharaonic history Pelusium replaced Sile as the frontier fortress against Palestine and as a customs post for Asiatic goods. Cambyses the Persian was the first of many invaders to meet with resistance there. In Roman times it was a station on the route to the Red Sea. (M. S. DR.)

PEMBA, an island in the Indian ocean off the east coast of Africa, forming part of the United Republic of Tanganyika and Zanzibar (*q.v.*), lies about 25 mi. (40 km.) N.N.E. of Zanzibar Island and 30 mi. (48 km.) from the coast of Tanganyika. Area, including offshore islets, 380 sq.mi. (984 sq.km.). Pop. (1958 census) 133,858, mostly Africans (including the aboriginal Pemba or Wapemba) but with a large Arab minority and some Indians. Formed and detached from the continent in the Miocene Age, Pemba is based upon various limestones including coral. Much of the island consists of small but steep undulating hills, and the western and southern coast line is deeply indented with creeks and bays characterized by dense mangrove vegetation. The rainfall is greater than that of Zanzibar but the climate is similar. Figures for Wete, the capital, are: mean annual rainfall 77 in., mean maximum temperature 30° C. (86° F.), mean minimum 23° C. (73° F.). Pemba has evidence of 10th- to 16th-century Persian settlement, and the indigenous people claim Persian affinity, calling themselves Shirazis. The Portuguese built settlements there in the 16th and 17th centuries, introducing the black domestic pig, which is now wild, and bullfighting, which is still practised. In the early days of Arab supremacy the Mazrui Arabs regarded themselves as independent of Zanzibar. Even when Pemba came under the sultan it remained a stronghold of slavery and slave running until the end of the 19th century. Much of Pemba is extremely fertile and it produces more than three-quarters of the republic's clove crop. There are three small towns: Wete in the north, Chake Chake in the centre and Mkoani in the south. Wete and Mkoani have good

port facilities. There are 70 mi. (113 km.) of motor roads. There is a small airstrip near Chake Chake and the island is in wireless contact with Zanzibar from which a weekly shipping service operates. (F. B. Wi.)

PEMBROKE, EARLS OF. The title of earl of Pembroke has been held successively by several English families. The earldom, created in 1138, was conferred by King Stephen on Gilbert de Clare (d. *c.* 1148), who inherited the lordship of Chepstow (or Striguil) from his uncle, Walter. In the civil war, Gilbert at first supported Stephen against the empress Matilda, but he was involved in Geoffrey de Mandeville's conspiracy in 1142 and rebelled against the king in 1147. From his son Richard (d. 1176) the earldom passed to William Marshal (d. 1219), who married Richard's daughter and heiress, Isabel (d. 1220). (*See* Pembroke, Richard de Clare, 2nd earl of; Pembroke, William Marshal, 1st earl of.)

William Marshal's five sons succeeded in turn to the earldom and all died childless. His eldest son, Earl William (d. 1231), was one of the 25 barons appointed in 1215 to safeguard the keeping of Magna Carta. In 1223 he defeated the Welsh prince Llewelyn ab Iorwerth and checked the extension of his power; his second wife, Henry III's sister, Eleanor, later married Simon de Montfort. Earl Richard (d. 1234) led in 1233–34 the baronial opposition which compelled the dismissal of the king's Poitevin ministers, Peter des Roches and Peter des Rivaux. While defending (Feb. 1234) his Irish possessions, which had been acquired by the marriage of Earl Richard de Clare (d. 1176) to Eva, daughter of Dermot Mac Murrough, king of Leinster, he was captured at Kildare and died of his wounds soon afterward, on April 16. The next earl, Gilbert, received fatal injuries in a tournament in 1241; Anselm (d. 1245), the last earl of the Marshal line, survived his brother, Earl Walter (d. Nov. 24, 1245), by less than a month, and was never invested with the earldom. The family's great estates in England, Wales, and Ireland were then divided among Anselm's five sisters and their descendants.

The earldom of Pembroke was revived for Henry III's favourite half brother, William de Valence (d. 1296), fourth son of Hugh X de Lusignan, count of La Marche, by his marriage with King John's widow, Isabella of Angoulême (d. 1246). William, with his brothers, Guy and Aymer, came to England in 1247 and he was married on Aug. 13 to Joan de Munchensy (d. 1307), a niece of Earl Anselm; her share of the Marshal lands included the lordship of Pembroke. He was one of Henry III's 12 representatives on the Committee of 24 which drafted the Provisions of Oxford (June 1258); later, his resistance to the Provisions resulted in his expulsion from England on July 14. He returned to England at Easter 1261. After the royalist defeat at Lewes on May 14, 1264, he escaped to France and his landing in the lordship of Pembroke in May 1265 began the campaign which led to De Montfort's death at the Battle of Evesham on Aug. 4. His loyalty to the king was rewarded by grants of forfeited estates and in 1270 he accompanied the future Edward I on his crusade. He served in the Welsh wars of 1277 and 1282–83, and in 1279 was the king's representative when the Agenais was transferred to Edward I by Philip III of France. Although not formally created earl of Pembroke, he was sometimes styled as such in Edward I's reign and was summoned to Parliament as earl in 1295.

Aymer de Valence (d. 1324), William's third and only surviving son, was regarded as having succeeded to the earldom after the death of his mother, Joan, in 1307. He was one of the lords ordainers in 1310–11, but in 1312 he joined the court party and was Edward II's chief adviser until 1314. As leader of the baronial "middle party," he was again virtually head of the administration between 1318 and 1321. After the royalist victory at Boroughbridge in 1322, his influence was replaced by that of the Despensers. He died childless in 1324; his second wife, Mary of St. Pol (d. 1377) founded Pembroke College, Cambridge.

The next earl, Aymer's great-nephew, Laurence (1320–1348), Lord Hastings, was recognized by Edward III in 1339 as having inherited the lordship of Pembroke as a county palatine. His son, John (1347–1375), captured by the Spanish in the Battle of La Rochelle in June 1372, died shortly after being ransomed three years later. His son John (1372–1389), the last Hastings earl of Pembroke, died without issue while still a minor, and his titles became extinct.

After being held from 1414 to 1447 by Humphrey (1390–1447), duke of Gloucester, and subsequently by William de la Pole (1396–1450), 1st duke of Suffolk, the earldom of Pembroke was granted, probably on Nov. 23, 1452, to Henry VI's half brother, Jasper Tudor (*c.* 1431–1495), who became the leading supporter of the Lancastrian cause in Wales during the Wars of the Roses (*see* Tudor). His defeat at Mortimer's Cross on Feb. 2, 1461, opened the way for Edward of York to advance to London and dethrone Henry VI; in Edward IV's first Parliament in December 1461, Jasper was attainted and his earldom forfeited. The next holder of the title was Sir William Herbert (*c.* 1423–1469) of Raglan Castle, who was granted the lordship of Pembroke by Edward in February 1462; on Sept. 8, 1468, having defeated Jasper Tudor's raid into North Wales and captured the sole remaining Lancastrian stronghold of Harlech Castle, Herbert was created earl of Pembroke. He incurred the hostility of Richard Neville, earl of Warwick, and was executed, after the Battle of Edgecote, on July 27, 1469. His son, William Herbert (*c.* 1455–1491), received in 1479 the earldom of Huntingdon in exchange for that of Pembroke, which Edward IV conferred on his heir, the future Edward V. Jasper Tudor returned from exile to fight at Bosworth in 1485; on Henry VII's accession he recovered his earldom of Pembroke and soon afterward was created duke of Bedford; but as a result of his death without heirs in 1495 the earldom of Pembroke once more reverted to the crown. (T. B. P.)

Anne Boleyn (*c.* 1507–1536) was created marchioness of Pembroke on Sept. 1, 1532, shortly before her marriage with Henry VIII.

The title of earl of Pembroke was next revived in favour of Sir William Herbert (*c.* 1506–1570), whose father, Richard, was an illegitimate son of Sir William (d. 1467), 1st Herbert earl of Pembroke. His first wife, Anne Parr, was a sister of Catherine Parr who married Henry VIII in 1543. In January 1544 Sir William was granted the rich estates formerly belonging to Wilton Abbey. Appointed a governor to the young king Edward VI, Sir William helped to suppress the rebellion in Devon and Cornwall in 1549, and supported John Dudley, earl of Warwick (afterward duke of Northumberland), against the duke of Somerset. In October 1551 he was created Baron Herbert of Cardiff and earl of Pembroke. After Edward VI's death he did homage to Lady Jane Grey, but withdrew his allegiance in time to attend the proclamation of Mary I in London. Mary made him a privy councilor and he led her troops against the rebel Sir Thomas Wyat early in 1554. On the accession of Queen Elizabeth I Pembroke continued a member of the privy council and from 1568 until his death he was steward of the royal household. Imprisoned in September 1569 for having favoured a proposed marriage between Mary Stuart and the duke of Norfolk, he was quickly released. He died at Hampton Court on March 17, 1570.

His son Henry (*c.* 1538–1601) was president of the Council of Wales from 1586 until 1601 and in 1586 was a commissioner for the trial of Mary Stuart. He married in 1577, as his third wife, Mary Sidney, the famous countess of Pembroke (*q.v.*). He died at Wilton House on Jan. 19, 1601, and was succeeded by his son William (1580–1630). William was lord chamberlain of the royal household (1615–26) and lord steward (1626–30). He took a lively interest in colonial and trading projects and in 1609 was a councilor for the colony of Virginia. He was also a member of various companies established to discover the Northwest Passage. He was chancellor of Oxford University from 1617 to 1630, and when, in 1624, Broadgates Hall was refounded by Thomas Tesdale and Richard Wightwick, it was named Pembroke College after him. (For his identification by some Shakespearean commentators with the "Mr. W. H." of the dedication in the 1609 edition of Shakespeare's sonnets, *see* Shakespeare, William: *The Poems.*) He died without issue on April 10, 1630, and was succeeded by his brother Philip (1584–1650). Philip was for several years a favourite of James I and was created Baron Herbert of Shurland in the Isle of Sheppey and earl of Montgomery on May 4, 1605. He

was with Charles I at York as captain general of a regiment of horse during the Bishops' Wars of 1639 and 1640, but joined the Parliament before the outbreak of the Civil War. Later he was made governor of the Isle of Wight, and represented Parliament in negotiations with the king at Uxbridge in 1645, at Newport in 1648, and when Charles was surrendered by the Scots in 1647. For his services to the parliamentary cause he was voted a dukedom by Parliament on Dec. 1, 1645, and was elected to the House of Commons as a member for Berkshire in 1649. He died at Westminster on Jan. 23, 1650.

Philip's great-grandson THOMAS (*c.* 1656–1733), 8th earl of the second Herbert creation, commanded the trained bands of Hampshire and Wiltshire gathered at Chippenham to oppose the rebels led by the duke of Monmouth in 1685. After the flight of James II in 1688 and the landing of William of Orange, Thomas took to the prince at Henley-on-Thames an invitation signed by many peers and privy councilors. He, who formed the greater part of the collection of pictures at Wilton House, died in London on Jan. 22, 1733. His son HENRY (*c.* 1689–1750) was largely responsible for the erection of Westminster Bridge. Henry's great-grandson ROBERT HENRY (1791–1862), 12th earl, died without issue and the title passed successively to his nephews, GEORGE ROBERT CHARLES (1850–1895) and SIDNEY (1853–1913), the sons of Sidney Herbert, 1st Baron Herbert of Lea, half brother of Robert Henry. SIDNEY CHARLES HERBERT (1906–), the present earl, is a grandson of Sidney (1853–1913).

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PEMBROKE, MARY HERBERT, COUNTESS OF (1561–1621), "the subject of all verse," as she is called in a famous epitaph, was the sister to whom Sir Philip Sidney (*q.v.*) dedicated his celebrated *Arcadia,* and was herself a patroness of the arts and of learning. She was born at Ticknell Palace, near Bewdley, Worcestershire, on Oct. 27, 1561, the fifth child of Sir Henry and Lady Mary Sidney. In 1575 Queen Elizabeth I invited her to court, promising to have "a special care" of her, and in 1577 she married Henry Herbert, second earl of Pembroke; their sons, William and Philip, were the "incomparable pair of brethren" to whom Shakespeare's First Folio (1623) was dedicated. (*See* PEMBROKE, EARLS OF.)

After her marriage, Lady Pembroke lived mainly at Wilton House, near Salisbury, Wiltshire, becoming so well-known for her patronage of writers and scholars that, as John Aubrey says in his *Brief Lives,* "in her time Wilton House was like a college, there were so many learned and ingenious persons." Among them were Adrian Gilbert, the chemist and astrologer; Thomas Moffet, the physician, poet, and entomologist; and Samuel Daniel, the poet and historian, who was tutor to her sons. Others who praised her for her patronage of their art were Spenser, Drayton, Nicholas Breton, Thomas Watson, John Davies of Hereford, and William Browne of Tavistock, who wrote the epitaph on her.

After her brother's death in 1586, Lady Pembroke undertook the publication of his works and completed the verse translation of the Psalms of which he had left the first 43. She also translated Robert Garnier's tragedy *Marc-Antoine (Antonius)* and Philippe Duplessis-Mornay's *Discours de la vie et de la mort (A Discourse of Life and Death)* (both 1592) and made a most elegant version in *terza rima* of Petrarch's *Trionfo della morte.* She played the lute, and Thomas Morley dedicated to her his *Canzonets* (1593). Pious and gentle, generous and accomplished, she was the most admired, after the queen herself, of Elizabethan *femmes savantes,* and was fitly compared (in Breton's dedication to her of his *Pilgrimage to Paradise,* 1592) with the duchess of Urbino, patroness of Baldassare Castiglione; in the chorus of contemporary praise, there is not once a discordant note.

Lady Pembroke died in London on Sept. 25, 1621, and was buried in Salisbury Cathedral.

See F. B. Young, *Mary Sidney, Countess of Pembroke* (1912); J. Buxton, *Sir Philip Sidney and the English Renaissance,* 2nd ed. (1964). (E. J. M. BR.)

PEMBROKE, RICHARD DE CLARE, 2ND EARL OF (*c.* 1130–1176), known as "Strongbow" and usually styled earl of Striguil, son of Gilbert de Clare, 1st earl, succeeded to his father's estates in 1148 but had forfeited or lost them by 1168. Probably in that year Earl Richard agreed to help Dermot Mac Murrough, king of Leinster, who had been driven from Ireland in 1166 and had gained permission from Henry II to raise forces in Britain. Dermot in return promised Richard his daughter Eva in marriage and the succession to the kingdom of Leinster. Richard, some of whose vassals had gone on ahead, crossed to Ireland probably in 1170. He took Waterford and Dublin and married Eva. The death of Dermot, in May 1171, provoked a general rising and Richard was besieged in Dublin by the king of Connaught (Connacht) for almost two months. Meanwhile Henry II became uneasy at his vassal's success; Richard crossed to England to meet him and agreed to surrender Dublin and the other coastal towns and to do homage for the remainder of Leinster. He returned to Ireland with Henry in October 1171.

In 1173 Richard went to Normandy to help Henry II against the rebels of 1173–74. He was at the relief of Verneuil in August 1173. Henry probably made him constable of Gisors, and rewarded his loyalty with the grant of Wexford and the custody of Waterford and Dublin. Later Henry committed the whole of Ireland to his care. Richard unsuccessfully invaded Munster in 1174, but his supremacy was eventually recognized in Leinster. He died in Dublin on April 20, 1176, and was buried in Holy Trinity Church (afterward Christ Church Cathedral). His son Gilbert de Striguil died unmarried, certainly before 1189, and as a minor was never styled earl. The earldom passed with Richard's daughter Isabel (d. 1220) to her husband William Marshal (*c.* 1146–1219).

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PEMBROKE, WILLIAM MARSHAL, 1ST EARL OF (*c.* 1146–1219), *rector regis et regni* (governor of the king and of the kingdom) during the first years of Henry III's minority, was the fourth son of John (FitzGilbert) the Marshal (d. 1165). As a youth he was in the household of William de Tancarville, chamberlain of Normandy, but in 1167 he passed into the service of his uncle, Earl Patrick of Salisbury, after whose death (1168) he entered the service (1170) of Henry Fitzhenry, the young king. From about 1187 he was in the service of Henry II, who promised him for wife Isabel (d. 1220), heiress of "Strongbow," Richard de Clare, earl of Striguil or Pembroke. She was later granted to him by Richard I. Occasionally termed earl during Richard's reign, he seems not to have been formally recognized as such until King John's coronation (May 27, 1199). He succeeded his brother as marshal of England in March 1194. William Marshal, regarded as the foremost knight of his time, by whom the young king chose to be knighted, had a predominantly military career. But he was one of the four barons who, with William Longchamp, bishop of Ely (superseded in October 1191 by Walter of Coutances, archbishop of Rouen), were constituted a council of regency during Richard's absence on crusade, and he occasionally sat on the bench at Westminster. In the early years of John's reign he was continuously engaged in fighting, both in England and in Normandy and Gascony, but from 1207 to 1213 he was mostly in Ireland administering the vast lordship of Leinster which his wife had brought him and which he seems not to have visited previously. He secured the adhesion (*c.* 1212) of the Irish barons to a declaration supporting John in his quarrel with Innocent III, and after his return to England (April 1213) he consistently supported the king and was with him at Runnymede in June 1215.

On John's death (October 1216) William Marshal was appointed guardian (*rector*) of the king and the realm and, together with the papal legate who represented Henry III's feudal superior, Honorius III, he was the virtual ruler of England. He pursued a policy of conciliation and moderation. Magna Carta was reissued (1216 and 1217), shorn of the obnoxious clauses directed against the late king. After his defeat of Louis of France and the dissident

barons at Lincoln (May 20, 1217), and the defeat off Sandwich (August 1217) of a French fleet bringing reinforcements, the Treaty of Kingston was concluded (Sept. 12, 1217). Louis withdrew, a general amnesty was granted, and the normal machinery of government was restored. The extent of William's participation in the administration between 1217 and 1219 is uncertain, though he did not relinquish control. He was, however, feeling the weight of years, and he died at Caversham, Berkshire, on May 14, 1219.

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PEMBROKE, a municipal borough in Pembrokeshire, Wales, comprises the two towns of Pembroke and Pembroke Dock, 1½ mi. apart, on the southern banks of Milford Haven 42 mi. (68 km.) W of Swansea. Pop. (1961) 12,737; Pembroke *c.* 4,500, Pembroke Dock *c.* 8,300.

Pembroke town, now primarily an agricultural and tourist centre, was incorporated by royal charter in 1090 and was once a walled town. Parts of the walls and some of the towers are still standing. The town is built on a limestone ridge around the long Main Street, at the western end of which is the castle. Surrounded by the tidal waters of the Pembroke River on the western and northern sides, the castle was originally a fortress. It was built by Arnulf de Montgomery in 1090, and in the 12th and 13th centuries it was enlarged by the earls palatine of Pembroke who made it their chief seat. Henry VII was born there in 1457. The castle's main feature is the circular vaulted keep built *c.* 1200 by William Marshal, earl of Pembroke, which is 75 ft. (23 m.) high, with walls 19 ft. (6 m.) thick at the base. The Church of St. Nicholas, known as Monkton Priory, was given by Arnulf de Montgomery to the abbey of Sées in Normandy in 1098 and became established as a Benedictine priory. The church was fully restored in 1882. Of the priory buildings the Old Hall and dovecote remain. St. Mary's Church, with a massive Norman tower, was founded in 1260.

Pembroke Dock, primarily industrial, was built as a result of the establishment of a royal dockyard in 1814 on the banks of Milford Haven. The town became a garrison town and still retains a military barracks. The dockyard closed in 1926, and the major part of the yard was handed over to the Royal Air Force in 1931 and used as a flying boat base until 1959. The Royal Navy still retains a small base in part of the old dockyard. Pembroke's main industries are ship-repairing, light engineering, and a woolen mill. (R. D. L.)

PEMBROKESHIRE (SIR BENFRO), the most westerly county of south Wales, is bounded northeast by Cardiganshire, east by Carmarthenshire, south by the Bristol Channel, and west and northwest by St. Bride's Bay and Cardigan Bay of St. George's Channel. The coastline is much indented and more than 160 mi. (257 km.) in length. The geographical area is 614.3 sq.mi. (1,591.0 sq.km.). Pop. (1961) 93,980.

From Haverfordwest (*q.v.*), the county town and main marketing centre, no fewer than ten roads radiate to all parts of the county. Fishguard and Milford Haven have the two most westerly railway termini in Wales. St. David's, nominally a city by possession of a cathedral, is in fact no more than a small village.

Physical Features.—Much of the county consists of undulating or hilly pasture land, the highest ground being in the north, where the Prescelly Hills (Mynydd Preseli) reach 1,760 ft. (536 m.). There are numerous streams, but the only rivers of importance are the East and West Cleddau, whose estuaries merge about 4 mi. (6 km.) SE of Haverfordwest and extend south to Milford Haven, thus severing direct communication between the Pembroke peninsula and the rest of the county. There are magnificent cliffs along the south coast, gray Mountain Limestone alternating with Old Red Sandstone. The long, narrow inlets represent drowned valleys and there are many sandy bays. There are submerged forests in the vicinity of Amroth. The north and south arms of St. Bride's Bay are prolonged by groups of small islands, of which Skokholm, Skomer, and Grassholm are well-known breeding places of seabirds. The islands are protected, and the Council for the Promotion of Field Studies has established a centre at Dale Head, inside the northern entrance to Milford Haven.

The region falls naturally into an upland northern section of older rocks and a lowland southern section of somewhat newer rocks. In the north the rocks range from Precambrian near St. David's to the Ordovician and Silurian, forming the mass of the Prescelly Hills. The general strike of the beds is southwest to northeast. From the Carmarthenshire border westward the rocks of the northern section of the county become older and older—Silurian, Ordovician, Cambrian, and finally Precambrian granitic and volcanic rocks near St. David's. As the rocks get older to the west, the elevation of the hills becomes reduced, terminating on the coast in numerous headlands, islands, and bays.

The rocks of the north and west are interspersed with igneous material such as the gabbros and diabases of Strumble Head, Fishguard, Llanwnda, and Prescelly; diorites northwest of St. David's, bostonites and porphyrites about Abercastle, and the basaltic laccolite of Pen Caer, besides various contemporaneous acid lavas and tuffs. The Ordovician and Silurian rocks extend southward to the neighbourhood of Narberth and Haverfordwest. Silver-bearing lead has been mined at Llanfrynach. The southern plain is open to the sea and may be looked upon geologically as a continuation westward of the south Wales coalfield, with associated Lower Carboniferous, Old Red Sandstone, and narrow belts of Silurian rocks, the whole having been considerably folded and faulted, producing a general northwest to southeast strike. The Coal Measures, highly inclined and anthracitic, stretch across from Carmarthen Bay to the shore of St. Bride's Bay; they are bordered on the north and southeast by the Millstone Grits, Carboniferous Limestone series, and Old Red Sandstone. Because of folding, the limestone appears again farther south of Pembroke, Caldy Island, and St. Gowan's Head, most of the remaining ground about Milford Haven being occupied by Old Red Sandstone with infolded strips of Silurian.

Antiquities, History, and Architecture.—The outstanding feature of the early history of Pembrokeshire is its importance in Megalithic times. The northwestern section of the county (including the southern slopes of the Prescelly Hills) is especially rich in Megalithic remains—dolmens, alignments, standing stones, and stone circles. There are similar remains in the southern half of the county but they are not nearly so marked, as a group, as in the northwestern district. This wealth of Megalithic remains suggests that northwest Pembrokeshire had cultural relations with many of the northwest coastal promontories of Europe in the days when metal was beginning to be known in the West.

Interest in the Stone Circle culture in Pembrokeshire was increased when it was shown that the stones forming the inner circle at Stonehenge (*q.v.*) were derived from rocks in Pembrokeshire. There are the well-preserved dolmens of the Longhouse near Mathry and the Pentre Evan near Newport. The stone circle known as Parc-y-Marw near Fishguard is also well preserved.

The number of hilltop camps, presumably of Romano-British type and date, is important, especially guarding ways in from the coast, though actual Roman influence in the county, which was originally within the territory of the Demetae, is slight. It is probable that the hilltop camps continued to be occupied through the post-Roman centuries as the county suffered from raiders from over the seas. In Pembrokeshire, as in Ireland, the native cultures lived on uninterrupted by Roman influences, and Pembrokeshire was apparently invaded by the Irish Deisi about A.D. 270. In those early centuries the county maintained its contacts with Ireland and Brittany and became a great centre of Celtic Christianity. Memorials of that period remain in the numerous church dedications and in the beautiful Celtic crosses such as those of Carew, Penally, and Nevern. Stones with Ogham inscriptions were found at Caldy Island, Bridell, St. Dogmaels, Nevern, Cilgerran, and other places.

The route that had linked Ireland, Pembrokeshire, Cornwall, Brittany, and northwestern Spain in Megalithic times became the route of the Celtic saints and, in the Middle Ages, an important pilgrim's way to the shrine of Santiago de Compostela in northwestern Spain (*see* A. Hartwell Jones, *Y Cymmrodor,* 1912). In a sheltered valley, at a focus of roads from small landing places on

the northwest coast of Pembrokeshire, was built the great Cathedral of St. David's (*q.v.*), soon to become a centre of pilgrimage, and at the landing places were built chapels for the pilgrims.

Pembrokeshire was known to the Welsh in those early times as Dyfed. On the death of Rhodri Mawr in 877, Dyfed fell nominally under the sway of the princes of Deheubarth, or south Wales; their hold was never very secure, nor were they able to protect the coast towns from the Scandinavian pirates. This is shown by the large number of Scandinavian place-names found in the coastal districts, especially near the southern coast. In 1092 Arnulf de Montgomery, son of Roger, earl of Shrewsbury, did homage to the king for the Welsh lands of Dyfed. With the building of Pembroke Castle, the Normans began to spread over southern Dyfed, while about the turn of the 12th century William Fitz Martin built Newport Castle, which became the *caput* of his extensive lordship of Kemes (Cemaes) between the Teifi River and the Prescelly Hills. Flemish settlers were planted in the hundred of Rhos, or Rhoose, in or about the years 1106, 1108, and 1111 with the approval of Henry I, and again in 1156 under Henry II. The castles of Haverfordwest and Tenby were erected to protect these aliens, and despite the fierce attacks of the Welsh princes their domain grew and their district became known as "Little England beyond Wales." In 1138 Gilbert de Clare was created 1st earl of Pembroke with the full powers of an earl palatine in Dyfed.

Examination of the medieval record shows a marked contrast between the *Englishery* of the south, with its compact villages and cultivation, and the *Welshery* of the north, with its scattered farms and tribal groups. The south was better populated than the north and maintained a closer contact with the affairs of the English plain; it was also the Norman stronghold and has long been famous for its medieval castles. The finest examples are to be observed at Pembroke; Manorbier, built in the 12th century and interesting as the birthplace and home of Giraldus Cambrensis; Carew, exhibiting many interesting features of both Norman and Tudor architecture; and Picton. Other castles are the keep of Haverfordwest and the fortresses at Narberth, Tenby, Newport, Wiston, Benton, Upton, and Cilgerran. There are remains of monastic houses at Tenby and Pembroke, but the most important religious communities were the priory of the Augustinian friars at Haverfordwest and the abbey of the Benedictines at St. Dogmaels. The latter, founded by Robert Fitz Martin in the 12th century, owned the priories of Pill and Caldy. Extensive ruins of the abbey exist near the left bank of the Teifi about one mile below Cardigan. Of the ancient preceptory of the Knights of St. John at Slebech scarcely a trace remains, but of the College of St. Mary at St. David's, founded by Bishop Houghton in 1377, the shell of the chapel survives.

Interesting examples of medieval domestic architecture are the ruins of the former episcopal mansions at Llawhaden, St. David's, and Lamphey, the two latter of which were erected by Bishop Gower between the years 1328 and 1347. The cathedral at St. David's is the greatest ecclesiastical monument in the county as well as in the principality. The nave dates largely from 1180–98, and the building was continued into the 13th century, added to in the 14th and 16th centuries, and restored in the 19th century.

The earldom of Pembroke was formally established as a shire by Henry VIII in 1536 and English law was imposed from 1542. Some parts of the county were for the king in the 17th century, though the influence of the Parliament grew as the castles of Tenby and Haverfordwest fell to the Parliamentary forces.

Population and Administration.—The administrative area of the county is 614.3 sq.mi. and the population in 1961 was 93,980. The municipal boroughs are Haverfordwest (pop. [1961] 8,872), Pembroke (12,737), and Tenby (4,752). There are four urban and four rural districts. The hamlet of Bridgend (*q.v.*) and a part of St. Dogmaels Parish are within the municipal limits of Cardigan. Newport (Trefdraeth), once the chief town of the barony of Kemes or Cemaes, was incorporated by Sir Nicholas Fitz Martin (*c.* 1210–82). Pembrokeshire has one court of quarter sessions and eight petty sessional divisions. It lies in the Wales and Chester circuit. From 1918 the county returned one member to Parliament. It is in the diocese of St. David's.

The Economy.—The county is mainly agricultural. Milk production is particularly important and there is a milk processing factory at Merlin's Bridge, Haverfordwest. The north is devoted more to storing cattle, while the Prescelly Hills are used chiefly for sheep rearing. Crops, grass, and rough grazings cover about four-fifths of the county, oats, wheat, and potatoes being the main crops. Early potatoes and turkeys are among the special products for which Pembrokeshire is well known.

Milford Haven (*q.v.*) is a deep-sea fishing port and also since 1960 a major oil port. In 1960 an oil refinery was constructed on the northern shore of the waterway to process about 5,000,000 tons of crude oil a year, and at another site a terminal was built for the yearly importation of a further 5,000,000 tons of crude oil to be pumped through a 60-mi. (97 km.) pipeline to a refinery at Llandarcy (Swansea). In 1964 another refinery was completed on the southern shore. In the same year plans were announced for a further refinery on the northern shore, a large oil-fired power station, and a bridge across the Haven near Pembroke Dock. The Milford Haven waterway is one of the finest natural harbours in the world.

Prior to the introduction of the new oil activities, industries were relatively small and mostly connected with agriculture, although some shipbuilding and repairing is carried on at Pembroke Dock and at Milford Haven. These two towns are the main industrial areas of the county. In 1958 the control of navigation was made the responsibility of a newly established Milford Haven Conservancy Board. Fishguard, on the north coast, is the port for passenger steamers to Rosslare in the Republic of Ireland. Since World War II Pembrokeshire has become increasingly popular as a tourist area, the chief centres of attraction being Tenby (*q.v.*) and smaller places around the coast such as Broad Haven, Little Haven, Newport, St. David's, Saundersfoot, and Solva. In 1952 the Pembrokeshire Coast National Park was established, comprising, as well as the coast itself, some inland areas covering 225 sq.mi. or about one-third of the county. In 1963 the National Trust owned 1,500 ac. and protected 2,397 ac. Skomer Island is a national nature reserve.

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PEMMICAN, a North American Indian (Cree) word for "journey meat" prepared in such a way as to contain a maximum of nourishment in a minimum of bulk. Thin slices of lean bison or venison were dried in the sun and then pounded to a powder, seasoned, blended with equal parts of melted fat, and packed in rawhide bags. The food thus prepared could be easily transported, kept indefinitely, and could be eaten without cooking. It could also be dissolved in a gruel, and berries or dried fruit could be added. Pemmican was adopted by Europeans, especially the French-Canadian *voyageurs*, for whom it sometimes formed the principal diet. A form of pemmican made from beef continued to be used by explorers into the early 20th century, when foods preserved by modern methods superseded it. (R. W. HD.)

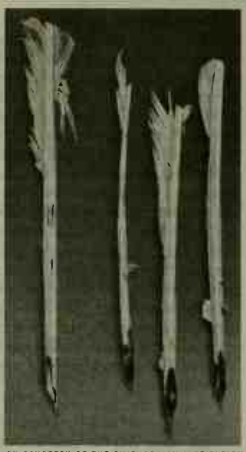
PEMPHIGUS: *see* SKIN, DISEASES OF.

PEN, an instrument for writing or for forming lines with ink or other coloured fluid. Although brushes, reeds, bird feathers and other materials have been used for making pens, there are only three modern types: (1) steel pen nibs; (2) fountain pens; and (3) ball-point pens.

Early Types.—The earliest writing implement probably was the brush, which the Chinese used in recording the history of their nation. The Egyptians made a reed pen from the calamus or arundo plants; hollow joints of bamboo also were used. A specific allusion to the quill pen occurs in the 7th-century writings of St. Isidore of Seville, but the quill pen probably was in use at an even earlier date. Quills were the main writing instrument until the middle of the 19th century and are still used occasionally (*see* FEATHER: *General: Uses of Feathers by Man*).

In 1809 Joseph Bramah of England devised and patented a ma-

chine for cutting the quill into separate nibs (points) that were slipped onto a holder for writing. In 1822 J. I. Hawkins and S. Mordan patented the use of horn and tortoise shell in making pen nibs, the points of which were made durable by small pieces of diamond, ruby or other very hard substance, or by lapping a small piece of thin sheet gold over the end of the tortoise shell.



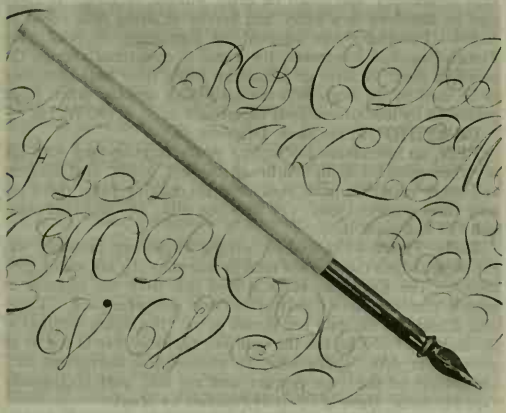
BY COURTESY OF THE SMITHSONIAN INSTITUTION

EARLY 19TH-CENTURY QUILL PENS FROM CONNECTICUT

Steel Pen Nibs.—Metallic pens, although known since the days of Pompeii, were little used until the 19th century and did not become common until near the middle of that century. Steel pens were handmade in France as early as 1748 and a Birmingham, Eng., split-ring manufacturer, Samuel Harrison, made a steel pen by hand for Joseph Priestley in 1780. Steel pens made and sold in London by a man named Wise in 1803 were of a tube or barrel design; the edges met to form the slit, while the sides were cut away as in the quill. In 1809 a patent was granted in the United States to Peregrine White on the slitting of metallic pens; these units also were handmade. Ordinary points were relatively expensive (about five shillings each) and, since they were hard, stiff and unsatisfactory, they were not in great demand.

John Mitchell of Birmingham, Eng., introduced machine-made pens in 1828, and James Perry is believed to have made the first steel slip pens. In 1830 Perry patented a design that provided greater flexibility because of a hole placed above the slit and branch slits cut on each side of the central slit. In 1831 an improvement consisting of an elongated point on the nib was described by Joseph Gillott. Steel pen nibs, after their retail price was reduced and they became available in various styles of point widths and flexibilities, soon became more popular than the quill.

In the early days steel pens were manufactured from rolled sheets of high-quality cast steel made from Swedish charcoal iron. These sheets, after being cut into strips of suitable width, annealed in a muffle furnace and pickled in a bath of sulfuric acid to free the surface from oxidized scale, were rolled between steel rollers until they were reduced to ribbons about $\frac{1}{140}$ in. thick. From these ribbons the pen blanks were punched out and after being imprinted with the name of the maker or embossed with other marks they were pierced with the central perforation and the side or shoulder slits. After another annealing the blanks, which up to this point had been flat, were raised or rounded between dies into a semicylindrical shape. The next process was to harden and temper the pens by heating them in iron boxes in a muffle furnace, plunging them in oil and then reheating them over a fire in a rotating cylindrical vessel till their surfaces attained the dull-blue tint characteristic of spring steel. Subsequently they were scoured in a bath of dilute sulfuric acid and polished in a revolving cylinder. The points were then ground with emery and the central slit was cut by two fine-edged cutters. Finally the pens were polished again and coloured by being heated over a fire in a rotating cylinder and in most cases were coated with a varnish of shellac dissolved in alcohol.



STEEL PEN NIB WITH WOODEN HOLDER

In the modern process long coils of high-carbon pen steel (equivalent to watch spring steel) are produced in the steel mills for the various manufacturers. Use of this type of steel made possible the employment of high-speed automatic presses in the various blanking, piercing, marking, forming, grinding and slitting operations. These coils are available in many thicknesses from less than that of a sheet of paper (.0020 in.) for making superfine mapping pens to .0150 in. for very rigid points used in carbon and manifold work. Modern methods also utilize completely automatic and atmosphere-controlled furnaces that eliminate the need for scouring. Increasing quantities of pens are plated with metal alloys that give them a silverlike finish and increased resistance to the ink acids and atmospheric conditions.

The first steel pen company in the U.S. was established at Camden, N.J., by Richard Esterbrook, Jr., in 1858, but local manufacturing did not begin there till early in 1861. Five craftsmen were brought from Birmingham, Eng., three of whom had worked for John Mitchell. Although Birmingham was the principal centre of the industry for many years, the U.S. company eventually became the largest producer of steel pens in the world. After World War I other companies began manufacture in the Camden area and the centre of production shifted there from Birmingham.

Metals other than steel—gold, silver, zinc, nickel silver, brass, aluminum, aluminum bronze and titanium—have been suggested in the making of nibs. In 1926 pens made from stainless steel were introduced; these pens are highly resistant to the acids and alkalies in writing inks and do not tarnish under extreme climatic conditions. (E. B. Ha.)

Fountain Pens.—In this pen a quantity of writing fluid is contained in a reservoir in a holder, the fluid communicating with the writing point or nib through a series of capillary channels called a feed. The nib extends from one end of the holder and is covered with a cap when the fountain pen is not in use.

Although crude prototypes were introduced much earlier, the fountain pen did not become popular until L. E. Waterman of New York introduced the first practical fountain pen in 1884. After that time millions of fountain pens were produced and sold each year.

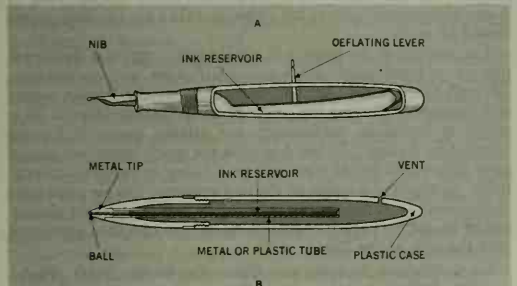
The writing point of the fountain pen is generally made in various point gradations ranging from a needlelike point to one that produces a line about $\frac{1}{16}$ in. in width. About 90% of the nibs sold are in the fine and medium gradations. A full assortment includes the following types: accountants, extra fine, shorthand, fine, medium coarse, stub, broad stub, italic stub, left oblique, right oblique and music points. Nibs also are produced in various degrees of flexibility ranging from manifold to flexible, the manifold being a rigid point and the flexible one bending with the least amount of pressure for shaded writing such as the copperplate or Spencerian forms of penmanship. In the 1930s a fountain pen with a detachable, renewable point was introduced.

Because of the expected long life of a fountain pen, a metal highly resistant to the corrosive action of writing fluids is used for the nibs; the most popular metals for points are stainless steel and 14-carat gold. Because these materials are relatively soft, the portion of the nib that contacts the writing surface is provided with a relatively hard tipping material, *e.g.*, an alloy of metals of the platinum group, in order to resist wear and thus obtain a long life.

The feed for controlling the movement of the writing fluid is made of plastic or hard rubber and underlies and, in most instances, supports the nib. Air and writing-fluid channels in the feed communicate between the reservoir in the holder and the nib, fluid from the reservoir moving down the fluid channels to supply the nib as air moves up the air channel to take the place of the fluid in the reservoir. These channels are of capillary dimensions, and the balance of pressures outside and inside the reservoir holds the fluid in the reservoir and overcomes the force of gravity. This balance is broken in writing when the cells of the paper or other writing surface draw fluid from the slit in the nib, the slit being supplied from the fluid channel of the feed.

Since the reservoir is seldom completely full of fluid, it frequently contains air. Changes in temperature and air pressure cause the air in the reservoir to expand or contract; some pens are equipped with threaded caps that offset these effects by creating an air seal. Care should be exercised when releasing the seal under extreme conditions of temperature or pressure; *e.g.*, at high altitudes the ink may run out of the reservoir because of the reduced air pressure. In all normal circumstances when the pen is held in a writing position, the air is behind the fluid and helps force it out of the reservoir. Comb cuts in the feed accommodate excess fluid. Continued writing uses the oversupply in the comb cuts before fluid again is drawn from the reservoir.

The filling of the reservoir, which was performed manually with an eye dropper in early fountain pens, is done in several different ways in modern pens. The flexible rubber-sac type of reservoir is deflated mechanically or pneumatically; upon release of the deflating means (*e.g.*, a lever), the sac inflates because of its own resiliency and fills by suction when the nib is immersed in writing



(A) CUTAWAY VIEW OF FOUNTAIN PEN WITH LEVER IN POSITION FOR FILLING INK SAC; (B) CROSS SECTION OF A BASIC BALL-POINT PEN

fluid. In another common type the bore of the holder is the reservoir and the movement of a piston fitted to the bore creates a suction that fills the bore as the nib is immersed in writing fluid.

Also in use are plastic ink-filled cartridges that can be discarded when emptied. When a cartridge is placed in the holder and screwed into place, a bore pierces the cartridge and forms a channel for the ink to flow to the nib.

The holder, once made of vulcanized rubber, is now usually made of a plastic. The plastic materials are structurally stronger than rubber. Several plastics are used, depending on the quality of the product or the facilities of the manufacturer. The plastic holders at first were drilled from solid rods. Later they were wrapped into cylindrical form from sheet material and still later were molded from plastic molding powders.

Ball-Point Pens.—In this type of pen a ball housed within a socket in the tip transfers a viscous ink from a reservoir onto the writing surface. Patents on ball-point pens date back to the late 1800s; commercial models appeared as early as 1895. The first workable ball-point pen was patented in 1937 by Laszlo Jozsef Biro, a Hungarian living in Argentina. His pen became popular in Great Britain during 1938 and 1939, and by about 1944 the ball-point pen had gained world-wide acceptance. The impetus for acceptance in the U.S. was supplied by the quartermaster general of the U.S. army, who had requested a writing instrument that would not leak in high altitudes, would use a quick-drying ink unaffected by climatic changes and would contain a supply of ink large enough to last a considerable length of time.

The ball-point pen usually comprises a holder for containing a replaceable writing unit, although in some models the holder itself is the writing unit and is discarded after the ink is used up. In all cases the writing unit consists of a metal tip having at the point a socket that contains a ball. The lip of the socket is constructed so that the ball cannot fall out yet can rotate freely when in contact with the writing surface. The inner construction of the socket is such that the ball is constantly bathed in ink from a reservoir.

Ball-point-pen inks are highly specialized materials. They are viscous liquids having either oil- or spirit-soluble dyes. The type of ink containing the oil-soluble dyes dries by absorption into the paper or other writing surface, while the type of ink containing the spirit-soluble dyes dries by evaporation.

The ink reservoirs of ball-point pens are of two types. One comprises a flexible, synthetic resin sac housed in a metal shell and the other a metal or plastic rigid tube, one end of which is open and is attached to the writing tip. The ink capacity of ball-point-pen reservoirs generally ranges from 0.5 to 1.5 ml. The tube of the 0.5-ml. reservoir is open at both ends; the viscosity of the ink prevents its leaking out. The 1.5-ml. reservoirs, however, require a vented plug and the use of a second more solid but still viscous material known as a follower. The follower is solid enough to prevent back-end leakage but is liquid enough to follow the ink down the tube as it is used.

At one time most of the balls used were steel ball bearings; in some instances synthetic sapphire balls were used. Later, tungsten carbide became the major material in high-quality ball-point pens. Most manufacturers use a ball 1 mm. in diameter, although a few special-purpose pens use larger or smaller balls.

See also DRAWING (TECHNIQUES OF); CALLIGRAPHY; INK; PEN DRAWING. (F. L. KG.; E. B. HA.)

PENANCE, that repentance or sorrow for sins which in the Christian revelation is a requisite for salvation: "Unless you repent, you will all perish" (Luke 8: 5). In Roman Catholic usage penance has a threefold meaning: first, interior repentance, a disposition of mind and will which includes both sorrow for past sins and a purpose of amendment for the future; second, the sacrament of penance, a religious rite in which, after confession of sins and an act of interior penance, the sinner receives divine forgiveness through the absolution of the priest; finally, the word designates penitential works, either those imposed on the penitent by the priest in the sacramental rite, or those performed voluntarily by a repentant sinner, as a form of satisfaction to God for past sins and a manifestation of interior repentance. *See* CONFESSION; SACRAMENT: *see* also references under "Penance" in the Index.

PENANG, the name of an island and of one of the Malayan states within the federation of Malaysia. The island lies off the northwest coast of Malaya, separated by a strait whose smallest width is 2½ mi. (4 km.). Its area is about 113 sq.mi. (293 sq.km.) and it is tortoise shaped, with a granitic, mountainous interior (highest point 2,428 ft. [740 m.]) and narrow coastal plains, most extensive in the northeast where Malaya's chief port, George Town (*q.v.*; often called Penang), uses the sheltered harbourage of the strait.

Since 1957 Penang Island together with Province Wellesley on the mainland has formed a state with an elected local government headed by a governor. The latter is appointed by the supreme ruler of the federation after consultation with the chief minister. The total area of the state is 398 sq.mi. (1,031 sq.km.) and the population (1961 est.) was 642,221. The state is the successor of a British colony founded in 1786 by Capt. Francis Light who secured an agreement from the sultan of Kedah to cede the territory to the East India Company. At that time the island, called Prince of Wales Island until after 1867, was virtually uninhabited and had ready access to Calcutta and Madras, with shelter and water for sailing vessels. It was also isolated from the restless, squabbling peoples on the mainland. Penang flourished as a port of call for shipping on the India–China run, quickly attracting a

cosmopolitan population of Chinese, Indians, Sumatrans, and Burmese, and rapidly surpassing any other trading post in western Malaya. From the mid-19th century Penang was a point of transit for immigrants to the mainland and a market for the tin miners of Perak, from which it developed into the chief port for the northern sector of the west Malayan tin and rubber belt. Malay influence, tradition, and economic life almost disappeared, and Penang remains predominantly Chinese by race and European in manner and economic outlook.

While the harbour was surpassed by Singapore, as the southern end of the peninsula was developed, Penang's decline was proportional rather than actual and it is still Malaya's chief outlet, usually handling twice as much oceangoing shipping as Port Swettenham and dealing with around one-fifth of the total Malayan seaborne trade. The island's rural population (39,000) grows vegetables and fruit for the urban market and there are rubber smallholdings in the foothills. A few Malays, both of immigrant Sumatran stock and from the peninsula, produce a little rice and fish, particularly toward Balik Pulau on the southwest. During the alternating seasons of northeast and southwest winds, the incidence of rain is affected by the "shadow" of the hilly interior. In George Town rainfall averages 105 in. annually with maxima in October and May, no month having less than 3 in. Mean monthly temperatures at the coast are 27° C (80° F) and the drop of about 6° F on the crest of Penang Hill attracts tourists, though, despite a cable railway to the top, nothing comparable to the hill stations of India has developed. A coast road about 75 mi. (121 km.) long encircles the island. An airport at Bayan Lepas on the southeast corner has domestic services to Kuala Lumpur and Kota Bharu and air links to Singapore, Medan in Sumatra, and Bangkok, Thailand.

Province Wellesley, the mainland part of Penang State, has a different character physically and economically and is continuous with the west Kedah plain on the one side and the tin and rubber belt on the other. It carries more than 35,000 ac. (14,100 ha.) of paddy worked by Malays, market gardening by Chinese farmers, and nearly 55,000 ac. (22,000 ha.) of rubber worked by Chinese and Indians. In area and population the mainland district is bigger than the island and has a productive rather than a trading economy. It exports about 6,000 tons of rubber annually from George Town and its 15,000 tons of rice are consumed locally. The shallow meandering streams, often flanked by nipa swamps, impede overland transport and the shallow waters hinder coastal approaches, a heavy longshore drift from the north tending to silt up the piers and harbour works; yet Province Wellesley is an important focus of land and sea transport for the overseas trade of Penang. Arterial roads from Kedah and Perak bring rubber, copra, and tin ore to Butterworth, the ferry point for George Town. South of Butterworth and separated from it by a muddy estuary is Prai, the terminus of a branch of the Malayan railway, which has its own passenger and goods ferry to Penang. From Prai, the railway runs inland to the market town of Bukit Mertajam from where the line runs north through Kedah to Thailand and south to Ipoh, Kuala Lumpur, and Singapore. Butterworth, though overshadowed by George Town, also has Malaya's chief oil-importing facilities and the most modern tin smelter. Butterworth and Prai are open settlements and tend to merge; they are dominated by Chinese and Tamils, though the province has a large Malay rural population. (E. H. G. D.)

PENARTH, an urban district in Glamorgan, south Wales, is situated around a promontory about 200 ft. (61 m.) above sea level, 5¼ mi. (8½ km.) S of Cardiff by road. Pop. (1961) 20,897. Bounded on the east by the Bristol Channel, the headland is dominated by the saddleback tower of St. Augustine's Church, a well-known landmark for sailors. The Turner House Art Gallery exhibits art collections of the National Museum of Wales.

Penarth is a popular seaside and residential town with well-laid-out parks and treelined streets, pier, and esplanade. Pleasure steamers provide a frequent service to Bristol Channel resorts. Air services operate from Cardiff (Rhoose) Airport.

Local industries include the production of precast concrete products, bricks, and wood joinery. (H. M. Jo.)

PENATES, the household gods of the Romans and other Latin peoples, more properly *di penates*. Strictly speaking they were gods of the *penus*, "storeroom," or the *penetralia*, the innermost part of the house, but by extension their protection reached the entire household. They are associated with other deities of the house: Vesta (*q.v.*), the goddess of the hearth, and particularly the lares (*q.v.*), with whom they are often named interchangeably. They cannot be identical, however, for the penates, unlike the lares, are never referred to in the singular. The penates are thus all or some specific group of deities with household connections. Their number and precise identity were a puzzle even to the ancients. Thus Jupiter, Juno, Minerva, Neptune, Apollo, and others (besides Vesta and the lares) are reckoned at times among their number.

The penates were worshiped privately as protectors of the individual household and also publicly as protectors of the Roman state. Each house had a shrine, however simple, with images of them that were worshiped at the family meal and on such personal occasions as birthdays and other anniversaries of special events. Offerings were of portions of the regular meal or of special cakes, wine, honey, incense, and more rarely a blood sacrifice. The state as a whole worshiped them as the *penates publici*, about whom there were various opinions of nature and origin. There was a tradition connecting them with the "great gods" of the Samothracians (*see* CABEIRI) as well as the tradition, followed by Virgil in the *Aeneid*, that Aeneas brought them from Troy. A conflation of these two has the Samothracian deities introduced first at Troy and subsequently brought by Aeneas to Latium. The connection with the Cabeiri explains their further association with Castor and Pollux (*q.v.*), with whom they were popularly assumed to be identical. Indeed, their cult statue in the temple on the Velia in Rome represented them as the twins, and they are similarly represented on coins.

The worship of the penates in a state cult occupied a significant role as a focal point of Roman patriotism and nationalism. Through the republic the chief magistrates of the Roman people and commanders taking the field offered special sacrifices at their shrine at Lavinium, traditionally the original shrine in Latium founded by Aeneas. In the Augustan era much stress was placed upon the revival of the state cult as a factor in creating national unity, loyalty, and support of the new regime. The personal gods of the house of Augustus (*i.e.*, the Julian *gens*, which had already traced its origins back to Aeneas himself) became thus associated with the gods of the Roman state.

See G. Wissowa, *Religion und Kultus der Römer* (1912); Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft.* (R. B. Ld.)

PEN-CH'I (also known as PENKI), industrial centre of Liaoning province, China, in southern Manchuria, 40 mi. (64 km.) SE of Mukden, on the railroad leading to North Korea. Pen-ch'i, originally known as Penchihu or Penhsihu, is a steel-smelting centre based on local coking-coal and iron-ore deposits. The steel plant was founded in 1915 as a mixed Chinese-Japanese enterprise but passed subsequently to full Japanese control. Pen-ch'i iron ore, mined south of the city, is low in phosphorus and sulfur and is suitable for special steels, which are smelted at Pen-ch'i in Bessemer converters and electric furnaces. Coking coal is mined along the valley of the T'ai-tzu Ho east of the city. Pen-ch'i also produces cement and refractories. In the 1953 census, when the city limits included the iron- and coal-mining districts, the population of Pen-ch'i was 449,000. (T. Sp.)

PENCIL, a solid rod of graphite or other marking material enclosed in a wooden case or other type of holder and used primarily for writing or drawing.

History.—During the Middle Ages paper was marked with inks using a brush called a *penicillus* (Latin for "little tail"), from which comes "pencil." *Pinsel* in modern German means a "brush" and has never been used for lead pencil; the German *Bleistift* for "pencil" translates literally as "lead pin," or "lead pencil." A rod made of lead and tin alloy and called a silverpoint tool (*see* PENCIL DRAWING) was used by Albrecht Dürer in the early 16th century; marks made with this instrument were erased with bread.

Konrad von Gesner in *De omni rerum fossilium genere* (1565) first described a writing article in which graphite was inserted into a wooden holder.

The modern lead pencil was made possible by the discovery in 1564 of an unusually pure deposit of graphite (*q.v.*) in Borrowdale, Cumberland, Eng. According to tradition, the mine was found when a large oak tree was uprooted by a storm. Graphite was then thought to be a type of lead and consequently was called black lead or plumbago. Gesner was the first to describe it as a separate mineral, calling it *stimmi anglicanum*, or English antimony. Carl Wilhelm Scheele in 1779 showed it was a form of carbon, and Abraham G. Werner in 1789 gave it the name graphite, based on the Greek *graphein*, "to write."

The black lead from Borrowdale was first used in chunks called marking stones; later, shaped sticks of the graphite were wrapped with string and unwound from one end as needed. Pieces were also pushed into tubes and later were held in the claws of metal holders called *porte-crayons*, or portcrayons; these were the forerunners of the mechanical (propelling) pencil.

Graphite from the Borrowdale mine, which was operated as a crown monopoly, was of such high quality that as long as the supply lasted it could be used in its native condition. However, as the graphite became scarcer, methods were sought for binding graphite dust into usable shapes with gums, resins, glue and other adhesives. Later, natural graphites were discovered in Bavaria, Mexico, Madagascar, Ceylon and Korea. The first graphite composition pencil was made at Nürnberg, Ger., in 1662, where Kaspar Faber (*see* FABER) established his pencil-making business in 1761. The mixture that came closest to matching the writing qualities of pure graphite consisted of one part sulfur to two parts graphite. Graphite shapes glued to fir or cedar were described by J. Pettus in 1683; manufacture of this type of pencil was begun in Britain by T. and R. Rowney in 1789.

Late in the 18th century, when imports into France were cut off by warfare, Napoleon Bonaparte commissioned Nicolas Jacques Conté (*q.v.*) to develop a substitute for imported pencils. In January 1795 a French patent was issued to Conté for a pencil lead-manufacturing process that was the forerunner of the modern process. He mixed clay and graphite with water and pressed the paste into grooves in wood to dry. The dried leads were then baked in a kiln to fire the clay. In Vienna at about the same time, Joseph Hardtmuth achieved the same results and by varying the clay content varied the hardness of the leads. In 1839 Johann Lothar von Faber of Nürnberg improved the Conté process by extruding the paste through a die and introducing machinery that cut and grooved the wooden slats that enclosed the leads to form a pencil.

The first copying lead was made by Karl Puscher in 1857. Leads of this type contain a dyestuff and are not fired.

In the United States Joseph Dixon (*q.v.*) started manufacturing pencils at Salem, Mass., in 1827. A man named Wood, the associate of another early manufacturer, William Monroe, is credited with using the first machinery to manufacture pencils. In 1876 Dixon's company introduced lead with a round, rather than square, cross section. Meanwhile, in Britain, varnished pencils were introduced by George Rowney and Co. in 1846.

In the 1930s methods were developed for bonding the lead securely to the wood casing and thereby increasing the resistance to point breaking.

Erasers.—The *Proceedings* of the French Academy for the year 1752 reported that a man named Magellan proposed the use of caoutchouc as a replacement for bread crumbs in erasing black lead marks. Joseph Priestley, the English chemist, is credited with applying the name "rubber" to caoutchouc in 1770 since it was being used to rub out marks. The modern eraser is essentially a mixture of vulcanized vegetable oil (factice), fine pumice and sulfur bonded with rubber. The mix is processed, extruded and vulcanized in rubber-processing equipment. The first patent on an integral pencil and eraser (U.S. pat. no. 19783) was issued to Joseph Rechendorfer of New York on March 30, 1858.

Mechanical Pencils.—Mordan and Hawkins have been credited with introducing the mechanical pencil in 1822. Alonzo T. Cross made a mechanical pencil in 1868 and a mechanical pencil holding a lead of large diameter was patented June 26, 1877. The lead in the 1877 invention was held by spring-loaded jaws on a principle similar to that used in modern pencil holders used by draftsmen. Mechanical holders in which small-diameter leads were propelled by twisting the body appeared in 1895. The leads were of various diameters at first but eventually leads 0.046 in. in diameter became more or less standard. In 1938 lead 0.036 in. in diameter was introduced. In the 1950s ball-point pencils became available; these differed from ball-point pens in that the marking could be erased.

The use of mechanical holders for drafting leads was increasing in the second half of the 20th century and the screw-tightened chuck largely gave way to spring-loaded jaws, which were operated by pushing the top of the holder. While many patents have been granted on mechanical pencils, the two most popular designs have been: (1) the split collet type, in which the lead is propelled by a screw; and (2) the propel-repel-expel type, in which the lead is forced at the top end into a split cup that is moved forward and backward by a screw while the lead protrudes loosely through a bored tip at the writing end.

Coloured Leads.—Coloured leads are made with either water-soluble or water-insoluble pigments. Both kinds of lead are essentially a mixture of colouring material, filler, lubricant and binder. The filler frequently is clay or talc, the lubricant is a fatty acid and/or a wax or waxlike material and the binder is either a natural gum (*e.g.*, tragacanth), a man-made gum or a cellulose ether (synthetic resins also are used to a limited extent). The function of the binder is to give mechanical strength. Copying leads are made of pigment and binder, while indelible leads are essentially methyl violet, graphite and binder. The general practice is to make a well-mixed dough of the ingredients, extrude the lead through a die and dry the wet strands.

Method of Manufacture.—The method generally used in the manufacture of black lead pencils is as follows:

Ball clay and natural graphites (sometimes wet-ground together) are thoroughly mixed with water and dispersing agents to produce a stiff dough. The mass is packed solidly into the cylinder of an extrusion press and the dough is forced through a small hole in a die made from diamond, sapphire, agate or cemented carbide. The tough, pliable, wet strands are cut to pencil length, dried and then fired while packed in a sagger in a kiln. Firing temperatures from 1,600° to 2,200° F. (about 871° to 1,204° C.) are used, with 1,900° to 2,000° F. (about 1,037° to 1,093° C.) being commonest. The brittle fired leads are then "waxed" by being impregnated with a lubricant (usually a mixture of fats and fatty acids with or without wax additions). After chemical treatment to remove excess wax from their surface, the leads are ready to be encased in the wooden sheath.

Leads to be used in wood casings are customarily extruded with diameters of between .070 and .170 in.; the softer leads are made with the larger diameters to offset their weaker strength and their greater rate of wear. Leads for mechanical pencils are usually extruded in diameters of .036 or .046 in.

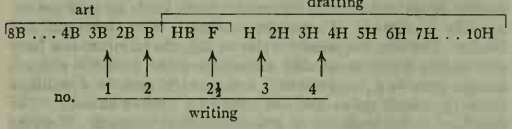
Wooden pencils are manufactured in an assembly operation. Two to nine parallel and evenly spaced semicircular grooves are cut in wooden slats that are 184 mm. long, 5 mm. thick and up to 65 mm. wide (about $7\frac{1}{4} \times \frac{1}{4} \times 2\frac{1}{2}$ in.). Leads of the same diameter as the grooves are sandwiched in the grooves of two matching slats, to which an adhesive has been applied, and the block is held under pressure until the adhesive sets. Hide glue was almost completely replaced with polyvinyl acetate emulsion adhesive in the 1940s. High-frequency electricity is sometimes used to set the glue rapidly (*i.e.*, in about 50 sec.).

The individual pencils are cut lengthwise from the glued blocks in high-speed rotary shaping machines; most pencils are either round or hexagonal with rounded edges. Pigmented nitrocellulose lacquers are then applied by pushing the pencils lengthwise through lacquer and wiping off the excess by passing the coated pencil lengthwise through a rubber gasket; the pencils fall on a moving belt, where they dry. From three to ten coats of lacquer are applied; the higher-quality pencils usually receive the most lacquer.

After the ends of the pencils are trimmed, the name and other identification is hot impressed from foil. If desired, a machine then tips the pencils by affixing a metal ferrule and an eraser plug on one end.

Quality and Hardness.—The quality of a wooden pencil depends chiefly on the quality and fineness of the graphites and clays used in the lead and on the quality of the cedar used to enclose the lead. Californian incense cedar (*Libocedrus decurrens*) is used in the better pencils; it has largely replaced red cedar (*Juniperus virginiana*) from Kenya and the eastern U.S., which was once used almost exclusively. The hardness of lead, which is independent of quality, is determined chiefly by the ratio of clay to graphite; the more clay, the harder the lead. The temperature of firing and the type of waxing exert a minor influence and must be controlled to attain uniformity of hardness in different batches.

Two systems are used for designating hardness. Drafting and artists' pencils range in designation from 8B, the softest, to 10H, the hardest. Hardness in writing pencils is designated by numbers ranging from 1 to 4; the range overlaps the ranges of both art and drafting pencils, which also overlap each other (*see* below).



The degree of hardness of a lead is a measure of how much the lead resists abrasion by the fibres of the paper being marked on; the greater the rate of wear, the softer the lead. The apparent blackness of the mark depends on the size of the small particles of the lead deposited on the paper. The particles are of the same blackness regardless of the degree of hardness; only their size and number determine how much of the paper will be obscured. The type of paper and the atmospheric humidity also influence the amount of lead abraded, as do the fineness of the lead point and the amount of writing pressure used.

Other Types of Pencils.—Many special types of pencils are made for special uses; *e.g.*, rectangular or square carpenter pencils whose shape facilitates marking with a guide and also prevents rolling if dropped. Another special pencil is the kind used for filling in blanks in examination answer sheets that are scored electrically; these leads conduct electricity. Other special pencils will mark on glass or can be used in offset printing. Yet others are made as cosmetics (*q.v.*).

See Clarence Fleming and A. L. Guptill, *The Pencil Since 1565* (1936); Erhard Sattmann, *Vom Faustkeil zum Bleistift* (1953).

(S. B. Se.)

PENCIL DRAWING. The common instrument used in pencil drawing is composed of graphite enclosed in a casing of wood (*see* Pencil). The cylindrical graphite pencil, because of its usefulness in easily producing linear gray-black strokes, became the successor of the older metallic drawing stylus with which late medieval and Renaissance artists and tradesmen sketched or wrote on paper, parchment or wood.

The silverpoint (silver stylus) was the favourite instrument for metal-point drawing or writing although styluses of lead or lead alloys were frequently used. Metal points containing lead could be used on the natural surface of paper or parchment, but the metal points of silver, gold, brass and bronze required that the drawing surface be covered with an applied ground. This ground, usually made with lead white and a binding solution of glue or gum arabic, was brushed over the surface and when dry provided the means by which the metallic tools produced strokes. The ground, either white or slightly tinted with the addition of a coloured pigment, in combination with the silverpoint provided a medium of very delicate and precise drawing. These characteristics, along with its fine linear effects, appealed to many of the great draftsmen of the late middle ages and Renaissance. Van Eyck, Dürer, Raphael and Leonardo were some of the outstanding masters who used the metal point antecedents of the graphite pencil.

The metal points of lead or lead alloys, because of the metallic reflections and slightly rougher texture of their dark gray strokes, were the most apparent forerunners of the pencil. This superficial similarity in the appearance of lead-point and graphite strokes led, in England, to an erroneous and widespread identification of the graphite pencil as a "lead pencil," a mistaken identification that is still common.

Although graphite was being mined as early as the 16th century, the utilization by artists of pieces of natural graphite, inserted in a *porte-crayon* (holder), has not been established in extant drawings produced before the 17th century. At that time minor graphite details were included in sketches, notably in landscape renderings by Dutch artists such as David Teniers the Younger and Aelbert Cuyp. During the 17th and most of the 18th century graphite served as a means of making preliminary sketch lines for drawings to be completed in other media. Exceptions were drawings completely finished with graphite, as in the case of a few 18th-century works by Thomas Gainsborough and George Romney.

Although pencil drawings were much less commonly produced by artists of those centuries than sketches in the preferred mediums of chalks, charcoal and pen and ink, the use of graphite gradually increased among painters, miniaturists, architects and designers. By the late 18th century an ancestor of the modern pencil was constructed in the form of a rod of natural graphite fitted into a hollow cylinder of wood. However, it was not until 1795, when Nicolas Jacques Conté devised his method of producing pencil rods from mixtures of graphite and clays, that a true prototype of the modern graphite pencil was developed. Conté's technical improvement made possible the production of fine pencils whose strokes could be controlled, varying from type to type in softness and hardness, darkness and lightness. The excellent quality of these graphite pencils encouraged wider use by artists of the 19th century, and pencil drawing was to become a common method for creating studies and preliminary sketches. The fact that the graphite pencil could be used on almost any type of drawing surface helped to make it an indispensable instrument of the artist's studio.

Although graphite pencils provided a substantial range of light-dark effects and the opportunity for tonal modeling, the greatest masters of pencil drawing always retained in their creations the elements of a simple linearism or limited shading that were appropriate to drawing in this medium. This concept of pencil drawing contrasted with that sometimes employed in the 18th and 19th centuries in which extensive tonal modeling of three-dimensional forms and elaborate effects of light and shade were produced by artists and miniaturists by rubbing the soft graphite particles with a stump, a tightly rolled piece of soft paper or chamois.

The preciseness and clarity associated with the use of a moderately hard graphite pencil were developed in the highly selective draftsmanship of the French neoclassicist Jean Auguste Dominique Ingres. His figure sketches and portrait studies were the epitome of a type of pencil drawing in which lucid contours and limited shading combined to create a spirit of elegance and restraint. This manner of drawing was accepted by many artists throughout Europe, including German draftsmen such as Ludwig Richter, who exhibited a preference for the hardest of pencils and sharpest of points in order to produce wirelike delineations of figures and landscapes. Softer and darker graphite pencils offered the possibility of appropriate effects to artists whose tastes required more freedom and spontaneity of drawing. The sketches of the romanticist Eugène Delacroix, created swiftly and filled with flamboyant and undetailed strokes, possessed a visual suggestiveness of dramatic figures and compositions. Van Gogh chose a broad carpenter's pencil for powerful, blunt strokes.

One of the most sensitive of those who used the graphite pencil in the 19th century was Edgar Degas. A master pastelist and draftsman with coloured chalks and charcoal, Degas created pencil drawings possessing warmth and charm that were quite unlike the cool, classic works of Ingres or the highly animated and sometimes violent sketches of Delacroix. Degas, with high selectivity, combined graciously fluid outlines with soft, limpid tonal shadings. In creating these effects he often employed more than a single

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GRAPHITE DRAWINGS BY AN ENGLISH AND TWO FRENCH MASTERS

Top left: "Lady Holding a Book" by George Romney (1734–1802), English. In the Metropolitan Museum of Art

Top right: "An Arab on Horseback Attacked by a Lion" by Eugene Delacroix (1798–1863), French. In the Meta and Paul J. Sachs collection of the Fogg Art museum, Harvard university

Right: "Mlle. Josephine Lacroix" by J. A. D. Ingres (1780–1867), French. In the Pierpont Morgan library

PENCIL DRAWING

BY COURTESY OF (TOP LEFT, BOTTOM LEFT) THE FOGG ART MUSEUM, (TOP RIGHT) RHODE ISLAND SCHOOL OF DESIGN

THREE PORTRAITS BY DRAFTSMEN OF THE LATE 19TH AND 20TH CENTURIES

Top left: "Portrait of Mme. Hertel," a study for his painting "The Lady with the Chrysanthemums" by Edgar Degas (1834–1917), French. Graphite pencil. In the Meta and Paul J. Sachs collection, the Fogg Art museum, Harvard university

Top right: "Portrait of Leopold Zborowski" by Amedeo Modigliani (1884–1920), Italian. Graphite pencil. In the collection of the Museum of Art of the Rhode Island School of Design

Left: "Portrait of Nicolas Kopeikine" by Pavel Tchelitchew (1898–1957), Russian-born. Silverpoint on a white ground with accents in graphite pencil. In the Meta and Paul J. Sachs collection, Fogg Art museum, Harvard university

pencil in order to extend the range of softness or darkness in various parts of his figure studies.

Pencil drawing seems to have been a desirable medium for sculptors, and the sketches of Auguste Rodin, Aristide Maillol and others suggest the efficacy of the pencil for studies of contours and masses so important in sculptured figures and in the compositional grouping of sculptural forms.

Artists of the 20th century continue to use the graphite pencil as a device for sketching and for making preliminary rehearsals of conceptions later carried out in painting or sculpture. Because of the nature of much contemporary painting, there is less cause for artists to draw or preplan their paintings with the assistance of pencil studies; nevertheless, the function of drawing persists, and among many artists it is still considered an essential skill. Distinguished artists such as Henri Matisse, Amedeo Modigliani, Pablo Picasso and others, whose taste for basically linear conceptions was revealed in their graphic works, selected the graphite pencil as a device for creating lucid and simple images. *See also* DRAWING (TECHNIQUES OF); PEN DRAWING; PENCIL.

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(Js. A. W.)

PENCK, ALBRECHT (1858–1945), German geographer and geologist, and the founder of Pleistocene stratigraphy, was born at Reudnitz near Leipzig on Sept. 25, 1858. He trained as a geologist and petrologist at the University of Leipzig. Through field work for the Geological Survey of Saxony he was led to the problem of Pleistocene glaciation. He began his academic career as a lecturer in geography at the University of Munich in 1883 with a thesis *Vergletscherung der deutschen Alpen* (1882) which opened a new epoch of Pleistocene research by combining stratigraphical and geomorphological observations. In 1885 he was appointed professor of geography at Vienna, and wrote his *Morphologie der Erdoberfläche* (two volumes, 1894), the first textbook on the subject. His main work with Eduard Brückner, *Die Alpen im Eiszeitalter* (three volumes, 1901–09), the result of comprehensive field research, confirmed the four phases of Pleistocene glaciation. In 1906 Penck took the chair of geography at the University of Berlin, where he was also director of the Institute of Oceanography. In 1908 he was Silliman lecturer at Yale University, and exchange professor at Columbia University with William Morris Davis in 1909. He originated and promoted the 1:1,000,000 map of the world. Travels in North America, east Asia, Australia, and southern Africa widened his knowledge in other fields of geography. He was a versatile organizer and for many years the most prominent figure of German geography. He survived his son Walter, a geologist, and his grandson Martin, also a promising geologist. He died in Prague on March 7, 1945.

(C. T. T.)

PENDA (d. 654), Anglo-Saxon king of the Mercians from 632, or soon after, until 654, son of Pybba, already in 628 led the Mercians in the Battle of Cirencester against the West Saxons and obtained the lands of the Hwicce (*q.v.*). He and Cadwallon of Wales destroyed Edwin of Northumbria in 632. Though he became subject to Northumbria in 633, he recovered independence when he killed its king Oswald in 641. Though not included in Bede's list of kings with dominion over all kingdoms south of the Humber, he was not far from holding such power. The areas corresponding to Cheshire, Shropshire, and Herefordshire were acquired, he made his son Peada subking of Middle Anglia by 653, he subdued East Anglia, killing its kings Sigeberht, Ecgric, and, about 653, Anna, and he drove out Coenwalh of Wessex for three years. In 654 he invaded Northumbria with forces drawn from many kingdoms, but was slain by Oswiu at the battle of the Winwaed. The statement in the Anglo-Saxon Chronicle that he was then 80 is proved false by the ages of his sons and relations. Though a pagan, he did not persecute Christians; his son Peada, and a daughter, married into the Christian royal house of Northumbria, and Peada introduced Christianity into Middle Anglia in Penda's reign.

(D. WK.)

PENDENTIVE, in architecture, a triangular segment of a spherical surface, filling in the upper corners of a square, rectangular, or polygonal room, in order to form, at the top, a circular support for a dome. Its intersections with the walls against which it abuts are semicircles, and are usually carried by arches. The problem of supporting a dome over a square or polygonal hall was of continually growing importance to the late imperial Roman builders. This they attempted to solve, either by corbelling out the corners, projecting each course of masonry slightly over the one below, or by throwing across the corner diagonal arches or niches, which are known as squinches (*q.v.*). An early approximation of the pendentive form occurs in a domed room in one of the side buildings of the baths of Caracalla (A.D. 217). This form, however, was obtained by corbelling, whereas the true pendentive is built like a portion of a dome with radiating joints. It remained for the Byzantine architects to recognize the possibilities of the form and give it definitive development. One of the earliest examples is also one of the largest—that of the great church of Hagia Sophia at Istanbul (begun 532). Pendentives occur commonly in the domed Romanesque churches of Aquitaine in France, as in S. Front at Perigueux (begun 1120). They occur spasmodically in Romanesque work in Italy. During the Renaissance the development of domed churches gave great importance to the pendentive. As a result of Byzantine influence, pendentives are frequent in Islamic architecture, often decorated with stalactite ornament or sometimes, as in Iran, with delicate ribbing. A vaulting form in which the curve of the pendentive and dome is continuous, without a break, is known as a pendentive dome.

See BYZANTINE ARCHITECTURE; DOME; ROMANESQUE ARCHITECTURE.

PEND OREILLE, a large, question-mark-shaped lake in northern Idaho, U.S., fed chiefly by the Clark Fork and drained by the Pend Oreille River. Noted for its rugged shore line and size (43.2 mi. long and 6.25 mi. wide), it covers 123 sq.mi. and a depth of 1,150 ft. has been recorded. Sport fishing for trout, including Kamloops, or Kootenay trout, which like steelheads are exceptionally large rainbows (up to 30 lb. or more), whitefish, and landlocked salmon is popular. The name, meaning "earbob," is believed to refer either to the shape of the lake surface (a pendant hanging from an ear) or to earrings worn by the local Indians. The first trading post in Idaho, Kullyspell House, was established by David Thompson at the mouth of the Clark Fork in 1809. Albeni Falls Dam, about 20 mi. below the lake on the Pend Oreille River, controls the water level of the lake.

(M. E. MS.)

PEN DRAWING. Pens have had the longest history and greatest popularity of all the drawing media of the artist. In part, this is the result of the variety of linear effects that can be provided by the three basic types of pens and of their adaptability to the changing styles of draftsmanship that have occurred over many centuries. These three basic types are: quill pens, cut from the wing feathers of fowls and birds; reed pens, formed and trimmed into proper shapes from stems of bamboolike grasses; and metal pens, fabricated from various metals, especially fine steel.

Pen drawing is fundamentally a linear method of image-making with the visual descriptions of the drawing being produced by a simple outline or a complex of ink strokes. In pure pen drawing where the artist wishes to supplement his outlines with tonal suggestions of three-dimensional form, this modeling must necessarily be effected by the close juxtaposition of a series of strokes forming areas of hatching or crosshatching. On the other hand, many pen studies are produced with the substitution of tonal washes laid onto the drawing with a brush, in which case the outlines or other important definitions of the figures or landscape are established by the pen lines.

Paper and Ink.—Pen drawing is usually done on papers expressly produced for this purpose. In the middle ages and the Renaissance parchment also was occasionally used. Although the pen was the instrument with which the artist distributed the delineating strokes in their desired arrangement on the paper, ink was the actual medium that made pen drawing possible. Inks used in

pen studies were of various types and contributed an additional diversity to the final effects in sketches. The prime requisites of inks for drawing were great fluidity as well as strong tinting power.

Three types of ink possessed these qualities and were most frequently chosen by the great masters of drawing. One was black carbon ink, made from extremely fine particles of the soot of burnt oils or resins incorporated into a solution of either glue or gum arabic. This ink retained its original blackness over long periods of time, and old drawings produced with it reveal lines as strong as when they were initially made. The finest type of black carbon ink was known as Chinese ink and was the prototype of the modern black India ink used by artists, architects, engineers and other draftsmen. A brown ink popular with the old masters was known as bistre. It was prepared by boiling wood soot in order to obtain the liquid and transparent brown extract. Many artists chose bistre for its warm, luminous colour qualities, and it was especially effective for the illusionistic drawings of 17th- and 18th-century masters, including Rembrandt and Giovanni Battista Tiepolo. The third important ink was an iron gall or chemical ink. Its principal ingredients were iron sulfate, the extract of gall nuts and a gum arabic solution. It was, in fact, the common writing ink for centuries and was employed for most early drawings. Its colour when first applied to the paper was bluish-black, but it rapidly turned blackish and, over the course of years, became a dull brown; the effect is commonly seen in old handscript letters and documents as well as old drawings. Other inks, usually coloured inks made from natural or synthetic dyestuffs, were used on rare occasions. Throughout the history of drawing, however, coloured inks were less favoured, and studies in which chromatic effects were introduced are exceptional.

Pens.—The oldest of the artist's pens was the reed, although its use in antiquity and in the middle ages was for writing; it was not employed for drawings until the Renaissance, when its fibrous structure and blunt point were found attractive to some draftsmen for creating simple, heavily linear drawings, as those by Luca Cambiaso, or for large drawings, as those by Odoardo Fialetti and Marco Boschini. The outstanding master of the reed pen was Rembrandt, who used it many times in combination with the quill pen and washes to produce the richly suggestive atmospheric illusionism of his works. His usual method was to introduce very bold strokes of a broadly cut reed in order to articulate forms within shadows, while the more illuminated parts of the drawing were indicated with delicate quill lines.

The reed pen never had the widespread popularity of quill or metal pens, but for special effects it served artists admirably. Vincent van Gogh in his last years used it to produce the blunt, powerful strokes that in his drawings were counterparts of the heavy brush strokes typical of many of his Expressionist canvases. Among modern artists the reed pen occasionally has been chosen because of the simple or vigorous strokes that it easily creates; Henri Matisse and George Grosz, both distinguished practitioners of drawing, selected the reed pen for strong linear elements falling halfway between those usually associated with a fine steel pen and a wide brush.

In the history of drawing as it developed in the western world, the quill pen made from the large, hollow wing feathers of the goose, swan or raven has served with the greatest distinction of all pens, and until the time of the acceptance of the modern steel pen there were few master draftsmen who did not engage in quill-pen drawing. Before the end of the middle ages, when papermaking was introduced into Europe, providing a relatively cheap material for sketches and other types of studies, the quill pen was used in making the fine delineations of images in manuscripts. Just as it was the best pen for the precise handscript lettering of the manuscripts, so also its nibs, which could be sharpened to extreme fineness, permitted the craftsman to create small linear figures or ornamental decorations on the pages or along the borders of the parchment leaves. Whereas the fibrous reed pen gave the sensation of being dragged over the paper, the delicately cut point of the quill pen glided over the surface and needed only to be guided by the hand of the artist to create a graceful and calligraphic type of drawing. This characteristic, combined with the flexibility of the quill point, which responded to pressure for varying the widths of lines or forming accents, made it adaptable to the diverse hands and personal styles of draftsmen. Moreover, its adaptability to artistic demands enabled the quill to meet the requirements of changes in style that took place from the 15th to the end of the 19th century. Whether the requirements were for highly controlled but restless vigour as in Albrecht Dürer's linearism, graceful contour drawing similar to that of Raphael, or spontaneous and suggestive strokes as in Rembrandt's studies, the quill served artists equally well.

In most respects the metal pen became the successor of the quill. Although pens of silver, bronze, brass and gold alloy had been tried in the past, it was the development of excellent steel pens by James Perry in the 1830s, and mass production by stamping pens from steel blanks, that led to the supplanting of the quill by the metal pen. Nevertheless, artists were reluctant to adopt the steel pen, even after its ready acceptance for writing, and most drawings in pen and ink done prior to the 20th century were still produced with quills.

Although contemporary artists on occasion select reed or quill pens for the handsome and diversified effects they provide in drawing, the steel pen now is used for drawing almost exclusively. This type of metal pen has its virtues both in its easy availability and in the great variety of shapes and sizes, stiffness or flexibility. Because of the crisp, incising type of line it can produce with modern black inks, it is especially appreciated by artists and draftsmen who execute drawings to be reproduced in books and periodicals. It has become standard studio equipment of the illustrator, cartoonist and designer. Pen drawings by outstanding painters and sculptors such as Pablo Picasso, Matisse and Henry Moore suggest the assistance the steel pen provides in producing the sharpness of linear definitions generally preferred by modern masters. *See* also DRAWING (TECHNIQUES OF); ENGRAVING, LINE; INK; PEN; PENCIL DRAWING.

For bibliography *see* PENCIL DRAWING. (JS. A. W.)

PENELOPE, in the *Odyssey*, the wife of Odysseus and daughter of Icarius of Sparta and the nymph Periboea. During the course of the long absence of her husband after the fall of Troy many chieftains of Ithaca and the islands round about became her suitors. To rid herself of their importunities she bade them wait until she had woven a winding sheet for old Laërtes, the father of Odysseus. But every night she undid the piece that she had woven by day. This she did for three years, until her maids revealed the secret. She was relieved by the arrival of Odysseus. In the *Telegonia*, she married Telegonus, the son of Odysseus and Circe, after he had killed his father, and dwelt with him in the Island of Aeaea or in the Islands of the Blest. Probably quite distinct from her is an Arcadian Penelope, mother of Pan. *See* HOMER; ODYSSEUS.

PENGE, an urban district of Kent, Eng., which under the London Government Act 1963 was to be amalgamated with Beckenham, Bromley, Orpington and the southern part of Chislehurst and Sidcup to form the new London borough of Bromley (*see* LONDON). Penge urban district is residential with some industry (plastic goods, glass, buttons, general and aeronautical engineering). Pop. (1961) 25,743. Area 1.2 sq.mi. The Crystal palace, moved from Hyde park and opened at Penge place in 1854, burned down in 1936. In 1952 the London County council took over the site and plans were accepted (1955) for a national youth and sports centre and an exhibition centre to be built there, leaving the television mast of the British Broadcasting corporation standing. In Penge are the Watermen's almshouses (1840) and Queen Adelaide's Naval cottages (1847) for 12 widows of naval officers.

PENGUIN, a name for flightless, swimming seabirds widely known for their clownish behaviour and tuxedo-clad appearance. These birds of the Southern Hemisphere number 16 species, constituting the family Spheniscidae. The two southernmost species reach the Antarctic continent; others reach the coasts of New Zealand, Australia, South Africa, and southern South America; one, the most northerly species, lives on the Galápagos Islands on the Equator. Originally, "penguin" was applied to the now extinct great auk (*q.v.*), to which some spheniscids bear a likeness.

"Classical Landscape" by Claude Lorrain (Gellée) (1600–82), French. Quill pen and iron-gall ink. In the Art Institute of Chicago

LORRAIN,
REMBRANDT
AND TIEPOLO

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"Nathan Admonishing David" by Rembrandt (1606–69), Dutch. Reed pen, quill pen brush and bister ink. In the Metropolitan Museum of Art

"Group of Female Figures Seated on a Cloud" by Giovanni Battista Tiepolo (1696–1770), Italian. Quill pen, iron-gall ink, carbon ink wash and graphite. In the Pierpont Morgan library

PEN DRAWING

"Reclining Nude" by Pablo Picasso (1881–), Spanish-born. Pen and ink. In the Meta and Paul J. Sachs collection of the Fogg Art museum, Harvard university

"Peasant of the Camargue" by Vincent van Gogh (1853–90), Dutch. Reed pen. In the Fogg Art museum, Harvard university

PICASSO, VAN GOGH AND GROSZ

"The Survivor" by George Grosz (1893–1959), German. Reed and steel pens, carbon ink. In the Art Institute of Chicago

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CAMERA PRESS—PIX FROM PUBLIX

ADÉLIE PENGUINS (PYGOSCELES ADELIAE): (LEFT) A GROUP ENTERING THE WATER; (RIGHT) PARENT BROODING CHICKS

Penguins range from duck size to a standing height of about four feet and a weight of 90 pounds (large emperor penguins). These birds are stout-bodied with short necks; stout bills; short, webbed feet placed far back on their bodies; short tails; and wings modified into flippers and covered with small scalelike feathers, without quills.

At sea penguins go in flocks. On the surface of the water the birds swim with little more than head and neck exposed. They travel and feed like porpoises, diving and surfacing repeatedly, with wings alone used for propulsion underwater, the feet serving only for steering. Penguins feed on fish and crustaceans.

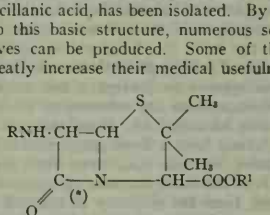
Penguins come ashore to nest in colonies, where there may be much calling and elaborate displaying. Usually the colony is near the edge of the sea, but occasionally it may be miles inland. The Adélie penguin (*Pygoscelis adeliae*) may travel as far as 60 miles over the ice to reach its nesting site in the Antarctic. These birds can leap seven feet out of the water to land on the ice. When traveling over the ice, they may walk upright or toboggan along on their bellies.

The emperor and king penguins (*Aptenodytes forsteri* and *A. patagonica*) lay a single white egg and incubate it by holding the egg on their feet and covering it with a loose fold of skin. Other penguins make nests of stones or of bits of vegetation in the open, under vegetation, in a rock crevice, or in a burrow that they dig. There they lay one to three white eggs and incubate them in normal fashion.

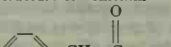
Both sexes take part in nest duties, but the share of each varies with the species. In the emperor penguin, nesting in the cold and dark of the Antarctic winter, the male alone incubates, without feeding, for the whole period of two months. In the Adélie penguin, nesting in the spring, the parents change places once in the 35-day incubation period, and in more northern species the changeover may be twice daily. The newly hatched young are scantily down covered but later develop a heavy down coat. Although they walk about, they must wait until they are full grown and feathered before going into the water. *See* also BIRD. (A. L. RD.)

PENIBÉTICO, SISTEMA (also called CORDILLERA PENIBÉTICA or BAETIC CORDILLERA), comprises the Andalusian Mountains of southern Spain. The northern mountains, or Sub-Baetic, run about 360 mi. from Cape Trafalgar to Cape Nao. The central and southern ranges, the Penibaetic proper, extend a shorter distance from Estepona to Cape Gata. Separating the two systems is a complex series of structures, traceable in longitudinal corridors and high basins for 180 mi. between Antequera and Baza, and again between Lorca and the Guadalentín Valley. The depressions are exhumed Tertiary basins, synclines, and grabens. To the south, in the Penibaetic proper, the interior mountains include the Sierra Nevada (*q.v.*), with the highest peak of the peninsula Mulhacén 11,411 ft. (3,478 m.), the Sierra de Baza (7,444 ft.), the Sierra de los Filabres (7,113 ft.), and the Sierra de las Estancias (4,783 ft.), oval domes orientated from east-northeast to west-southwest and separated by synclinal depressions, sometimes linked with Las Alpujarras (*see* ALPUJARRAS, LAS). Triassic limestones overlying ancient crystalline rocks comprise the highest summits. The lower, less continuous coastal ranges include the Sierra de Gádor (7,356 ft.), the Sierra de Almijara (6,017 ft.), and the Sierra Alhamilla (4,744 ft.). Vegetation ranges widely, from subtropical at sea level to alpine higher up, within distances of only 20 to 30 mi. (J. M. Ho.)

PENICILLIN is a powerful antibacterial substance elaborated by certain molds of the genus *Penicillium*. It is classified as an antibiotic; *i.e.*, a substance produced by living organisms that has a specific antagonistic effect on microorganisms. It was at first thought that there is only one penicillin, but it was later discovered that the mold can produce at least four penicillins called F, G, X, and K, which differed slightly in their chemical structure. Of these, only penicillin G has been used extensively. The penicillin molecule can be altered by adding substances to the fermentation liquor in which the mold is grown. The relatively stable compound that constitutes the basic ring structure of all penicillins, 6-Amino-penicillanic acid, has been isolated. By adding various side chains to this basic structure, numerous semisynthetic penicillin derivatives can be produced. Some of these possess properties that greatly increase their medical usefulness.



Basic Chemical Structure of Penicillin

In potassium penicillin G, R =  and R^1 = K. In 6-aminopenicillanic acid, R = H and R^1 = H. The asterisk on the C-N bond in the lower left part of the basic structure indicates the site of action of staphylococcal penicillinase.

History.—Penicillin was described and named by Sir Alexander Fleming (*q.v.*) in 1929. The work was initiated in 1928 by the unexpected contamination of a culture plate of staphylococcus by spores of *Penicillium notatum*. In the neighbourhood of the growth of the contaminating mold the colonies of staphylococcus, which had been well developed, appeared to be undergoing dissolution. The mold was isolated in pure culture and was found to produce a substance that had a powerful destructive effect on many of the common bacteria that infect man, while it had no effect on many others. This antibacterial substance, which was christened penicillin, was liberated into the fluid in which the mold was grown. This liberation is the basis of all commercial production of penicillin.

Although penicillin displayed a strong antibacterial action, it apparently was nontoxic to human cells. This combination of destructive action on bacteria and absence of toxicity for human cells was unique. All the antiseptics then in common use were more toxic to human cells than they were to bacteria. Subsequently it was discovered that penicillin acts mainly if not solely by inhibiting the synthesis of cell walls in bacteria. Animal cells do not have cell walls and this selective action is a reasonable explanation for the virtual lack of toxicity to human cells.

In 1939 a team of Oxford workers headed by Sir Howard Florey (*q.v.*) decided to investigate antibiotics. They selected penicillin as a promising one to commence with and succeeded in concentrating and purifying it. They demonstrated its curative properties first on experimental infections in mice and then on human patients suffering from staphylococcal and other infections. The next goal was production on a large scale. The Oxford workers developed methods of production and extraction, and in 1941 Florey took these to the U.S. and induced the authorities there to commence production. The pharmaceutical manufacturers in England also interested themselves and there was free interchange of information. The progress was phenomenally rapid and many advances in methods of production were made: (1) the culture medium was improved by the addition of "corn steep liquor" and other substances; (2) the fermentation was carried out in large tanks instead of in thousands of bottles; (3) it was found that

other strains of mold of the *Penicillium notatum-chrysogenum* group gave larger yields of penicillin than did the original strain isolated in 1928; (4) better methods of extraction were evolved.

The penicillin molecule has been synthesized (1957), but the synthetic method of production was found to be much less economical than production by mold fermentation. The materials used in the fermentation are cheap, so that when the initial outlay in manufacturing plant has been written off the cost of production of penicillin is relatively small.

Following World War II, penicillin G came into widespread clinical use. With the inexpensive production of a relatively pure compound, it became possible to administer increasingly larger doses for prolonged periods of time. Thus, bacteria that were relatively resistant to penicillin could be treated.

Theory of Penicillin Action.—Following the addition of penicillin to a culture of sensitive bacteria, the synthesis of mucopeptide, a component of the cell wall, stops. Compounds that appear to be the basis for the chemical building blocks of the highly polymerized mucopeptide then accumulate inside the cell. Penicillin thus appears to prevent a late stage of mucopeptide synthesis. Mucopeptides are common to all bacteria; however, in gram-positive bacteria (*i.e.*, those that can be stained with Gram's stain), they form a larger proportion of the cell wall than in gram-negative bacteria (*i.e.*, those that are not stained by Gram's stain); in the latter bacteria, special substances typical of a given species form the majority of the cell wall. As a rule, penicillin is more effective, molecule for molecule, on gram-positive than on gram-negative bacteria.

The action of penicillin in inhibiting cell-wall synthesis explains why the antibiotic is effective on actively growing bacteria. Although at minimally effective concentrations penicillin appears to be merely bacteriostatic (*i.e.*, capable of arresting bacterial multiplication), at slightly higher concentrations it is bactericidal (capable of killing bacteria). The morphological changes following exposure to penicillin have been studied thoroughly in some organisms, particularly the gram-negative bacilli. In one of these organisms, *Escherichia coli* (the commonest normal organism of the intestinal tract), the changes are as follows: At bactericidal concentrations, the rod-shaped organism develops a break in its cell wall. The intracellular components are then extruded through the opening and a curious form called a spheroplast is produced. The spheroplast has lost the rigidity provided by the cell wall and is vulnerable to changes in the salt concentration of the surrounding medium in that it can be lysed in distilled water but is protected by higher salt concentrations. Under suitable conditions the spheroplasts continue to grow and can divide to produce colonies that are markedly different from ordinary bacterial colonies. If penicillin is removed from the medium, they can usually revert to normal bacteria.

At concentrations approaching the minimally effective concentration the *Escherichia coli* do not form spheroplasts. Instead, the rods continue to grow longer as if the site of production of the intercellular septum is the most vulnerable area to the action of penicillin. If penicillin is removed from the medium, intercellular septa begin to grow and convert the elongated filamentous forms into a chain of rods.

Unit of Penicillin.—When the Oxford workers concentrated penicillin in 1940 they established a unit of potency. This corresponded with the amount that, when dissolved in 50 ml. of nutrient broth, would just inhibit the growth of their test organism, a staphylococcus. After penicillin was obtained in a pure and crystalline form an international unit corresponding to the original Oxford unit was agreed upon. This international unit is equal to 0.0006 mg. of penicillin G; consequently, 1,000,000 units represents 0.6 g.

Bacterial Resistance.—Resistance of bacteria to penicillin may be divided into two general categories: (1) that associated with the inherent resistance of the individual organism to penicillin; (2) that associated with the production of enzymes called penicillinases, which are capable of destroying penicillin. The first type of resistance may be virtually absolute, as with *Pseudomonas aeruginosa*, or it may be relative, as with many other gram-negative bacteria, such as *Escherichia coli* or *Proteus mirabilis*. Whereas the gram-positive bacteria, such as pneumococci, and hemolytic streptococci are sensitive to penicillin in doses of tenths to hundredths of a unit per millilitre, the relatively resistant gram-negative organisms may require from 1 to 100 units. Bacterial mutations that increase resistance to penicillin may be demonstrated in the laboratory, but, at least with gram-positive organisms, they are not encountered in the patient.

The second type of resistance, the ability to form penicillinases, is particularly important with respect to staphylococci. Some strains do not produce penicillinase and are susceptible to penicillin. Other strains produce the enzyme and, if they are present in sufficient numbers, may be resistant to large amounts of penicillin. After the use of penicillin became widespread, the penicillinase-producing strains became more common, particularly in hospitals and other places in which penicillin was widely used.

Therapeutics.—Penicillin is used for the treatment of many types of bacterial infections. For serious infections it is usually given intramuscularly or intravenously. It is rapidly excreted by the kidneys. Since the drug is virtually nontoxic, millions of units may be given and the dose may consequently be adjusted according to the species of bacteria, the location of the disease process, and the severity of infection. After injection the penicillin circulates in the blood and can affect organisms almost anywhere in the body except in the normal cerebrospinal fluid. However, in the presence of meningitis, penetration into the cerebrospinal fluid is improved and therapy with large doses of intravenous penicillin may be employed. The use of penicillin locally in the form of ointments, creams, powders, or sprays is discouraged since such methods of application result in uncertain levels in the tissues and are accompanied by an increased risk of allergic reactions in the patient.

One of the great social benefits of penicillin has been its effectiveness in the treatment of syphilis and gonorrhea. Although more prolonged treatment may be necessary for moderately resistant strains, a single dose is usually sufficient for the treatment of gonorrhea; syphilis requires more prolonged treatment.

Development of Additional Penicillins.—Although penicillin G is an extremely effective antibiotic it has certain deficiencies, which has encouraged the synthesis of variously modified compounds. Some, such as procaine penicillin, are absorbed more slowly after intramuscular injection, with the result that fewer doses need be given. Others, such as penicillin V, are acid stable and therefore give higher and more dependable levels after administration by mouth. Some penicillin compounds are relatively unaffected by staphylococcal penicillinase and can be used to treat infections caused by so-called "penicillin-resistant" staphylococci. Other penicillin derivatives are more effective than penicillin G against some gram-negative bacilli.

A species of mold isolated in Sardinia was found to produce at least three different antibiotics. This organism, a cephalosporium, produced two substances with properties similar to penicillin. One of these, cephalosporin N, has a ring structure identical to that of penicillin G, while the other, cephalosporin C, has a slightly different ring structure. Derivatives of this latter compound have different degradation products and do not appear to cause allergic reactions in individuals with a history of allergy to penicillin.

See ALLERGY AND ANAPHYLAXIS; ANTIBIOTICS; *see* also references under "Penicillin" in the Index.

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PENINSULAR WAR, the name given to that part of the Napoleonic Wars (*q.v.*) fought between 1808 and 1814 in the Iberian Peninsula, where the French were opposed by British, Spanish, and Portuguese forces. Napoleon's Peninsular struggle contributed considerably to his eventual downfall, but until 1813 the conflict in Spain and Portugal, although costly, exercised only

an indirect effect upon the progress of French affairs in central and eastern Europe. The war in the Peninsula was of primary interest to the British, however, because their army made no other important or notably successful contribution to the war on the continent between 1793 and 1814. Not the least of Napoleon's mistakes in attempting the conquest of Spain and Portugal was that he thereby allowed the British to employ their limited army to greatest advantage.

Napoleon's pact with Russia at Tilsit (July 7, 1807) left him free to turn his attention toward Britain and Sweden and Portugal, the two powers which remained allied or friendly to Britain. Russia, it was decided, would deal with Sweden, while Napoleon, allied to Spain since 1796, summoned (July 19) the Portuguese "to close their ports to the British and declare war on Britain." His intention was to complete the continental system, designed to make economic war against Britain, for there was no other means to bring it to seek peace than by striking at its trade. Although this purpose was the immediate cause of his invasion of Portugal, his Spanish allies were to discover that he was also intent upon conquest for its own sake.

French Invasion of Portugal.—As the Portuguese refused to carry the conciliation of France to the point of confiscating British goods, a French expeditionary force of 30,000 men under Gen. Andoche Junot crossed the Bidassoa River on Oct. 18, 1807, to march through Spain, which was still the ally of France under the decadent government of Charles IV and his favourite, Manuel de Godoy. The abortive Franco-Spanish Convention of Fontainebleau of Oct. 27, 1807, determined the partition of Portugal: a northwestern province was to go to Charles Louis, king of Etruria, in return for the cession of Etruria to France; Algarve and Alentejo to Godoy; and the central territories and Lisbon to Napoleon. On Nov. 30 Junot arrived in Lisbon, from which on the previous day the Portuguese royal family and fleet had left for Brazil. Additional French forces began to enter Spain late in November 1807, ostensibly as reserves for Junot. Joachim Murat took over their command at Burgos on March 13, 1808. On March 23 he reached Madrid, where his approach had led to Godoy's arrest by the supporters of Charles IV's son Ferdinand (later Ferdinand VII) and the abdication (March 19) of Charles IV on behalf of Ferdinand. At Bayonne on May 10 Napoleon finally obtained both Spanish rulers' surrender of the throne, which he granted to his brother Joseph Bonaparte.

A brief rising against Murat in Madrid on May 2 was ruthlessly suppressed but was followed three weeks later by another at Oviedo, the first of many provincial insurrections throughout Spain. The revolt spread to such effect that Joseph, who reached the capital on July 20, abandoned it on Aug. 1, and subsequently withdrew to the Ebro River. Representatives of the insurrectionary junta from the province of Asturias had arrived in London on June 7, and were promptly offered support. The British government was soon to deplore the rivalries and particularism of the juntas (committees of administration) which were established in Andalusia, Galicia, Murcia, Valencia, Aragon, and Catalonia. Nevertheless, the strength of local sentiment played a substantial part in the formation of Spanish opposition to French rule as well as hindering the coordination of national resistance to Napoleon's forces.

Napoleon's army in the Peninsula, including Junot's corps, numbered only 116,000 by May 31. Of these, less than one-third came from the regular French Army, the rest being composed of recently incorporated conscripts and foreign auxiliaries. The front-line troops of the *Grande Armée* remained in Germany. The regular Spanish forces were too few, too dispersed, and too ineffective to endanger the French, who were principally concentrated around Madrid and in the north. At first mistaking the revolt to be no more than isolated risings, Napoleon detached 22,000 men from the 53,000 around Madrid to pacify Andalusia and Valencia. This dispersal led to a serious reverse, for at Bailén on July 23 the outnumbered Gen. Pierre Dupont surrendered to the rebels with a loss in casualties, captured, and deserters of 17,600 men. This defeat had a considerable effect on European opinion, the more so because Dupont's poor handling of operations, the inadequacy of his troops, and the presence of a large majority of regular soldiers in the opposing Spanish forces were generally overlooked.

The Campaign in Portugal, 1808.—Sir Arthur Wellesley (later duke of Wellington) disembarked in Mondego Bay in Portugal with an expeditionary force of 13,500 men on Aug. 1 and his army was swelled by 5,000 national troops. Three weeks later at Vimeiro, near Lisbon, where Wellesley had about 19,000 men, he was attacked by Junot's force of 13,000. The French were severely defeated (Aug. 21), but the new British commander in chief, Sir Hew Dalrymple, who arrived immediately after the battle, proved unwilling to exploit Wellesley's success. On Aug. 31 Dalrymple concluded the Convention of Sintra with the French. Its terms were of arguable advantage to the British, for they provided for the evacuation to France of the French Army in Portugal, more than 25,000 men, who were thus able to return to Spain in December 1808; on the other hand, the British occupied Lisbon on Sept. 9 and were free to march eastward into Spain to assist the insurrectionaries.

Sir John Moore's Campaign of 1808–09.—Meanwhile the French had been driven back by the Spaniards behind the line of the Ebro, where they were confronted by four ill-equipped and badly coordinated Spanish forces. In September the British government decided that its troops in Portugal should support the Spanish on the Ebro, and by mid-October Sir John Moore, the new commander in chief, with an army of 20,000 strong, had begun his march northeastward toward Salamanca. By way of reinforcement, 12,500 men under Sir David Baird were ordered to leave England for Corunna and to join Moore, if possible at Valladolid. Napoleon, however, determined to increase his numbers in Spain and to resume the offensive. By late October he had assembled nearly 120,000 front-line troops on the Ebro, where he assumed personal command of 70,000 at Vitoria on Nov. 6. One Spanish army had been defeated at Zornosa, near Durango, on Oct. 29, another at Espinosa de los Monteros on Nov. 11, and on Nov. 23 at Tudela, on the Ebro, the Spanish were finally routed. On Dec. 4 Napoleon occupied Madrid, where he issued a stream of decrees for the reorganization of Spanish affairs, including the closure of two-thirds of the religious houses.

Moore halted his march at Salamanca on Nov. 14 when he received news of the Spanish defeat at Zornosa and of the French advance toward Valladolid. In the north, Baird had arrived at Corunna with his infantry on Oct. 13, and after a month's delay for his cavalry to join him, he set out for Astorga, which he reached on Nov. 22. There he heard at last of the Spanish reverses at Zornosa and at Espinosa de los Monteros and decided to suspend his march. Moore had remained at Salamanca where he learned on Nov. 28 that the forces on the Spanish right had been defeated at Tudela on the 23rd. He resolved at once to withdraw to Portugal, called in his detachments and sent Baird instructions to retire on Corunna, where he was to embark his men to join Moore in Lisbon. Soon afterward, however, Moore was asked by J. H. Frere, the British minister at Madrid, to make an effort to save the capital, and although very doubtful of the wisdom of such a policy, on Dec. 5 he ordered Baird to return to Astorga. Hearing on Dec. 9 that Madrid had fallen, Moore determined to take advantage of the dispersal of the heavily superior French forces and strike at their communications by attacking N. J. de Dieu Soult's isolated corps of 20,000 men west of Burgos. When Baird joined him at Mayorga on Dec. 20 his effective strength rose to 26,000 men.

Two days later Napoleon realized that far from withdrawing into Portugal Moore had set out on this hazardous enterprise and he hastily deployed more than 80,000 men in an enveloping movement against him. It was not until Dec. 23, when he had completed his preparations to attack Soult next morning, that Moore heard the not unexpected news of Napoleon's advance, and ordered an immediate withdrawal on Corunna. The British retreat over the mountains of Galicia was hurried and painful, but Moore succeeded in keeping ahead of his pursuers. Napoleon gave up personal direction of operations on Jan. 3, 1809, and soon afterward left for Paris to meet the danger from Austria, whose preparations for war had been encouraged by the large number of

French troops confined in the Peninsula. Moore reached Corunna on Jan. 11, three days before his transports arrived. He took up a position with 15,000 men and 9 light cannon in order to cover his embarkation, and was attacked on Jan. 16 by Soult, who had about 16,000 men and 40 guns. The French were repulsed, but Moore lost his life in the battle which enabled his army to take ship for England. In itself, his campaign had been unsuccessful, but it secured substantial benefits by drawing Napoleon's troops from southern Spain and from Portugal.

WELLINGTON'S CAMPAIGNS, 1809–14

Although Napoleon's brief campaign of 1808 had disclosed some of the obstacles to the conquest of the Peninsula, his personal commitment to the enterprise and his over-optimistic appreciation of its long-term requirements led him to persist in his largely unnecessary undertaking. One important consequence of the British government's decision to continue its support of the insurgents after the return of Moore's force to England was the choice (March 1809) of Sir Arthur Wellesley (created Viscount Wellington in September 1809) as the commander of the British forces in Portugal. Wellington was quick to perceive the opportunities offered him by the peculiarities of the strategic situation, and after his first campaign he exploited them with mounting success. His task was anything but easy. At the outset, his army, with reinforcements, numbered only 26,000. The operations in Portugal were poorly supported and widely criticized at home until Wellington obliged André Masséna to retire from the lines of Tôrres Vedras in March 1811 (*see* below). Caution had been enforced upon him in these first difficult years; the brilliant and victorious campaigns of 1812–14 when he had a stronger hand were to demonstrate, if proof were still needed, the extent of his military and political gifts, and the judgment and tenacity of purpose with which he had earlier followed his course. He supplemented his small numbers to some extent by the Portuguese, whose troops were reorganized under William Carr (later Viscount) Beresford and other British officers and of which there were more than 50,000 in the field by 1810; the Portuguese Militia too was used for support purposes.

The Spanish, however, took less kindly to British direction; their governments, unstable and short-lived, and their regular army, ill-equipped and inefficiently led, failed to cooperate effectively with Wellington. Thus the British, who alone of the allies possessed properly constituted forces, provided almost all the effective conventional resistance to Napoleon's army. Yet it was the bitter opposition of the Spanish people which furnished the conditions necessary for so much of Wellington's success, and which, all in all, decided the outcome of the Peninsular War. Reluctant to organize, support, or join a substantial regular army, large numbers elected to engage in local guerrilla warfare fought with exceptional savagery on both sides.

The guerrillas' activities, whether inspired, as in many cases, by genuine patriotism and religious fervour, or as in some instances, verging upon brigandage, took a daily toll of men and supplies and obliged the French to make constant detachments to control disaffected areas and protect rear services. Not only were the French further handicapped by inadequate roads and difficult terrain, but the country could not support their numerically superior armies, even where it had not been ravaged by earlier operations. Thus their campaigning forces were often unable to remain united for long enough to defeat the usually inferior regular formations opposed to them.

These conditions Wellington turned to great effect in his early years when he lacked the men and matériel to undertake a prolonged offensive. His strategy also drew strength from the more positive advantages that his lines of retreat were guaranteed by command of the sea, and that he was provisioned in part by sea transport. Moreover, to increase his freedom of movement he organized an effective system of supply in the field. By these means, and his outstanding success in raising the technical efficiency of his army, the series of limited operations in the early campaigns enabled Wellington to secure his hold on Portugal and to inflict substantial losses on the dispersed French armies.

Campaign in Portugal and Spain, 1809.—Wellesley reached Lisbon from England at the end of April 1809 to find that the French had made considerable progress toward the conquest of the Peninsula. After the Battle of Corunna (January 1809) Soult had marched south into Portugal, where he had taken Oporto (March); he was now opposed only by some disheartened Portuguese levies. Michel Ney, who had also joined in the pursuit of Moore, was engaged farther north in the pacification of Galicia. The French force closest to Wellesley was that under Claude Victor Perrin at Mérida, within 40 mi. of the Portuguese frontier, well placed to invade Portugal via the Tagus River and opposed by no more than the demoralized army of the Spanish general, Gregorio de la Cuesta, who had been defeated on March 28 at Medellín, east of Mérida. The central Spanish army had suffered two earlier defeats, at Ucles, east of Ocaña, on Jan. 13, and at Ciudad Real on March 27. To the east, in Catalonia, the French general, Gouvion-Saint-Cyr, had gained substantial victories over the rebels.

Soult and Victor, however, had both halted their advance by April and were separated by 200 mi.; furthermore, although they were meant to be acting in concert, they were not in communication. Wellesley, whose total forces numbered 25,000 British and 15,000 Portuguese under Beresford, advanced northward from Coimbra against Soult on May 7. Suspecting nothing, Soult had scattered his encampments north and south of Oporto. Wellesley failed to cut off the detachments south of the town, but surprised the French by crossing the Douro River on the 12th just above Oporto. The French began their retreat northward in the utmost confusion, and their destruction was averted only by the timidity of Gen. George Murray, one of Wellesley's divisional commanders. Soult had lost nearly 6,000 men and all his artillery when his hard-pressed withdrawal ended at Lugo on May 23. His escape owed much to the fact that reports of Victor's advance on the Tagus made Wellesley abandon the pursuit on the 18th.

Victor's movement was in fact a reconnaissance in force to obtain intelligence of Soult, but when Joseph Bonaparte in Madrid received news from Paris of Soult's reverses he ordered Victor to withdraw along the Tagus to Talavera de la Reina. At Lugo, Soult quarreled violently with Ney and the joint operations they had planned to mount against the Galician insurgents came to nothing; Galicia, in fact, remained in rebel hands for the rest of the war. By the beginning of July Joseph was in a position, if necessary, to concentrate 100,000 in the Tagus valley; Ney and Soult had moved southward to Astorga and Benavente and their force, together with Edouard Mortier's corps at Valladolid numbered 50,000; Joseph disposed of 27,000 men in the region of Madrid; at Talavera Victor's corps numbered 23,000.

On his return (June) to Abrantes from northern Portugal Wellesley proposed that he with 23,000 British troops, and Cuesta, who brought 36,000 Spanish on campaign, should advance on Madrid by way of the Tagus. The British marched on June 27 to join Cuesta at Plasencia and on July 17 the allied armies set out for the capital. Wellesley was soon made aware of his error in undertaking operations conjointly with the Spanish; not only was the elderly and incompetent Cuesta unwilling to cooperate, but his unreliable troops had been sent into the field without the supplies and transport promised by the Spanish government. Victor fell back before the allies until reinforcements from Joseph brought his strength up to 46,000 men. When, accordingly, the allies were obliged to retire from their position just east of Talavera, the disorder of the Spanish troops turned retreat into flight. With much difficulty Wellesley halted the panic and on July 27 took up his position at Talavera, where, that night and next day, he drove off Victor's attacks, suffering 5,000 casualties as against Victor's loss of 7,000 men and 17 guns. On Aug. 1 Soult's arrival in the Tagus valley from the north put an end to any thought of exploiting Victor's repulse, and Wellesley hastened to withdraw his army into Portugal via Badajoz. For his success at Talavera, Wellesley was created Viscount Wellington in September 1809.

The Spanish embarked on a new campaign during the winter of 1809, and at Ocaña on Nov. 19 Carlos Areizaga, Cuesta's successor,

was totally defeated. Against this reverse, however, could be set the wasteful diversion of the troops under Soult and Joseph, who invaded Andalusia in January 1810. There the French undertook the futile enterprise of besieging Cadiz, which was virtually impregnable without the assistance of a naval force and whose garrison was presently reinforced by 8,000 British troops.

Of more importance was the fact that Napoleon had defeated Austria at the Battle of Wagram (July 1809) and the end of the war with Austria (October 1809) had released 138,000 men for service in Spain. Greater numbers, however, were required to achieve superiority over the regular armies in the field while containing guerrilla activity. Napoleon added to the difficulties by attempting to direct operations from Paris, and the differences between the French marshals, whom Joseph proved unable to subordinate to a common purpose, greatly hindered coordinated offensives against the British. Within a year of Wagram, moreover, Napoleon's preoccupation with the situation in eastern Europe prevented him both from imposing a unified strategy in Spain and from concentrating sufficient forces to overcome allied resistance.

Wellington's Plans for the Defense of Portugal.—There were three principal routes by which the French could attack Wellington in Portugal: from the northeast, via Salamanca and Almeida (a frontier town in Portugal, northwest of Ciudad Rodrigo); from the east, along the line of the Tagus River; and finally, from the south, by way of the Guadiana River. Wellington had to reckon with the first two of these approaches: the third was blocked by the fortress of Badajoz which remained in Spanish hands. In consequence he would have to divide his forces to cover both avenues, but he could expect that in all probability the French would not attack him in strength along both routes at the same time. Although they could bring heavily superior numbers against him, he could hope that the problems they would encounter in supplying their army, together with the mobility he would gain from the reorganization of his own commissariat, would redress the balance in his favour. The keystone to his carefully considered plans to meet the French was furnished by the construction between the Tagus and the sea of the elaborately fortified lines of Tôrres Vedras, 25 mi. N of Lisbon. These sealed off the peninsula containing his base from virtually any attack the logistic difficulties of the position would permit the French to mount.

Campaign of 1810.—For the campaign of 1810, 65,000 French were assigned to the army of Portugal under André Masséna, while Soult commanded as many in the army of Andalusia. With 18,000 British and 14,000 Portuguese, Wellington awaited Masséna near Almeida. The route by the Tagus was guarded by Gen. Sir Rowland Hill with about 20,000 men, mostly Portuguese. After the siege and capture (July 10) of the fortress of Ciudad Rodrigo, Masséna's troops entered Portugal. Wellington fell back before their advance to Bussaco, north of Coimbra, where, having summoned Hill to him, he took up a very strong position with 52,000 men and offered battle. Masséna attacked on Sept. 27 with about 60,000 and was repulsed with 4,600 casualties as against Wellington's 1,250. The allied retreat was now resumed and on Oct. 10 Wellington's army occupied the lines of Tôrres Vedras. Masséna remained before them for a month before want of subsistence obliged him to retire 30 mi. NE to Santarém to continue his observation of the allies.

The reason for Masséna's persistence—the expectation that the Whigs would replace the existing ministry in Britain and so implement their demands for the withdrawal of British forces from the Peninsula—was not the only consideration which gave Wellington cause for alarm at the beginning of 1811. In January 1811 Soult advanced from Andalusia on Badajoz. The Spanish Army there offered battle (known as the Battle of Gebora) on Feb. 19 in spite of Wellington's plea that it should not, and, as he expected, it was defeated. On March 5, Masséna at last began his retreat from Santarém toward Salamanca, followed by Wellington with 44,000 men. Of these, he was obliged to send 7,000 at once to Beresford, who had already been ordered to march against Soult, because Badajoz had been quite unjustifiably surrendered to Soult on March 10. Pursued by Wellington's remaining forces, early in April Masséna's exhausted troops crossed the Portuguese frontier en route for Salamanca. His fruitless campaign had cost him 25,000 casualties.

Campaign of 1811.—Meanwhile the allied forces invested at Cadiz had gained a successful action against their besiegers at the Battle of Barrosa (March 5). In consequence, Soult hurried back from Badajoz to Andalusia. On April 22, Beresford, whose Anglo-Portuguese force had been raised to 18,000 men, laid siege to Badajoz. The main allied army, which had suspended its pursuit of Masséna, was now engaged in the blockade of Almeida. Masséna returned to its relief, and the two armies met at Fuentes de Oñoro on May 3, when Masséna was driven off with a loss of 650 men to Wellington's 250, and again on the 5th, when Masséna attempted a general assault against Wellington's faulty position and was repulsed chiefly by the steadiness of the allied troops. His forces on that day suffered 2,200 casualties to Wellington's 1,450. Two days later Masséna began his retreat to Salamanca. The French abandoned Almeida on the 10th.

Soult returned from the south with 24,000 men in May to attempt the relief of Badajoz. Beresford gave battle, inexpertly, with 24,000 Spanish and Portuguese and 10,000 British troops at Albuera, southeast of Badajoz, on May 16. The resolution of Beresford's troops saved the day, and obliged Soult to retire with a loss of 8,000 casualties. The British casualties, however, numbered 4,000 and their allies' 1,760. A fortnight later Wellington resumed the siege of Badajoz with inadequate Portuguese cannon. The siege was again raised on June 10, when Wellington withdrew his 37,000 British and 17,000 Portuguese troops behind the Caia River, west of Badajoz, to oppose Soult and Auguste Marmont, who had replaced Masséna. The two marshals joined forces at Mérida on June 17 and advanced toward Wellington with nearly 60,000 before they decided to avoid battle. Disagreement between them led next to Soult's departure (June 28) for Andalusia, and Marmont, with 43,000 men, withdrew north on July 15 to the Tagus valley. While the bulk of his forces remained to protect the eastern frontier, Wellington brought his siege train from Lisbon to blockade Ciudad Rodrigo (Aug. 11). Marmont advanced with 58,000 men to its relief, but when Wellington raised the blockade to await him with 30,000 British and 16,000 Portuguese troops, Marmont contented himself with a reconnaissance in force on Sept. 25 and retired to the Tagus on Oct. 1.

Campaign of 1812.—Anxious to secure the northeastern approach to Portugal, Wellington again invested Ciudad Rodrigo on Jan. 8 and captured it by storm, with a loss of 550 casualties, on Jan. 19, long before Marmont could intervene. After remaining in cantonments Wellington's troops marched on Feb. 16 and besieged Badajoz on March 16. The fortress fell on April 6, and cost Wellington 5,000 casualties. The French had already lost their siege train at Ciudad Rodrigo and now at Badajoz their pontoon train was captured. On May 19 a detachment under Hill captured and destroyed the French bridge of boats across the Tagus at Almaraz and so forced Soult and Marmont to use the bridge of Toledo for their communications.

While Hill remained with 22,000 men at Mérida to keep watch on Soult, Wellington on June 13 advanced with 48,000 British and Portuguese against Marmont at Salamanca. Marmont withdrew north to the Douro River until the arrival of reinforcements enabled him to assume the offensive on July 16 in a manœuver against Wellington's communications. A race ensued between the two armies to obtain a favourable position for battle; on more than one day they marched in parallel columns separated by only a few hundred yards. Finally, on July 22, at the Battle of Salamanca Wellington seized the opportunity afforded by the isolation of Marmont's left wing from the rest of the French Army to inflict a crushing defeat on his adversary. The allies, with Spanish reinforcements, disposed of 50,000 men and 60 guns; Marmont had 48,000 and 78 guns. Wellington suffered 4,760 casualties, Marmont's losses numbered 14,000 men and 20 guns.

The French withdrew to Burgos, which Wellington proceeded to besiege (Sept. 19) after his triumphant entry into Madrid on Aug. 12. The concentration against him of French troops from all over Spain obliged him to abandon his unsatisfactory invest-

ment of Burgos on Oct. 22 and begin his retreat. With difficulty he gained time for Hill to join him as he withdrew. At Salamanca on Nov. 11 the French with 90,000 refused his offer of battle with 68,000 troops, and eight days later his retreat and the campaign ended at Ciudad Rodrigo. His extremely skilful retreat had cost him 6,000 casualties. The advance on Madrid was undoubtedly a mistake, but the campaign had been brilliant. The French had suffered far higher casualties, including 20,000 captured, and had been driven out of all Spain south of the Tagus.

Campaign of 1813.—While the catastrophic outcome of Napoleon's campaign in Russia in 1812 obliged him to draw heavily on his forces in the Peninsula, Wellington marched from Portugal to begin the campaign of 1813 with an army of 100,000 men, of whom 52,000 were British. In Biscay and Navarre the activities of the Spanish guerrillas occupied the attentions of four French divisions under Gen. Bertrand Clausel. The French were unable to defend the Douro, and fell back northeastward, abandoning Burgos, to the line of the Ebro. When Wellington turned the northern flank of this position, Joseph, advised by Marshal Jean Baptiste Jourdan, decided to fight a delaying action south of Vitoria to cover his further retreat. Joseph had only 57,000 men, for Clausel, despite repeated orders, had not joined him; he was attacked on June 21 by Wellington with 72,000. Had Wellington's orders been followed, few of the French would have escaped. Yet although Joseph's casualties were only 8,000 to Wellington's 5,000, he lost the whole of his artillery train, 150 guns, and all his baggage. The French retreated over the Pyrenees into France. Wellington halted his pursuit at Pamplona, for it was necessary first to reduce the fortresses of Pamplona and San Sebastian before the allies could continue their advance. Until these should fall he occupied the main western passes of the Pyrenees on a front about 50 mi. SE of San Sebastian.

On July 12 Soult arrived to take over from Joseph command of the troops who had retreated from Spain. Just over a week later he launched a counteroffensive with 70,000 men along the three main valleys of the Pyrenees which lead to Pamplona. Against Wellington's divisional commanders Soult achieved some initial success, but when he encountered 16,000 under Wellington at Sorauren, northeast of Pamplona, on July 28, his attack with 30,000 was repulsed with heavy loss. Wellington now followed up his advantage and after six days' fighting had driven the thoroughly disorganized French back to the northern slopes of the Pyrenees. Between July 25 and Aug. 2 Soult lost 13,000, Wellington about half as many.

San Sebastian, first assaulted by the allies on July 25, was then blockaded, owing to lack of ammunition, until Aug. 22, when the siege was resumed; the fortress was successfully stormed with considerable loss of life on Aug. 31. In all it had cost over 3,700 casualties. Soult made a final effort to save San Sebastian on the day of its capture, and was driven off after two days' fighting with a loss of 3,800 casualties as opposed to the allies' 2,600. He next resolved to stand on the defensive and constructed a fortified line to the south of the Bidassoa River. This Wellington attacked in October and carried after the combats of Oct. 7–9 with losses of about 1,600 to both sides. Soult then proceeded to prepare a fresh position to the north on the Nievelle River, and Wellington, having brought his troops across the Bidassoa, halted his advance to await the fall of Pamplona. The fortress was captured on Oct. 25. On Nov. 10 the allied army drove Soult's troops from their lines on the Nivelle, capturing 59 guns; the French suffering approximately 4,300 casualties, the allies about 3,500. At this point Wellington was compelled to send most of his ill-found Spanish troops back to Spain, for he was anxious that they should not jeopardize his position by their maltreatment of the French population.

The Invasion of France, 1814.—With the news on Dec. 8, 1813, of Napoleon's decisive defeat at Leipzig (October) came orders that Wellington should press his invasion of France. Next day he attacked Soult in his position on the Nive River south of Bayonne. The engagement lasted for five days, Soult launching unsuccessful counterattacks on Dec. 10 and 11, and again on the 13th. Having lost 5,900 in the five days' fighting, which cost the allies 5,000, Soult withdrew to the Adour River. Bad weather delayed the operations against Soult's new front until mid-February 1814, when Wellington began a series of skilful movements in which he maneuvered Soult out of his position on the Adour (Feb. 19–24). Leaving Sir John Hope to besiege Bayonne, Wellington set out in pursuit of Soult. He overtook the French at Orthez on Feb. 27, and with 43,000 men drove Soult's 37,000 from the field; his victory cost him 2,000 casualties, Soult losing twice as many. The British continued to press Soult's retreat until bad weather brought them to a standstill and contact was lost on March 3.

While Soult hurried his disorganized troops in the direction of Toulouse and did not halt until Tarbes, where he arrived on March 18, Wellington occupied Bordeaux to provide a new sea base. On March 18 Wellington resumed the pursuit with an army raised to nearly 50,000 men by the arrival of a Spanish contingent and engaged Soult's rear guard during the 19th. Next day Soult fought a small and unprofitable combat at Tarbes which delayed his withdrawal and made him retire on Toulouse in the utmost confusion. Wellington, however, moved after him slowly, delayed by heavy rain and made cautious by reports that Napoleon had fallen back to Orléans, which might mean that the emperor intended to join forces with Soult and raise southern France against the allies.

When Wellington appeared before Toulouse on March 26 he was still unaware of Napoleon's defeat on the previous day at La Fère-Champenoise. The condition of Soult's army encouraged Wellington to dispense with most of the preparatory operations and the precautions that an attack on the very strong French position would have normally demanded. The allied army's hazardous assault on April 10 cost him 4,500 casualties, half again as many as Soult's, but on the 12th Soult evacuated Toulouse to continue his retreat. The same day Wellington received news of the fall of Napoleon and at once informed Soult. The last engagement was fought at Bayonne where the French garrison made a sortie on the night of the 14th, which cost them 900 and the allies 800 casualties. On the 18th an agreement for the suspension of hostilities was signed and the Peninsular War was over.

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PENITENTIAL, a manual used by priests of the Western Church, especially during the early Middle Ages, in administering ecclesiastical penance. Penitentials contained (1) detailed lists of sins which the priest was to consider in assisting the penitent with his examination of conscience and confession; and (2) corresponding penances which were to be assigned by way of satisfaction for these sins. Penitentials originated as a development of the church's traditional belief that sin may not be pardoned by ecclesiastical authority except on condition that a penance properly proportioned to the offense be performed. In the early church the determination of the length and severity of this penance was left to the discretion of the local bishop or his delegate, the so-called priest-penitentiary. In some instances, however, church councils and eminent ecclesiastics enacted canons which stipulated the penance to be done for certain grave sins. The unrealistic severity of public penance led to its gradual decline and prepared the way for the introduction of private penance, a form of ecclesiastical pardon which retained all the essential juridical features of the older ritual—contrition, confession, satisfaction, and absolution granted by the bishop or priest—yet no longer required the

enrollment of the sinner among the penitents who were publicly expiating their guilt. (*See* also CONFESSION: *Discipline of Penance.*) Penitentials played a significant role in the development of private penance, since, as their use spread more and more widely among the parish clergy, the concept of ecclesiastical penance as involving public excommunication gradually receded, until its only vestige remained in the directive that no one guilty of serious sin should approach the Eucharist until after having first received absolution in the sacrament of penance.

For reasons closely connected with the rise of Celtic monasticism, the first penitential books appeared in Ireland and Wales. The earliest extant compilations are probably those associated with St. David and various Welsh synods of the 6th century, though the so-called *Canons of St. Patrick* (*c.* 450) are occasionally, and somewhat loosely, spoken of as the first penitential. Among the more important of the early books are those of St. Finnian (*c.* 550), St. Columban (*c.* 600), and the influential penitential attributed to Theodore, archbishop of Canterbury (668–690). The Celtic penitentials were brought to the continent of Europe by missionary monks at a very early date. Their introduction met with opposition of ecclesiastics who favoured the older, traditional public penance, but there is considerable documentary evidence that penitential books were in use among the Franks by the late 6th century, in Italy by the late 8th century, and among the Spanish Visigoths by the early 9th century.

Besides their importance in the history of theology, the penitentials are of value to the philologist as source material for comparative studies of Latin, Anglo-Saxon, Old Irish and Icelandic forms; to the social historian for the vivid, often revolting picture they present of the manners and morals of barbarous peoples just coming under the influence of Christianity; and to the student of jurisprudence for the information they afford relative to the early history of composition by payment of the *wergeld.*

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PENN, SIR WILLIAM (1621–1670), British admiral who fought in the first two Dutch Wars (1652–54 and 1665–67) and who commanded the expedition which captured Jamaica in 1655, was born at Bristol on April 23, 1621. In his youth he served at sea with his father, a merchant and naval captain, and in the Civil War fought for Parliament, being appointed rear admiral of the Irish seas in 1647. He was arrested in 1648 on suspicion of corresponding with Charles I, but was soon released. In 1651 he pursued the royalist ships under Prince Rupert in the Mediterranean.

On the outbreak of the First Dutch War in 1652, Penn was appointed vice-admiral to Robert Blake and was present at the battle in the Kentish Knock on Oct. 8–9 (new style; Sept. 28–29, old style). He took part in the three days' battle off Portland on Feb. 28–March 2 (N.S.; Feb. 18–20, O.S.), 1653, and also served in the final battles of the war. He was made a general of the fleet in December 1653. After secretly offering in 1654 to carry the fleet over to Charles II, then in exile, he sailed in December in command of the expedition which Oliver Cromwell sent to the West Indies, and which captured Jamaica in May 1655. Although he was not responsible for the shameful repulse at Santo Domingo, Hispaniola, in April, on his return to England he and his military colleague Robert Venables were sent to the Tower of London (September 1655). Released in October, he retired to Ireland.

He continued to communicate with the royalists and at the Restoration in 1660 was knighted and appointed a commissioner for the Navy. In the Second Dutch War (1665–67) he served as captain of the fleet with the duke of York (afterward James II) at the battle off Lowestoft on June 13, (N.S., June 3, O.S.), 1665. Penn died at Wanstead, London, on Sept. 16, 1670, and was buried in the church of St. Mary Redcliffe, Bristol. By his wife Margaret he was the father of William Penn, the founder of Pennsylvania. Penn was the author of a code of naval tactics which was the basis of the "Duke of York's Sailing and Fighting Instructions," for long the orthodox tactical creed of the Navy.

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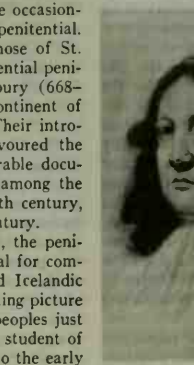
PENN, WILLIAM (1644–1718), English Quaker, advocate of religious toleration, and founder of Pennsylvania, was born at Tower Hill, London, on Oct. 14, 1644, the son of Admiral Sir William Penn. He acquired the foundations of a classical education at Chigwell school, where he came under Puritan influences, and went on in 1660 to Oxford, from which he was "sent down" at the beginning of his second year for nonconformity. (He was later to denounce the English universities as "Signal Places for Idleness, Looseness, Prophaneness, Prodigality, and gross Ignorance.") After a period of travel on the continent of Europe, during which he spent nearly two years at the Protestant university of Saumur, France, he returned to England to give himself briefly to the study of law at Lincoln's Inn. This was the extent of his formal education; but, such as it was, it was to stand him in good stead in his writings and his encounters with British justice.



BY COURTESY OF THE HISTORICAL SOCIETY OF PENNSYLVANIA

WILLIAM PENN. PORTRAIT IN PASTEL BY FRANCIS PLACE (1647–1728) IN THE HISTORICAL SOCIETY OF PENNSYLVANIA

Quaker Activities.—In 1666 his father sent him to Ireland to manage the family estates. It was there that he decided to throw in his lot with the despised sect of Quakers (*see* FRIENDS, SOCIETY OF). The instrument of his "convincement" was Thomas Loe, an itinerant Quaker preacher of Oxford. For his presence at a Quaker meeting at Cork in 1667 Penn was thrown into prison—the common fate of the Quakers under the Clarendon code. He was quickly released, but not before he had expressed in a letter to the earl of Orrery, lord president of the province of Munster, Ireland, his commitment to the principle of religious freedom. His father, outraged by his devotion to his new found faith, threatened to disinherit him, but young Penn refused to be turned aside and soon emerged as an able and outspoken defender of the religion of the Inner Light.

Truth Exalted (1668), a pamphlet attacking in turn the doctrines of the Roman Catholics, the Anglicans and the dissenting bodies, marked his entry into the theological lists. Before his literary career was over, Penn was to publish more than 100 works, ranging in length from broadsheets to lengthy books. *Truth Exalted* was followed by *The Sandy Foundation Shaken* (1668), in which he questioned the doctrine of the Trinity as commonly received. Though later, in *Innocency With Her Open Face* (1669), he qualified his heterodoxy, he was committed to the Tower of London. In the tower he wrote his most famous book, *No Cross, No Crown* (1669), in which he expounded with learning, eloquence and occasionally humour, the Quaker-Puritan morality. Perhaps the book's most characteristic dictum is: "True Godliness don't (*sic*) turn Men out of the World, but enables them to live better in it, and excites their Endeavours to mend it"—a sentence which reflects both the Puritan conception of "intramundane asceticism" and the Quaker ideal of social reform. *No Cross, No Crown* stands alongside some of the letters of St. Paul, Boëthius' *Consolations of Philosophy* and Bunyan's *Pilgrim's Progress* among the world's finest examples of prison literature.

Though many of Penn's doctrinal and devotional works have lasting value, it is as a protagonist by word and act of religious toleration that he earned his prominent place in English history. In 1670 he wrote *The Great Case of Liberty of Conscience*, the most systematic and thorough exposition of the theory of toleration produced in Restoration England. Though he founded his arguments on theological and Scriptural grounds, he did not overlook rational and pragmatic considerations: he pointed out, for instance, that the contemporary prosperity of Holland was based on "her Indulgence in matters of Faith and Worship."

In that same year he had an unsought opportunity to strike another blow for freedom of conscience and for the traditional rights of Englishmen. On Aug. 14, 1670, the Quaker meeting-house in Gracechurch street, London, having been padlocked by the authorities, he preached in the street to several hundred persons. After the meetings, he and William Mead were arrested and imprisoned for riot. A full account of their trial in the Old Bailey, a vivid courtroom drama, was soon published under the title *The People's Ancient and Just Liberties Asserted* (1670). With calm courage born of his Quaker faith and with skill in pleading derived from his legal training, Penn exposed the illegality of the proceedings; the jury, under the leadership of one Edward Bushell, manfully resisted the browbeating of the mayor and recorder. For their refusal to bring in a verdict of "Guilty," as directed by the bench, the jurymen were fined and imprisoned; but they were vindicated, when Sir John Vaughan, lord chief justice, enunciated the principle that a judge "may try to open the eyes of the jurors, but not to lead them by the nose." "Bushell's case" stands as a landmark in English jurisprudence, establishing beyond question the independence of the jury.

Sir William Penn died in 1670, having finally become reconciled to his son's Quakerism. Young Penn inherited his father's estates in England and Ireland, and became, like his father, a frequenter of the court, where he enjoyed the friendship of Charles II and his brother James, an unusual experience for a Quaker. In 1672 he married Gulielma Springett, daughter of Mary Penington by her first husband Sir William Springett, and stepdaughter of Isaac Penington, a Quaker, like Penn, of high birth and literary attainments. Of this marriage eight children were born, four of whom died in infancy.

During the 1670s Penn was ceaselessly busy as a polemicist and minister, producing no less than 40 controversial tracts, in which he engaged theologians of various persuasions on matters of religious doctrine and practice. These productions are probably the least interesting of his writings to the modern reader, though they were of the utmost importance to the Society of Friends, still struggling to vindicate its place among Christian bodies and fortunate to have so able and fluent a defender. Penn also undertook two preaching missions to the continent. In 1671 he traveled through Holland and into northern Germany visiting small groups of Friends and religious seekers, including the followers of the mystic Jean de Labadie (who rebuffed him) and the princess palatine Elizabeth (who welcomed him gladly). Six years later, in company with George Fox, Robert Barclay and George Keith, three of the foremost Quakers of the time, he made another missionary journey through the same region, renewing his friendship with Princess Elizabeth and established contacts which would later help him in peopling Pennsylvania with emigrants from the Low Countries.

The latter years of the decade were occupied with political activities. In the midst of the excitement generated by the "popish plot," he twice supported the candidacy of the radical republican Whig Algernon Sidney for parliament. At Guildford and later at Bramber in 1679 he campaigned vigorously but unsuccessfully for his friend, drawing down upon himself the criticism of those Quakers who considered such activity unsuitable for one of their religious profession. During these years he also wrote a number of pamphlets on behalf of the radical Whigs. *England's Great Interest in the Choice of This New Parliament* (1679) is especially noteworthy as one of the first clear statements of party doctrine ever laid before the English electorate.

Settlement of Pennsylvania.—Even before this excursion into English politics, he had become involved in American colonization as a trustee for Edward Byllynge, one of the two Quaker proprietors of West New Jersey. Though recent scholarship tends to give Byllynge the major credit for writing the "Concessions and Agreements" of West New Jersey, there is no doubt that Penn had a hand in making it the remarkable democratic and libertarian document it is. In 1681 he and 11 other Quakers bought the proprietary rights to East New Jersey from the widow of Sir John Carteret. In the same year, discouraged by the untoward turn of political events in England, where Charles II was ruling without parliament and prospects for religious freedom seemed dark, he sought and received a vast province on the west bank of the Delaware river, which was named Pennsylvania for his father (to whom Charles II had owed a large debt cancelled by this grant). A few months later the duke of York granted him the three "lower counties" (later Delaware). In Pennsylvania Penn hoped to provide a refuge for Quakers and other persecuted people and to erect an ideal Christian commonwealth. "There may be room there, though not here," he wrote to a friend in America, "for such a holy experiment."

The fundamental law of this "holy experiment" was to be the Sermon on the Mount, whose principles the Quakers construed not as counsels of perfection but as practical guides to life. As proprietor, Penn was free to create a government which should embody his Quaker-Whig ideas. In drawing up the Frame of Government he intended, he said, to leave himself and his successors "no power of doing mischief, that the will of one man may not hinder the good of a whole country." Freedom of worship was, of course, to be absolute, and all the traditional rights of Englishmen were carefully safeguarded. The actual machinery of government outlined in the Frame proved in some respects clumsy and unworkable, but he wisely included an amending clause—the first in any written constitution—so that it could be altered as necessity required.

Penn himself sailed for his province late in 1682 in the "Welcome," leaving his family behind. He found his experiment well under way. The city of Philadelphia was already laid out as a "green country town" on a gridiron pattern according to his instructions and settlers were pouring in to take up the fertile lands lying around it. Presiding over the first assembly, he saw the government of the "lower counties" united with that of Pennsylvania and the laws "agreed upon in England" incorporated in the "Great Law" of the province. In a series of treaties based on mutual trust he established good relations with the Leni-Lenape Indians. (Benjamin West's famous painting of the "Great Treaty" at Shackamaxon, however, must be regarded as an exercise of the historical imagination.) He also held an unsuccessful conference with Lord Baltimore, proprietor of the neighboring province of Maryland, to negotiate a boundary line. This boundary was to remain a bone of contention for more than half a century; in 1684, after only two years in his colony, he was obliged to go back to England to defend his interests against Baltimore.

Before his return, he published *A Letter to the Free Society of Traders* (1683), containing his fullest description of Pennsylvania and including a valuable account of the Leni-Lenape, based on firsthand observation. With the accession of his friend the duke of York as King James II, he found himself in a position of great influence at court, whereby he was able to have hundreds of Quakers, as well as political prisoners such as John Locke, released from prison. When James issued his Declaration of Indulgence in 1687, Penn welcomed it, though this attitude laid him open to criticism, since the declaration provided only for the toleration of dissent at the royal pleasure, not as a matter of fundamental right. But the Act of Toleration (1689), passed after James's abdication, finally established the principle for which Penn had laboured so long and faithfully.

His close relations with James brought him under a cloud when William and Mary came to the throne. His colony was temporarily (1693–94) taken from him, and for a time he was forced to live virtually in hiding to avoid arrest. He used this period of enforced retirement to write some of his most charming and thoughtful books. Among other works he produced *An Essay Towards the*

Present and Future Peace of Europe (1693), in which he proposed an international organization to prevent wars by arbitrating disputes; *Some Fruits of Solitude* (1693), a collection of religious and practical maxims which Robert Louis Stevenson was to praise, two centuries later, as a "sweet, dignified, and wholesome book"; and *The Rise and Progress of the People Called Quakers* (1694), the earliest effort to set down the history of the Quaker movement. He also drafted (1696) the first plan for a union of the American colonies.

In 1696, his first wife having died, he married Hannah Callowhill of Bristol, by whom he had seven children, five of whom lived to adulthood. Meanwhile, affairs had been going badly in Pennsylvania. The assembly quarreled constantly with the council and with Penn's deputy governors. The "lower counties" were unhappy at being unequally yoked with the larger province. Relations with the home government were strained by the Quakers' conscientious refusal to provide military defense. And the quitrents, by which the proprietor hoped to gain an income from his province, proved almost impossible to collect. In 1699 the proprietor with his wife returned to his province and took up residence at Pennsbury, his handsome country seat on the Delaware, north of Philadelphia (now reconstructed by the commonwealth of Pennsylvania). He contrived to settle many of the outstanding difficulties and in 1701 promulgated a revised constitution, known as the charter of privileges, under which legislative power was vested in a single-chamber assembly. This democratic instrument of government was to remain in force until 1776. After less than two years his affairs at home once more demanded his presence and he left the province, never to see it again. His Pennsylvania interests he left in the capable hands of his secretary, James Logan, who upheld them loyally for the next half century.

Retirement and Death.—Penn's final years were unhappy. His eldest son, William Jr., turned out a scapegrace. His own poor judgment in choosing his subordinates (save for the faithful Logan) recoiled upon him: his deputy governors proved incompetent or untrustworthy, and his steward, Philip Ford, cheated him on such a staggering scale that he was forced to spend nine months in debtors' prison. In 1712, discouraged at the outcome of his "holy experiment," he commenced negotiations to surrender Pennsylvania to the crown, saving only the precious principle of religious freedom. A paralytic stroke, which seriously impaired his memory and dulled his once-keen intellect, prevented the consummation of these negotiations. He lingered on, virtually helpless, until 1718, his wife undertaking the management of his proprietary concerns. He died July 30, 1718, and was buried at Jordans in Buckinghamshire.

Penn's collected works were published in 1726 (reprinted 1771, 1782, 1825). *The Witness of William Penn*, edited by Frederick B. Tolles and E. Gordon Alderfer in 1957, is an anthology of his writings.

See also references under "Penn, William" in the Index.

BIBLIOGRAPHY.—Samuel M. Janney's *Life of William Penn* (1850) is still valuable, especially for its many excerpts from Penn's letters. Three useful modern biographies are William I. Hull's *William Penn: a Topical Biography* (1937); William Wistar Comfort's *William Penn 1644–1718: a Tercentenary Estimate* (1944); and Catherine Owens Peare's narrative *William Penn* (1957). (F. B. T.)

PENNANT, THOMAS (1726–1798), Welsh naturalist and traveler, whose *British Zoology* (1766 *et seq.*) gave a strong impetus to zoological and particularly ornithological work in Great Britain, was born on June 14, 1726, at Downing, Flintshire. Pennant has been called the leading British zoologist since John Ray and before Charles Darwin. According to Samuel Johnson he was "the best traveller I ever read; he observes more things than anyone else does." Pennant's portrait by Thomas Gainsborough is in the National Museum of Wales, Cardiff. He died at Downing on Dec. 16, 1798.

His *Synopsis of Quadrupeds* (1771) was later enlarged into a *History of Quadrupeds* (1781). The *Arctic Zoology* was published in 1784–87. His travel books, all containing valuable information on local customs, natural history, and antiquities, include the *Tour in Scotland in 1769* (1771), followed by an account of another Scottish tour (1774); *A Tour in Wales* (1778), the second edition of which (1784) incorporated the *Journey to Snowdon;* and *The Journey from Chester to London* (1782). His *Tour on the Continent* describes a journey in 1765 when he met G. L. Buffon, P. S. Pallas, and other eminent naturalists, as well as Voltaire. It remained in manuscript until published by the Ray Society in 1948. Other works include his popular *London* (1790) and *Outlines of the Globe* (unfinished). Pennant took no degree while at Oxford; but academic honours conferred later included membership of the Royal Society of Uppsala (1757), fellowship of the Royal Society (1767) and doctor of civil law of Oxford (1771). Among his many correspondents in Great Britain and abroad was Gilbert White, whose *Natural History of Selborne* is largely in the form of letters to Pennant. (C. MN.)

PENNELL, JOSEPH (1857–1926), U.S. etcher, lithographer, and writer, was born in Philadelphia, Pa., on July 4, 1857, and first studied there and in Germantown. Like his compatriot and friend, J. M. Whistler, he afterward went to Europe and made his home in London. He produced numerous books (many of them in collaboration with his wife, Elizabeth Robins Pennell), but his chief distinction is as an original etcher and lithographer, and notably as an illustrator. He contributed, indeed, more than any other artist of his period to the art of illustration. During his lifetime Pennell produced more than 900 etchings and mezzotints and more than 600 lithographs, on subjects ranging from the Panama Canal and Yosemite National Park to the factories of England and the temples of Greece. His publications include *Pen Drawing and Pen Draughtsmen* (1889), *Lithography and Lithographers* (1898), a biography of Whistler, with Mrs. Pennell (1908), *Etchers and Etching* (1919), and *The Adventures of an Illustrator* (1925). Pennell moved back to the United States during World War I and died in Brooklyn, N.Y., on April 23, 1926.

See E. R. Pennell, *Life and Letters of Joseph Pennell* (1929).

PENNEY, SIR WILLIAM GEORGE (1909–), English physicist, known for his work in the field of atomic weapons, was born on June 24, 1909, and educated in the technical school, Sheerness, and the Royal College of Science, London University. After holding research fellowships and exhibitions at Wisconsin University (1931–33) and at Trinity and Pembroke colleges, Cambridge, he was assistant professor of mathematics at the Imperial College of Science and Technology, London University (1936–45). He was elected fellow of the Royal Society in 1946. During World War II, he was engaged in scientific work for the Ministry of Home Security and the Admiralty; and in 1944–45, he was principal scientific officer of the department of scientific and industrial research at the Los Alamos Laboratory, N.M. In 1946–52, he was chief superintendent of armament research, Ministry of Supply. He was created a knight of the British empire (1952), was made director of atomic weapons research and development at Aldermaston, Berkshire (1953), and became deputy chairman of the U.K. Atomic Energy Authority in 1961. His publications include many papers on the theory of molecular structure. (D. MCK.)

PENNINES, an extensive system of hills in the north of England formed by an upfold of Carboniferous rocks running southward from the Scottish border into Derbyshire. The name is probably derived from the Celtic *pen*, "high." On the north a well-marked depression, falling below 500 ft. in height, between the lower valleys of the Irthing and the South Tyne, from which it is known as the Tyne Gap, separates the Pennines from the Cheviots. On the northwest the Eden Valley falls between the Pennines and the hills of the Lake District, and the division is continued by the upper valley of the Lune. For the rest the physical boundaries consist of extensive lowlands—on the east the vale of York, on the west the coastal belt of Lancashire and the plain of Cheshire, and on the south and southeast the valley of the Trent River. The Pennines thus cover parts of Cumberland, Westmorland and Northumberland, Lancashire, Yorkshire and Durham, Cheshire and Derbyshire, while the southern foothills extend into Staffordshire and Nottinghamshire.

The Pennine system is often wrongly called a chain, but it is hardly even a range. The hills are broken up into numerous short ranges by valleys cut back into them in every direction, for the

Pennines form a north and south watershed which determines the course of all the larger rivers in the north of England. They are divided into two sections by a gap formed by the Aire River flowing east and the Ribble flowing west. To the north of this gap rise the Craven Uplands and to the west Bowland Forest.

The northern section of the Pennine system is broader and generally higher than the southern. Its western slope is generally short and steep, the eastern long and gradual, this distinction applying to the system at large. In the northwest a sharp escarpment overlooking the Eden Valley is known as the Cross Fell Edge from its highest point, Cross Fell (2,930 ft. [893 m.]), to the southeast of which a height of 2,780 ft. (847 m.) is reached in Milburn Forest and of 2,591 ft. (790 m.) in Mickle Fell. This range is marked off eastward by the upper valleys of the South Tyne and the Tees. In the northern section the highest points are Cross Fell, Whernside (2,419 ft.), Ingleborough (2,373 ft.), and Penyghent (2,273 ft.), and in the southern Kinder Scout (2,088 ft.) which includes the Peak. It is seen that the higher elevations, like the steeper slopes, lie toward the west. The hills between the Lune Valley on the west and the headstream of the Eden and the Ribble on the east are broken into masses by the dales of tributaries to the first-named river. The Ribble and Eden valleys afford a route for the railway between Settle and Appleby. Well-marked eastward ranges occur there between Swaledale and the Ure River, which traverses Wensleydale, and between the Ure and Wharfe. In the first the highest points are High Seat (2,328 ft.) and Great Shunner Fell (2,340 ft.); and in the second Buckden Pike (2,302 ft.) and Great Whernside (2,310 ft.). There is then a general southerly slope to the Aire Gap.

In the southern section heights above 2,000 ft. are rare; the centre of the section is the well-known Peak of Derbyshire. Throughout the system the structure is of Carboniferous limestone and millstone grit with some local shales between. The drier parts of the hills are covered with heather moor while the wet peaty areas are covered mostly with cotton grass. Where the limestone has been exposed, as in the limestone pavement of Ingleborough, the surface is bare except in the fissures where there is a luxuriant vegetation. The summits of the hills are rounded or nearly flat so that the profile of the Pennines is not striking as a rule, but much fine scenery is found in the narrow dales throughout—Wensleydale, Wharfedale, and other Yorkshire dales. The population in the uplands is scanty, though some sheep are kept. There are many farms in the fertile dales and valleys. In the parts about Settle below Ingleborough, in Derbyshire and elsewhere remarkable caverns and subterranean watercourses in the limestone have been explored to great depths. In Ingleborough itself are the Ingleborough Cave, near Clapham; the chasm of Gaping Gill, more than 350 ft. deep; Helln or Hellan Pot, a vast swallow hole 359 ft. deep, only exceeded by Rowten Pot (365 ft.) near Whernside; and many others. Malham Tarn, near the head of the Aire, is drained by a stream which quickly disappears below ground, and the Aire itself is fed by a brook gushing forth in full stream at the foot of the cliffs of Malham Cove. A notable example in Derbyshire is the disappearance of the Wye into Plunge Hole, after which it traverses Poole's Cave, close to Buxton. There may also be noted the remarkable series of caverns near Castleton. Lakes are few and small in the Pennines but there are reservoirs for the supply of the populous manufacturing districts of Lancashire and the West Riding of Yorkshire. The Pennines are much visited by vacationers, among them many climbers and walkers who use the Pennine way, a 250-mi. (402 km.) footpath running along the hills from end to end.

Prehistoric remains are numerous, the great circle at Arbor Low being one of the best known. The Romans left many traces, chief among them being Hadrian's Wall (*q.v.*) which was built across the northern Pennines from Carlisle to the mouth of the Tyne and part of which stands on the Whin Sill. *See* ENGLAND; CUMBERLAND; YORKSHIRE; etc.

PENNS GROVE, a borough of New Jersey in Salem County on the Delaware River opposite Wilmington, Del. Originally a part of Upper Penns Neck Township, the settlement developed around a riverboat landing. By 1830 it consisted of eight dwellings, a tavern, and a store and was a daily point of call for the Wilmington-Philadelphia steamboat. In 1876 the railroad entered the town from Woodbury, and in 1894 Penns Grove became a separate borough. Its subsequent growth was stimulated by the expansion of the Du Pont industries, whose gunpowder plant was started in 1891 immediately south of Penns Grove and whose dye works were established in 1917, the year a trolley line was built from Salem. Afterward, lead-ethyl plant expansion was a further source of employment. For comparative population figures *see* table in NEW JERSEY; *Population.* (H. F. WI.)

PENNSYLVANIA, popularly known as the "Keystone state" because of its central position among the 13 original states, is one of the four states of the U.S. which are officially styled commonwealths. It is bounded north by Lake Erie and New York; east by New York and New Jersey; south by Delaware, Maryland and West Virginia; and west by the Panhandle of West Virginia and by Ohio. Thirty-third among the 50 states in size, Pennsylvania has a total area of 45,333 sq.mi. (117,413 sq.km.), of which 326 sq.mi. (844 sq.km.) are water surface. The state capital is at Harrisburg (*q.v.*). Pennsylvania's state flower is the mountain laurel, the state tree is the hemlock and the state bird is the ruffed grouse. The name, meaning "Penn's woods," was given by Charles II of England in honour of Adm. William Penn, father of William Penn, the founder of the colony.

PHYSICAL GEOGRAPHY

Physical Features.—Pennsylvania is in the form of a rectangle lying between latitude 39° 43′ (the Mason and Dixon line) and 42° N. and longitude 74° 43′ and 80° 31′ W. of Greenwich, with three exceptions: a triangular projection to latitude 42° 16′ N. gives it almost 40 mi. of Lake Erie shore line; two large bends of the Delaware river cut deeply into New York and New Jersey; and an unusual semicircular boundary separates it from Delaware.

The state has five principal physiographic divisions: the coastal plain, the older Appalachians, the newer Appalachians, the Allegheny plateau and a small part of the Lake Erie plain. The Appalachian mountain system, which curves across the state from southwest to northeast, is the most prominent feature of its topography. The state varies in height from sea level on the Delaware river to 3,213 ft. (979 m.; Mt. Davis) in Somerset county. At the extreme southeast the coastal plain touches Pennsylvania in a narrow belt along the Delaware near Philadelphia (*q.v.*).

The southeast province of the older Appalachians includes the piedmont with its limestone lowlands in Chester, Lancaster and York counties and Triassic lowlands extending from Bucks county to Adams county. The northern edge of this province is a discontinuous line of uplands and hills which rise to become South

BY COURTESY OF STANDARD OIL CO. (N.J.)

STATE CAPITOL OF PENNSYLVANIA AT HARRISBURG, COMPLETED IN 1906. THE DOME IS PATTERNED AFTER THAT OF ST. PETER'S BASILICA

HERBERT LANKS FROM A. DEVANEY—PUBLIX

SUSQUEHANNA RIVER VALLEY AT WYALUSING ROCKS IN THE NORTHEASTERN SECTION OF THE STATE

mountain a few miles west of the Susquehanna river, reach an elevation of 2,100 ft. at the Maryland border and continue southward as the Blue Ridge.

A region of ridges and valleys lying beyond South mountain and its related uplands, bordered on the northwest by the high eastern edge or front of the Allegheny plateau, is known as the newer Appalachians or the central province. This province has two main subdivisions, the Great valley and the ridge and valley section, separated by the long ridge of Kittatinny or Blue mountain. The Great valley, locally called the Lehigh, Lebanon or Cumberland valley, is 12 to 20 mi. wide and 120 mi. long. The ridge and valley section, which parallels it with a width of 45 to 70 mi., is notable for ridges of considerable length and uniformity of crest lines, broken only by an occasional V-shaped wind gap, a narrow water gap or a rounded knob, and for long parallel valleys usually only a few miles wide.

In the northeast the newer Appalachians meet the Pocono plateau, a part of the Allegheny plateau which continues on to form the Catskill plateau in New York. The Allegheny plateau extends from the Allegheny front to and beyond the south, west and north borders of the state, and includes the state's highest elevations.

Nearly all of the southeast and central provinces and the northeast portion of the Allegheny plateau are drained by the Susquehanna and Delaware river systems into Chesapeake and Delaware bays. The greater part of the Allegheny plateau is drained by the Allegheny and Monongahela rivers into the Ohio. Tributaries of the Potomac drain a small part of the southeast and central provinces; the Lake Erie plain is drained by short streams into the lake; and a small section of the Allegheny plateau in northern Potter county is drained by the Genesee river into Lake Ontario.

The Susquehanna, which drains almost half of the state, is a wide, shallow stream with numerous islands. At Northumberland it forks into two major tributaries, the North branch and the West branch, both with zigzag courses. The Susquehanna and the Delaware and their principal tributaries flow for the most part transverse to the geological structure. The gorges and water gaps through which they pass in the mountain region provide some of Pennsylvania's most picturesque scenery. The gorges are also of great economic importance as passages for railways and highways. As a result of the sinking of the coastal plain the sea has entered the lower portion of the Delaware river, making a tidal estuary at the head of which the port of Philadelphia developed.

The Allegheny and Monongahela, after following southwesterly and northwesterly courses, join to form the Ohio river at Pittsburgh (*q.v.*). They are of economic importance for transportation in the western Pennsylvania industrial region, and the Ohio river makes Pittsburgh the state's second port.

Climate.—Since the prevailing winds are from the west, Pennsylvania has what is called a humid continental type of climate with extremely variable weather, but with rainfall usually adequate for most crops grown in its latitude. Climatically speaking, there are two regions: one with long summers and mild winters in the southeast and in the Ohio-Monongahela valley, and one with short summers and severe winters in the Allegheny plateau and the north. The mean annual temperature is about 52° F. (about 11° C.) in the southeast, 50° F. in the centre, 47° in the northwest and 49° on the shore of Lake Erie. Temperatures over 100° and below zero have been recorded in the long-summer region, while the short-summer region sometimes has daytime summer temperatures over 90°, although the nights are cool. The summer maxima on the mountains are usually 8° to 10° less than in the valleys directly below them. The average annual rainfall is 42 in.

Soil.—In keeping with its topography, Pennsylvania has many types of soil. The limestone soils of the Lancaster plain, the southeastern part of the Great valley and the valleys of the ridge and valley section are the best for agriculture, although there are some good limestone soils in the southwest. The alluvial soils along the river valleys are also good. In other parts of the state where sandstone and shale predominate the soils are less fertile, varying from good to poor.

Vegetation.—Originally Pennsylvania was covered with forests, but the settlers cleared their farms, the charcoal iron furnaces used vast quantities of timber and finally great lumbering operations in the latter part of the 19th century cut down virtually the last of the original stands. In 1897 the state began the purchase of forestry reserves, and from this grew the department of forests and waters with its scientific forest conservation program, of which Gifford Pinchot (*q.v.*) was a leader. Trees were planted, seedlings provided to private land owners and forest fires fought.

By the 1960s the total forest area of Pennsylvania amounted to more than 15,000,000 ac. or over half the area of the state. More than 1,870,000 ac. were in state forest, 470,000 ac. in national forest, 900,000 ac. in state game land and about 11,000,000 ac. in privately owned woodland which included farm woodland. On the higher elevations the trees are mostly white pine, yellow pine and hemlock, but in the valleys oaks, hickories, maples, locusts and birches predominate. Beautiful smaller trees and shrubs include the dogwood and the mountain laurel. Among the wild flowers are hepatica, wild honeysuckle, trillium, dog's-tooth violet and anemone.

Animal Life.—The primeval forest of Pennsylvania was rich in animal and bird life. Elk, moose, deer, black bear, panthers, wildcats, wolves and passenger pigeons were abundant. The protection and restoration of wildlife was a part of the conservation movement in the state. The state game commission opened its first game refuge in 1905 and by the purchase of game lands, the licensing and regulation of hunting and the propagation of game birds and animals it has greatly increased the wildlife resources of the state. The black bear was saved from extinction and is now fairly common in mountain regions, the white-tailed deer was restocked, and smaller animals such as raccoons, squirrels, rabbits, skunks and woodchucks are common. Wild ducks and geese,

ruffed grouse, quail, pheasants and turkeys are among the game birds. The fish commission protects and propagates fish, stocking streams and regulating and licensing fishermen. Consequently, hunting and fishing have remained major sports in Pennsylvania.

State Parks and Recreation.—In keeping with the increased interest in outdoor recreation, the state has developed an elaborate system of parks and recreation areas. There are more than 125 parks, forest picnic areas, forest monuments and historical parks. More than 3,000 mi. of roads and 4,000 mi. of marked trails have been constructed by the state in developing such sites as Hickory Run northeast of Hazleton, a 12,721-ac. forested tract, and Pymatuning north of Jamestown where a 17,000-ac. lake originally designed to supply water to industry is open to boaters and fishermen. The historical parks include famous sites such as Valley Forge, where Washington's army spent the winter of 1777–78, and

EWING GALLOWAY

REVOLUTIONARY WAR CANNON GUARDS RESTORATION OF GEORGE WASHINGTON'S WINTER HEADQUARTERS, 1777–78, AT VALLEY FORGE

The commonwealth of Pennsylvania maintains 2,068 ac. of the original encampment as a state park

Bushy Run battlefield, scene of an Indian defeat during Pontiac's rising in 1763. In addition, the Pennsylvania historical and museum commission has restored and developed 21 historical properties. The Civil War battlefield at Gettysburg is a national military park.

HISTORY

The country along the lower Delaware river was disputed by the English, Dutch and Swedes in the early days of exploration, trade and settlement. Henry Hudson, an Englishman in the service of the Dutch, entered Delaware bay in 1609. Subsequently both the Dutch and the English traded along the river and established temporary posts in what is now Pennsylvania, but the Swedes were the first to make a permanent settlement, an expansion of settlements which they had begun in Delaware in 1638. In 1643 Johan Printz, a governor of New Sweden, built a fort on Tinicum Island (at Essington) which he called New Gothenborg. Another settlement was soon established at Upland (renamed Chester by William Penn), and other small farming settlements grew up along the river. Since Finland was then under the Swedish crown, Finns made up a large proportion of the settlers. The Dutch seized the Swedish colony in 1655, but were in turn dispossessed by the English who took over their colonies in 1664 as a grant to the duke of York. The Duke's Laws were put into operation along the Delaware and a court was established at Upland. The Swedish and Finnish settlers remained as a nucleus for Penn's colony.

The Quaker Colony.—William Penn (*q.v.*) and other Quakers early became interested in a colony in America for Quakers suffering persecution in England under the so-called Clarendon code. Despite his Quaker beliefs Penn was in good standing with Charles II and his brother the duke of York, later James II, because of the services of his father, Adm. William Penn (*q.v.*). Furthermore, the younger William had inherited a substantial claim against the crown. In 1680 he petitioned for a grant of land for a colony, the duke supported his petition and on March 4, 1681, Charles II granted the charter. Penn was made proprietary of the lands, but the laws of England were to be applicable in the colony until replaced by new laws adopted with the consent of the freemen and subject to review by the crown. Penn granted several successive "frames of government" or constitutions, gradually increasing the powers of the elected assembly until the Charter of Privileges in 1701 gave it more privileges and powers than any other legislative body in the English colonies. In keeping with the purpose of his colony, provisions guaranteeing religious freedom were embodied in its first law code, the Great Law, adopted Dec. 7, 1682. All Christians holding certain amounts of property were eligible as voters and officeholders.

Penn sent commissioners to lay out, in a regular pattern, a "great town" which he named Philadelphia ("city of brotherly love"). In an advantageous location between the Delaware and Schuylkill rivers, the city grew rapidly in population and prosperity. The first assembly was held at Chester in 1682, soon after Penn's arrival in the colony, but Philadelphia was thereafter the seat of the government. Penn maintained a friendly and peaceful policy toward the Indians, taking care to purchase their claims before surveying and settling lands. Of the many treaties which he held with them the most famous was the "Great treaty" of Shackamaxon, according to Voltaire "the only treaty not sworn to and never broken." This policy of fair dealing preserved Pennsylvania from Indian hostilities during Penn's lifetime and indeed until 1755.

In 1692, following the fall of James II and the accession of William and Mary, Penn was removed from the governorship and the colony was placed under the rule of Gov. Benjamin Fletcher of New York. Penn was reinstated, however, in 1694. Except during his two visits, in 1682–84 and 1699–1701, he and his heirs governed through deputy or lieutenant governors bound by detailed instructions and advised by a provincial council. After Penn suffered a stroke in 1712 his wife Hannah acted as proprietary, first for him until his death in 1718 and then for their children, John, Thomas and Richard, until her own death in 1727. John, who had a half interest, died in 1746, and Thomas Penn then became the chief proprietary until his death in 1775. Thomas Penn was a shrewd and somewhat narrow man who lacked his father's idealism and took an interest in the colony chiefly for the financial return it brought him. Two sons of Richard Penn were the last lieutenant governors of the colony, John Penn in 1763–71 and 1773–76 and Richard Penn in 1771–73. John Penn continued to live in Pennsylvania until his death in 1795.

Colonial Immigration.—The liberal and tolerant principles of Pennsylvania's government attracted a constantly increasing flow of immigrants, not only from the British Isles but also from the Rhine country of Germany. Some came for refuge from intolerance, oppression and war; others came to seek a better living in a new country, lured by the enthusiastic pamphlets which Penn had circulated widely. English Quakers were the dominant element to the time of the Revolution, but Welsh Quakers came in large numbers before 1700, a large colony settling in the "Welsh barony" in Montgomery and Delaware counties. The southeastern counties became predominantly English.

German immigration began with the Mennonite Francis Daniel Pastorius, who came to Pennsylvania with some Dutch Quakers in 1683 and founded Germantown (*q.v.*), the pioneer German settlement. The earlier German settlers were for the most part members of the smaller sects who came and settled as groups; they included the Mennonites, Amish, Dunkers or German Baptists, Schwenkfelders and Moravians. After 1727 the volume of German immigration greatly increased but then it consisted mainly of "church people," members of the Lutheran and Reformed churches who were thus distinguished from the smaller "sects." The Pennsylvania Dutch, as they came to be called, predominated in Northampton, Berks and Lancaster counties and adjacent areas. Their farming skills made this region a rich agricultural area and helped to increase the prosperity of the colony. By the time of the Revolution they numbered about 100,000, more than a third of the population.

The third important element in the colony's population was the Scotch-Irish who began to immigrate in numbers about 1728. A hardy, restless, pioneering people, they naturally gravitated to the frontier, pushing forward the area of settlement into the Cumberland valley and southwestern Pennsylvania. Because they differed from the Quakers and the Germans in temperament and in the problems which they faced on the frontier, they formed an opposition to the ruling Quaker element throughout the 18th century. They numbered about 70,000 by the end of the colonial period.

There was also a considerable amount of remigration from other colonies, with Marylanders settling in York county, Virginians moving into southwestern Pennsylvania and Connecticut "Yankees" settling in the beautiful Wyoming and Muncy valleys on the North branch of the Susquehanna after 1770.

This remigration reflected to some extent the serious boundary disputes with Maryland, Virginia and Connecticut. After a long period of litigation, the boundary between Maryland and Pennsylvania was surveyed in 1763–67 by Charles Mason and Jeremiah Dixon, and this Mason and Dixon line (*q.v.*) later became significant as separating the free and the slave states. Farther west, Virginia laid claim to southwestern Pennsylvania and the two colonies established rival county governments in the area in the 1770s. In 1779 a joint commission was set up, and it was decided that the Mason and Dixon line should be extended to a point five degrees west from the Delaware river, with the western boundary extending thence due north to Lake Erie. Connecticut's claim to the northern third of Pennsylvania arose out of the vague language of its sea-to-sea charter, but it was promoted by a private association called the Susquehanna company, organized in 1753. Vigorous efforts to settle the Wyoming valley gave rise to the so-called Yankee-Pennamite wars of 1769–75. During the Revolution a special court of arbitration set up by the Continental Congress decided in favour of Pennsylvania's claim in the Trenton decree, 1782. The boundary with New York, surveyed in 1786–87, caused no serious dispute. In 1792 Pennsylvania bought the Erie triangle, the small triangular strip north of the 42nd parallel, from the federal government in order to have a port on Lake Erie.

Colonial Politics.—The natural conflict between the proprietary and popular elements of the colony's government led to sharp political controversy, in which Benjamin Franklin after 1740 became the leader of the Quaker or popular party. This party, which usually controlled the assembly, contended for the right to tax proprietary lands, to issue paper money and to control expenditures; and one after another the governors went down to defeat. These party battles, which taught Pennsylvanians the art of politics, did not interfere with the colony's rapid economic and cultural growth, however.

Pennsylvania led the colonies in the production of cereals, hay and livestock, and had a surplus for export. The lumber, textile, shipbuilding and iron industries made early beginnings. Printing and publishing began in 1686, and the first paper mill was erected by William Rittenhouse before 1693. By 1775 the colony had nine newspapers. Strategically located to draw upon the resources of Pennsylvania, western New Jersey and Delaware, the merchants of Philadelphia developed an extensive foreign trade, and the city rapidly became a commercial metropolis. The cultural and intellectual life of the colony kept pace with its material prosperity. Science and invention, medicine and the arts made notable progress. Architecture flowered in such public buildings as the statehouse (later called Independence hall) and in the fine colonial mansions of the Philadelphia area. The American Philosophical society, one of the world's oldest learned societies, was founded in Philadelphia in 1743, and the University of Pennsylvania dates back to the same period.

The French and Indian War.—The peaceful development of the colony was interrupted by the conflict between France and Great Britain for possession of the Ohio valley, where Pennsylvania and Virginia traders had begun to trade with the Indians as early as the 1720s. The French, who considered the Ohio river an essential link between their colonies of Canada and Louisiana, became alarmed by the British penetration and especially by the formation of the Ohio Company of Virginia to exploit the lands in southwestern Pennsylvania, then claimed by Virginia. As a result, the French in 1753 began building a line of forts to secure possession of the valley, of which the first were Ft. Presque Isle (at present Erie) and Ft. Le Boeuf (at Waterford, Erie county). After sending George Washington to Ft. Le Boeuf in Dec. 1753 to warn the French against encroaching on British territory, Virginia prepared to build a fort at the forks of the Ohio where the city of Pittsburgh now stands. In April 1754 a French expedition drove away the Virginia workmen and built Ft. Duquesne on the site. An expedition led by Washington defeated a French scouting party, but was later besieged by a stronger French force at the hastily erected Ft. Necessity and compelled to surrender. The British then sent an army under Gen. Edward Braddock against Ft. Duquesne, but on July 9, 1755, at the battle of the Monongahela, Braddock's army was cut to pieces by a smaller force of French and Indians. In the same year the French built Ft. Machault at Venango (present Franklin) to strengthen their communications.

Cut off from their usual trade with the British, impressed by French successes and perhaps recalling some old grievances about sales of land, the Indians took the French side and began raiding Pennsylvania's outlying settlements. To protect the settlers the Pennsylvania government built a line of forts, and even staged a successful raid against the Indian village of Kittanning on the Allegheny (1756). In 1758 an expedition under Gen. John Forbes was successful in taking Ft. Duquesne, and in 1759 the capture of Ft. Niagara by Sir William Johnson compelled the French to evacuate their other forts on Pennsylvania soil. When Forbes took possession of the ruins of Ft. Duquesne he named the place Pittsburgh in honour of the British prime minister, and a new fort was built there and called Ft. Pitt. (*See* also FRENCH AND INDIAN WAR.)

In 1760 the forts in northwestern Pennsylvania were rebuilt, but they were taken and destroyed by the Indians in 1763 at the outbreak of Pontiac's War, and Ft. Pitt was besieged. Col. Henry Bouquet defeated the Indians in a two-day battle at Bushy Run and relieved Ft. Pitt. The next year he led a bloodless but impressive expedition into Ohio as far as the Muskingum river and compelled the Indians to sue for peace. As a result, southwestern Pennsylvania was opened to settlement, which proceeded rapidly and made the area the first important trans-Allegheny extension of the American colonies.

Pennsylvania and the Revolution.—Pennsylvania's opposition to the Stamp act and other tax measures by which Britain sought to raise revenue from the colonies was strong but quiet in its expression. Philadelphia merchants adopted nonimportation agreements, and John Dickinson (*q.v.*) wrote the famous *Letters From a Farmer in Pennsylvania* in defense of American rights. In 1770 Philadelphia citizens refused to permit a tea ship to unload its cargo, but there was no demonstration like the Boston "tea party" and the vessel returned to England. After the so-called Coercive acts were passed to punish Boston, protest meetings were held in Pennsylvania, and an extralegal government by committees of correspondence and committees of safety gradually took shape after 1774.

Pennsylvania's attitude in the dispute with the mother country was of great importance because of its resources and central loca-

tion. The opposition of many Quakers, Dunkers and Mennonites to war and revolution, the loyalty of the Church of England minority to Britain and the disinterest of the German population made Pennsylvania's position doubtful. The Scotch-Irish on the frontiers strongly favoured independence, however, and the fact that the first and second Continental Congresses met in Philadelphia (1774 and 1775–83) also helped Pennsylvania's revolutionary leaders. After the adoption of the Declaration of Independence, which Pennsylvania's delegation supported by only a narrow majority, a provincial convention met in Philadelphia, took over the government and wrote a state constitution which went into effect in Sept. 1776 without being submitted to a vote of the people. This constitution provided for an assembly of one house and for a multiple executive, the supreme executive council, which consisted of 12 members, one elected from each county and one from the city of Philadelphia. By a joint vote the two bodies annually elected a president of the council, who was titular head of the government. Existing inequalities in representation were corrected in favour of the western counties, and the suffrage was extended to all freemen who paid taxes. The Revolution in Pennsylvania was more than a break with Britain; it marked the end of Quaker dominance in the government.

Under the leadership of Joseph Reed and George Bryan the new radical government ruled with a strong hand, disfranchising the opposition by a test act and even confiscating the estates of suspected loyalists. It contributed greatly to the success of the Revolutionary War by furnishing troops and supplies. By the divesting act of 1779 the Penn heirs were deprived of the proprietary lands, although they were allowed to keep the estates or manors which had been surveyed and were further compensated by a grant of £130,000, which was paid after the end of the war. The most lasting achievement of the radicals was the passage of the gradual emancipation act of March 1, 1780, which provided that no child born in Pennsylvania after that date should be a slave. Thus slavery was ended in a generation. While the radicals ruled the state, conservatives aided the Revolutionary cause in congress and the army. Robert Morris organized congressional finances, raising money when others failed. Dickinson wrote many important documents, among them the Articles of Confederation. Anthony Wayne was the most brilliant of the generals from Pennsylvania.

Some important campaigns of the war were fought on Pennsylvania soil (*see* AMERICAN REVOLUTION). Toward the end of the Revolution, a political reaction began which eventually brought the conservatives to power, and they confirmed their gains by repealing the test act. In spite of strong radical opposition, they secured Pennsylvania's ratification of the federal constitution on Dec. 12, 1787, and went on in 1790 to draft a second state constitution. The supreme executive council was abolished, the office of governor was restored with extensive powers and a two-house legislature was established. From 1790 to 1800 Philadelphia, then the largest and wealthiest city in the United States, was the seat of the federal government.

Pennsylvania to the Civil War.—Under Gov. Thomas Mifflin (1790–99) Pennsylvania at first supported the Federalist party, and the state aided in suppressing the Whisky rebellion in western Pennsylvania (1794) and the "Hot Water rebellion" in eastern Pennsylvania (1799), both directed against unpopular federal taxation. The rising opposition elected Thomas McKean governor in 1799, and from then until 1860 the Democrats were the majority party, even though intraparty quarrels sometimes gave victory to their opponents. The westward movement of population and agrarian distrust of the metropolis moved the capital from Philadelphia to Lancaster in 1799, and from Lancaster to Harrisburg in 1812.

After the Revolution settlement increased beyond the mountains in western Pennsylvania. Purchases from the Indians at Ft. Stanwix (1784), Ft. McIntosh (1785) and Ft. Harmar (1789) opened northwestern Pennsylvania to settlers, a large part of these lands being granted to veterans. The upper Susquehanna valley also had many settlers in this period. In 1800 the state's population reached 602,000. The extension of settlement led to a demand for better communications, and there was a widespread campaign for internal improvements. Roads were extended to all parts of the state, and many bridges were built. The first important turnpike in America was the Philadelphia-Lancaster turnpike, completed in 1794, and by 1832 about 3,000 mi. of road had been built by 220 turnpike companies. The building of canals began in 1797, but the first long canal was the Union canal, completed in 1827 between Middletown on the Susquehanna river and Reading on the Schuylkill. In 1826 the state undertook to build a line of "state works" from Philadelphia to Pittsburgh, with the Allegheny portage railroad and the Columbia and Philadelphia railroad serving as links in the canal system. This was opened for traffic in 1834. Numerous branch canals were also built. The canals greatly benefited the economic development of the state, but they were ruinously expensive and created such a burden of debt that they were sold between 1843 and 1858, and later abandoned when railroads took their place. The early railroads were mainly short lines to carry coal from the mines to canals or rivers, but they eventually developed into a great transportation network.

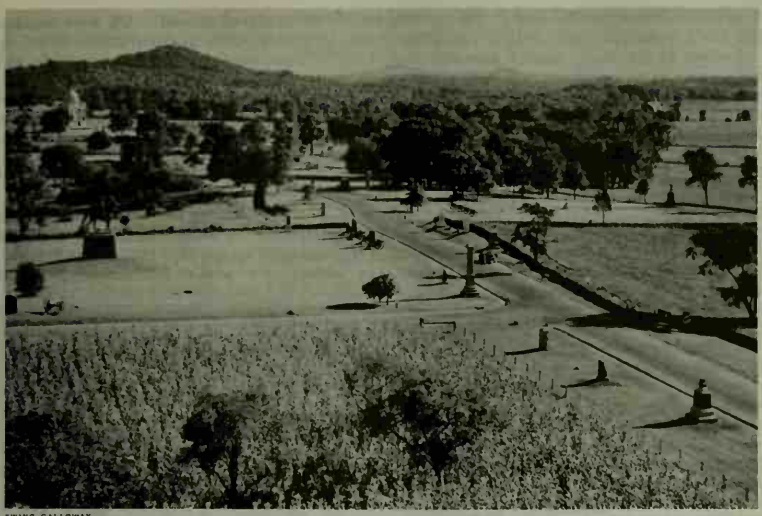
Throughout the period there was a trend toward more popular government. A new constitution in 1838 lessened the powers of the governor, increased the number of elective officers and shortened the tenure of office. In the political controversy which led up to the Civil War, Pennsylvania generally held to a moderate course, helping to elect James Buchanan of Pennsylvania to the presidency in 1856. However, the antislavery movement found much support from the Quakers and other humanitarian groups. This and the growth of the protectionist movement drew Pennsylvania toward the newly formed Republican party. In 1860 Pennsylvania elected the Republican Andrew G. Curtin as governor and gave Lincoln a majority for the presidency.

The Civil War.—As the crisis of Southern secession developed early in 1861, the state legislature pledged support to the Union, and Governor Curtin organized the state's resources in men and money. Pennsylvania supplied 323,629 soldiers to the army, as well as 14,307 sailors and marines. Industrial development was spurred by the need for munitions and supplies. During the war Pennsylvania suffered several Confederate invasions, and the turning point of the war came on Pennsylvania soil when Gen. Robert E. Lee's march into the Cumberland valley was halted at the battle of Gettysburg (July 1–3, 1863). Nearly one-third of the Union troops in that battle were Pennsylvanians. (*See* also AMERICAN CIVIL WAR; GETTYSBURG.)

After the Civil War.—Politically the state was dominated after the Civil War by a remarkable dynasty of "bosses," founded by Simon Cameron and continued by his son James Donald Cameron and by Matthew Stanley Quay and Boies Penrose until the latter's death in 1921. Under their astute management the Republican party generally ruled Pennsylvania, although reform movements occasionally interrupted their control, as when the Democrat Robert E. Pattison was elected governor in 1882 and 1890. During and after the Civil War there was tremendous expansion in the iron and steel industry, in coal mining and other industries, which transformed Pennsylvania from a predominantly agricultural state to an industrial giant. The demand for labour in the growing industrial economy brought a new wave of immigration from 1865 to 1914, and Poles, Italians, Czechs, Hungarians, Russians and others supplemented the earlier population groups. As the state grew industrially a labour movement developed and gave rise to the American Federation of Labor and the Congress of Industrial Organizations, both of which began in Pennsylvania.

Progress was made in extending the services of government. Insurance and banking departments were created in 1873 and 1891 as regulatory agencies. During the administration of Gov. Samuel W. Pennypacker (1903–07) a number of new departments were created, including forestry, health and highways, and a state police force was organized. In 1915 a department of labour and industry was established. Under Gov. William C. Sproul (1919–23) the public-school system was reorganized, an extensive program of highway building was undertaken and a department of welfare was created.

After the death of Penrose, the progressives in the Republican party gained more influence; Gifford Pinchot was elected governor



EWING GALLOWAY

GENERAL VIEW OF THE CIVIL WAR BATTLEFIELD AT GETTYSBURG

The Union battle line extended along the road from the lower right to the Round Tops in the left background, part of Cemetery ridge. The equestrian statue at left is of Union Gen. George Meade

in 1922 and 1930. During his first term (1923–27) the administrative code was enacted to consolidate departments and centralize control, thus increasing the governor's power. This was amended and made still more complete under the intervening conservative Gov. John S. Fisher (1927–31). The division in the Republican party and the coming of the New Deal brought victory to the Democrats in 1934 for the third time since the Civil War, and they elected George H. Earle as governor and one United States senator. The Republicans regained the governorship in 1938 by electing Arthur H. James, and then elected three governors in succession, Edward Martin, James H. Duff and John S. Fine. The Democratic party, however, did not revert to its former weak position; it elected George M. Leader governor in 1954 and David L. Lawrence in 1958. The Republicans returned to power in 1962, electing William W. Scranton to the governorship.

During the depression the state undertook a program of building construction at health, penal, military and educational institutions through the General State authority, approved in 1937. The first section of the Pennsylvania turnpike from Carlisle to Pittsburgh was begun in 1938. At the close of World War II the state also undertook extensive highways and public works construction, and notable progress was made in a conservation program which involved clearing rivers of silt and pollution, reforestation and soil conservation.

GOVERNMENT

Pennsylvania is governed under its fourth state constitution, adopted in 1873 and amended frequently after 1901. Amendments must be approved by a majority of each house in two successive legislatures and then ratified by a majority of a popular vote.

Executive.—The governor, lieutenant governor, auditor general and state treasurer are elected for four years and are ineligible for a second consecutive term. The secretary of internal affairs is also elected for four years but without any limitation on succession. The governor has extensive powers, appointing, subject to the advice and consent of two-thirds of the state senate, the heads of all departments except those who are elected, the members of all independent administrative boards and commissions and—with few exceptions—the members of all departmental boards and commissions. He fills vacancies in various offices which occur when the senate is not in session. His power of veto extends to items in appropriation bills; it may be overridden by a two-thirds vote in each house. His power of pardon is exercised only on the recommendation of three members of a board of pardons consisting of the lieutenant governor, secretary of the commonwealth, attorney general and secretary of internal affairs. In the event of the governor's death, resignation, conviction on impeachment or other disability, the lieutenant governor succeeds him.

A law known as the administrative code, adopted in 1923 and amended in 1927 and later, consolidated the administrative agencies of the state into 19 departments: state, justice, auditor general, treasury, public instruction, internal affairs, military affairs, agriculture, forests and waters, labour and industry, health, highways, public welfare, banking, insurance, mines, property and supplies, revenue and commerce. Important independent administrative commissions include game, fish, public utility, milk control and historical and museum; and similar boards include liquor control, parole and tax equalization. The governor and six department heads whom he designates constitute the executive board which standardizes employment in the various departments and approves the establishment or discontinuance of bureaus or other divisions in the departments. Through the budget bureau, authorized in 1929, and the office of administration, established in 1955, the governor exercises control of expenditures, personnel and policies in all but the three elective departments.

Legislative.—The legislative branch of the government is officially called the general assembly. It consists of a senate of 50 members elected for four years and a house of representatives with members elected for two years; legislation reducing the number of house seats from 210 to 209, reapportioned according to population (1960 census), was passed in 1963. The lieutenant governor presides over the senate but has no vote on the final passage of legislation. The senate has the right of confirming or rejecting appointments made by the governor and sits as a court of impeachment. The house originates appropriation bills and impeachment proceedings. The general assembly may not pass any local or special bills on a wide range of subjects but especially with regard to the affairs of counties, cities, townships, boroughs and school districts. It meets annually on the first Tuesday of January, but the sessions in even-numbered years are limited to fiscal matters. The governor may call it into special session, in which case legislation is limited to the subjects specified in his proclamation.

Judicial.—The supreme court dates from 1705, with the number of justices varying from three to five until the constitution of 1873 fixed it at seven. They are elected for terms of 21 years by the voters of the state at large; minority representation is secured by the provision that each elector shall vote for one less than the number of justices to be chosen at each election. The work of the supreme court had increased to such an extent by 1895 that the general assembly passed an act creating the superior court, consisting of seven judges elected for ten years and eligible for re-election. The supreme court handles all appealed cases involving more than $2,500 or involving felonious homicide, and is the court of last resort. The superior court handles all other appealed cases. Below the appellate courts there are courts of common pleas, courts of quarter sessions and oyer and terminer and or-

phans' courts which function in 59 judicial districts, usually corresponding to counties. Philadelphia has a municipal court, and Allegheny county a county court. Justices of the peace, magistrates and aldermen, elected in townships, city wards and boroughs, have jurisdiction over lesser crimes and disputes.

Local Government.—Counties, townships, cities, boroughs and other civil subdivisions in Pennsylvania derive their powers of self-government from the state, and the general assembly has enacted codes for each type of subdivision. Counties have been divided into eight classes on the basis of population, and cities into four classes. Under a constitutional amendment of 1922, the general assembly granted cities the right to frame and adopt their own charters, as was done by Philadelphia in 1951–52. The council-manager form of government was restricted to boroughs and townships until an enabling act passed in 1957 permitted cities to adopt the plan; Bradford and Titusville were the first to do so, in 1962.

Pennsylvania has 67 counties including Philadelphia (*q.v.*) where the functions of county government are performed by the city. The constitution provides for the election of various county officers, including a board of three county commissioners which acts as the chief administrative agency. The 51 cities are each governed by a mayor and city council, but in the third-class cities the mayor is a member of council and he and the other members direct various departments. The 938 boroughs are governed by a burgess and borough council, and there is also one town, Bloomsburg, where the president of the council performs most of the functions of the burgess. Townships are divided into two classes. The 63 first-class townships are populous suburban areas and are governed by township commissioners. The second-class townships, mainly in rural areas, are governed by township supervisors whose authority is relatively limited.

Finance.—The chief sources of state revenue are a selective sales and use tax and taxes on motor vehicles, corporations, motor fuels, alcoholic beverages, tobacco and inheritance. In 1933 the state assumed control of the sale of alcoholic beverages, setting up a system of state stores for the sale of wine and liquor. From this source it derived an income of more than $80,000,000 annually in the 1960s. More than half the state's income was spent on education and highways. The state net debt more than trebled during the post World War II period. It was greatly increased in 1949 and 1957 as the result of state-wide elections authorizing the payment of bonuses to veterans of World War II and the Korean War.

POPULATION

The population of Pennsylvania in 1790 was 434,373; in 1830 it was 1,348,233; in 1870, 3,521,951; in 1910, 7,665,111; in 1950, 10,498,012; and in 1960, 11,319,366. This last figure represented an increase of 7.8% over 1950. The population per square mile in 1960 was 249.7, as compared with 231.6 in 1950 and with 49.6 for the U.S. in 1960.

The urban area, defined as including all incorporated places of 2,500 or more, all townships having a total population of 10,000 and a density of 1,000 or more persons per square mile, the thickly settled suburban area or "urban fringe" adjacent to cities of 50,000 or more and unincorporated places of 2,500 or more outside this fringe, had a population in 1960 of 8,102,051 or 71.6% of the state total. In 1950 the comparable figures were 7,403,036 and 70.5%. In 1960 the state's 12 standard metropolitan statistical areas had a population of 8,813,274 or 77.9% of the state total; enlargement of SMSAs in 1963 increased population in these areas by about 111,000. Occupied dwelling units in 1960 numbered 3,350,839; average population per household was 3.3.

The population of the state was distributed by colour and nativity in 1960 as follows: 87.1% native white; 5.2% foreign-born white; and 7.6% nonwhite, practically all Negro. Of the foreign-born population in 1960, 20.4% were born in Italy, 12.0% in Poland, and 11.1% in the United Kingdom. There were 94.8 males per 100 females in 1960, compared with 97.0 in 1950. Ten per cent of the population was 65 years old or over; 38.9% of the population 14 years old and over was in the labour force.

Of the total number of employed persons, 2.6% were engaged in agriculture, 1.6% in mining, 4.2% in construction, 38.7% in manufacturing, 7.5% in transportation, 18.7% in wholesale and retail trade and 13.5% in service activities.

In spite of the great volume of immigration from southern and eastern Europe which came mainly to the industrial centres in the latter part of the 19th century, the original population pattern of the state is still noticeable in customs, architecture and speech. This is especially true in Lancaster, Berks, Lebanon, Lehigh and neighbouring counties where persons of German descent, the Pennsylvania Dutch, predominate. Of these the most distinctive are the "plain people," members of the Mennonite, Amish, Dunkard and other small sects, who make up less than 10% of the Pennsylvania Dutch. The "plain people" tend to retain more of the old

HERBERT LANKS FROM A. DEVANEY—PUBLIX

GEOMETRIC "HEX" SIGNS ON A BARN IN BALLY, BERKS COUNTY, A PREDOMINANTLY PENNSYLVANIA DUTCH AREA IN THE SOUTHEASTERN SECTION OF THE STATE

speech, customs and dress than the other Pennsylvania Dutch. The industrious diligence of the Pennsylvania Dutch has kept their region as a prosperous farming country for two centuries, and they are noted for their well-kept fields and large barns, often decorated with geometric designs called "hex" signs. Authorities differ on whether these are talismans for protective purposes or merely for decoration. The Pennsylvania Dutch love of colour and decoration is expressed in their folk art.

EDUCATION

Public-School System.—Pennsylvania's system of free public education began with the Free Public School act of 1834 which created local school districts, permitted the levy of taxes for the support of free elementary schools and provided state aid to districts accepting the act. Earlier laws had provided schooling for children 5 to 12 years old whose parents were unable to pay for it, but these were called pauper education acts and parents were reluctant to educate their children on such terms. Despite some early opposition, the public-school system gradually expanded and the state constitution of 1873 definitely provided for the education of all children above the age of six years and for a state superintendent of public instruction. High schools were established in Philadelphia and Pittsburgh in 1836 and 1849 and were authorized in every district of the state in 1895.

In 1834 the minimum school term was three months; by 1899 it had been lengthened to seven months; and it was finally extended to a minimum of 180 days of school. In 1895 the first compulsory school attendance law required all children 8 to 13 years of age to attend school 16 weeks a year, with certain exemptions provided by law. This was subsequently extended to make attendance compulsory for all children between the ages of 8 and 16 throughout the school year. About 1,750,000 children enrolled annually in the public schools and about 460,000 in private and parochial

*Pennsylvania: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	11,319,366	10,498,012	9,900,180	8,720,017	6,302,115
Abington†	55,831	28,988	20,857	8,684	3,803
Aliquippa	26,369	26,132	27,023	2,931	620
Allentown	108,347	106,756	96,904	73,502	35,416
Altoona	69,407	77,177	80,214	60,331	38,973
Ambler	6,765	4,563	3,953	3,094	1,884
Ambridge	13,865	16,429	18,968	12,730	—
Archbald	5,471	6,304	8,296	8,603	5,396
Arnold	9,437	10,263	10,898	6,120	1,426
Ashland	5,237	6,192	7,045	6,666	6,438
Aston†	10,595	5,576	3,116	2,107	2,641
Avalon	6,859	6,463	6,155	5,277	2,130
Baden	6,109	3,732	2,135	895	427
Baldwin	24,489	—	—	—	—
Bangor	5,766	6,050	5,687	5,402	4,106
Beaver	6,160	6,360	5,641	4,135	2,348
Beaver Falls	16,240	17,375	17,098	12,802	10,054
Bellefonte	6,088	5,651	5,304	3,996	4,216
Bellevue	11,412	11,604	10,488	8,189	3,416
Berwick	13,353	14,010	13,181	12,181	3,916
Bethel	23,650	11,324	5,966†	1,653†	839†
Bethlehem	75,408	66,340	58,490	50,358	7,293
Blakely	6,374	6,828	8,106	6,564	3,915
Bloomsburg	10,655	10,633	9,799	7,819	6,170
Brackenridge	5,697	6,178	6,400	4,987	—
Braddock	12,337	16,488	18,326	20,879	15,654
Bradford	15,061	17,354	17,691	15,525	15,029
Brentwood	13,706	12,535	7,552	1,695	—
Bridgeport	5,306	5,827	5,904	4,680	3,097
Bridgeville	7,112	5,650	4,459	3,092	—
Bristol	12,364	12,710	11,895	10,273	7,104
Bristol†	59,298	12,184	5,857	5,027	1,397
Brookhaven	5,280	1,042	—	—	—
Brownsville	6,055	7,643	8,015	2,502	1,552
Butler	20,975	23,482	24,477	23,778	10,853
California	5,978	2,831	2,614	2,480	2,009
Camp Hill	8,559	5,934	3,630	1,636	360
Canonsburg	11,877	12,072	12,599	10,632	2,714
Carbondale	13,595	16,296	19,371	18,640	13,536
Carlisle	16,623	16,812	13,984	10,916	9,626
Carnegie	11,887	12,105	12,663	11,516	7,330
Castle Shannon	11,836	5,459	3,970	2,353	—
Catasauqua	5,062	4,923	4,764	4,714	3,963
Centerville	5,088	5,845	6,317	4,793	260
Chambersburg	17,670	17,212	14,852	13,171	8,864
Charleroi	8,148	9,872	10,784	11,516	5,930
Cheltenham†	35,990	22,854	19,082	11,015	6,154
Chester	63,658	66,039	59,285	58,030	33,988
Clairton	18,389	19,652	16,381	6,264	—
Clearfield	9,270	9,357	9,372	8,529	5,081
Clifton Heights	8,005	7,549	4,921	3,469	2,330
Coatesville	12,971	13,826	14,006	14,515	5,721
Collingdale	10,268	8,443	8,162	3,834	603
Columbia	12,075	11,993	11,547	10,836	12,316
Connellsville	12,814	13,293	13,608	13,804	7,160
Conshohocken	10,259	10,922	10,776	8,481	5,762
Coraopolis	9,643	10,498	11,086	6,162	2,555
Corry	7,744	7,911	6,935	7,228	5,369
Crafton	8,418	8,066	7,163	5,954	1,927
Danville	6,889	6,994	7,122	6,952	8,042
Darby	14,059	13,154	10,334	7,922	3,429
Darby†	12,598	3,454	2,899	3,077	1,388
Dickson City	7,738	8,948	11,548	11,049	4,948
Donora	11,131	12,186	13,180	14,131	—
Dormont	13,098	13,405	12,974	6,455	—
Downington	5,598	4,048	4,645	4,024	2,133
Doylestown	5,917	5,262	4,976	3,837	3,034
Du Bois	10,667	11,497	12,080	13,681	9,375
Dunmore	18,917	20,305	23,086	20,250	12,583
Duquesne	15,019	17,620	20,693	19,011	9,036
Duryea	5,626	6,655	8,275	7,776	—
Easton	31,955	35,632	33,589	33,813	25,238
East Stroudsburg	7,674	7,274	6,404	4,855	2,648
Economy	5,925	—	—	—	—
Edgewood	5,124	5,292	—	—	—
Edwardsville	5,711	6,686	7,998	9,027	5,165
Elizabethtown	6,780	5,083	4,315	3,319	1,473
Ellwood City	12,413	12,945	12,329	8,958	2,243
Emmaus	10,262	7,780	6,731	4,370	1,468
Ephrata	7,688	7,027	6,199	3,735	2,451
Erie	138,440	130,803	116,955	93,372	52,733
Etna	5,519	6,750	7,223	6,341	5,384
Falls†	29,082	3,540	2,364	1,789	1,856
Farrell	13,793	13,644	13,899	15,586	—
Folcroft	7,013	1,909	1,592	—	—
Ford City	5,440	5,352	5,795	5,605	2,870
Forest Hills	8,796	6,301	5,248	—	—
Forty Fort	6,431	6,173	6,293	3,389	1,557
Fountain Hill	5,428	5,456	4,804	2,339	1,214
Frackville	5,654	6,541	8,035	5,590	2,594
Franklin	9,586	10,006	9,948	9,970	7,317
Freeland	5,068	5,909	6,593	6,666	5,254
Gettysburg	7,960	7,046	5,916	4,439	3,495
Glassport	8,418	8,707	8,748	6,959	—
Glenolden	7,249	6,450	4,825	1,944	873
Greensburg	17,383	16,923	16,743	15,033	6,508
Green Tree‡	5,226	2,818	1,880	1,043	678
Greenville	8,765	9,210	8,149	8,101	4,814
Grove City	8,368	7,411	6,296	4,944	1,599
Hanover	15,538	14,048	13,076	8,664	5,302
Harmony†	5,106	4,501	2,317	—	—
Harrisburg	79,697	89,544	83,983	75,917	50,167
Harrison†	15,710	15,116	13,161	74	650
Hatboro	7,315	4,788	2,605	1,102	823
Haverford†	54,019	39,641	27,594	6,631	2,414
Hazleton	32,056	35,491	38,009	32,277	14,230
Hellertown	6,716	5,435	4,031	3,008	745
Hempfield†	29,704	22,463	20,687	18,598	9,256
Hershey§	6,851	6,076	—	—	—
Hollidaysburg	6,475	6,483	5,910	4,071	2,998
Homestead	7,502	10,046	19,041	20,452	12,554
Honesdale	5,569	5,662	5,687	2,756	2,864
Huntingdon	7,234	7,330	7,170	7,051	6,053
Indiana	13,005	11,743	10,050	7,043	4,142
Jeannette	16,565	16,172	16,220	10,627	5,865
Jefferson	8,280	5,534†	5,585†	5,009†	4,219†
Jenkintown	5,017	5,130	5,024	3,336	2,091
Jersey Shore	5,613	5,595	5,432	6,103	3,070
Jim Thorpe‖	5,945	—	—	—	—
Johnstown	53,949	63,232	66,668	67,327	35,936
Kane	5,380	5,706	6,133	7,283	5,296
Kingston	20,261	21,096	20,679	8,952	3,846
Kittanning	6,793	7,731	7,550	7,153	3,902
Lancaster	61,055	63,774	61,345	53,150	41,459
Lancaster†	10,020	6,859	6,151	2,647	1,782
Lansdale	12,612	9,762	9,316	4,728	2,754
Lansdowne	12,601	12,169	10,837	4,797	2,630
Lansford	5,958	7,487	8,710	9,625	4,888
Latrobe	11,932	11,811	11,111	9,484	4,614
Lebanon	30,045	28,156	27,206	26,643	17,628
Lehighton	6,318	6,565	6,615	6,102	4,629
Lewisburg	5,523	5,268	3,571	3,204	3,457
Lewistown	12,640	13,894	13,017	9,849	4,451
Lititz	5,987	5,568	4,840	3,680	1,637
Lock Haven	11,748	11,381	10,810	8,557	7,210
Lower Burrell	11,952	—	—	—	—
Lower Merion†	59,420	48,745	39,566	23,866	13,271
Lower Southampton†	12,619	3,562	1,843	—	—
Luzerne	5,118	6,176	7,082	5,998	3,817
McKeesport	45,489	51,502	55,355	46,781	34,227
McKees Rocks	13,185	16,241	17,021	16,713	6,352
Mahanoy City	8,536	10,934	13,442	15,599	13,504
Marple†	19,722	4,779	2,170	900	812
Meadville	16,671	18,972	18,919	14,568	10,291
Mechanicsburg	8,123	6,786	5,709	4,688	3,841
Media	5,803	5,726	5,351	4,109	3,075
Middletown	11,182	9,184	7,046	5,920	5,608
Middletown†	26,894	4,987	3,136	1,365	1,383
Midland	6,425	6,491	6,373	5,452	—
Millcreek†	28,441	17,037	7,444	12,848	3,891
Millvale	6,624	7,287	7,811	8,031	6,736
Milton	7,972	8,578	8,313	8,638	6,175
Minersville	6,606	7,783	8,686	7,845	4,815
Monaca	8,394	7,415	7,061	3,838	2,008
Monessen	18,424	17,896	20,257	18,179	2,197
Monongahela	8,388	8,922	8,825	8,688	5,173
Monroeville	22,446	—	—	—	—
Montoursville	5,211	3,293	3,019	1,949	1,665
Morrisville	7,790	6,787	5,493	3,639	1,371
Mount Carmel	10,760	14,222	17,780	17,469	13,179
Mount Lebanon†	35,361	26,604	19,571	2,258	—
Mount Oliver	5,980	6,646	6,981	5,575	2,295
Mount Pleasant	6,107	5,883	5,824	5,862	4,745
Munhall	17,312	16,437	13,900	6,418	—
Nanticoke	15,601	20,160	24,387	22,614	12,116
Narberth	5,109	5,407	5,217	3,704	847
Nazareth	6,209	5,830	5,721	4,288	2,304
Nether Providence†	10,380	6,173	3,793	2,344	2,033
New Brighton	8,397	9,535	9,630	9,361	6,820
New Castle	44,790	48,834	47,638	44,938	28,339
New Cumberland	9,257	6,204	4,525	1,577	1,035
New Kensington	23,485	25,146	24,055	11,987	4,665
Norristown	38,925	38,126	38,181	32,319	22,265
Northampton	8,866	9,332	9,622	9,349	—
North Braddock	13,204	14,724	15,679	14,928	6,535
North Versailles†	13,583	9,821	6,341	4,844	4,882
Norwood	6,729	5,246	3,921	2,353	1,286
Oakmont	7,504	7,264	6,260	4,512	2,323
Oil City	17,692	19,581	20,379	21,274	13,264
Old Forge	8,928	9,749	11,892	12,237	5,630
Olyphant	5,864	7,047	9,252	10,236	6,180
Palmerton	5,942	6,646	7,475	7,168	—
Palmyra	6,999	5,910	5,239	3,646	—
Penn Hills†	51,512	25,280	15,578	8,342	3,407
Philadelphia	2,002,512	2,071,605	1,931,334	1,823,779	1,293,697
Phoenixville	13,797	12,932	12,282	10,484	9,196
Pitcairn	5,383	5,857	6,310	5,738	2,601
Pittsburgh	604,332	676,806	671,659	588,343	321,616
Pittston	12,407	15,012	17,828	18,497	12,556
Pleasant Hills	8,573	3,808	—	—	—
Plum	10,241	—	—	—	—
Plymouth	10,401	13,021	15,507	16,500	13,649
Port Vue	6,635	4,756	3,601	2,538	1,803
Pottstown	26,144	22,589	20,194	17,431	13,696
Pottsville	21,659	23,640	24,530	21,876	15,710
Prospect Park	6,596	5,834	5,100	2,536	1,050
Punxsutawney	8,805	8,969	9,482	10,311	4,375
Quakertown	6,305	5,673	5,150	4,391	3,014
Radnor†	21,697	14,709	12,012	8,151	5,474
Rankin	5,164	6,941	7,470	7,301	3,775
Reading	98,177	109,320	110,568	107,784	78,961
Red Lion	5,594	5,119	4,891	3,198	1,337
Ridgway	6,387	6,244	6,253	6,037	3,515
Ridley†	35,738	17,212	8,641	5,342	1,973
Ridley Park	7,387	4,921	3,887	2,313	1,234
Rochester	5,952	7,197	7,441	6,957	4,688

*Populations are reported as constituted at date of each census. †Township population. ‡Returned until 1940 as Greentree. §Returned in 1950 as Hershey-Swatara. ‖East Mauch Chunck and Mauch Chunck consolidated to form Jim Thorpe borough.
Note. Dash indicates place did not exist during reported census, or data not available.

*Pennsylvania: Places of 5,000 or More Population (1960 Census)** (continued)

Place	Population				
	1960	1950	1940	1920	1900
Ross†	25,952	15,744	10,827	4,949	2,671
St. Clair	5,159	5,856	6,809	6,495	4,638
St. Marys	8,065	7,846	7,653	6,967	4,295
Sayre	7,917	7,735	7,569	8,078	5,243
Schuylkill Haven	6,470	6,597	6,518	5,437	3,654
Scott†	19,094	8,686	6,297	4,927	3,975
Scottdale	6,244	6,249	6,493	5,768	4,261
Scranton	111,443	125,536	140,404	137,783	102,026
Sewickley	6,157	5,836	5,614	4,955	3,568
Shaler†	24,939	16,430	11,185	6,806	4,294
Shamokin	13,674	16,879	18,810	21,204	18,202
Sharon	25,267	26,454	25,622	21,747	8,916
Sharon Hill	7,123	5,464	4,467	1,780	1,058
Sharpsburg	6,096	7,296	8,202	8,921	6,842
Sharpsville	6,061	5,414	5,129	4,647	2,970
Shenandoah	11,073	15,704	19,790	24,726	20,321
Shillington	5,639	5,059	4,932	2,175	—
Shippensburg	6,138	5,722	5,244	4,372	3,228
Somerset	6,347	5,936	5,430	3,121	1,834
Souderton	5,381	4,521	4,036	3,125	1,077
South Williamsport	6,972	6,364	6,033	4,341	3,328
Springdale	5,602	4,939	4,989	2,929	2,929
Springfield† (Delaware Co.)	26,733	10,917	5,488	1,298	889
Springfield† (Montgomery Co.)	20,652	11,403	5,603	3,374	2,400
Spring Garden†	11,387	8,338	5,719	2,766	879
State College	22,409	17,227	6,226	2,405	851
Steelton	11,266	12,574	13,115	13,428	12,086
Stowe†	11,730	12,100	12,577	10,665	2,852
Stroudsburg	6,070	6,361	6,186	5,278	3,450
Sunbury	13,687	15,570	15,462	15,721	9,810
Swarthmore	5,753	4,825	4,061	2,350	903
Swissvale	15,089	16,488	15,919	10,908	1,716
Swoyersville	6,751	7,795	9,234	6,876	2,264
Tamaqua	10,173	11,508	12,486	12,363	7,267
Tarentum	8,232	9,540	9,846	8,925	5,472
Taylor	6,148	7,176	9,002	9,876	3,215
Titusville	8,356	8,923	8,126	8,432	8,244
Turtle Creek	10,607	12,363	9,805	8,138	3,262
Tyrone	7,792	8,214	8,845	9,084	5,847
Uniontown	17,942	20,471	21,819	15,692	7,344
Upper Darby†	93,158	84,981	56,883	8,956	5,385
Upper Moreland†	21,032	8,936	5,103	2,195	—
Vandergrift	8,742	9,524	10,725	9,531	2,076
Warminster†	15,994	7,127	1,977	—	—
Warren	14,505	14,849	14,891	14,272	8,043
Washington	23,545	26,280	26,166	21,480	7,670
Waynesboro	10,427	10,231	10,231	9,720	5,396
Waynesburg	5,188	5,514	4,891	3,332	2,544
West Chester	15,705	15,168	13,289	11,717	9,524
West Hazleton	6,278	6,988	7,523	5,854	2,516
West Mifflin	27,289	17,985	—	—	—
Westmont	6,573	4,410	3,741	1,976	499
West Norriton†	8,342	4,879	3,016	1,375	—
West Pittston	6,998	7,230	7,943	6,968	5,846
West View	8,079	7,581	7,215	2,797	—
West York	5,526	5,756	5,590	3,320	—
Whitehall	16,075	7,342	—	—	—
White Oak	9,047	6,159	—	—	—
Wilkes-Barre	63,551	76,826	86,236	73,833	51,721
Wilkins†	8,272	4,261	3,884	3,455	2,427
Wilkinsburg	30,066	31,318	29,853	24,403	11,886
Williamsport	41,967	45,047	44,355	36,198	28,757
Wilson	8,465	8,159	8,217	3,243	—
Windber	6,994	8,010	9,057	9,462	—
Winton	5,456	6,280	7,989	7,583	3,425
Wyomissing	5,044	4,187	3,320	2,062	—
Yeadon	11,610	11,068	8,524	1,308	689
York	54,504	59,953	56,712	47,512	33,708

*Populations are reported as constituted at date of each census. †Township population.
Note: Dash indicates place did not exist during reported census, or data not available.

schools. Even in 1834 the state made substantial contributions to the support of the schools. In 1921 the state appropriations were made contingent on the maintenance of certain minimum standards as to courses and teachers' salaries and qualifications. By the second half of the 20th century the annual state appropriations amounted to almost $200,000,000.

Higher Education.—After 1854 the need for trained teachers led to the establishment of normal schools under private auspices. These schools received a gradually increasing amount of state aid, and in 1911 the state was authorized to purchase them. In 1926 they were reorganized as state teachers' colleges at Bloomsburg (originally founded in 1839), California (1852), Cheyney (1837), Clarion (1866), East Stroudsburg (1893), Edinboro (1857), Indiana (1871), Kutztown (1866), Lock Haven (1877), Mansfield (1858), Millersville (1854), Shippensburg (1871), Slippery Rock (1889), and West Chester (1869). They offer four-year courses leading to the degree of bachelor of science in education and became state colleges in 1959.

Pennsylvania State.—Pennsylvania State university at University Park, a land-grant institution, receives almost its entire financial support from public revenue. Originally chartered in 1855 as Farmers' high school, it first gave instruction on the college level in 1859. The name was changed to the Agricultural College of Pennsylvania in 1862, to Pennsylvania State college in 1874 and to Pennsylvania State university in 1953.

The university includes colleges of liberal arts, agriculture, business administration, chemistry and physics, education, engineering and architecture, home economics, physical education and athletics, and mineral industries and schools of journalism and forestry. Fourteen two-year branch campuses are located throughout the state. A department of nuclear engineering was set up in 1958, and the Research Reactor building on the University Park campus contains an atomic reactor used in various research projects. Also in 1958 the Groth institute of crystallography and a centre for continuing liberal education were established. The university owns a student-operated FM station.

The University of Pennsylvania.—The University of Pennsylvania, Philadelphia, was founded in 1740 as a charity school. Largely through the efforts of Benjamin Franklin and other leading citizens of Philadelphia, it was transformed in 1753 into an academy, with Franklin as president of the first board of trustees. Two years later it was chartered as the College and Academy of Philadelphia. With the foundation in 1765 of the first medical school in North America the institution became in fact a university, but it was not so called until 1779 when it was, for a time, state supported. Following the passage of an act of the state legislature in 1791 it became a privately endowed and controlled institution, although it receives some state aid.

The divisions of the university include the colleges of arts and sciences, liberal arts for women and general studies, schools of education, engineering, law, dentistry, medicine, veterinary medicine, social work, allied medical professions, nursing and fine arts and the Wharton school of finance and commerce. The Wistar Institute of Anatomy, the first anatomical institute in America devoted entirely to research, was founded in 1892. Also part of the university are the Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis, affiliated with the university in 1910; the William T. Carter foundation of Child Helping; the Institute of Local and State Government; the Albert M. Greenfield Center for Human Relations; and the Psychological Laboratory and Clinic, founded in 1887, the oldest such institution in the United States. Among its activities the university offers through the Institute for Humanistic Studies a special program for corporation executives. Teaching and research programs in radio, television and allied fields are given by the Annenberg school of communications. The university participates with Princeton in the operation of a high-energy nuclear research centre sponsored by the U.S. Atomic Energy commission.

Other Universities and Colleges.—Pennsylvania is especially rich in institutions of higher learning, many of them dating back to the 18th century. Dickinson college at Carlisle (Methodist) was founded in 1773; Franklin and Marshall college, Lancaster (United Church of Christ), the University of Pittsburgh (nonsectarian) and Washington and Jefferson college, Washington (nonsectarian), were all founded in 1787. Philadelphia, which first became a cultural centre in colonial times, is the seat of Temple university (1884; nonsectarian), Drexel Institute of Technology (1891; nonsectarian), LaSalle college (1863; Roman Catholic) and St. Joseph's college (1851; Roman Catholic), among others. Bryn Mawr college for women (1880; nonsectarian), Haverford college (1833; Society of Friends), Swarthmore college (1864; nonsectarian) and Villanova university (1842; Roman Catholic) are located nearby in municipalities of the same names. Other Pennsylvania universities and colleges include Allegheny college, Meadville (1815; Methodist), Bucknell university, Lewisburg (1846; nonsectarian), Duquesne university (1878; Roman Catholic) and the Carnegie Institute of Technology (1900; nonsectarian), both at Pittsburgh, College Misericordia, Dallas (1924; Roman Catholic), Gannon college, Erie (1944; Roman Catholic), Geneva college, Beaver Falls (1848; Reformed Presbyterian), Gettysburg college, Gettysburg (1832; Lutheran), Grove City college, Grove City (1876; Presbyterian), Lafayette college, Easton

(1826; Presbyterian), Lehigh university, Bethlehem (1865; nonsectarian), the University of Scranton (1888; Roman Catholic) and Marywood college (1915; Roman Catholic), both at Scranton, Westminster college, New Wilmington (1852; Presbyterian) and Wilkes college, Wilkes-Barre (1933; nonsectarian). *See* also PHILADELPHIA.

HEALTH AND WELFARE

Care of the needy was recognized as a public responsibility even under the duke of York and again in the Great Law of 1682. For a long period poor relief was administered by poor boards or overseers of the poor in a complex system which had no uniform pattern, and there were county homes or almshouses for institutional relief in most of the counties. In 1937 a uniform system was established. The county homes and similar institutions were placed under county institution districts and a state department of assistance was created to function through county boards of assistance in administering old-age assistance, general assistance to the unemployed, aid for dependent children and the disabled, blind pensions, unemployment counseling, school medical assistance, burial assistance and foster homes. In the 1960s almost half the money expended for these programs came from the federal government. The department of assistance was merged with the department of welfare in 1958 to create the department of public welfare.

The department of welfare operated 18 hospitals for mental disorders, four schools for mental defectives and ten state-owned general hospitals. The management of penal and correctional institutions was transferred to the state justice department in 1953. They include four penitentiaries, an institution for defective delinquents, an industrial home for women, an industrial school and two diagnostic and classification centres. A board of parole was created in 1941.

THE ECONOMY

Agriculture.—Although Pennsylvania is an industrial rather than an agricultural state, it remains important for its farm production, ranking among the first 15 states in cash receipts from farm products in the second half of the 20th century. About 50% of its area was in farms and more than half of its farm acreage was improved. The number of farms increased from 127,577 in 1850 to 224,248 in 1900 but gradually decreased thereafter as submarginal farms were abandoned and also as small farms were consolidated into larger farms. The value of all farm property in 1930 was $1,535,484,000. This decreased by about one-third during the depression and World War II years, but the earlier position had been substantially regained by the 1960s.

Farming in Pennsylvania began as general farming with emphasis on grain growing. About 1790 livestock farming began to assume greater importance, but there was also diversification into fruit growing and truck farming. About 1900 dairy farming to produce milk became the most important farm enterprise, and milk, dairy products, poultry, eggs and other livestock products came to exceed by far all other agricultural products in value. Dairy farming predominates in the northern counties, where a shorter growing season favours pastures and the growing of hay, but the greatest number of cattle are in the south and west. More than 6,000,000,000 lb. of milk are produced annually. The number of sheep declined precipitously after 1900, but swine increased in both numbers and value. Chicken raising is an important source of farm income.

Usually all the rough, and most of the concentrated, food for stock is raised on the farms. Corn is the leading crop in value. Others include tame hay, wheat, oats, potatoes, barley, rye, buckwheat and commercial truck crops. Pennsylvania ranks high among the states in buckwheat production. Most of the buckwheat, barley and oats are grown in the northern and western counties, while corn, wheat and rye are raised more extensively in the northeast. Tobacco is raised chiefly in Lancaster county; Pennsylvania leaf is especially valued as a cigar filler and wrapper. Adams, Franklin and York counties in the south central part of the state and Erie county in the northwest are the principal fruit-growing sections. Adams county leads in the production of apples. Peaches are grown in most of the southern counties and grapes are raised mainly in the lakeshore section of Erie county.

Important farm groups have formed state associations for the study of improved methods and the advancement of their interests, beginning with the dairy farmers in 1874. A state board of agriculture was created in 1876 and this became a department in 1895. Agricultural education has been developed extensively in the schools, and the extension services of the college of agriculture of Pennsylvania State university have helped to introduce scientific methods. Soil conservation districts have been set up by many counties in co-operation with the state department of agriculture to control and prevent erosion and otherwise maintain soil resources.

Industry.—Pennsylvania consistently ranks second to New York in the value of its manufactures, which increased from about $2,800,000,000 in 1914 to more than $7,000,000,000 in 1923, declined to around $3,000,000,000 during the depression of the 1930s but rose to much more than $25,000,000,000 by the mid-1950s. Reflecting the same economic trends, the number of plants fell from around 27,500 in 1914 to about 12,000 in 1933 and then rose to about 20,000 in the 1960s, when there were about a third more employees than in 1914. These figures reflect a trend toward larger plants.

The development of manufacturing resulted largely from abundance of fuel, the facilities for shipment through the port of Philadelphia, the availability of the ores of the Lake Superior region and the development of transportation, first by canal and later

EWING GALLOWAY

STEEL MILL ON THE ALLEGHENY RIVER AT ETNA, NEAR PITTSBURGH

by railroad. By far the most important industry is the production of iron and steel. The first ironworks in Pennsylvania was a bloomery forge, a hearth-type furnace loaded with alternate layers of charcoal and iron ore to produce wrought iron, erected by Thomas Rutter in Berks county in 1716. Charcoal iron furnaces were numerous in eastern Pennsylvania after that time, and the industry continued to prosper and expand there when anthracite took the place of charcoal. With the increase in the use of bituminous coal and of coke made from it, and with the development of the steel industry, western Pennsylvania became the iron and steel manufacturing centre and the Pittsburgh district in particular received a new impetus from the introduction of iron ore from the Lake Superior region.

Pennsylvania's industries are remarkable for their diversity and balance. Although metals are by far the most important, it is virtually impossible to mention a single manufactured product which is not made somewhere in the state. Such diversification has tended to diminish the effects of the decline in coal mining and similar but more temporary slumps in various industries. In the 1960s the leading manufactures were primary metal products, fabricated metal products, electrical and other machinery,

food and kindred products, textiles, apparel and related products, paper, pulp and products, printing and publishing, chemicals, stone, clay and glass products, transportation equipment and petroleum and coal products.

Philadelphia is the great manufacturing centre of the state and one of the most important in the nation. It is surrounded by an area of highly diversified industry. In the 1960s, for example, there were within the city more than 4,000 factories which had a product valued at more than $5,000,000,000, or about one-quarter of the total produced in the state. Despite the development of steel mills in other parts of the state and nation, Pittsburgh remained the centre of the iron and steel industry. After Philadelphia and Pittsburgh, the more important manufacturing cities are Erie, Scranton, Reading, Allentown, Bethlehem, Chester, Wilkes-Barre, New Castle, Lancaster, Harrisburg, York, Altoona and Williamsport (*qq.v.*).

Mining.—*Coal.*—A large part of Pennsylvania's mineral output is represented by coal. With the exception of small areas in Colorado and New Mexico, Pennsylvania contains the only anthracite deposits in the United States. They are found within an area of less than 500 sq.mi. in the northeastern part of the state, chiefly in Lackawanna, Luzerne, Carbon, Schuylkill and Northumberland counties. In addition, Pennsylvania has extensive bituminous coal measures, and most of the coal obtained from these is of high quality. They form the northern extremity of the great Appalachian coal field and underlie an area of 15,000 sq.mi. or more in the west of the state. The Pittsburgh district, comprising the counties of Allegheny, Washington, Fayette and Westmoreland, is exceptionally productive. The coal in Allegheny and Washington counties is noted for its gas-producing qualities, while the famous Connellsville coking coal is obtained in Fayette and Westmoreland counties. The output of coal in Pennsylvania rose steadily from 1880, when 28,650,000 tons of anthracite and 18,425,000 tons of bituminous were mined, to World War I, when the peak figures were 99,612,000 tons of anthracite in 1917 and 178,551,000 tons of bituminous in 1918. Thirty years later, in 1948, the respective tonnages had fallen to 57,140,000 and 132,550,000, and by the 1960s had declined to about 17,000,000 and 65,000,000. This decline reflected technological changes in industry and transportation and a shift from coal to natural gas and oil for home heating. It caused much unemployment in the coal regions, which have sought to develop new industries. The state makes loans to aid local authorities in attracting new plants to these depressed areas, and research is being conducted to find new ways of utilizing coal. Vast coal reserves remain underground. In the early 1960s recoverable reserves, assuming 50% recovery, were estimated at more than 35,000,000,000 tons.

Petroleum.—Extending from the southwest corner of the state is the Pennsylvania section of the Appalachian oil field which, with a small section in New York, furnished nearly all of the country's supply of petroleum for several years after the discovery of its value for illuminating purposes. The first petroleum well was drilled by Edwin L. Drake near Titusville in 1859, and oil wells were developed rapidly in the Oil creek valley and up the Allegheny river from Franklin to Tidioute. The state's output of petroleum reached its peak in 1891 with a production of 31,424,206 bbl. Thereafter the yield declined as the older wells were exhausted and few new wells were developed; in the 1960s production was only about 5,000,000 to 7,000,000 bbl. a year. While the quantity produced has become relatively small, however, the physical and chemical characteristics of Pennsylvania oil give it special value as a base for lubricants.

Natural Gas.—Much natural gas was found and wasted in the early years of oil production, but later it was utilized as a fuel and an illuminant. The peak recorded natural gas production, 138,000,000,000 cu.ft., came in 1906 but it fell to 61,000,000,000 cu.ft. in 1932. This figure was subsequently raised by the discovery of the Leidy gas field in Clinton county.

Iron.—Deposits of various kinds of iron ore were found in the southeastern, eastern, central and some of the western counties, and from the middle of the 18th century until near the close of the 19th Pennsylvania ranked high among the states in production of iron ore. As late as 1880 it was first with 1,951,496 long tons. After the first successful experiments in making pig iron with coke made from bituminous coal, the state's iron foundries rapidly moved westward into the bituminous coal area and away from the early producing centres. The shipment of iron ore from the Lake Superior region, beginning about 1853, caused a further decline of iron mining within the state, since Lake Superior ore could be shipped to the Pittsburgh region at less cost than ore could be shipped from mines within the state. In 1932 the ore mined amounted to only 103,000 long tons, but it increased somewhat thereafter. Most of this ore comes from one mine, the famous Cornwall ore banks, worked continuously since 1740.

Miscellaneous Minerals.—Pennsylvania has extensive areas of limestone rock suitable for making cement, and enormous quantities of it are used in this industry in Northampton and Lehigh counties. In Lehigh county the first successful portland cement plant in the United States was erected in 1870, and thereafter Pennsylvania continued to lead all states in annual cement output. Limestone and dolomites suitable for building purposes are obtained chiefly in Montgomery, Chester and Lancaster counties. Until increased facilities of transport brought more desirable stones into competition they were used extensively in Philadelphia. There are limestone quarries in nearly two-thirds of the counties and great quantities of this stone are used for flux in iron furnaces, for making quicklime, for railway ballast and in road building. Northampton, Lehigh and York counties contain the most productive slate quarries in the U.S. Northampton and Lehigh slate is the only kind in the United States used for school blackboards. There is an extensive area in the southeastern part of the state containing shale clay of a superior quality for making common brick. Kaolin abounds in Chester and Delaware counties, and fire clay in several of the western counties. The state leads all others in the value of its clay and clay products. Glass sand is abundant in both the eastern and western regions, and for many years Pennsylvania has ranked among the leading states in the manufacture of glass. In Chester county, also, is one of the most productive deposits of feldspar, second only to those of Maine.

Trade and Finance.—From colonial days when Philadelphia merchants developed a prosperous commerce with other colonies and with Europe, trade has been an important element in the state's economy. The internal improvements of the 19th century opened channels of trade with the west, and Pittsburgh grew to economic importance as the commercial gateway to the Ohio valley. In the 1960s there were more than 15,000 wholesale trade establishments and 120,000 retail establishments in the state.

Pennsylvania has one port of entry on the Atlantic coast, one on the Ohio river and one on the Great Lakes. Philadelphia, the Atlantic port, exports chiefly coal, grain and flour and imports chiefly petroleum, iron ore, sugar, drugs and chemicals, manufactured iron, hemp, jute and flax. It has long ranked second among the ports of the United States in the tonnage of its foreign commerce, surpassed only by New York city. Pittsburgh has ranked high among U.S. interior ports. Erie has been an important port in the Great Lakes trade and received its first ocean-going vessel through the St. Lawrence seaway in May 1959.

The thriving commerce of colonial Philadelphia built up surplus wealth for investment and gave it an early lead as a financial centre. The first fire insurance company to be chartered in America was the Philadelphia Contributionship, founded in 1752, and the first life insurance company was formed in 1759. In 1780, 90 Philadelphians formed a bank to finance the Revolutionary army, and this bank was succeeded by the Bank of North America, chartered by congress in 1781 and by Pennsylvania in 1782, the first bank to be chartered in America. The first and second Banks of the United States were also located in Philadelphia, and many other banking institutions developed there and elsewhere in Pennsylvania. Although New York city became the leading financial centre after the Civil War, Pennsylvania remained important in this field with many insurance companies and with banks and savings and loan associations in all important centres of population. A decline in the number of banks reflected the growth of branch banking.

Transportation and Communication.—Transportation was an essential factor in Pennsylvania's development. Since the mountain ranges made east-west travel difficult, it was necessary to overcome these difficulties by roads, canals and railways. After the early roads, turnpikes and canals (see *History*, above), a network of railways began to develop between 1830 and 1860. The Philadelphia & Reading railway, begun in 1835, and the Lehigh Valley railroad, chartered in 1846, gradually extended their lines to link the coal regions with New York state. The Pennsylvania railroad, chartered in 1846, opened its line from Harrisburg to Pittsburgh in 1852, using the tracks of the state's Allegheny portage railroad until its own mountain division was finished. Later, it purchased the main line of the state works and thus had a complete rail line from Philadelphia to Pittsburgh, with the state's Columbia railroad. It then extended its lines rapidly to become one of the nation's most important railroads. With these and other railways the state had a virtually complete network of rail transportation by the time of the Civil War. Although some additions were made later, the basic pattern was already established. The railway mileage, 8,453 in 1890, increased to 11,693 in 1915. This had decreased somewhat by the early 1960s, but Pennsylvania still had more than 9,000 mi. of track.

In 1911 the state began an extensive program of highway construction. After 1918 funds were provided by bond issues, drivers' licence fees and a gasoline tax. By the 1960s the state highway system included more than 40,000 mi. of improved roads, while county, township, city, and borough highways totaled over 60,000 mi. In 1938 the Pennsylvania turnpike was begun as a toll road penetrating the Allegheny mountains through seven tunnels to connect eastern and western Pennsylvania. This four-lane limited-access highway was opened from Carlisle, near Harrisburg, to Pittsburgh in 1940, and later extended from the Ohio border to the Delaware river, where it was connected with the New Jersey turnpike in 1956. In 1957 a northeastern extension to Clarks Summit was completed, and the entire system totaled 470 mi.

The communication of ideas was also important to Pennsylvania's progress. The first newspaper was established in Philadelphia in 1719, the fourth in the American colonies. By 1775, 9 newspapers were published in Pennsylvania and by 1810 there were 73. These grew to more than 400 with a total circulation of over 8,000,000. Other means of communication also developed early.

The first commercial telegraph line in the United States was opened from Philadelphia to Lancaster in 1846 and the telephone was introduced in the 1880s. The first commercial radio broadcasting station in the world was KDKA, Pittsburgh, which began a regular daily schedule on Nov. 2, 1920. Pennsylvania has almost 100 telephone companies and more than 5,000,000 telephones are in use. There are more than 200 radio stations and more than 20 television stations.

See also references under "Pennsylvania" in the Index.

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PENNSYLVANIA, UNIVERSITY OF, a U.S. institution of higher learning, founded in 1740 at Philadelphia, Pa. *(see* PENNSYLVANIA: *Education*).

PENNY, a British coin (German *pfennig*), equal in value to one-twelfth of a shilling *(q.v.)*, denoted after a numeral by *d.* (from Lat. *denarius*). The term is also used colloquially in the United States to denote a cent, the hundredth part of a dollar.

Whatever earlier currency the name and denomination may have had, it was not until the reign of Offa (757–796) that English coinage was formally based on a silver penny showing the king's name on the obverse. Offa's penny weighed 22½ gr. and 240 pennies weighed one Saxon pound (or Tower pound, as it was afterward called), hence the term pennyweight (dwt.). In 1257 Henry III struck experimentally a gold penny of the value of 20 silver pence. During the reign of his successor, Edward I, halfpence and farthings (four to a penny) became a regular part of the coinage, the penny having been cut for trade purposes into halves, quarters, and perhaps even thirds. The silver penny remained the general coinage of England until the introduction of the gold florin by Edward III in 1344. The weight and value of the silver penny declined from 1300 onward. Whereas in 1066 it weighed 22½ gr., in 1300 it weighed 22 gr. and by 1601 it weighed only 7¾ gr.

Silver pence were struck for general circulation until the reign of George II; since then they have been coined only as part of the royal alms on Maundy Thursday. Copper halfpence were first issued by Charles II, but it was not until 1797 that copper pence were struck, weighing 1 oz. avoirdupois, together with copper twopences weighing 2 oz.: both series were found cumbersome and were soon discontinued. In 1860 bronze was substituted for copper, the alloy containing 95 parts of copper, four of tin, and one of zinc. The weight was also reduced, 1 lb. of bronze making 48 pennies, as against 24 of the earlier copper pennies. The figure of Britannia first appeared on the copper coins of Charles II.

See also NUMISMATICS: *Coins of the British Isles, Colonies and Commonwealth.* (JO. M. L.)

ROCHE

AMERICAN PENNYROYAL (HEDEOMA PULEGIOIDES)

PENNYROYAL, an aromatic herb formerly much used in medicine, the name being a corruption of the old herbalist's name "Pulioll-royall," *Pulegium regium*. It is a member of the mint genus, and has been known to botanists since the time of Linnaeus as *Mentha pulegium*. It is a perennial herb with a slender branched stem, square in section, up to a foot in length, and rooting at the lower nodes, small opposite stalked oval leaves about half an inch long, and dense clusters of small reddish-purple

flowers in the leaf axils, forming almost globular whorls. It grows in damp gravelly places, especially near pools, on heaths and commons. It has a strong smell somewhat like that of spearmint, due to a volatile oil which is readily obtained by distillation with water, and is known in England as *Oleum pulegii*. The specific name recalls its supposed property of driving away fleas (*pulices*). Like the other mints it has carminative and stimulant properties.

The similar American pennyroyal (*Hedeoma pulegioides*), also belonging to the mint family (Labiatae), occurs in dry fields from Cape Breton Island to Ontario and North Dakota, southward to Florida and Arkansas.

PENOLOGY (or Correction), that part or division of criminology concerned with the philosophy and practice of prison administration and the treatment of prisoners. *See* Crime; Criminology; Juvenile Delinquency; Prison.

PENRITH, a market town and urban district of Cumberland, Eng., lies 18 mi. SSE of Carlisle on the trunk (A6) road to Scotland and at the foot of Penrith Beacon (937 ft. [286 m.]). Pop. (1961) 10,931. In the town are the ruins of Penrith Castle, built in the 14th century as a defense against raids from the Scots and dismantled during the Civil War in the 17th century. The parish church of St. Andrew is of Norman foundation with a 14th-century tower and a list of vicars complete from 1223. In the churchyard are the "Giant's Grave" (ancient hogback stones and cross shafts) and the "Giant's Thumb" (the remnant of a 10th-century rose cross). A 14th-century grammar school was refounded by Elizabeth I in 1564. Buildings of historical interest include the Gloucester Arms, associated with Richard III; Hutton Hall (1480), incorporating an old peel tower; Roger Bertram's house, dated 1563; and Gerard Lowther's house (1584), now the Two Lions Hotel. Samuel Plimsoll, the social reformer, and John Loudon McAdam, the inventor, were temporary residents of the town. Long-case or "grandfather" clocks, manufactured by the Porthouse family, made Penrith famous during the 18th century.

The ruins of Brougham Castle, with a 12th-century keep, stand on the site of the Roman fort of Brocavum, 1½ mi. (2½ km.) SE of Penrith, and 5 mi. (8 km.) N are the remains of Voreda, a Roman military settlement. Edenhall village, 3½ mi. (5½ km.) NE, recalls the 13th-century Syrian enameled glass goblet, known as the "Luck of Eden Hall," which belonged to the Musgrave family and is now in the Victoria and Albert Museum in London. Penrith Beacon, with golf course adjoining, is a fine viewpoint for the mountains of the Lake District (*q.v.*).

Penrith is a rail and road junction. The nearest air services operate from Carlisle and in the early 1960s provision was made for a helicopter landing site.

Penrith depends mainly upon agriculture, particularly livestock rearing, and weekly cattle sales. It is also a tourist centre by virtue of its position as the northern gateway to the Lake District, being only five miles from Ullswater. (C. H. Hu.)

PENROSE, RICHARD ALEXANDER FULLERTON, JR. (1863–1931), U.S. economic geologist, who left a large fortune to scientific societies, was born in Philadelphia, Pa., on Dec. 17, 1863. He was graduated from Harvard University (A.B., 1884; Ph.D., 1886), where he acquired a broad view of science and a practical one of geology. After writing his thesis on phosphates, he managed mines for the Anglo-Canadian Phosphate Company (1886–88) and later surveyed mineral deposits for the states of Texas (1888–89) and Arkansas (1889–92).

In 1892 he became professor of economic geography at the University of Chicago, and was full professor, 1895–1911. In 1895 Penrose was a founder of the Commonwealth Mining and Milling Company at Pearce, Ariz., which produced gold; and in 1903 he founded, with his father and brother Spencer, the Utah Copper Company at Bingham, Utah. The property proved to be in the largest deposit of porphyry copper in the world and became the largest single producing area in the United States.

A founder of the Society of Economic Geologists in 1920, he was its first president. He established the Penrose gold medal for economic geology and a similar medal for outstanding work in any aspect of geology, to be awarded by the Geological Society of America. He was president of that society in 1930–31. He never married and at his death on July 31, 1931, the bulk of his estate of about $10,000,000 was left to the Geological Society of America and the American Philosophical Society.

PENRY, JOHN (1563–1593), an Elizabethan Puritan, author of some of the most famous early Puritan treatises, was born in Brecknockshire and in 1580 proceeded to Peterhouse, Cambridge, where he graduated in 1584. Although he came from a farm in the uplands of Wales, he seems to have been in easy circumstances. An anonymous pamphleteer maintained that when he went to Cambridge he was "as arrant a Papist as ever came out of Wales," but this is probably without foundation. At Cambridge, however, he became convinced of his own sinfulness. He thereupon adopted a Puritan mode of life and began to advocate Presbyterianism as the ideal form of church government. After graduating he left Cambridge, presumably returning to Wales, but in 1586 he was at Oxford, where he proceeded to the M.A. degree. He did not take holy orders.

Penry's primary concern after leaving the university was with the religious condition of Wales. On this he wrote three treatises which are known by their short titles, the *Aequity* (1587), the *Exhortation* (1588), and the *Supplication* (1588). They are violent and antiepiscopal in tone. He advocated the preaching of the gospel in Welsh, the return to Wales of Welsh-speaking incumbents of English livings, and, if necessary, the use of lay evangelists. The first treatise led to his being summoned before the Court of High Commission and to his imprisonment for a month. Presumably on this account, his subsequent treatises were printed on a secret press. From the same press came the celebrated Martin Marprelate tracts (*see* Marprelate Controversy), which attacked the bishops with scurrility and wit. A bookbinder who turned informer accused Penry of being their author. Another suspect was his friend Job Throckmorton, member of Parliament for Warwickshire. In a letter from prison later, however, Penry denied that either he or Throckmorton even knew who Martin was, and this denial is now generally accepted. When the search for the press intensified, Penry fled in 1590 to Scotland. In the meantime he had married Eleanor Godley of Northampton.

In Scotland Penry abandoned Presbyterianism in favour of Separatism, and one of his posthumous works, *The Historie of Corah, Dathan, and Abiram* (published 1609), is a notable contribution to the literature of religious toleration. On his return in 1592 he threw in his lot with the London Separatists. At this time Richard Bancroft (*q.v.*) was actively suppressing Puritanism. Penry was arrested and was charged under the Act of Uniformity. Although that act did not carry the death penalty, he was condemned to death and executed on May 29, 1593.

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PENRYN, a market town, port, and municipal borough in the Falmouth and Camborne-Redruth parliamentary division of Cornwall, Eng., 2 mi. NW of Falmouth and 34 mi. (55 km.) ENE of Land's End by road. Pop. (1961) 4,451. The town lies at the head of the estuary of the Penryn River, which opens on the west coast of Carrick Roads, into which flows the Fal. It owed its development to the bishops of Exeter, within whose demesne lands it stood. These lands appear in Domesday Book under the name of Trelivel. Its first charter was granted by Bishop Bruiere in 1236. Glasney College was founded by Bishop Walter Bronescombe in 1265; it appears to have been suppressed in 1547. Bishop Walter de Stapeldon secured a market on Thursdays, a fair at the Feast of St. Thomas, and, in 1311, a three days' fair at the Feast of St. Vitalis. Mary I gave the parliamentary franchise to the burgesses in 1553. James I granted and renewed the charter of incorporation, providing markets on Wednesdays and Saturdays and fairs on May 1, July 7, and Dec. 21. The charter having been surrendered, James II by a new charter among other things confined the parliamentary franchise to members of the corporation. This proviso, however, was soon disregarded, the franchise being freely exercised by all the inhabitants paying scot and lot. From 1553 to 1832 the borough returned two members to Parliament.

An attempt to deprive it of its members, because of corrupt practices, was defeated by the House of Lords in 1827. The act of 1832 extended the franchise to Falmouth, in spite of the rivalry existing between the two boroughs. In 1885 the united borough was deprived of one of its members.

There is no parish church within the borough boundaries, but the Church of St. Gluvias, to the north, fulfills this function. Although largely restored in 1883 it retains a 15th-century tower. Penryn is the principal port for the shipment of granite which is extensively quarried in the neighbourhood, and dressed and polished at Penryn. There are also engineering works, boat repairing, and lumberyards. The harbour dries at low tide, but at high tide has 13 ft. (4 m.) of water.

PENSACOLA, a city of Florida, U.S., located in the northwestern part of the state on the northern shore of Pensacola Bay about 6 mi. (11 mi. by channel) N of the Gulf of Mexico and 50 mi. SE of Mobile, Ala.; the seat of Escambia County. The city is separated from the Gulf of Mexico by Santa Rosa Island. At the western end of the island is Ft. Pickens and across the channel to the west is Ft. Barrancas. Pensacola retains much of the atmosphere of an old Spanish city, with its Plaza Ferdinand VII, Seville Square, Spanish street names, and religious festivals. From the ochre-yellow banks of the bay the city rises gently to heights commanding views of beautiful bayous and the Escambia River, which flows into the bay on the east. Public parks and beaches give pleasure to thousands. There are two public junior colleges: Pensacola, organized in 1948, and Washington, opened in 1949. The city has a council-manager form of government in effect since 1931.

The city's trade area includes parts of Alabama, Louisiana, and Georgia. Nylon yarn, paper, wallboard, industrial chemicals, lumber, naval stores, tile, concrete, cottonseed oil, and small boats predominate as manufactured products. The deep-water port of Pensacola suffers because of its proximity to Mobile.

Pensacola Bay was discovered in 1516 by a ship's pilot, Diego Miruelo. In 1528 Pánfilo de Narváez with 242 followers made a water stop at Pensacola. In January 1540 Diego Maldonado, commander of Hernando de Soto's fleet, entered the harbour and named it Puerto d'Achusi.

Tristán de Luna in 1559 colonized the bay, which he renamed Santa María de Gálvez, but the settlement was abandoned two years later.

An expedition under Juan Enríquez Barroto and Antonio Romero rediscovered Pensacola Bay on Feb. 6, 1686, while searching for a colony planted by René Robert Cavelier, sieur de la Salle. Reports describing the friendly Panzacola Indians and the magnificent bay inspired an expedition, led by Adm. Andrés de Pez and Carlos de Sigüenza y Góngora, a noted Mexican mathematician, to explore Pensacola Bay in 1693. It was, however, renewed French interest in the area which galvanized the Spanish into action. In 1698 expeditions under Andrés de Arriola and Capt. Juan Jordán de Reina established Ft. San Carlos at the entrance of the bay.

In the brief French-Spanish War of 1719–20 Pensacola was seized by Jean Baptiste le Moyne, sieur de Bienville, almost immediately recaptured by Spain, seized again and burned by France and restored to Spain in the treaty of Feb. 17, 1720. A small garrison was maintained by Spain after 1720 and, except for a hurricane which destroyed the town in 1754, the post was undisturbed. At the end of the Seven Years' War the Floridas, including Pensacola, were transferred to England. Although the Spanish inhabitants left for Mexico and Cuba, the British swiftly reestablished the settlement and Pensacola was made the capital of West Florida.

During the American Revolution Pensacola was a haven for Tories. On May 9, 1781, it was captured by Bernardo de Gálvez, the Spanish governor at New Orleans, and Spanish possession was confirmed in the definitive treaty of peace of 1783.

During the War of 1812 the British made Pensacola a centre of operations despite Spanish protests, and in 1814 entered the harbour to take formal possession, but were repulsed by Gen. Andrew Jackson. In 1818 General Jackson captured the city from the Spanish, maintaining that they were encouraging the Seminole Indians in raids against the U.S., and in 1821 Florida as a whole was finally transferred to the U.S. In 1824 Pensacola was chartered as a city and was selected as the site of a federal navy yard. Three months before outbreak of the American Civil War, on Jan. 12, 1861, the navy yard was seized by the state government but Ft. Pickens remained under federal control and on May 8, 1862, the Confederates evacuated the city.

Railroad development after the Civil War led to extensive lumbering, which in a few years devastated the pine forests of the area. In 1872 commercial shipment of fish began and by the 1880s Pensacola seafood, especially red snapper, was shipped to an ever-widening market. In 1913 the inactive navy yard was reopened as a naval air station and became a large aviation training school.

Pop. (1960) 56,752; for comparative population figures *see* table in FLORIDA: *Population.* In that year, for the first time in a federal census, the population exceeded 50,000 and the Pensacola standard metropolitan statistical area (Escambia and Santa Rosa counties, pop. 203,376) was established. (E. C. Jo.)

PENSHURST, a village in the Sevenoaks rural district of Kent, Eng., lies at the confluence of the Eden and Medway, 5 mi. (8 km.) SW of Tonbridge. Pop. (1961) 1,895. The village has some old houses, including timbered cottages of the 15th century. Penshurst Place is the home of the Sidney family, who have held it since 1552. Sir Philip Sidney, the poet and scholar, was born there in 1554. His younger brother, Sir Robert, was created earl of Leicester in 1618. In 1945 William Philip Sidney, created Viscount De L'Isle in 1956, became owner of the house. The mansion is quadrangular and has a court, chapel, and hall (*c.* 1341) with open timber roof and a minstrels' gallery. The state rooms are open to the public during the spring and summer. (FX. H.)

PENSION, a term applied to periodic money payments to a person who retires because of age or disability. The payments usually continue for the rest of the natural life of the recipient. Pensions are provided by governments or by employers either as a direct charge, *i.e.*, by inclusion in the organization's regular expenditures, or as an indirect charge, *i.e.*, by periodic contribution to a pension fund. Pensions are provided by governments for various reasons: (1) as compensation to former members of the armed forces or their dependents for old age, disability, or death (usually from service causes); (2) as old-age retirement or disability benefits for civilian employees; (3) as social security payments for the aged, disabled, or deceased citizens made in accordance with the rules governing social service programs of the country. Pensions under the first heading are of great antiquity. Under the second heading they have been in force in one form or another in some countries for nearly 100 years. Those coming under the third heading are of relatively recent origin, though they are of the greatest magnitude. They are not included in this article but are discussed in SOCIAL SECURITY.

The custom of providing pensions for aged employees who are no longer able to discharge their duties efficiently began during the 19th century in Europe and then spread to other parts of the world. A new development in the 20th century was the appearance of pension plans for workers who were paid by the hour. These plans were often established under trusteeships as a result of union-management negotiations. A further development was the encouragement, by means of a special tax release, of individual self-employed persons to establish their own pension funds.

Pensions are variously viewed as charity, paternalism, deferred pay, rewards for service rendered, or as a means of promoting the general welfare. The fundamental provisions of any pension plan set forth rules of eligibility, conditions for the receipt of pensions, a pension benefit formula, and the source of contributions. The method of funding benefits on the death of the employee and the procedure for withdrawal prior to retirement are sometimes included; in nongovernmental plans the equities on termination are also stated. The cost of pensions granted to citizens by the government for military or civil services is normally met out of taxation, and only rarely is any reserve accumulated for payments beyond the current fiscal year. By contrast, pensions provided as old-age retirement or disability benefits are usually provided by

drawing upon a fund accumulated during the lifetime of eligible persons. Such pensions may be paid to the eligible person or to his widow or children. The accumulation of an adequate fund is a principal concern for such plans and the magnitude of the accumulation may depend upon the number of eligible persons, estimates of their annual earnings, the formula for determining the pension, the nature of secondary pension benefits to widows or children, and the current level of investment income that can be expected from the accumulated money. The true cost outlay of a pension plan can be known only in retrospect and may be expressed as benefits paid plus expenses less the interest earned on the reserve funds. An exact accounting can be completed only long after the source of income is closed. Through the application of actuarial principles, however, it is possible to prepare current estimates of annual contributions required to develop a reserve fund in satisfactory form to meet future liabilities.

UNITED STATES

War Veterans.—The history of military compensation and pensions in the United States goes back to the colonial period. The Pilgrims of Plymouth Colony in 1636, for example, enacted a law providing that "If any person shalbee sent forth as a soldier and shall return maimed hee shalbee mayntained competently by the Collonie during his life." Later, other American Colonies made similar provisions. The Continental Congress also passed laws during the American Revolution promising benefits to those who enlisted in the colonial army, but no funds were approved to finance the program. The first pension law in the United States was passed by Congress on Sept. 29, 1789. It was followed at intervals by other laws and developed into the comprehensive Servicemen's and Veteran's Survivor Benefits Act, which became effective Jan. 1, 1957. (*See* VETERANS ADMINISTRATION, U.S.)

Public Employees and Teachers.—Public employment includes not only the employees of federal, state, county, and municipal governments, but also those of publicly owned corporations, municipal transit companies, the Tennessee Valley Authority (TVA), and the Federal Reserve System. The federal government, with other members of the United Nations, also contributes toward the provision of pensions for employees of international bodies such as the United Nations, the International Bank for Reconstruction and Development, the International Monetary Fund, the International Labour Office, and other similar organizations. The Federal Civil Service Retirement and Disability Fund was established in 1920 and by the early 1960s contained the following main provisions: Employees with 15 years of service might retire at age 62 or continue to work until age 70, at which age retirement was mandatory. Under certain conditions, retirement before age 62 was possible for employees with 25 or 30 years of service. The amount of the pension was determined by the employee's length of service and by his highest five-year average annual salary. The employee received 1½% of such annual salary for each year of service, or 1% of such salary plus $25 for each year of service if this yielded a higher return; the maximum benefit was 80% of the employee's salary. The law also provided for a total disability pension after five years of service, determined by the more liberal of the two formulas above. Employees contributed 6% of their salary to the fund; in case of death or termination of service prior to retirement they (or their beneficiaries) received a refund of their contributions with interest. If, however, at the death of an employee with five or more years of service, a qualified dependent survived (widow or child), one-half of the regular pension was payable to the widow, beginning at age 50. Whether the mother was 50 or not, an additional one-fourth of the regular pension (with certain limits) was payable to each child under 18 years of age; if the child alone survived he received half the regular pension. In case of termination of service after five years the employee might leave his refund and be credited with a vested deferred pension (beginning at age 62) computed on the more desirable of the two formulas mentioned above; this method was automatic if he left after 20 years of service. Various optional death benefit forms of pension were available at retirement. Optional additional employee contributions might be made to augment the regular pension but without direct additional government contributions. According to the law, the pensions and death benefits not provided by employee contributions were to be met from annual appropriations by Congress.

Several special plans for other classes of federal employees were enacted after 1900, including one covering members of Congress. Other plans covered public school teachers in the District of Columbia, policemen, firemen, the U.S. judiciary, certain commissioned services such as the Public Health Service, and organizations such as the Federal Reserve System, permanent TVA employees, and others.

The earliest state pension plans for public employees were those for superannuated teachers, starting in 1896 in New Jersey when a noncontributory plan was adopted. The first contributory state teachers' plan was adopted in Massachusetts in 1913. Pension plans for other state employees followed and were soon established in most of the states. Pension plans for state employees and teachers have many of the characteristics of other pension plans; some have adequate funding arrangements, others fund on retirement, and still others meet costs as pensions are paid. Pension plans for policemen and firemen date back to the beginning of the century, but the large municipal employee plans came somewhat later. While large cities maintain their own plans, in many states the smaller towns and political subdivisions were permitted to participate in the general state employee plan. After 1950, state and local employees and teachers were permitted as groups to come under the federal Social Security Act. Many teachers' plans are money purchase plans, with various modifications; there is a tendency for these plans to be revised and to adopt a "final salary" basis whether they are on a full reserve basis or not.

Discussion of the teachers' plans should include mention of the Teachers Insurance and Annuity Association of America (TIAA), which was incorporated in 1918 in the state of New York as a nonprofit legal reserve life insurance company. The Carnegie Foundation for the Advancement of Teaching financed the foundation of this company and gave it financial assistance for many years in order to put it on a self-supporting actuarial basis. In 1952 TIAA developed an affiliate called the College Retirement Equities Fund (CREF) to implement a new pension idea whereby CREF annuities would vary according to the market value of its fund, which would be invested mainly in common stocks. Teachers could decide what portion of their contributions should go toward the variable annuities of CREF, and the fixed annuity of TIAA, subject to the restriction that at least 50% of such contributions must go to the fixed annuity form.

Employees of Religious Bodies.—The churches at an early date recognized their responsibility for the care of their aged and disabled workers and, in fact, the first pension fund in the United States was founded for such a purpose. The Roman Catholic Church has a long tradition of taking care of all the members of its hierarchy during their dependent years. The Protestant churches' funds have been started for the same purpose; most of them include widows' annuities and orphan pensions as well as pensions to the ministers themselves. More than 20 of the leading Protestant denominations established the Church Pension Conference in the mid-1950s and accumulated substantial reserve funds to meet their liabilities.

Employees of Nonprofit Organizations.—Legislation in 1950 made it possible for all nonprofit organizations in the United States to be covered by the federal Social Security Act subject to election by the individual employer and by at least two-thirds of the employees. As a result, most of the nonprofit employees have been covered by the Social Security Act and have coordinated their own pension plans with an additional benefit. They include such organizations as hospitals, charities, and foundations. Some of them, notably the YMCA and YWCA, have established their own pension plans. In order to make a start in solving the problem of the small nonprofit employer the National Health and Welfare Retirement Association was formed to help in centralizing pension planning and funding. The association was incorporated in January 1945 under the insurance laws of New York State and was made subject to supervision by the state superintendent of

insurance. Benefit payments and guarantees were protected through reinsurance with a well-established insurance company.

Industrial Employees.—By the 1960s there were more than 22,000 private industry pension plans in operation in the United States, including profit-sharing plans that were grouped with the pension plans by the Internal Revenue Service. All these plans had been reviewed and approved by the Internal Revenue Service so that the employer could claim his contributions as tax deductions and the investment income of the fund would be exempt from any federal taxes. Pension trust funds are usually set up with investment control in the hands of the corporate trustee with the assistance of a stock broker or, possibly, of an investment counsel. The administrative work is usually done in the office of the employer.

Most of the large employer pension funds are on a trustee basis. The U.S. Steel Corporation started its fund in this manner in 1911, and the American Telephone and Telegraph Company started one in 1913, though it did not set aside separate funds until 1927. Trust companies did not actually bid for the business until the early 1940s. Passage of the Social Security Act in 1935 stimulated the growth of industrial pension plans. World War II restrictions on wage and salary increases caused workers to turn their attention to so-called fringe benefits that included pension plans. In 1949 pensions were classified by the courts as proper subjects for collective bargaining so that union interest in them was also stimulated. Since pension contributions were deductible for income tax purposes, the excess-profits tax of World War II provided the stimulus for a broad expansion of pension programs. Tax deductions permitted by the Internal Revenue code made it possible for business concerns to provide pensions at a much-reduced real cost.

Insurance companies began to offer contracts for pension plans in the early 1920s. The pension instrument took various forms: the individual policy held by a trustee; the group permanent contract (life insurance to retirement age with maturity then as pensions); the group annuity contract (the direct purchase of units of pension for each year of service rendered); the deposit administration contracts (insurance companies administer unallocated funds with the direct purchase of individual annuities at retirement); and the deposit administration contract with immediate participation guarantee, by which the individual annuities are paid out of the unallocated funds and the guarantee of benefit applies only at the termination of the contract.

It is normally not financially feasible to fund a pension plan unless it is approved by the Internal Revenue Service, for such approval makes the contributions tax deductible. In general, in order to qualify for approval, a fund must show that it is an irrevocable trust, that the funds under it cannot be diverted prior to the satisfaction of all liabilities under the trust, and that it does not discriminate in favour of the more highly paid employees. The plan must also be made known to the employees. There is a substantial volume of rules and regulations that governs the approval of pension plans.

In general, pension plans fall into three main categories. In the first category the pension is related to the salary and length of service of the employee. In the second group the pension is fixed or relates only to the years of service or amount of contributions. In the third category the benefit is dependent entirely on the contributions made by the member or on his behalf. The first type is used generally for salaried employees; the salary upon which the pension is calculated may be either the average salary throughout the period of service, the average salary of the few years immediately prior to retirement or, in a few cases, the salary of the year preceding retirement. When the pension is related to salary the usual practice is to assign a percentage figure for each year of service so that the final pension takes into account both the salary and length of service.

Since the extension of the federal Social Security Act most pension plans make an adjustment to avoid duplication of benefits. In some cases, the adjustment is a straightforward deduction for the whole or part of the Social Security benefit. A more common method, however, is a determination of the benefit by means of two percentages, one of which, the lower, applies approximately to that portion of wages and salaries subject to Social Security contributions, and the other, the higher, applies to all wages and salaries above that. As a result, whenever the level of wages subject to the Social Security tax is raised, a question arises about making corresponding adjustments in the private pension plan. Such adjustments, if they are made, are generally made only after some delay, which often has the effect of skipping one social security adjustment and catching up on the next.

Continuing depreciation in the purchasing power of the pension dollar due to constantly rising prices created during the 1950s some concern with the long-run adequacy of fixed pensions. The variable annuity plan was offered as a partial answer. Under such a plan, a portion of the total contribution is placed in a fund that is invested in common stocks. The dollar amounts invested are measured in terms of "units of accumulation" and benefit rights are expressed as "units of annuity." The value of each type of unit varies with the market price of the securities comprising the fund. All the variable annuity plans involve payment of a pension in annuity units that vary each year with the market price of the annuity fund as of a specific date. The underlying assumption is that the movement of prices of the common stocks in the fund will correspond to the movement of prices in general and will thus offer the pensioner some protection against loss of purchasing power. So far as is known, all of the variable annuity plans subscribe to the principle that at least 50% of the contribution should go into fixed annuity benefits.

Pensions for workers who are paid by the hour are usually not based directly on earnings. Most of the plans negotiated by unions provide a benefit expressed in terms of dollars per month per year of service, sometimes with a total dollar ceiling. While many of these plans, notably in the automotive industry, have been directly negotiated in the form of specified benefits, many of the other joint employer-union plans have been negotiated in terms of contributions of a certain number of cents per hour with the benefit to be determined on the basis of actuarial advice with full regard to all the circumstances in the case.

GREAT BRITAIN

The actuarial theories of pension plans and many of the current practices in connection with them originated in Great Britain, though the United States has initiated some modern improvements. The self-administered pension plan, for example, was developed in Britain but the corporate bank-trustee type with its more aggressive approach to the investment aspects had its origin in the United States. The insurance company contracts for group annuities and deposit administration are also due to American initiative. Generally the interchange of ideas and personnel between the two countries has been to the advantage of both. The conditions for approval by the tax authorities in Great Britain are practically identical with those in the U.S. In Great Britain overall limits are placed on the size of the maximum pension and its relationship to the salary at retirement. These limits are larger if the plan, or scheme, as it is generally called in Britain, is noncontributory than if the employees contribute.

A major difference between the U.S. and Great Britain is that British employees may claim contributions to an approved fund as a tax deduction. Pensions for self-employed persons are also granted tax privileges, if they are established by an approved contract with an insurance company, a friendly society, or a trustee. For those born in 1916 or later, contributions in general may not exceed £750 a year or 10% of "net relevant earnings." For those born in 1907 and earlier the limits are £1,125 or 15%. The contract must provide for an annuity benefit to begin after age 60 and before age 70 and not to be surrendered, commuted, or assigned. A great number of pension plans for salaried employees contain a benefit formula basing the pension on the average salary of the three or five years immediately preceding retirement. This is in large measure due to the standard set by the Local Government Superannuation Acts 1921–1953, which established uniform pension benefits and contributions for local government employees throughout Great Britain. In 1953 the Ministry of Pensions,

which dated from 1916, was combined with the ministry of national insurance.

Civil Service.—The pension system for British civil servants is governed by special acts of Parliament. The cost of the current pension roll is a charge on the national budget, and no funds are accumulated other than for widows and orphans benefits. Only established (*i.e.*, permanent) staff members are eligible for pensions, and contributions are required only to provide benefits for widows and orphans. A disability pension is payable on retirement due to ill health after ten years of service. The minimum retirement age is 60, after ten years of service, but early retirement may take place after age 50. In the latter case the pension begins at age 60 unless immediate payment is allowed on compassionate grounds.

Pensions are computed at the rate of one-eightieth of the salary at time of retirement for each year of reckonable service. Lump sum payments are made in addition at the rate of three-eightieths of the retiring salary for each year of service. Not more than 40 years of service up to age 60 may be reckoned, but those who serve after the age of 60 may count further service subject to a maximum of 45 years. Pensions paid to those who retire because of ill health are calculated on the basis of years of service, except that for those retiring with between 10 and 20 years of service it is based on 20 years, or on the service the employee would have completed had he served for five years after the retiring age, if that is less. The average salary of the last three years of service is used in all these calculations. Temporary service after the age of 18 counts as established service if rendered after July 1949; if rendered before that date it counts as one-half. Officers who serve overseas in unhealthful climates receive additional pension rights. The system provides for transfers of staff between the civil service and many other forms of public employment.

The pension for a widow is one-third of the civil servant's own pension, or, if he dies while still serving, of the pension he would have been paid if he had retired because of ill health on the date of his death. The widow may also be paid a children's pension varying according to the number of children from one-twelfth of the officer's pension (for one child) to one-third (for four or more children). If there are children but no widow, the children's pension is at a higher rate, varying from one-sixth to one-third of the officer's pension.

About half the estimated cost of these benefits is paid by the contributions of civil servants, made either by periodic deductions of one-eightieth of salary during service, or by a deduction from the lump sum or death gratuity payable at the end of the service. All married men must participate in this plan. A retiring civil servant may also, subject to his passing a medical test, surrender up to one-third of his pension to provide an actuarially equivalent pension for his wife or some other dependent. There is also a voluntary contributory plan for pensions to dependents other than widows and children. There is also provision for short-service gratuities on death, withdrawal, or dismissal before completion of ten years of service. A gratuity is also paid to women civil servants with not less than six years of service who resign or marry.

Armed Forces.—Retirement pay and pensions for officers and men in the Navy, Army, and Air Force are governed by royal warrant or other appropriate prerogative instrument. The basis of the officers' plan is a series of standard rates of retirement pay related to rank. These rates are payable to officers who are forced to retire either because they have reached the compulsory retiring age for the rank, because they have not been promoted, or because no further employment is available for them. Normally, 20 years of service is necessary to qualify for retirement pay; the service needed to qualify for the full standard rate ranges from 20 years in the lowest rank to 30 years in the highest. The rates take account of the relatively early retirement of many officers and are designed to provide some compensation for shortness of career. Officers permitted to retire at their own request receive reduced rates of retirement pay. After 1950 officers also became eligible on retirement for a lump-sum terminal grant in addition to retirement pay or pension, at the rate of three times the retirement pay. The rates of retirement pay, pension, and terminal grant are published in the command paper entitled *Services Pay and Pensions* (HMSO, London). There is a basic scale of pension for men in various ranks completing 22 years of service, with additions for longer periods of service. The scale is based partly on length of service and partly on rank. Retirement pay and pensions for members of the women's services are approximately two-thirds of those for men.

Provision is also made for pensions for widows and orphans of regular members of the forces. The plan is noncontributory and covers widows of officers and other senior ranking men who had completed enough service at the time of death to qualify for service pension. The plan also includes other ranks below staff sergeant, but with a longer qualifying period.

Judges.—English judges receive pensions close to £3,000 per year and in Scotland nine-sixteenths of their salary at the time of retirement if they have completed 15 years of service or if they retire because of permanent ill health. County court judges, stipendiary magistrates, and the two full-time sheriffs and sheriff's substitute in Scotland receive pensions based on their salaries and length of service. A lump sum is also paid to the retiring judges, and from it is deducted a contribution to the widows' and children's pension plan. The lord chancellor of Great Britain receives a pension of £3,750 no matter how short his service. He usually continues to sit judicially in the House of Lords without salary.

Local Government.—The Local Government Superannuation Acts provide pensions on a uniform basis for employees of municipalities, counties, and kindred political subdivisions. Certain of the larger authorities such as the London County Council, the City of London, Manchester, and some London boroughs operate their own pension schemes, which are similar. Superannuation funds may be operated by a single municipality or county, which may admit an authority within its boundaries, or by local authorities in combination with one another. Employees are classified as officers (*i.e.*, salaried employees) or servants (wage employees). All full-time officers are compulsorily covered but servants and part-time officers are included only at the option of the employing authority. Retirement may occur at age 65, at age 60 after 40 years of service, or at an earlier age due to ill health after 10 years of service. Pension credits can be earned to the age of 70, subject to a maximum of 45 years of service.

The pension is one-eightieth of the average salary of the three years immediately preceding retirement multiplied by the years of service (noncontributory service, if any, counts at half rate). A lump-sum grant of three times the annual pension is also made, but it is reduced to one year's pension if the pensioner contributes to the widows' pension. The widows' pension is one-third of the members' pension and continues to the end of the widow's life.

Officers contribute 6% and servants 5% of their current salaries. These contributions are refunded upon death or upon withdrawal prior to retirement. The employing authority pays an equal contribution to finance current pensions and makes an annual payment to make good the deficiency shown at each quinquennial valuation. There is a system of transfer values for preserving pension rights on transfer to the Civil Service and other forms of national employment.

National Health Service.—A program is in operation under the Ministry of Health for employees of the regional hospital boards and for medical and dental practitioners. Pension formulas for members and widows are similar to those provided under local government schemes. Contributions are 6% for the employee and 8% for the employer (5% and 6% in the case of manual workers). The program is not funded but provision is made for preservation of rights on interchange with other superannuation plans.

Teachers.—The teachers' superannuation plan is a national plan applicable mainly to teachers in schools aided by government grants. The main benefits are pensions and lump sums payable at the age of 60 or upon retirement at a later age. The plan also provides disability pensions after ten years of service and gratuities payable on death after five years of service. Teachers contribute 6% of their salary but the plan is not funded. It is to the

exchequer that contributions are paid and from which benefits are received.

Policemen and Firemen.—Pensions for policemen and their dependents are provided under acts of Parliament. Pensions are normally calculated on the average pay during the three years preceding retirement and an ordinary service pension rises from one-half of average pay after 25 years of service to a maximum of two-thirds pay after 30 years of service. Members retiring on grounds of health after 10 years of service are granted pensions on a proportionate basis. Injury in line of duty qualifies an officer for an ill-health pension even if he has less than 10 years of service, and it may be supplemented if his earning capacity is affected. A widow's pension is granted on the basis of the husband's pay at the time of his death or as a lump-sum award according to his rank. Children's allowances are payable with the lump-sum award. Policemen pay contributions up to 6½% of their pay toward the cost of pensions and the balance is borne in equal shares by the exchequer and by the local government employing authority. Broadly similar provisions apply to firemen under a separate act. Only 25% of the rest of the cost of firemen's pensions is met from government sources.

The Civil List.—In this category are small pensions (£100 to £150 per annum) granted by the sovereign upon the recommendation of the first lord of the treasury. They are granted for personal service to the crown, for performance of duties to the public, or for useful discoveries in science or attainments in literature and the arts. The maximum annual allotment is £5,000.

Perpetual or Hereditary Pensions.—Pensions of these types were freely granted in the 17th and 18th centuries but as the result of parliamentary agitation they were gradually extinguished by commutation. Thereafter no further perpetual pensions were granted, but capital sums were voted to certain distinguished commanders after World War I. After World War II, neither capital sums nor perpetual pensions were granted, but only titles as a recognition of distinguished service.

Political Pensions.—The only national political pensions are those payable to former prime ministers. These pensions are regulated by acts of Parliament. Former prime ministers are entitled to a pension of £2,000 a year provided they are not receiving a salary of more than £750 drawn from public funds. In addition, the House of Commons Members Fund enables payments to be made to former members of the House of Commons or to their widows or children if they are in reduced circumstances. The payments are made from funds provided solely by compulsory contributions of members of the House of Commons. Public money is not involved.

Ecclesiastical Pensions.—Archbishops, diocesan bishops, and suffragan bishops of the Church of England whose sees are in England are entitled to receive pensions on retirement at or after the age of 70 under a contributory program governed by the Episcopal Pension Measures, 1926 and 1945, and administered by the church commissioners. All other Church of England clergy rendering ecclesiastical service or holding educational, charitable, or public appointments in England are entitled to receive pensions on retirement at or after the age of 70 under a noncontributory program governed by the Clergy Pensions Measures, 1948 and 1954, and administered by the Church of England Commissioners. Under this plan there are reciprocal arrangements for overseas service in many other countries. The Church of England Pensions Board also administers contributory programs for pensions for widows and dependents and for deaconesses and lay workers.

OTHER COUNTRIES

The development of pension plans in countries throughout the world has been very uneven. Some countries rely heavily on government schemes of social security and others place more reliance on private pension plans. In most countries social security and private pension schemes exist side by side and are integrated in a variety of ways. The section that follows indicates briefly the pension developments in Canada, Australia, and a number of countries in Europe.

Canada.—Private pension plans in Canada are similar to their counterparts in the United States. Employees' contributions up to $1,500 are tax deductible. The employer may deduct as the result of the 1958 Income Tax Law the whole or any part of past service liabilities to the extent that he made a payment in the year; contributions for current service are deductible up to $1,500 per employee. In 1957 Canada introduced a pension tax allowance for self-employed individuals. According to the law, a Registered Retirement Saving Plan may be set up and may enjoy freedom from taxes on interest and capital appreciation. The maximum yearly tax-deductible contribution under such a plan is $2,500. The same privileges are extended to an individual covered by a pension; he may contribute 10% of his salary up to a maximum of $1,500 less his own pension contributions. The plan must provide an annuity beginning not later than his 71st birthday and must be based on a contract that may not be surrendered for cash or used as security for a loan. Each plan must be individually registered by the government and be issued by an approved underwriter—generally an insurance company, the government annuity branch, a trust company, or a mutual fund.

In 1963 the Liberal government introduced a new pension plan but it was opposed by the governments of Ontario and Quebec, which had pension plans of their own in process of adoption.

The Canadian government has issued annuity contracts since 1908. Group contracts on a formal basis have been issued since 1938. The maximum annuity issued is $12,000 a year, and there is no cash value unless the annuity is greater than $10 per month.

Australia.—The government old-age pension, which is subject to a means test, is reduced shilling for shilling for the excess of any private pensions over £3 10*s.* per week. This provision of the law influences employers to provide lump-sum benefits on retirement, mainly by means of insurance. Employee contributions to private pension plans up to £200 a year are deductible when calculating personal income tax. Employers obtain a deduction of £100 or 5% of the employee's salary, whichever is greater, for each employee if the plan is approved by the commissioner of taxes.

Belgium.—Private pension plans in Belgium are nearly all instituted to supplement government pensions for salaried employees. The majority of the plans are based on career earnings. Only a few base benefits on a more current average salary. Both employers and employees obtain tax deductions for contributions to properly constituted plans. Under a 1956 compulsory pension scheme, self-employed persons are required to establish a pension account either by depositing funds or by obtaining an annuity policy providing a pension of 18,000 francs for a man at 65 (one-half to the widow) or 12,000 francs for a woman at 60. Payments and pensions are raised or lowered if the retail-price index moves up or down at least 5%.

France.—In addition to the regular old-age pension, engineers and management personnel have a supplementary retirement system (known as Régime Complémentaire de Retraites des Cadres) organized for various types of employment. Contributions are paid on that part of the employee's remuneration between the ceiling for old-age contributions—660,000 francs and a maximum of 3,204,000 francs. The tax rate starts at 8% (6% by the employer and 2% by the employee) and may rise to any figure between 8% and 16% according to the circumstances of the institution. Retirement normally takes place at the age of 65 if the employee has completed ten years of salaried employment. A widow, if she is over 50, receives 60% of the participant's pension, and orphans receive 20%. All pensions are determined in "pension points" by the AGIRC (L'Association Général des Institutions de Retraites des Cadres). Rights acquired each year in points are determined by dividing the contribution for the period by a reference salary which is the mean of all salaries subject to contribution in the period (value about 650 points). Years prior to 1947 have a value between 40 and 120 points per year. The pension is determined by multiplying the sum total of points accumulated by a participant by a point value for each year. The point values are obtained by dividing the total contributions to the institution during the preceding year, less expenses and 10% for a stability re-

serve, by the present value of future charges in the institution over the next ten years.

Effective April 1, 1957, a system similar to the AGIRC was set up for non-Cadre salaried employees. It is known as UNIRS (Union National des Institutions de Retraites des Salaries). Membership is voluntary and the system after two years of operation covered nearly 5,000,000 employees. Total contributions vary from 2½% (employer 1½%, employee 1%) to 4% (employer 2.4%, employee 1.6%) and are paid on total earnings. There are many supplementary private pension plans, most of which are on a pay-as-you-go basis. Both employer and employee contributions to all pension plans are tax deductible.

Federal Republic of Germany.—Such private pension plans as are established in the Federal Republic of Germany either cover personnel not included in the public pension system adopted in 1957 or supplement the public pension. Employers may take a tax deduction for contributions, the amount depending upon the type of plan. Employees may obtain a tax deduction for contributions except that, in states where the employer does not pay the special 8% premium tax, the employee cannot claim that there is any insurance element in the contribution. Most private plans are not insured.

Netherlands.—Private plans are numerous in the Netherlands and must be formally established and actuarially sound before being approved. Assets must be separated from the employer's assets, but up to 10% of the fund may be used to buy the employer's stock. Employers may deduct contributions as a business expense, and in addition they may deduct sums placed in an earmarked retirement reserve not separated from their assets. Employees may deduct contributions to an approved fund, and in addition may deduct premiums to an individual annuity up to 3,600 florins a year. Private plans are usually designed to produce a pension of about 70% of final pay. A general pension plan for widows and children became effective in 1960.

Norway.—Both private plans and group pension insurance plans exist in Norway, but the number of private funds is small. There are also non-actuarial funds that exist to accumulate money to set up private plans in due course. A further large pension element includes the collective plans set up by the large professional societies of which the Medical Society and the Dentists Society are the largest. Norwegian pension plans provide old-age pensions, disability pensions, and pensions for widows and children. Old-age pensions amount to approximately 60% of the average pay of the last five or ten years after 30 years of service. It is reduced by one-thirtieth for each year the total service falls short of 30 years. A widow's pension is usually 60% of the pension the husband was receiving or would have received had he continued in service to pension age at the pay he was receiving at the time of his death. The children's pension is 40%, 60%, 75%, 90%, and 100% of the widow's pension for one, two, three, four, five or more children, respectively. If the child has no mother the pension is doubled. The disability pension is paid during disability due to sickness or accident that has continued for three months; the amount is the fraction of the old-age pension representing the degree of disability. The disability pension is increased 10% for each pensioner's child under 18. About one-half of the pension plans do not include disability pensions. Retirement age ranges from 67 to 70 for men and from 65 to 67 (sometimes 70) for women.

Sweden.—Practically all supplementary pension plans in Sweden are underwritten by Svenska Personal-Pensionskasse, which has a virtual monopoly of pension insurance. These benefits are actuarially calculated and reserves are accumulated. Supplementary pension plans for salaried employees are contributory and provide benefits geared to salary. Wage-earners' benefits, if any, are a flat annual amount and are arranged in some way so as not to reduce the governmental supplementary "means test" pensions. There are a number of cases of supplementary plans for wage earners negotiated on an industry-wide basis by unions and employers.

See also references under "Pension" in the Index.

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(M. T. W.; W. F. MA.)

PENSIONARY, the designation, indicating that he drew a salary, of an official of importance in Netherlands' history.

From the 15th century onward the name pensionary, with *clerc* and advocate as occasional alternatives, was given to the secretary of certain town corporations in the Netherlands. The pensionary conducted the town's legal business and was its representative at meetings of the provincial estates. The office originated in Flanders. The first towns in Holland to appoint a pensionary were Dordrecht (1468) and Haarlem (1478).

The order of nobles in the estates of Holland also had a pensionary to act on their behalf in the estates. As the nobility had the right to preside over the assembly, this pensionary was actually its chairman. This office was in Holland combined with that of "land's advocate," that is, legal adviser to the estates, an official whose appointment was found necessary for the first time in 1544. After 1619 the name "land's advocate" was changed into *raadpensionaris* or councilor pensionary, usually translated into English as grand pensionary. The first to give the office its full importance was Johan van Oldenbarnevelt (*q.v.*), who from 1586 to 1619 dominated the estates of Holland and through them the States General: all correspondence passed through his hands, and he in fact controlled foreign policy; but his authority was the product of circumstances and of his personal influence and was not founded on any constitutional ruling. After his execution the office lost its importance until Johan de Witt (*q.v.*), grand pensionary from 1653 to 1672, restored its glory during the "First Stadholderless period." After him the best-known grand pensionaries of Holland were Antonius Heinsius (*q.v.*; 1689–1720) and L. P. van de Spiegel (1787–95). The office was abolished in 1795. The estates of Zeeland also employed a grand pensionary, but this official was much less important than his Holland counterpart.

(E. H. K.)

PENSTEMON, the beardtongue genus of perennial herbs (family Scrophulariaceae), comprising about 250 species, chiefly natives of North America, with showy open-tubular flowers. Noteworthy species are *P. laevigatus* (smooth beardtongue), *P. digitalis* (foxglove beardtongue) and *P. hirsutus* (hairy beardtongue) of the eastern and southern states; *P. alpinus* (alpine beardtongue), *P. cyananthus* (blue beardtongue) and *P. barbatus* (bearded penstemon) of the Rocky mountain region; and *P. antirrhinoides* (snapdragon beardtongue), *P. difusus* (spreading beardtongue) and *P. centranthifolius* (scarlet bugler) of the Pacific states; these and various others are more or less cultivated. The penstemon of the florist has, however, sprung from *P. hartwegi* of Mexico and *P. cobaea* of southwestern United States and possibly some others.

RUTHERFORD PLATT

PENSTEMON, KNOWN ALSO AS BEARDTONGUE

The plants endure mild winters unharmed in favoured situations. They winter safely in cold frames, protected by mats or litter during frost, but tend to die out in a year or two, especially if

grown in open sunlight. They produce seed freely, new kinds being obtained by that means.

PENTAGON, a large five-sided building in Arlington county, Virginia, near Washington, D.C. It was built in 1941–42 to bring under one roof the U.S. war department offices then housed in widely scattered buildings. After World War II it became the headquarters of the department of defense, including all three services—army, navy and air force. The largest office building in the world, the Pentagon covers 34 ac. (including a 5-ac. central court), offers 3,700,000 sq.ft. of usable air-conditioned floor space and provides work space for about 30,000 persons, military and civilian. Built of structural steel and reinforced concrete, with some limestone facing, the entire structure cost $83,000,000.

The Pentagon consists of five concentric pentagons or "rings" with ten spokelike main corridors connecting the whole. (*See* WASHINGTON, D.C., for photograph.) With only five floors, plus a mezzanine and basement, the height of the building is far less than its horizontal dimensions. A huge concourse, larger than two American football fields, provides a shopping centre for Pentagon workers. Beneath the concourse are bus and taxi terminals. Parking areas adjacent to the building can accommodate over 8,000 cars. A heliport for the Pentagon was added in 1956.

See Gene Gurney, *The Pentagon* (1964). (H. C. T.)

PENTASTOMIDA (LINGUATULIDA) are a small group (usually considered a class) of wormlike, bloodsucking arthropods that live as internal parasites of vertebrates. The body of an adult is externally ringed—and in many species looks like a thick string of beads—though there is no true internal segmentation. The alternate name Linguatulida or "tongue worms" is descriptive of the linguiform or tongue-shaped body of other species. Although some authorities consider the pentastomes a separate phylum, certain characteristics point to their very close arthropod relationship: (1) jointed legs in the embryo; (2) ecdysis or molting in the larval stage; and (3) the presence of breathing pores scattered over the body.

The name Pentastomida refers to the five openings arranged in a crosswise line on the head; the centrally located one is the oval, chitinous mouth, and the other two flanking pairs are the openings of pockets or sacs containing protractile hooks. The body is elongate and cylindrical in most species, a few being short and somewhat flattened. Adjoining a short head region is the long abdomen (from about ½ to 6 in. in length) marked with a variable number of superficial rings that do not represent true internal body segments and devoid of appendages. Although reproductive, nervous, and digestive systems are present, there are no organs of circulation or respiration. Mouth parts are lacking, and the digestive canal opens posteriorly. Sexes are separate, and the females are several times larger than the males.

PHOTOGRAPH BY COURTESY OF HOWARD R. HILL

VENTRAL VIEW DRAWING OF HEAD OF POROCEPHALUS AND PHOTOGRAPH SHOWING HEAD OF ARMILLIFER MONILIFORMIS EMBEDDED IN LUNG TISSUE OF PYTHON HOST

These bloodsuckers usually attain their adult stage within cold-blooded vertebrates, the nymphal forms occurring in warm-blooded vertebrates upon which the adult hosts feed. Adults live in the air passages of their host, whereas nymphs are most frequently found encysted in the liver of their host. Development is usually combined with a change of host.

The number of known species is over 50, and they are not always restricted to a single host species. *Raillietiella furcocerca orientalis* is a common parasite of snakes in the Eastern Hemisphere. *Reighardia sternae* is a cosmopolitan parasite of gulls and terns. In America, *Kiricephalus coarctatus* is often found in the air passages of snakes.

Linguatula serrata, usually found in dogs, wolves, and several other mammals, and *Armillifer armillatus* have occasionally been found in man. The eggs of *L. serrata* are scattered in sneezing, and the larvae develop in the viscera of the intermediate host—usually a rabbit, rat, or sheep. After several molts the nymphal stage is attained, which may last for two or three years. Man can serve both as an intermediary and as a final host.

The adult of *Armillifer armillatus* is a common parasite in the lungs of large snakes in the Eastern Hemisphere. Pythons often become infected by devouring an infected mammal. In man, infection takes place by swallowing eggs scattered over vegetables or in water. The encysted larvae settle in various organs, and a heavy infection may lead to grave disturbances and may even result in death.

Pentastomida are divided into two orders: (1) the Cephalobaenida, with two families and four genera (*Cephalobaena, Raillietiella, Reighardia*, etc.); and (2) the Porocephalida, with two families and 14 genera (*Porocephalus, Linguatula*, etc.). These two orders are distinguished by the structure of their reproductive and nervous systems, the Cephalobaenida being the more primitive.

One of the best treatises is by R. Heymons, "Pentastomida," in Bronn's *Klassen und Ordnungen* (1935). For an extensive list of literature *see* Howard R. Hill, "Annotated Bibliography of the Linguatulida," *Bull. S. Calif. Acad. Sci.*, vol. 47, pt. 2 (1948). (H. R. HI.)

PENTATEUCH. The name Pentateuch (from the Greek *pentateuchos biblos*, "book of five volumes") designates the first five books of the Old Testament—Genesis, Exodus, Leviticus, Numbers and Deuteronomy—which embody the Law of Moses and hence are called also Torah. The Pentateuch consists of narratives into which collections of laws are interpolated; the narratives begin with the creation of the world and conclude with the death of Moses, just before the entrance of the Israelites into the land of Canaan. They relate the primitive history of man, the stories of the patriarchs, the exodus of the Israelites from Egypt and their journey to Canaan, and the institution of the Israelite Covenant and laws at Sinai.

Development of Criticism of the Pentateuch.—Jewish and Christian tradition until the 19th century, with a few rare and uninfluential exceptions, attributed the Pentateuch to Moses. The French physician Jean Astruc suggested in 1753 that Moses compiled Genesis from two documentary sources, one of which employed the divine name Yahweh and the other the divine name Elohim. Astruc did not intend to question the authorship of Moses; but his introduction of the divine names as a criterion of documentary sources gave the impulse to the literary criticism of the Pentateuch which engaged almost every major biblical scholar of the 19th century.

The text of the Pentateuch exhibits numerous traits which indicate a complex literary origin. There are two creation accounts (Gen. i, 1–ii, 4a; ii, 4b–24). The account of the deluge (Gen. vi, 5–ix, 17) shows evidences of two accounts which have been compiled into one (the number of animals taken into the ark, the duration of the deluge, the two entrances of Noah into the ark, the blessings and covenant pronouncements after the deluge). Ex. iv, 19 is the logical sequence of Ex. ii, 23. The expulsion of Hagar by Abraham (Gen. xvi; xxi), the call of Moses (Ex. iii; vi) and the miracles of the quail and the manna (Ex. xvi; Num. xi) are narrated twice. The wife of a patriarch is taken into the harem of a foreign ruler, or threatened with this, three times (Gen. xii; xx; xxvi). When the text is studied closely, other similar phenomena are observed. If these passages are analyzed and grouped, three strands of narrative emerge, each with distinctive characteristics of vocabulary and style, of which variation in the use of the divine names is only one.

Proceeding on these data, J. G. Eichhorn (1781) distinguished various sources in Genesis. K. D. Ilgen (1798) observed the source called Elohist could not be considered as a single source but must be divided into two. Geddes (1792), Vater (1802–05)

and De Wette (1805) proposed the "theory of fragments," which assumed that there was no single document in the Pentateuch; they found in it a compilation of fragments of numerous different documents. The most important contribution of De Wette was his isolation of Deuteronomy as a distinct source. The unity of the sources, however, was too evident to be denied; and Ewald (1823) and De Wette (1840) adopted the "complementary theory," which assumed that one basic document was enlarged by the addition of fragments from other sources. This basic document was called the Elohist. Subsequently H. Hupfeld (1853) restored Ilgen's theory of two Elohist documents. One of these (the Priestly source of later scholars) he called the First Elohist as the oldest; the Jahwist document followed, and the Second Elohist was the most recent. With the addition of Deuteronomy the lines of the four-document hypothesis were drawn.

The decisive contribution was made in 1865 by Graf, who proposed that the First Elohist was actually the most recent of the sources and was postexilic, the work of the Jerusalem priesthood. He introduced the sign "P" to designate this source. Kuenen (1869) announced that he had reached the same conclusions independently. Julius Wellhausen, in a series of works published between 1876 and 1901 and remarkable for brilliant and persuasive clarity, presented this hypothesis both to scholars and to the general public, and after 1900 it was almost universally accepted. Wellhausen's own contribution was a theory of the historical and cultural evolution of Israel and its religion, which explained the growth of Israelite belief as a rectilinear progress from the primitive polytheism of early Israel through the ethical monotheism of the prophets, the great creative thinkers of Israel, to the formal legalism and sacerdotalism of postexilic Israel. This theory of the evolution of Israel cannot now be sustained; Wellhausen worked at the beginning of the period of the great discoveries relating to the history and culture of the ancient near east, and these discoveries have rendered the theory as a whole impossible. But since in the early years of the 20th century the theory of the religious evolution of Israel was not always distinguished from the theory of the literary origins of the Pentateuch, many conservative theologians of all churches regarded Wellhausen's theory as an attack on revealed religion.

Documentary Theory.—In its classical form the documentary theory finds the Pentateuch to be a compilation of four documents: the Jahwist (German spelling; J), composed in the 9th century B.C.; the Elohist (E), composed in the 8th century B.C.; the Deuteronomist (D), composed in the 7th century B.C.; and the Priestly document (P), composed in the 5th century B.C. The Jahwist is Judahite, the Elohist Ephraimite in origin. These two versions of early Israelite tradition were fused into one document after the fall of Israel in 721 B.C. Deuteronomy was added after the exile. These were amalgamated with the Priestly source into the present Pentateuch about 400 B.C.

This hypothesis did not explain all questions of detail. Subsequent work was devoted to further analysis of the documents, to the isolation of other sources and to a more precise dating of the documents. The analysis of the documents was pushed by some scholars to the point where it issued in a new "fragment theory," and analysis based on minutiae has been proved exaggerated; the unity of the sources in some form must be explained. It is generally accepted that the documents represent strata of material rather than single unified compositions, and that the processes of redaction and expansion are too complex to permit a definitive analysis of the entire text. For the same reasons a precise date for each of the sources is scarcely possible.

Later critics, especially those of the Scandinavian school, have affirmed that the entire documentary hypothesis is false, since it does not reflect ancient methods of composition and transmission. This school asserts the primacy of oral tradition; the "documents," they say, are modern historical conceptions. While the oral traditions may be designated by the symbols J, E, etc., these actually are cycles of oral traditions not written until a relatively late date, postexilic in any case. Most contemporary critics believe that the Scandinavian school exaggerates the place of oral tradition; ancient near eastern culture offers numerous examples of the collection of traditions in writing. It is altogether probable, however, that most of the traditions of the Pentateuch were orally composed and orally transmitted in their early stages of development.

Later criticism also emphasizes the importance of literary form and of the "situation in life" in which the traditions arose. Noth, von Rad and others see in these traditions not mere popular or tribal memories, but traditions which have arisen from cultic recitals. On such great feasts as Passover the ritual included a recital of the saving deeds of Yahweh on behalf of Israel. These took variant forms in different cultic centres; the traditions of northern Israel, for instance, make Jacob prominent, while the traditions of Judah give greater prominence to Abraham. But the traditions all have in common that they are "history of salvation," a profession of the faith of Israel. Scholars agree that the study of any particular tradition must take account of its preliterary history as far as this can be traced: its local origin, its clan or tribal emphasis, its cultic significance. The compilers of the written sources were not creators; they found well-formed oral traditions which they arranged into a new literary unity.

Jahwist.—The literary composition of the Jahwist tradition probably may be placed in the reign of David or of Solomon as an expression of the new unity and prosperity of Israel under the monarchy. It began with the creation of man in Eden and contained the stories of the fall, primitive man, the deluge and the tower of Babel. The patriarchal stories of the Jahwist give the chief place to Abraham, who dwelt in the south, the later territory of Judah; it incorporates selected materials from the northern cycles of Jacob and Joseph, in particular the story of the marriages of Jacob and the births of the eponymous ancestors of the tribes. In the story of Joseph the Jahwist makes Judah the protagonist of the brothers. Analysis of the sources in Exodus and Numbers is more difficult; the Jahwist appears to have made Kadesh-barnea the focal point of his account of the wandering.

The Jahwist has been called the national epic of Israel. His are some of the best-known pieces of biblical narrative; they are concrete, vivid and moving. His conception of the deity is the most anthropomorphic of all the sources, and his human characters are portrayed with earthy realism. In spite of the childlike and primitive traits of his narrative, some of the most profound theological ideas of the Bible are expressed in such stories as those of the fall, the deluge, primitive man, the destruction of Sodom. Israel escapes from the curse, which he traces to human origins, by accepting the blessing granted to Abraham and to his seed; and the promises are obviously fulfilled in the peace and prosperity of the monarchy of David.

Elohist.—Compared to the Jahwist, the Elohist appears to be a torso; no doubt the document was edited by the Judahite compilers when it was fused with the Jahwist. The Elohist begins with Abraham and emphasizes Covenant rather than blessing. It contains at length the stories of Jacob and Joseph, the heroes of the northern tribes. The story of the exodus is centred about the Covenant of Sinai. The Elohist lacks the vividness of the Jahwist; his conception of the deity avoids grosser anthropomorphisms, and his human characters are more idealized. The literary composition of the Elohist is to be placed after the establishment of the divided kingdom; like the Jahwist, it is an expression of the traditions of the kingdom, with more emphasis upon the northern element in those traditions.

Priestly.—The Priestly source is often called a précis of history. It begins with an elaborate account of creation (Gen. i); but elsewhere it appears as brief notices, genealogies and lists, and the narrative is prolonged only when religious institutions are concerned, many of which it retrojects to earliest times. It has created an artificial chronological scheme. Its style is dry and pedestrian and easily detected. The historical sketch of the Priestly source is intended as framework for the priestly collection of law.

Law and History.—In addition to the priestly collection of laws there are other collections of laws of various date and provenance. A historical prologue usually stood at the beginning of ancient near eastern legal collections. This is in a sense the

conception which governs the compilation of the Pentateuch. Israelite law arises out of the history of Israel, but not its secular history; law is incorporated into the history of the saving deeds and the revelation of Yahweh, who elects Israel as his people and lays down as terms of his Covenant the laws by which Israel should live.

In the history of Judaism the Torah, the law of Moses, as the Pentateuch was designated, was the dominant influence. The Torah was the exclusive object of study and interpretation in the rabbinical schools, whose interpretations were collected in the Talmud. The Pentateuch is designated as law in the prologue of Ecclesiasticus (written about 132 B.C.) and frequently in the New Testament. From the Pentateuch arises the characteristic Jewish conception of Israel as a people chosen by God, delivered and preserved by his saving deeds, established in a commonwealth by him and living under his revealed law. This conception of Israel as the people of God was incorporated into the teaching of primitive Christianity and applied to the church.

See BIBLE and articles on the separate books; for the special problems of DEUTERONOMY *see* that article; on the extension of the sources of the Pentateuch in subsequent books of the Old Testament *see* HEXATEUCH. *See* also references under "Pentateuch" in the Index.

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PENTATHLON is an athletic contest involving five distinct types of competition (from the Greek *penta*, "five," and *athlon*, "contest"). In the ancient Greek Olympics, the pentathlon included a race the length of the stadium (about 210 yd.), the broad jump, discus throw, javelin throw, and a wrestling match between the two athletes scoring highest in the previous four events.

This Greek pentathlon was adapted for modern track and field competition by setting the sprint distance at 200 m. and by substituting a 1,500-m. run for the wrestling match. The event was introduced to the Olympic Games in 1912 but discontinued after 1924.

The modern or military pentathlon, which has been included in the Olympic Games since 1912, demands far greater diversity of skills than its track and field counterpart. It requires each contestant to perform the tasks that might confront a mounted courier under historical battle conditions.

Entrants are required to: (1) ride a strange horse, selected by lot, over a 5,000-m. obstacle course; (2) engage each of his rivals in an épée fencing match; (3) shoot with pistol at a silhouette target; (4) swim 300 m.; (5) run 4,000 m. on an unfamiliar cross-country course. The competition takes five days.

Each nation enters three contestants and they are scored according to a point table established by the International Pentathlon Union. Team prizes are awarded by adding up the three individual scores. World championships, under International Amateur Athletic Federation auspices, are held in non-Olympic years. The women's pentathlon—shot-put, high jump, 200-m. dash, 80-m. hurdles, broad jump—was added to the program of the 1964 Olympic Games. *See* OLYMPIC GAMES. (E. J. G.)

PENTECOST (from Greek *pentekostos*, "50th"), the Jewish Feast of Weeks, or Shavuoth, celebrated on the 50th day after Passover. The name also is given to the Christian feast popularly called Whitsunday, celebrated on the 50th day after Easter to commemorate the descent of the Holy Spirit on the apostles. *See* JEWISH HOLIDAYS; WHITSUNDAY.

PENTECOSTAL CHURCHES. A group of religious bodies that emphasize holiness or Christian perfection as an experience climaxed by a spiritual endowment in which the recipient speaks in "unknown tongues" (*see* TONGUES, GIFT OF). The name and practices are derived from the phenomenon of the Day of Pentecost described in Acts 2:1–13.

Theologically, these churches belong to the ultraconservative or so-called fundamentalist school (*see* FUNDAMENTALISM). No definite creed is applicable to all the bodies, but their beliefs and practices follow a general pattern. Holiness is a work of grace subsequent to justification or conversion, the gift of tongues being a still higher experience. An intense premillenarianism and expectancy of the imminent Second Coming of Christ is usually present (*see* MILLENNIUM) based on the theory of the verbal inspiration of the Bible and the literal interpretation of the apocalyptic passages. Divine healing is frequently practised. Glossolalia, or speaking in tongues, is the characteristic feature, accompanied by a strong emotional element which induces motor automatisms and sometimes runs to wild and bizarre practices. In other aspects the Pentecostals do not greatly differ from other fundamentalist groups. Most of them have two sacraments, baptism (usually by immersion) and the Lord's Supper (often accompanied by foot washing). Among numerous small Negro Pentecostal churches are several "Jesus Only" sects, which reject the doctrine of the Trinity and baptize only in the name of Jesus; and a parallel group of "Father Only" cults, which baptize only in the name of the Father.

Many bodies, such as the Latter-day Saints, Foursquare Gospel adherents, and numerous small Negro sects, that inculcate the charismatic principle, including the gift of tongues, are not usually classed among the Pentecostal churches.

Pentecostal denominations are widespread throughout the United States and are found in many other countries. Forty or more identifiable groups in America practise glossolalia; in addition, there are hundreds of obscure "storefront" congregations that cannot be included in any reliable computation. Pentecostal churches abound also in remote mountain and other rural areas, and it is mainly among these that the pronounced emotional manifestations are found. The larger bodies are organized in the Pentecostal World Conference, an international fellowship which has headquarters in the United States and publishes in England a periodical called *Pentecost*.

Most of the Pentecostal churches, properly so-called, in America trace their origin directly or indirectly to the "Latter Rain" revival movement led by A. J. Tomlinson, founder of the Church of God, who promoted the revival so vigorously that it spread throughout the country during the first quarter of the 20th century. Schisms began to occur in 1917, and in a few years the movement split into numerous groups while many independent bodies were set up. The divisions were due mainly to the strong individualism of the doctrines preached, to the independence of the local congregations, to the rivalry of various leaders for power, and to Tomlinson's insistence on the exercise of total authority. There were several splits during his lifetime, and after his death misunderstanding between his two sons and the leaders of the Cleveland (Tenn.) church brought about further schisms. Four large Tomlinson sects survive. Other bodies indirectly derived from the Latter Rain revival are the Assemblies of God (*q.v.*); United Pentecostal Church, Inc.; Pentecostal Holiness Church; International Pentecostal Assemblies; Pentecostal Church of God; Calvary Pentecostal Church, Inc.; and Pentecostal Fire-Baptized Holiness Church. There are a dozen smaller churches in North America and several elsewhere. The revival flourished among the Italian communities in New York and Chicago and the resultant churches were federated in the Italian Pentecostal Assemblies of God and the Unorganized Italian Christian Churches of North America. *See* also GOD, CHURCHES OF; GOD IN CHRIST, CHURCH OF.

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PENTELIKON (ancient Greek BRILESSOS or BRILETTOS, later called PENTELIKON after the village Pentele; Latin PENTELICUS; modern Greek PENDELIKÓN), a mountain in Attica, Greece, about 10 mi. (16 km.) NE of Athens, height 3,638 ft. (1,109 m.), famous for its white marble. This was not regularly worked until late in the 6th century B.C.; later all the chief buildings and sculptures of Athens were made of it. The ancient quarries (still visible) are mostly on the south side; the modern quarries on this and the north side. There was a sanctuary of Athena at the summit.

PENTLANDITE, a sulfide of nickel and iron, is the chief source of nickel. It is abundant in the nickel mines of Canada, as in the Sudbury district of Ontario where the mineral has an average nickel content of 35%. It also occurs in Norway, Sweden, and South Africa; in the United States it is found in Nevada and Yakobi Island, Alaska. It was named after J. B. Pentland who first noted the mineral. The formula is (Fe, Ni)S. It crystallizes in the cubic system but is never found in distinct crystals. It has a metallic lustre and light bronze-yellow colour. It is nearly always associated with pyrrhotite. For production and uses *see* NICKEL. (W. F. FG.; X.)

PENUMBRA (Lat. *paene,* "almost," *umbra,* a "shadow"), in astronomy, the partial shadow of a heavenly body as cast by the sun. It is defined by the region in which the light of the sun is partially but not wholly cut off through the interception of a dark body. *See* also ECLIPSE.

PENUTIAN, a superfamily of. North American Indian languages defined by the linguist E. Sapir as extending originally from British Columbia to Mexico. The families and languages are, from north to south: Tsimshian; Chinook (including Wishram); Sahaptian (Sahaptin, including Nez Perce, Yakima; Molala-Cayuse; Klamath); Oregon Penutian (Coastal: Alsea, Siuslaw, Coos; Kalapuya; Takelma); Californian (Wintun, Maidu, Miwok-Costanoan, Yokuts); Mexican Penutian (Zoque, Huave). Penutian is part of a larger grouping (phylum), Macro-Penutian, which includes Azteco-Tanoan (Uto-Aztecan, Kiowa-Tanoan), and, perhaps, Mayan and Totonac in Mexico. The relationships have not been worked out in detail, but all except the last two may be considered valid. Zuñi has been shown to be remotely related to California Penutian. About 5,000 speakers of Penutian remained in the 1960s, with some of the languages extinct.

Penutian languages have structures reminiscent of Indo-European—inflectional suffixes, internal stem-change, noun cases—with much variation. *See* also CENTRAL AND NORTH AMERICAN LANGUAGES; AMERICAN ABORIGINAL LANGUAGES; INDIAN, NORTH AMERICAN. (G. L. T.)

PENZA *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., formed in 1939, lies southeast of Moscow on the western flank of the Volga uplands. Area 16,680 sq.mi. (43,201 sq.km.). Pop. (1959) 1,509,566. From a maximum height of 1,089 ft. (332 m.) in the east its rolling interfluves drop gently to the Oka-Don plain in the extreme west. The north and east drain to the Volga by the Sura, the west to the Oka by the Moksha and its tributaries and the south to the Don by the Khoper and Vorona. The climate is continental: January average temperature is −13° C to −11° C (8°–11° F), July average about 20° C (68°) and rainfall moderate, 16 to 20 in. annually. The *oblast* lies in the zone of forest-steppe and about one-fifth of the surface is in pine or oak forest, mostly in the Sura Basin. In forested or formerly forested areas are leached chernozems or gray forest earths; in the steppe areas are chernozem (black earth) soils. Natural vegetation has been widely removed for agriculture, and subsequent soil erosion has been severe.

Of the 1959 population 499,384 (33%) were urban, living in 11 towns and 13 urban districts. Apart from Penza (255,481) and Kuznetsk (56,880), the urban centres are all small. Agriculture, the occupation of the majority of the working population, is overwhelmingly dominated by grain growing, especially by winter rye. Oats, fodder maize (corn), millet, and wheat are also grown. Industrial crops (chiefly sunflowers, hemp, and potatoes) are less important, while livestock farming is underdeveloped. Engineering, the main industry, is concentrated in Penza and Kuznetsk, other towns being mainly concerned with processing food and agricultural products, flax retting, and making woolen textiles, leather goods, and footwear. Timber working is important in the surviving forest areas, and paper is made. (R. A. F.)

PENZA, a town and administrative centre of Penza *oblast* in the Russian Soviet Federated Socialist Republic, U.S.S.R., lies 441 mi. (710 km.) SE of Moscow at the confluence of the Penza and Sura rivers. Pop. (1959) 255,481. The town had its origin in 1666 as a strongpoint at the western end of the Syzran defensive line, although a fort was founded there earlier by Ivan IV (the Terrible; 1530–84). With the settlement of the surrounding chernozem (black earth) lands, Penza became an important agricultural centre. Grain was sent to Moscow first by the Sura River and, after the 1870s, by rail. The processing of farm products is still one of the significant industries of Penza, but it has been surpassed in importance by engineering. Textile and chemical machinery, diesel engines, compressors, calculating machines, and bicycles are made; there are also watch making, paper making, and timber working. Penza has pedagogic and industrial institutes. That part of the town lying on the right bank of the Sura was formed into the separate satellite town of Zarechny in 1958. (R. A. F.)

PENZANCE, a municipal borough, seaport, and holiday resort, in the St. Ives parliamentary division of Cornwall, 280 mi. (451 km.) WSW of London by road and the most westerly town in England. Pop. (1961) 19,281. After 1934 the borough included Newlyn, Mousehole, Gulval, and Heamoor. It is the only quarter sessions borough in Cornwall.

The town stands on rising ground overlooking Mounts Bay, and has a remarkably equable climate, enabling many subtropical plants to flourish in the open air. Great quantities of early vegetables, flowers, and fruits are raised locally and in the Scilly Isles (*q.v.*), and are sent to London and elsewhere. Penzance is connected with the Scilly Isles by steamer and air services. Some fishing is done from Penzance Harbour, but most of the fishing boats work from Newlyn Harbour. From the mean sea level in Newlyn Harbour—ordnance datum—is calculated the elevation of all places shown on ordnance survey maps. Newlyn is a well-known centre for artists.

Edward III granted Penzance a charter market in 1332. In 1512 Henry VIII granted a charter as to profits from all ships visiting the harbour, although the town's importance as a fishing port dates from the 14th century. The charter of incorporation was granted in 1614 and in 1663 Penzance was constituted a coinage town for tin, and so remained until 1838. The old name (Pensans) is thought to have referred to a chapel of St. Anthony (patron saint of fishermen) formerly on the headland south of the harbour. The seal and coat of arms granted by the College of Heralds in 1934 to replace the old corporate seal, however, make a very free translation of the name and depict the head of St. John the Baptist on a charger.

PEONAGE, a form of involuntary servitude. The beginning of peonage has been traced as far back as the conquest of Mexico by the Spaniards. Early in the history of Mexico the conquerors worked out a plan by which the poor, especially the Indians, could be forced to do the work of the planters and mine operators. The word *peon* became synonymous with the English word labourer, but it later was restricted in its meaning to those labourers who were compelled to serve their creditors to pay debts which by contract they had pledged themselves to pay in labour.

Although the 13th Amendment and congressional legislation prohibited any such involuntary servitude in the United States, the former slave-holding states devised certain legislation, following emancipation, to make labour compulsory. Under these state laws employers deceived ignorant men by inducing them to sign contracts for labour in payment of debts, and those who might have to pay fines imposed by the courts to sign other similar contracts. In rural districts far removed from the populous centres the chain-gang system of forced labour under the pretense of farming out the services of penal offenders resulted in great injustice. The practice of leasing short-term prisoners, both white and Negro, to managers of labour camps was continued in a few of the southern states. (C. G. W.)

PEONY (PAEONY), common name for *Paeonia,* a genus of plants remarkable for their large and showy flowers; it belongs to the buttercup family (Ranunculaceae). The peonies are native mostly to Europe and Asia; one species, *P. brownii* (the western peony), is found naturally along the Pacific coastal mountains in North America.

Known from ancient times, and called *paeonia* by the Greeks, after Paean (*q.v.*), a physician of the gods, the peony was regarded with the greatest respect. As late as the 17th century its

roots, flowers, and seeds were used in medicine in England. In China and Japan it has been grown for ages and esteemed for its beauty and fragrance. The Mongols in Siberia were reported, in the 18th century, to have eaten the roots and seeds of the peony.

There are two distinct general groups of peonies: the herbaceous and the tree or moutan peonies. The herbaceous are strong-growing perennials from two to three feet in height; the large, glossy, much-divided leaves, decorative from spring to fall, are supported on annual stems, which arise from the fleshy rootstock.

ROCHE

JAPANESE DOUBLE TREE PEONY (HORTICULTURAL VARIANT OF PAEONIA SUFFRUTICOSA)

The ample flowers, which blossom in late spring and early summer, when few flowers equal them in effect, vary in form from the open single to the globular sorts of the double varieties. The Chinese *Paeonia lactiflora* (or *P. albiflora*) and the European *P. officinalis* (the common peony—an old garden favourite), along with their many horticultural varieties, are the herbaceous garden peonies which produce the large single and double flowers of white, pink, rose, and deep crimson. Modern garden hybrids are quite beautiful, the flowers being in many instances delicately tinted with more than one colour, such as buff with bronzy centre, carmine with yellowish centre, rose with orange centre, white tinted with rose, etc. Hundreds of names are given to the colour variations of both the herbaceous and tree peonies.

The tree peonies, sometimes known as moutan peonies, have sprung from the wild Chinese species *P. suffruticosa*. They are stiff-growing plants with woody permanent stems. They are remarkable for their shrubby habit, forming vigorous plants sometimes attaining a height of four to six feet, and producing in late spring magnificent flowers which vary in colour from white to lilac, magenta, violet, rose, and red. These are produced on the young shoots and are in consequence liable, unless protected, to be cut off by spring frosts. Tree peonies require a thorough ripening in summer, and therefore a hot, dry season is desirable for their well-being. They can be increased by grafting in late summer or autumn on the roots of herbaceous peonies. A race of hybrids developed by crossing the tree peony with the yellow Chinese species *P. lutea* has both single and double flowers sometimes tinged with red. A variety of *P. lutea*, discovered in south-western Tibet in 1936 and named *P.* var. *Ludlowii*, bears magnificent large butter-yellow flowers on stems about six feet high. It is the earliest of the large tree peonies to flower in England, where it is perfectly hardy.

All peonies thrive in rich, moist but well-drained garden loam in a sunny location, planted—preferably in the spring—so that the buds or "eyes" of the fleshy roots are not more than three inches deep. They are not commonly grown from seed, which take about two years to germinate. After about a year they become well established and will produce blooms for years without the necessity of dividing.

An annual top-dressing of bonemeal or rotted manure is beneficial since peonies are heavy feeders; tree peonies benefit by a dressing of old leaves alone.

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PEORIA, a city of north-central Illinois, U.S., on the Illinois River where it widens to form Lake Peoria, roughly midway between Chicago and St. Louis, Mo., is a leading commercial centre of downstate Illinois and the seat of Peoria County.

Named for one of the five Indian tribes in the Illinois confederacy, Peoria represents one of the oldest settled locations in the state. The French under René Robert Cavelier, sieur de La Salle (*q.v.*), first built Ft. Crèvecoeur on the bluffs opposite the present city in 1680, but it was plundered and deserted later that same year. Subsequent settlements around Lake Peoria by the French, Indians, and Americans give an almost unbroken history to the region. After 1813 the location was known as Ft. Clark and when Peoria County was established in 1825, the community reverted to the French-Indian name of Peoria and was established as the county seat. Peoria was incorporated as a town in 1835 and chartered as a city in 1845. It was there, on Oct. 16, 1854, that Abraham Lincoln publicly denounced slavery in a rebuttal to a speech by Stephen Douglas.

Peoria is situated in the heart of the corn belt, with deposits of bituminous coal, sand, gravel, and gypsum nearby. It has excellent rail, road and air transport facilities including the Illinois waterway. The city's industry is both vast and varied. Producing more than 900 different products in more than 200 manufacturing plants, Peoria is as well known for its tractors, agricultural implements, and earth-moving equipment as it is for products of its numerous distilleries and breweries. The output of chemicals, food products, household goods, brick, tile and stone, radio equipment, and electric power is also extensive. The U.S. Department of Agriculture Northern Regional Research Laboratory, which searches for new and improved uses for farm commodities, is located there.

The city, extending for more than 10 mi. (16 km.) along the Illinois River, is noted for its setting amid the scenic beauty of the surrounding area. Six public parks totaling more than 2,000 ac. (809 ha.) offer opportunities for relaxation and recreation. Bradley University, located near the west edge of the city, was established by Lydia Bradley in 1897 and endowed by her with a gift of $2,000,000.

Population (1960) 103,162; standard metropolitan statistical area (Peoria and Tazewell counties), 288,833, to which Woodford county (pop. [1960] 24,579) was added in 1963. For comparative population figures *see* table in ILLINOIS: *Population*.

(R. M. SU.)

PEPE, GUGLIELMO (1783–1855), Neapolitan general prominent in the Italian *Risorgimento*, was born at Squillace in Calabria on Feb. 13, 1783. He attended a military academy at Naples before joining the army of the Parthenopean Republic (*see* NAPLES, KINGDOM OF) in 1799. Fighting against the Royalists, he was wounded and captured, but his life was spared because of his youth. Banished by the restored Bourbons, he made his way to France and joined the "Italian Legion" of exiled patriots at Dijon. He went back to Italy with Napoleon to fight at Marengo (1800) and later took part in operations against the anti-French brigands of central Italy. On a subversive mission to Naples, he was arrested and imprisoned. Set free when Joseph Bonaparte became king of Naples (1806), he resumed his army service. Having commanded a brigade in Spain (1811–13), he fought for Joachim Murat in 1814 and 1815.

Under the Bourbon kingdom of the Two Sicilies, Pepe served from 1818 against brigands in Calabria. This brought him into contact with the Carbonari (*q.v.*); and when revolution broke out in 1820, Pepe was made commander in chief of the army by the constitutionalists. Internal quarrels weakened the regime, and Pepe could not prevent the defeat at Rieti (March 1821) and the overthrow of the constitutional government. He went into exile, living mainly in England, writing on Italian affairs and keeping in touch with revolutionaries in Italy.

In 1848 Pepe returned to Naples after the revolution, was reinstated in the army and put in command of the force sent north against the Austrians (*see* ITALIAN INDEPENDENCE, WARS OF). The expedition was soon recalled, but Pepe refused to obey this order and crossed the Po with some of his troops to fight in the Veneto. Entering Venice (June 1848), he was made commander of the garrison and cooperated with Daniele Manin in defense of the city. The wisdom of his conduct there has been debated. When Venice surrendered (Aug. 1849), he went to Paris. After Louis Napoleon's *coup d'état* (1851), Pepe moved to Turin, where he died on Aug. 8, 1855. Pepe's publications in English include *Narrative of the Political and Military Events . . . at Naples in 1820 and 1821* (1821), *Memoirs of General Pepe* (1846), and

Narrative of Scenes and Events in Italy from 1847 to 1849, two volumes (1850).

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PEPERINO, an Italian name applied to a brown or gray volcanic tuff (*q.v.*), formed from volcanic ash or dust and containing fragments of basalt and limestone, with disseminated crystals of augite, mica, magnetite, leucite, etc. The typical peperino occurs in the Alban Hills, near Rome, and was used by the ancients, under the name *lapis albanus,* as a building stone and for the basins of fountains. Other tuffs and conglomerates in Auvergne and elsewhere are also called peperino. The name originally referred to the dark-coloured inclusions, suggestive of peppercorns. *See* also ROME: *The Ancient City: Materials.*

PEPIN (PIPPIN), the name of several members of the Carolingian dynasty.

PEPIN I (d. *c.* 640), called Pepin the Old or Pepin of Landen (after one of his estates near Trier), was a councilor of the Merovingian king Clotaire II and mayor of the palace in Austrasia. Through the marriage of his daughter Begga with Ansegisel, son of Arnulf (d. 641; bishop of Metz), Pepin was the founder of the Carolingian dynasty. Deprived of his mayoralty at the accession (629) of Dagobert I, he regained power in Austrasia after that king's death (January 639) but did not long survive to enjoy it.

PEPIN II (d. 714), called Pepin the Young, or sometimes Pepin of Herstal or Heristal, son of Begga and Ansegisel, escaped the massacre of his family which the ambition of his uncle Grimoald provoked in 662. After the death in 679 of Dagobert II of Austrasia, however, Pepin established himself as mayor of the palace in that kingdom and defended Austrasian autonomy against Thierry III of Neustria and Ebroïn, Thierry's mayor of the palace. Defeated by Ebroïn in 680 at Lucofao (Bois-du-Fay, near Laon), Pepin gained his revenge in 687 at Tertry (near Péronne) and became sole effective ruler of all the Merovingian territory. He nevertheless maintained Thierry III on the throne and after his death replaced him with three successive Merovingian kings. For Neustria and Burgundy, he delegated the functions of mayor first to one of his adherents, Norbert, then (*c.* 700) to his own son Grimoald.

Pepin, after several years of warfare, defeated the Frisians on his northeastern border (689) and married his son Grimoald to Theodelind, daughter of the Frisian chief Radbod. He also asserted himself over the Alamanni and encouraged Christian missionaries in Bavaria. He died at Jupille, near Liège, on Dec. 16, 714.

PEPIN III (d. 768), called Pepin the Short, was the younger of the two sons between whom Charles Martel (*q.v.*) divided his succession in 741. Pepin and his brother Carloman at first perpetuated the fiction of Merovingian sovereignty, placing Childeric III on the throne in 743. Carloman, however, retired to a monastery in 747, leaving Pepin in sole control of the kingdom; and about four or five years later Pope Zacharias agreed to the deposition of Childeric from the kingship in Pepin's favour. Pepin was then anointed, perhaps, as is often said, by St. Boniface, at Soissons between Oct. 31, 751, and Jan. 23, 752. This ceremony, new in Gaul, recalled Biblical traditions and the unction of the Visigothic kings of Spain. With his two sons, Charles and Carloman, Pepin was again anointed in July 754 by Pope Stephen II (III), who had come to seek his help against the Lombards in Northern Italy. In pursuance of his agreement with the pope, Pepin took an army to Lombardy in 754 and in 756, in an attempt to make the Lombard king Aistulf restore to Rome territory which the pope assumed had originally been ceded by Constantine to the bishop of Rome (*see* DONATION OF CONSTANTINE). In 763 Pepin acted as a mediator between the new Lombard king, Desiderius, and Pope Paul I.

Meanwhile, Pepin had much to do to keep his own territory in order and to repel hostile neighbours. He drove the Muslims from Septimania, but was continually threatened by the Frisians and by the Saxons, who repeatedly devastated the Rhineland area. Over Duke Tassilo III of Bavaria his authority was very uncertain: though Tassilo helped Pepin against the Lombards in 756, he withdrew his troops from Aquitaine in the middle of Pepin's campaign of 763 and thereafter acted quite independently. Aquitaine itself caused endless trouble: between 760 and 768 there were only two years during which Pepin was not at war in this region. Pepin died at Saint-Denis, on his way back from one of his Aquitanian expeditions, on Sept. 24, 768.

From the earliest years of his reign Pepin had carried out administrative, ecclesiastical, and legal reforms, and his numerous capitularies were to form the basis of Charlemagne's work.

PEPIN (d. 810), king of Italy, the second son of Charlemagne, was given the title of king of Italy in 781. He took part in campaigns against Tassilo III of Bavaria from 787 and led an army against the Avars in 796. His Venetian campaign (809–810) enabled Charlemagne later to treat with Byzantium on favourable terms. As early as 806 Charlemagne, in planning the division of his lands, had determined that when he himself died Pepin should have Italy, Bavaria, and the territory of the Alamanni together as a kingdom. But Pepin predeceased his father, dying on July 8, 810.

PEPIN I of Aquitaine (d. 838), second son of the emperor Louis I the Pious, was granted Aquitaine in July 814 and was recognized as king in 817, although it was clear that he was to remain subordinate to his elder brother Lothair, the heir to the imperial title. It was Pepin who in 830 started the revolt of Louis I's elder three sons against their father, but in February 831 he became reconciled with Louis. Rebelling again in 832, he was then deposed from his kingship by Louis, but could still exploit separatist feeling in Aquitaine and took part in renewed rebellion against Louis in 833. He finally repented in 834 and helped to restore the emperor's authority. Aquitaine was then given back to him, with Anjou in addition. He died, probably insane, on Dec. 13, 838.

PEPIN II of Aquitaine (d. after 864) was the son of Pepin I. When, in 839, the emperor Louis I granted Aquitaine to his youngest son Charles the Bald (*see* CHARLES II, emperor), a strong party in the kingdom repudiated Charles and proclaimed Pepin as king. In the war between Charles and his half-brothers after Louis I's death (840), Pepin supported his eldest uncle, Lothair, who found him a useful ally in Charles's rear; and after the Treaty of Verdun (843), which made no provision for him, he fought on alone against Charles. He won a victory in Angoumois on June 14, 844; and about a year later, at Saint-Benoît-sur-Loire, Charles received his homage and appointed him to rule in Aquitaine.

War soon broke out again, and Charles occupied Aquitaine step by step. Having taken refuge with Sancho, duke of the Gascons, Pepin was handed over to Charles in September 852. He was then tonsured and relegated to the monastery of Saint-Médard at Soissons. Escaping in 854, he renewed the struggle, but in 859 the Aquitanians began to abandon his cause. Thereafter he became a wanderer, sometimes joining Viking raiders, with a band of whom he attacked Toulouse in 864. Captured soon afterward, he was imprisoned at Senlis, where he died.

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(J. DE.)

PEPOLI, an Italian family, important especially in the history of Bologna. They first became prominent during the 13th century as merchant bankers of great wealth. They were Guelphs, and it was as leader of the Guelphs that ROMEO PEPOLI came near to obtaining lordship of Bologna early in the 14th century. He was stopped by a factious rising and died in exile in 1321. His son TADDEO was more fortunate: with popular support he was granted lordly power, with the title "conservator of peace and justice," in 1337; and later Pope Benedict XII confirmed his authority by appointing him vicar. His sons GIACOMO and GIOVANNI succeeded him on his death in 1347, but their rule was short: faced by the superior power of Giovanni Visconti, lord of Milan, they sold him the city in 1350. The government of Bologna underwent many revolutions in the following 100 years, but never again did the Pepoli manage to obtain power. They kept their wealth and land,

however, and a permanent place among the aristocracy of Bologna, the Papal States, and also southern Italy. Most notable, perhaps, among the soldiers, statesmen, and writers of the family were the conte CARLO (1796–1881) and the marchese GIOACCHINO NAPOLEONE PEPOLI (1825–81), both of whom played an active part in the Risorgimento. Gioacchino Napoleone, who belonged to the southern branch of the family, held public offices after the unification of Italy.

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PEPPER is a name applied to several unrelated plants from which pungent spices are obtained: black, white, and long pepper (*Piper*); red, chili, and cayenne peppers (*Capsicum*) and Melegueta pepper (*Aframomum melegueta*). Pepperroot (*Dentaria*) whose underground parts and peppergrass (*Lepidium*) whose fruits have a pungent taste are members of the mustard family. A number of plants named pepper, including the California pepper tree (*Schinus molle*), pepper vine (*Ampelopsis arborea*), and sweet pepper bush (*Clethra alnifolia*), are grown as ornamentals and are not used for spices.

Black Pepper.—The true pepper or black pepper (*Piper nigrum*, family Piperaceae) is native to northwest India, and in early historic times was widely cultivated in the tropics of southeastern Asia, where it became highly regarded as a condiment. Marco Polo in the 13th century observed great quantities of peppers being used in China and noted that their cultivation extended as far as Java. Pepper early became an important item of overland trade between India and Europe. It became a medium of exchange, and tributes were levied in pepper in Greece and Rome. The Venetians and Genoese were two of the chief distributors, and their virtual monopoly of the trade helped instigate the search for a sea route to the Far East.

H. HODGE

FRUITING BRANCH OF A BLACK PEPPER TREE (PIPER NIGRUM)

The pepper plant is a woody climber that by means of aerial roots reaches heights of 30 ft. or more. The shiny green leaves are broad, ovate, and alternately arranged. The inconspicuous flowers, which lack a perianth, are arranged in dense slender spikes of about 50 flowers each. The fruit, called a peppercorn, a small globose berrylike structure, ⅛–¼ in. in diameter, becomes yellowish red at maturity, and bears a single seed. A number of cultivated varieties are known.

The plant requires a long rainy season, fairly high temperatures, and partial shade to produce its best growth. Propagation is generally by stem cuttings, which are set out near a tree, or a pole that will serve as a support. The plants are sometimes interplanted in tea or coffee plantations. Peppers start bearing in two to five years and under good conditions may produce for 40 years or more. Harvesting is done by hand just before the fruits ripen. The peppercorns are spread out to dry in the sun, or occasionally over fires. In a few days the green fruits turn black and are ready for shipment. When ground, the whole peppercorn yields black pepper. For the preparation of white pepper, which has a milder flavour, the outer hull and pulp are first removed from the seed by fermentation in water. White pepper also is prepared from the whole dried peppercorns, by grinding off the outer coating.

Pepper owes its pungency to a resin and its flavour to a volatile oil. Piperine, an alkaloid with the same empirical formula as morphine, also is present. It is probably the world's most widely used spice and also has a limited usage in medicine.

The pepper is rather widely cultivated in India, Thailand, the East Indies, and islands of the South Seas, with Indonesia producing the bulk of the world's supply. The plant has been successfully introduced into tropical areas of Africa and of the Western Hemisphere. World exports have amounted to 170,000,000 lb. a year, with U.S. imports reaching 50,000,000 lb. a year.

Long pepper, whose culture and preparation is similar to that of black pepper, is prepared from *Piper retrofractum*, native to Java, and *Piper longum*, native to India. Although it was popular in Europe during the Middle Ages, it is little used today outside the areas where it is grown. Of the 600 to 700 species of *Piper*, a few others are of economic importance. Cubebs from *Piper cubeba*, native to the East Indies and cultivated in the Far East, formerly were used as a spice or condiment and now have a limited use in medicine for the treatment of catarrh. The roots of *Piper methysticum* are used throughout Oceania to produce the beverage kavakava. The leaves of the betel pepper (*Piper betle*) are chewed with the nuts of the betel palm in much of the tropics of the Old World as a masticatory. (C. B. H.)

Fleshy Peppers.—The genus *Capsicum*, of the nightshade family (Solanaceae; *q.v.*), comprises all the varied forms of fleshy-fruited peppers grown as herbaceous annuals—the green, red, and yellow peppers used in seasoning and as a vegetable food. The edible fruit, a podlike, many-seeded berry with a thick rind, is variously shaped and coloured. All garden peppers are derived from *C. frutescens* (incorporating *C. annuum* and *C. baccatum*), a tropical woody shrub up to eight feet tall, apparently a native of Central and South America. Most authors consider them varieties of the single species. The cultivated peppers used as spices and condiments include the pungent cherry (*cerasiforme*); cone, Tabasco, and coral gem (*conoides*); red cluster (*fasciculatum*); and long "hot" chili and cayenne (*longum*), often called capsicums. The mild bell or sweet peppers (*grossum*) have larger, variously coloured but generally bell-shaped, furrowed, puffy fruits that are used in salads and in cooked dishes. The term "pimiento," from the Spanish for "pepper," is applied to certain mild pepper varieties possessing distinctive flavour but lacking pungency; these include the European paprikas, which provide the paprika of commerce, a powdered red condiment. ("Pimiento," pronounced the same as "pimento," should not be confused with the latter, which is allspice; *q.v.*). The powdered red pepper of commerce is made from dried capsicums. An active principle obtained from capsicums is used as a counterirritant in medicine and to add pungency to ginger ale.

Pepper plants are treated as tender summer annuals outside their native habitat. Cultivation is the same as for their relative, the tomato (*q.v.*): seeds are sown under glass and the plantlets are set out when weather permits.

See Howard Scott Gentry, "Introducing Black Pepper into America," *Econ. Bot.*, vol. ix, pp. 256–268 (1955); Albert F. Hill, *Economic Botany* (1952).

PEPPERGRASS, a name given, especially in the United States, to certain species of *Lepidium* (family Cruciferae), which are widely spread as weeds. They are erect, mostly annual herbs with freely branching stems, about one-half to one and one-half feet high, small, toothed or deeply cut leaves, minute white or yellow flowers, followed by elongated, cylindrical clusters of small, short-stalked, flattened, nearly round, two-seeded, slightly notched pods. Examples are the wild peppergrass (*L. virginicum*), with mostly undivided leaves, found in fields from Quebec to Minnesota and southward to Mexico and the West Indies, and also naturalized in southern Europe, and the roadside peppergrass (*L. ruderale*), with narrowly divided leaves, native to Europe but now naturalized from Nova Scotia to Texas, and occurring also in Australia.

PEPPERMINT, a strongly aromatic perennial herb furnishing the well-known flavouring of wide use. It is one of many species of *Mentha—M. piperita*—distinguished from others of the genus by its stalked leaves and oblong-obtuse spikelike heads of flowers. It is native to Europe and has become naturalized in North America, found near streams and other wet sites. In several parts of the world, including Europe, Asia, and North America, it is cultivated

for its essential oil. Many varieties of peppermint have resulted from natural hybridization among wild species; but only two varieties, the black and white, are recognized by growers. The former has purplish and the latter green stems; the leaves are more deeply toothed in the white. Black peppermint (also known as English peppermint and mitcham mint) is the form extensively grown in the United States, probably because it is found to yield more oil. The white variety is less hardy and less productive but its oil is considered more delicate in odour and obtains a higher price.

U.S. DEPARTMENT OF AGRICULTURE
PEPPERMINT (MENTHA PIPERITA)

After about 1900 the United States became an important producer of peppermint oil. Production on a large commercial scale was first attained in southern Michigan and was later extended to northern Indiana. Shortly after World War II, the states of Washington and Oregon became important centres of peppermint culture because of climatic factors, including long summer days with abundant sunshine, which favour the production of high yields of oil. In the beginning of the second half of the 20th century, the United States was the leading peppermint-producing country, with production of over 2,000,000 lb. accounting for nearly three-fourths of the world's supply of peppermint oil. Bulgaria, Italy, the U.S.S.R., France, and other countries in Europe and Asia also produce the oil. Peppermint can be grown on a wide range of soil types but does best in deep, rich soils well supplied with moisture from rainfall or irrigation. In the United States it is produced on muck soils in Michigan and Indiana and sandy-loam soils in Oregon and Washington. Peppermint is propagated commercially by planting stolons (underground shoots) taken from existing fields. It is often grown in rows the first year and then allowed to spread over the field in solid stands spoken of as meadow mint. Fields may produce satisfactory crops for two to five years or longer if weeds and diseases are controlled. Best yields of oil are obtained when peppermint is harvested by cutting at the full-bloom stage.

Oil of peppermint is a volatile oil distilled with steam from the partially dried herb. It is widely used for flavouring dental creams, mouthwashes, toothpastes, cough drops, chewing gum, and confectionery, and to a lesser extent for masking the flavour and odour of numerous medicinal products. When pure, peppermint oil is nearly colourless and has an agreeable odour and a powerful aromatic taste, followed by a sensation of cold when air is drawn into the mouth. When oil of peppermint is cooled to 4° C it sometimes deposits colourless hexagonal prisms of menthol, which are soluble in alcohol and ether, almost insoluble in water, and fusible at 92° F; the oil consists chiefly of menthol and a ketone called menthone. Oil of peppermint is sometimes adulterated with phellandrene or other terpene compounds, water soluble glycols, or synthetic menthol. Adulteration with terpenes or glycols can be detected readily by using appropriate chemical or physical tests, but no satisfactory method has been found for proving adulteration with synthetic menthol. Oil of Japanese mint (*M. arvensis* var. *piperascens*) is a rich source of menthol, very different from peppermint oil. The name Japanese peppermint is sometimes used for this plant, but it should not be confused with true peppermint.

See E. Guenther, *The Essential Oils*, vol. 3, pp. 586–640 (1949); J. W. Parry, *Spices*, pp. 132–135 (1962). (L. M. Pz.)

PEPPERRELL, SIR WILLIAM (1696–1759), American merchant, colonial leader, and soldier who captured Louisburg in 1745, was born in Kittery, Me. (then a part of Massachusetts), on June 27, 1696, the son of Col. William Pepperrell. He studied navigation and surveying, both valuable in his later life as merchant and landlord and as an associate of his father in one of the most respected mercantile firms in colonial America. The Pepperrells were not so phenomenally successful or as daringly speculative as many American merchants, but over a period of 75 years they amassed considerable wealth. They prospered from New England's two major resources, lumber and fish, and from the flexibility of their trading policies, careful selection of business agents, maintenance of a reputation for honesty and integrity, and investments in real estate.

With success came a position of importance in New England society and politics. Pepperrell married the daughter of a wealthy merchant, Grove Hirst, and took an active interest in public affairs. He served at various times as a member of the Massachusetts General Court and the Governor's Council, as acting governor of Massachusetts, and as chief justice of the Court of Common Pleas. He succeeded his father as colonel of the Maine militia and, because of his military experience and his familiarity with the eastern frontier and with Indian affairs, he was selected by Gov. William Shirley to command the land forces in the siege of Louisburg in 1745 during King George's War. His success in this expedition resulted in his being created a baronet. For his service in raising troops during the French and Indian War he was given the rank of lieutenant general in the British Army. He died in Kittery, July 6, 1759.

See Byron Fairchild, *Messrs. William Pepperrell: Merchants at Piscataqua* (1954). (Ra. Mu.)

PEPPER TREE, a tree which has no proper connection with the true pepper (*Piper*), and is really a member of the family Anacardiaceae, being known botanically as *Schinus molle*, from the Peruvian name *Molle*. It is a native of tropical South America and is grown in the open air in the south of Europe. Introduced into California, it became widely popular as an ornamental tree, but later it was found to be a host plant for scale insects very destructive to orange orchards, with the result that in citrus districts the trees were cut down and further plantings discouraged. It is a small tree with unequally pinnate leaves, filled with volatile oil stored in large cells or cysts which are visible to the naked eye and appear like holes when the leaf is held up to the light. When the leaves are thrown upon the surface of water the resinous or oily fluid escapes with such force as to agitate them violently. The flowers are small, whitish, arranged in terminal clusters, and polygamous or unisexual, with five sepals, as many petals, ten stamens (as large as the petals in the case of the male flower, very small in the female flower, but in both springing from a cushionlike disk surrounding the base of the three-celled ovary).

The fruit is a small, globose, pealike drupe with a bony kernel enclosing a single seed; its fleshy portion has a hot aromatic flavour from the abundance of the resin it contains. The resin is used for medicinal purposes by the Peruvians, and has properties similar to mastic. The very similar Christmasberry tree (*S. terebinthifolia*), native to Brazil, with stiffer, less pendulous branches, more densely clustered flowers and smaller, bright red fruit, is sparingly planted for ornament. The Japan pepper tree is *Zanthoxylum piperitum* the fruits of which have also a hot taste. Along the Riviera the tree known as *Melia azedarach* or the "pride of India," is also incorrectly called the pepper tree.

PEPSIN is the powerful enzyme, or ferment, in gastric juice that digests proteinous foods such as meat, eggs, or seeds that are introduced into the stomach. Enzymes (*q.v.*), in general, are catalysts that in small quantities speed up biochemical reactions. They are formed by living tissues, and all cells are dependent upon them to speed up the many reactions that otherwise would proceed far too slowly.

Pepsin was first recognized in 1836 by the German physiologist Theodor Schwann. Nearly a century later, in 1930, it was crystallized and its protein nature established by John H. Northrop of the Rockefeller Institute for Medical Research.

The tissues lining the stomach make and store pepsin in an inactive form called pepsinogen, or propepsin. When pepsinogen is

secreted into the stomach and mixed with the acidic gastric juices, it is rapidly converted into pepsin. Pepsin speeds up this conversion, and since it is also a product of the conversion, the reaction once started goes faster and faster; *i.e.*, it is self-accelerating or autocatalytic. The digestive power of pepsin changes with acidity, and, as might be expected, it is fastest at the acidity of normal gastric juice (PH 1.5–2.5).

Proteins, in general, are made up of some 20 different kinds of amino acids linked together. Only the links between certain pairs of amino acids are opened by pepsin. In the digestive tract this leads to only partial degradation of proteins to smaller units called peptides, which are then either absorbed from the intestine into the bloodstream or are broken down further by pancreatic enzymes. The magnitude of the digestive power of pepsin may be indicated by pointing out that one ounce of pure pepsin can coagulate (an early step in the digestion) 200,000 gal. of milk in an hour at body temperature or can digest thousands of times its weight of other proteins in a similar period. Although pepsin is a protein, it is resistant to its own digestive powers.

Like other enzymes and proteins, pepsin is a large, complex molecule. On a weight scale in which an atom of hydrogen is 1 and ordinary table salt (sodium chloride) is 58, pepsin is 35,000.

Pepsin is prepared commercially from swine stomachs, which contain on the average about one gram (one-thirtieth of an ounce) of enzyme per stomach. Crude pepsin is used in the leather industry to remove hair and residual tissue from animal hides prior to their being tanned. It is also used in the recovery of silver from discarded movie films, which it does by digesting the gelatin layer that holds the silver compound. Still another commercial use is in the preparation of peptone (partially digested protein), which is an important ingredient of growth media for bacteria and related microorganisms.

See also DIGESTION: *Proteins;* PROTEINS.

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(R. M. HT.)

PEPUSCH, JOHN CHRISTOPHER (JOHANN CHRISTOPH) (1667–1752), Anglo-German musician, composer, theorist, and teacher, was born in Berlin in 1667 and settled in England about 1700. In 1712 he became music director to the duke of Chandos and not long after was appointed music director at Lincoln's Inn Fields Theatre. Among much other music for the theatre he arranged the tunes and composed the overture for John Gay's *Beggar's Opera* (1728) and its sequel *Polly* (unperformed till 1777). In 1737 he became organist of the Charterhouse and was in some demand as a teacher; William Boyce was among his pupils. He collected a magnificent library of music books and scores and was deeply interested in music of the Renaissance and that of ancient Greece and Rome. He had a strong influence on the early development of musical antiquarianism in England, which led to the publication of such collections as Boyce's *Cathedral Music* and to the performance of old music by societies of enthusiasts. He died in London on July 20, 1752.

With the exception of the overture to *The Beggar's Opera* and some chamber music, little of Pepusch's music is performed in modern times.

See C. W. Hughes, "J. C. Pepusch" in *The Musical Quarterly*, xxxi (1945).
(CS. CH.)

PEPYS, SAMUEL (1633–1703), English man of letters and naval administrator whose celebrated diary gives a valuable, entertaining, and intimate picture of the social life of his day, was born on Feb. 23, 1633, in Salisbury Court near St. Bride's Church, London. He was the son of a working tailor who had come to London from Huntingdonshire, in which county, and in Cambridgeshire, his family had lived for centuries as monastic reeves, rent collectors, farmers, and, more recently, small gentry. His mother, Margaret Kite, was the sister of a Whitechapel butcher. But, though of humble parentage, Pepys rose to be one of the most important men of his day, becoming England's earliest secretary of the Admiralty and serving in his time as member of

BY COURTESY OF THE TRUSTEES OF THE NATIONAL PORTRAIT GALLERY, LONDON

SAMUEL PEPYS AT THE AGE OF 33, FROM A PORTRAIT PAINTED BY JOHN HAYLS IN 1666. IN THE NATIONAL PORTRAIT GALLERY, LONDON

Parliament, president of the Royal Society (in which office he placed his *imprimatur* on the title page of England's greatest scientific work, Sir Isaac Newton's *Principia*), master of Trinity House and of the Clothworkers' Company, and a baron of the Cinque Ports. He was the trusted confidant both of Charles II, from whom he took down in shorthand the account of his escape after the Battle of Worcester, and of James II, whose will he witnessed before the royal flight in 1688. The friends of his old age included Sir Christopher Wren, Sir Isaac Newton, John Evelyn, Sir Godfrey Kneller, John Dryden, and almost every great scholar of the age.

Early Career.—Samuel Pepys (pronounced *Peeps*) was sent, after early schooling at Huntingdon, to St. Paul's School, London. In 1650 he was entered at Trinity Hall, Cambridge, but instead went as a sizar to Magdalene College, obtaining a scholarship on the foundation. In March 1654 he took his B.A. degree and in 1660 that of M.A. Little is known of his university career save that he was once admonished for being "scandalously overseene in drink." In later years he became a great benefactor of his college, to which he left his famous library of books and manuscripts. He was also once offered—but refused—the provostship of King's College, Cambridge.

In December 1655 he married a penniless beauty of 16, Elizabeth Marchant de St. Michel, daughter of a French Huguenot refugee. At this time he was employed as factotum in the Whitehall lodgings of his cousin, Adm. Edward Montagu, later 1st earl of Sandwich, who was high in the Lord Protector Cromwell's favour. In his diary Pepys recalls this humble beginning, when his young wife "used to make coal fires and wash my foul clothes with her own hand for me, poor wretch, in our little room at Lord Sandwich's, for which I ought ever to love and admire her and do." While there, on March 26, 1658, he was cut for the stone (a most perilous operation), thereafter always celebrating the anniversary of his escape by a dinner—"the day of my solemnity for my cutting of the stone."

In 1659 Pepys accompanied Montagu on a voyage to the Sound. About the same time he was appointed to a clerkship of £50 per annum in the office of George Downing, one of the tellers of the exchequer, after whom Downing Street was later named. It was while working in Downing's office and living in a small house in Axe Yard that on Jan. 1, 1660, he began his diary. A few months later he sailed, as his cousin's secretary, with the fleet that brought back Charles II from exile. Appointed, through Montagu's interest at court, clerk of the acts of the navy at a salary of £300 per annum, and given an official residence in the navy office in Seething Lane, he became in the next few years a justice of the peace, a commissioner for, and later, treasurer of, Tangier, and surveyor of naval victualling. When he entered upon his functions, he was ignorant of almost everything that belonged to them. His chief use of his position was to enjoy his newfound importance and the convivial companionship of his colleagues, Admirals Sir William Batten and Sir William Penn. But early in 1662 there came a change. The colleagues whose bacchanalian habits and social position had made them so attractive began to prove irksome, and their insistence on their superior experience and status galled Pepys's pride. In his isolation, he sought for ways by which he could show himself their equal. He had not far to look, for his fellow officers were anything but attentive to business. "So to the office," Pepys wrote, "where I do begin to be exact in my duty there and exacting my privileges and shall continue to do so." He had found his vocation.

Naval Administration.—It was not in Pepys's nature to do things by halves. Having resolved to do his duty, he set out to equip himself for its performance. In the summer of 1662, he occupied his leisure moments by learning the multiplication table, listening to lectures on shipbuilding, and studying the prices of naval stores: "into Thames Street beyond the Bridge, and there enquired among the shops the price of tar and oil, and do find great content in it, and hope to save the King money by this practise." At the same time, he began his habit of making careful entries of all contracts and memoranda in large vellum books—beautifully ruled by Mrs. Pepys and her maids—and of keeping copies of his official letters.

The qualities of industry and devotion to duty which Pepys brought to the service of the Royal Navy became realized during the Second Dutch War of 1665–67—years in which he remained at his post throughout the Plague and saved the navy office in the Fire of London. Before trouble with his eyesight caused him to discontinue his diary in 1669—an event followed by the death of his wife—these qualities had won him the trust of the king and his brother, the duke of York, the lord high admiral. In 1673, in the middle of the Third Dutch War, when York's unpopular conversion to Catholicism forced him to resign his office, Pepys was appointed secretary to the new commission of admiralty and, as such, administrative head of the navy. In order to represent it in Parliament—before whom he had conducted a masterly defense of his office some years before—he became member first for Castle Rising, and, later, for Harwich. For the next six years he was engaged in stamping out the corruption which had paralyzed the activities of the navy. His greatest achievement was carrying through Parliament a program which, by laying down 30 new ships of the line, restored the balance of sea power, upset by the gigantic building programs of France and the Netherlands. In his work both at the Admiralty and in Parliament Pepys's unbending passion for efficiency and honesty (combined with a certain childlike insistence on his own virtue and capacity for being always in the right) made him powerful and bitter enemies. One of these was Lord Shaftesbury, who in 1678 endeavoured to strike at the succession and at the Catholic successor, the duke of York, by implicating Pepys in the mysterious murder of the London magistrate Sir Edmund Berry Godfrey (*q.v.*), the crime on which the full credulity of the populace in the "Popish Plot" depended. When Pepys produced an unanswerable alibi his enemies endeavoured to fasten Godfrey's murder on him indirectly by accusing his confidential clerk, Samuel Atkins. Despite the third-degree methods employed against him, Pepys also proved an alibi for Atkins, who would otherwise almost certainly have perished. Six months later, his enemies brought into England a picturesque scoundrel and blackmailer called John Scott, who had begun his life of crime in what today is Long Island, N.Y., and whom Pepys had endeavoured to have arrested at the time of Godfrey's death on account of his mysterious activities disguised as a Jesuit. Pepys was flung into the Tower on an absurd charge of treason brought against him by Scott and supported by the Exclusionists in Parliament, as also on a minor and equally unjust charge of popery, brought against him by a dismissed butler whom he had caught in bed with his favourite maid. Had not Charles II almost immediately dissolved Parliament and prevented a new one from meeting for a further year and a half, Pepys would have paid the penalty for his loyalty, efficiency, and incorruptibility with his life. He employed his respite with such energy that by the time Parliament met again he had completely blasted the reputation of his accuser by collecting circumstantial details of his infamies from almost every country in the civilized world.

In 1683, when the king felt strong enough to ignore his opponents, Pepys was taken back into the public serivce. He had accompanied the duke of York in the previous year on a voyage to Scotland, and he now sailed as adviser to the earl of Dartmouth to evacuate the English garrison of Tangier—a voyage which he described in a further journal. On his return, in the spring of 1684, he was recalled by Charles II to his old post. Entitled secretary of the affairs of the Admiralty of England and remunerated by a salary of £2,000 per annum, he combined the modern offices of first lord and secretary of the Admiralty, both administering the service and answering for it in Parliament. For the next four and a half years, including the whole of James II's reign, Pepys was one of the greatest men in England, controlling the largest spending department of state. With his habitual courage and industry he set himself to rebuild the naval edifice which the inefficiency and corruption of his enemies had shattered, securing in 1686 the appointment of a special commission "for the Recovery of the Navy." When, at the beginning of 1689, after James II had been driven from the country, Pepys retired, he had created a navy strong enough to maintain a long ascendancy in the world's seas. Hitherto there had been brief spells when the emergence of a naval genius like Sir Francis Drake and Robert Blake had given England a temporary advantage over its maritime neighbours, but for long periods the English "sovereignty of the seas" had been an idle boast. When Pepys became associated with the navy in 1660 the line of battle had consisted of 30 battleships of a total burden of approximately 25,000 tons and carrying 1,730 guns. When he laid down his office he left a battle line of 59 ships of a total burden of 66,000 tons and carrying 4,492 guns. Not only had he doubled the navy's fighting strength; he had given it what it had never possessed before and what it never again lost—a great administrative tradition of order, discipline, and service. He had made the scabbard of the sword which the great 18th-century admirals used.

"To your praises," declared the orator of the University of Oxford, "the whole ocean bears witness; truly, sir, you have encompassed Britain with wooden walls." Pepys's last 14 years, despite attempts by his political adversaries to molest him, were spent in honourable retirement in his riverside house in York Buildings, amassing and arranging the library which he ultimately left to Magdalene College, Cambridge, corresponding with scholars and artists, and collecting material for a history of the navy which he never lived to complete, though he published in 1690 a prelude to it, describing his recent work at the Admiralty, entitled *Memoires of the Royal Navy*. He died on May 26, 1703, at the Clapham home of his former servant and lifelong friend, William Hewer. His fellow diarist, John Evelyn, wrote of him: "He was universally loved, hospitable, generous, learned in many things, skilled in music, a very great cherisher of learned men of whom he had the conversation."

The Diary.—The diary by which Pepys is chiefly known was kept between his 27th and 36th year. Written in Thomas Shelton's system of shorthand or *Tachygraphy* with the names in longhand, it extends to 1,250,000 words, filling six quarto volumes in the Pepys Library. It is far more than an ordinary record of its writer's thoughts and actions; it is a supreme work of art, revealing on every page the capacity for selecting the small as well as the large essential that conveys the sense of life, and it is probably, after the Bible and James Boswell's *Life of Samuel Johnson*, the best bedside book in the English language. Nor was Pepys only an artist: he possessed in a unique degree the quality of complete honesty, so that he excluded from his record nothing which seemed to him vital, however much its inclusion told against himself. He set down not only his major infidelities but those petty weaknesses which men endeavour to conceal even from themselves. In this sense he is both Everyman and the recording angel; his diary paints not only his own infirmities but the frailty of all mankind.

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(A. Br.)

PERAK, a state of the federation of Malaysia (*q.v.*), is the largest of the western Malayan states and a constitutional sultanate. Area 7,980 sq.mi. (20,668 sq.km.). Pop. (1961 est.) 1,384,321. Including a large part of the west coast plains, the state centres upon the Perak River (252 mi. [406 km.]), which runs roughly north to south between the little-used heights forming the central range (over 7,000 ft. [2,135 m.]) to the east and another range paralleling the river to the west. The river turns westward only at Telok Anson and meanders through a silting estuary to the Strait of Malacca. Although the Perak River acted as an artery for the original Malay community and is still symbolized by the sultan's seat beside it at Kuala Kangsar (pop. [1957] 15,302), it is insignificant in the modern economy of the state which is based on the tin mines of the Kinta Valley, particularly around Ipoh (*see* KINTA; IPOH). This area produces half of Malaya's output of tin. In addition, the state has more than 600,000 ac. (242,820 ha.) under rubber (equally distributed between estates and smallholdings), 100,000 ac. (40,470 ha.) under paddy (notably at Krian), large commercial plantations of coconut, and the biggest fish production in Malaya.

Perak's agricultural development dates from the end of the 19th century when tin mining changed focus from Taiping to Ipoh, and the great acreages of rubber and coconut finally surpassed the mines in value and number of people employed. As rubber and tin necessitated immigrant labour and capital, Perak has a complex racial structure, Chinese forming 44% of total population, Malays 40%, and Indians 15%. The state capital, Ipoh (125,770), Taiping (48,206), and the other mining towns are predominantly Chinese, the Malays forming majorities only in the agricultural districts of Krian, Sungei Manik, and Changkat.

About 6,000 sq.mi. (15,540 sq.km.) of Perak are under forest. The jungle-covered ranges are scarcely inhabited and uncrossed by roads, the Tapah-Cameron Highlands Road being the dead end. The state has a mountainous border with Thailand to the north. There is a good network of modern roads supported by the Malayan Railway along the foothills; a branch line runs to Telok Anson (37,000) in the south which handles steamers carrying copra and rubber along the coast. The Taiping Railway to Port Weld, the oldest in Malaya, is a relic now used for transporting firewood and charcoal from the Matang mangrove. Perak is served by the main airport at Penang but has airfields at Taiping and Ipoh for inland services. For historical aspects *see* MALAYA: *History*.

(E. H. G. D.)

PERAVIA, a province in southern Dominican Republic. Area, 626 sq.mi. Pop. (1960) 106,736. It is largely mountainous, being bounded on the north by the Cordillera Central and crossed in the central part by the Sierra de Ocoa (to 5,678 ft.). The southern coastal plain is semiarid. Peravia is a leading coffee producer and a significant producer of rice and peanuts. The province was created in 1944 from parts of Trujillo (San Cristóbal) and Azua provinces; the older name, Trujillo Valdez, was changed to Peravia in 1961. The provincial capital is Baní (pop. [1960] 14,472).

(D. R. D.)

PERCENTAGE, a relative value indicating hundredth parts of any quantity. The word is used in statements that fail to specify the value; *e.g.*, "In Burma a high percentage of the people are Buddhists." When the percentage is specified numerically the term per cent is substituted; *e.g.*, "In Burma about 90 per cent of the people are Buddhists." One per cent (symbolized 1%) is a hundredth part; thus 100% represents the entirety and 200% specifies twice the given quantity. For example, 1% of 1,000 chickens equals $\frac{1}{100}$ of 1,000, or 10 chickens; 20% of the quantity is $\frac{20}{100} \times 1{,}000$, or 200. These relationships may be generalized as

$$x = \frac{PT}{100} \qquad (1)$$

where T is the total reference quantity chosen to indicate 100%, and x is the quantity equivalent to a given percentage P of T. Thus in the example for 1% of 1,000 chickens: T is 1,000, P is 1, and x is found to be 10.

In many commonly occurring percentage problems x and T are known, and the percentage of T that x represents is sought. For such cases it is convenient to use equation (1) in the form

$$P = \frac{100x}{T} \qquad (2)$$

A frequent application of equation (2) is in calculating percentage of profit or loss in business transactions. Suppose a retailer buys a television set at a wholesale price T of $80 and sells it for $110 at a profit x of $30. From the equation his percentage profit is $\frac{100 \times 30}{80}$, or 37.5%. Similarly, a London bookseller may put a novel on sale, lowering the price T of 20*s.* to 17; a reduction x of 3*s.*, or 15%. (*See* also CAPITAL AND INTEREST: *Interest: Rate of Interest.*)

In statistics the notion of cumulative percentage (percentile, centile) is in common use. For example, a student who scores at the 83rd centile on a history examination has exceeded the performance of 83% of the students with whom he is being compared. Related quartile and decile systems are discussed under STATISTICS: *Averages and Dispersion.* The probability that a given event will occur may be expressed as a percentage (or its equivalent decimal value or fraction). A perfectly balanced coin will tend to fall head-side-up once in every two tosses; this probability may be given with equal accuracy as $\frac{1}{2}$, .50, or 50% (*see* PROBABILITY, MATHEMATICAL).

(C. Ce.)

PERCEPTION is the process by which a living organism becomes aware of stimuli. Though the term has become well established through traditional usage, some modern psychologists prefer to use the word perceiving to emphasize that a process or activity is involved. In 1765 the Scottish philosopher Thomas Reid distinguished between sensation (*q.v.*) and perception, applying the term sensation to the immediate data that come directly from stimulation and the term perception to the larger awareness that includes the reference of these sensations to the stimulus. This distinction held until the third decade of the 20th century when, under the influence of Gestalt psychology (*see* GESTALT PSYCHOLOGY), the concept of sensation tended to drop out of use and psychologists began to direct their attention to the larger systems of sensory stimulation, which, since objective reference is implicit in them, properly involve perceiving.

These definitions of sensation and perception, as well as the material that follows, are based on the commonplace assumption that there really are physical entities to be perceived. However, it should be noted that there are profound disagreements among philosophers concerning the very existence of physical reality; these are more fully discussed under IDEALISM and KNOWLEDGE, THEORY OF.

THEORIES OF PERCEPTION

A theory of perception undertakes to explain how the organism becomes aware of itself and of the external world. If an organism is to survive and succeed, it must have adequate information about its environment; and there have been several answers to the question of how is it possible for organisms to perceive correctly.

Discrimination.—A laboratory animal or person must react

discriminatively to objects or situations if others are to have evidence that the subject is perceiving. It is much easier to be assured of the occurrence of adequate discrimination than to know whether the process is consciously or unconsciously mediated. Unfortunately, the inner experiences of another organism cannot be directly observed; however, its manifest reactions can.

A rat can learn always to choose between two disks of equal size if the brighter disk consistently marks the door to a food box. The rat thus detects a difference in brightness. In a sense the animal may be said to be aware of the disks, but actually that question does not have to be raised; clearly, it defies an empirical answer. A man engrossed in conversation with his dinner companions finds that the little pile of nuts by his plate has disappeared and that he even has a nut in his mouth. Another man across the table saw him actually eat the nuts. He discriminated the nuts from other inedible objects which he did not try to ingest. Most psychologists would say that such well-habituated discrimination is unconscious, although an exact answer to that question depends on the definition of consciousness.

This general rule holds: efforts to study how other organisms perceive must be defined in terms of how they discriminate among stimuli.

Representation in Kind.—The Greeks believed that objects emit faint copies of themselves, copies which are transmitted by the senses to the sensorium which becomes aware of the object by perceiving its copy. While this view was too naïve to survive in the age of science, the basic idea recurs again and again in psychological theory. For instance, John Locke in 1690 distinguished between primary and secondary qualities of perceived objects. Primary qualities are those for which the experience resembles its object, like spatial extension. Secondary qualities are those for which the experience does not resemble its object, like colour. In modern terms for secondary qualities there is a functional dependence between experience and stimulus without representation in kind: experienced redness of external objects depends upon light of long wavelengths, but there is nothing long or undulatory about the experience red itself (*see* VISION).

About 1920 the Gestalt psychologists proposed psychophysiological isomorphism as a theory of perception. In respect to spatial relations this theory holds that there is a point-to-point correspondence between the experience and the underlying brain pattern, a correspondence such that all the spatial orders of one system are preserved in the other, although shapes and magnitudes may not be preserved. In other words, the correspondence between the brain pattern and the experienced pattern is viewed as topological, but not necessarily topographical. The chief evidence for this view comes from the physiological discovery that excitation of the visual area of the brain corresponds topologically, point for point, to the excitatory pattern on the retinas (*see* TOPOLOGY, GENERAL).

Thus there are four patterns, all held topologically isomorphic with one another: (1) the projected stimulus pattern of light; (2) the pattern of excitation on the retinas; (3) the neurally projected pattern on the visual areas of the brain; and (4) the pattern as experienced. In this way, for the visual perception of bidimensional spatial patterns, the simple theory of perceptual representation of the object in kind, a modern theory of primary qualities, is preserved.

The Gestalt psychologists carried isomorphism further. They believe that the principle holds for perceiving tridimensional visual space, that visual awareness of depth and solidity corresponds to a tridimensional field of excitation in the brain. They also hold that experiences of intensity, time, and movement are isomorphic. In certain cases this theory requires that the characteristics of the stimulus object (which are represented functionally but not in kind in the initial phases of excitation) must be reconstituted in the brain fields that mediate the experience. For instance, depth is represented on the retinas, not in kind but by disparity between the two retinal images. Isomorphism requires that this disparity operate in the action of the nervous system to reconstitute a solid excitatory field in the visual areas of the brain. The evidence was not yet conclusive in the 1960s as to how or even whether this reconstitution of the stimulus field actually occurs in the brain.

Functional Representation.—It is quite clear that not all perceptual qualities are primary; some are secondary. Not all perceptual representation is in kind; some of it is a correspondence between dissimilars, a correspondence that is adequate because it is functionally specific. The longest visible wavelengths of light always look red if they fall, uncombined with other wavelengths, upon the retina of a man who is not colour-blind. That is a functional correspondence of dissimilars, the case where isomorphism in perception is certainly not the correct principle.

This view is fully as old as Johannes Peter Müller's (*q.v.*) theory of specific nerve energies, first formulated in 1826 as a protest against the ancient doctrine that perceptual representation is always in kind. Müller argued for the existence of five specific nerve energies or qualities, one for each of the five classical senses. The sensorium perceives, he said, not the properties of the objects themselves but the properties of the nerves that the objects affect. Thus light and the experience of seeing are quite different. The reason that a person knows there is light when he sees is that there is, according to Müller, a "specific irritability" of the retina which makes it most easily excited by light. C. S. Sherrington later (1906) used the term "adequate stimulus" to designate this specificity of relation between a sense organ and its normal stimulus. A misleading experience occurs when an unusual stimulus is effective, in spite of its inefficiency, as when pressure on the eyeball arouses the experience of coloured patterns.

It would seem that all perceptual activities must imply functional representation of the perceived characteristics of the stimulus, both in the brain and in the experience. Sometimes, but not always, this representation is in kind; *i.e.*, isomorphic. Presumably there is a topological representation of the stimulus characteristics in perceiving temporal duration, stimulus intensity, visual and tactual spatial patterns in two dimensions, and visual, tactual, and auditory movement.

Perceptual Context.—Thus far only the sensory core of perceiving, a core which in familiar perceptions is adequate by itself for the identification of the stimulus object, has been considered. Often, however, the core alone is insufficient to constitute the complete perception that the organism seeks. A context must be added to the core if identification of the perceived object is to be satisfactory. I smell a rose. What have I perceived? An odour. But if, by association, there is added to the odour a visual image of a rose, then this visual context, accruing to the olfactory core, provides greater specificity of meaning and further completes the perception. I see a face. It is strange. Then a name comes to mind, and, because of that added context, I have recognized the face.

This context theory of perception is basically an associative theory of perceptual meaning. It was first elaborated by George Berkeley in 1709, then developed by the associationists (Thomas Brown in 1820, James Mill in 1829, Wilhelm Wundt in 1874), and finally made the basis for Wundt's "mental chemistry" in which meaning is always explained by compounding, by the association of two or more conscious items (*see* ASSOCIATION, MENTAL). The associations that form these identifying contexts are often learned, but they may be inherited reflexes. For instance, a human infant instinctively gives the startle reflex when stimulated suddenly by a loud sound. That reflex is not learned, yet it constitutes the context which makes the sound perceived as "something to be startled by." Similarly a protozoan that turns away from the light may be imagined to perceive the light as something to be avoided. The light is the core; the turning, the context.

The context theory of perception was named by E. B. Titchener in 1909. His chief contribution was to note that contexts may be conscious or unconscious, that novel perceptions generally require conscious contexts for their specification, but that the conscious context tends to drop off as the perception becomes familiar, leaving the meaning to be carried unconsciously and evidenced by the adequate discriminatory behaviour of the organism. When a person first sees the word "argali" the perception is inadequate. He does not know what the word means. When he has been told that

an argali is a kind of wild sheep or has been shown a picture of one, then for a while the verbal core will arouse an identifying context: the word sheep or the visual image of an argali. When the word has become familiar, this awareness of context drops off. He can now comprehend the meaning of argali without concentrating on the context, as is evidenced by the fact that later on he can demonstrate his understanding of a text which contains the word. New words need contexts, but in most reading there is no time for the perceptual contexts to accrue. Thus the context theory recalls that evidence of perceiving is found in discrimination.

The foregoing theories of perception are supplementary and not mutually exclusive. In perceiving, the perceived characteristics must have functional representation in the brain. Sometimes this representation is isomorphic, and there is further evidence that in some cases physiological mechanisms reestablish a topological correspondence between the stimulus field and the brain field, even when such correspondence has been lost in the initial phases of excitation.

TYPES OF PERCEPTION

This discussion of theories of perception indicates that perceiving may be consciously or unconsciously mediated, that the functional adequacy of perceiving normally enables the organism to obtain correct information about its environment and that a perception, especially a novel one, normally receives further specification by the addition to its sensory core of a context, either a learned association or an innate reflex. It is now proper to discuss further the reconstitution of objects in perception, the perception of relations, and unconscious discrimination.

Perceptual Reconstitution.—Stereoscopic vision furnishes one of the best examples of how the characteristics of the stimulating object are reconstituted in perception (*see* BINOCULAR INSTRUMENT: *Stereoscopes*). A solid object, viewed with both eyes, produces somewhat disparate images on the two retinas. Since both images are seen in a single perceptual field, one might expect to see this disparity as a double image. Instead, one perceives a solid object in three dimensions, with no doubling, in spite of the fact that the two retinal images would not coincide in superposition.

The fact that one sees objects single in binocular vision thus is also an instance of this principle of reconstitution. In this case a little is known about the physiological basis for the perception: corresponding points on the two retinas are projected to the same region of the brain.

Gestalt psychologists have made a great deal of what has been called the constancy phenomenon; that is to say, the tendency to see objects as constant in size, shape, brightness, and hue, even when the immediate stimulation from them varies greatly. For instance, a receding object does not lose apparent size nearly so rapidly as its retinal image diminishes. Experiments have shown that in free binocular vision an illuminated disk in the dark may not appear to diminish in size at all as the disk recedes from a distance of 20 ft. to a distance of 200 ft., although the retinal image under those conditions shrinks to $\frac{1}{10}$ of its initial linear size. Such perceived constancy depends, however, on the availability to the organism of clues to the distance, so that the perceiving mechanism can, as it were, correct the perception for the distance. When the clues to distance are reduced by eliminating the use of one eye and all reference-objects from the intervening space, then the perceived size is found to diminish with the size of the retinal image.

It is obvious that perceptual constancy can be of great advantage to the organism in its struggle for survival and success. Experiments show that chickens, trained to choose the larger grains of corn and to let the smaller lie, will choose remote large grains which have small retinal images, in preference to near small grains which have larger retinal images. They tend to choose larger objects rather than responding directly to the size of the retinal image.

The shape of objects also tends to be perceptually reconstituted when oblique viewing changes the shape of the retinal image. As the perceiver shifts from direct to oblique regard, a circle continues to look like a circle, even though its retinal images may have become narrow ellipses.

The apparent brightness of an object likewise tends to remain constant in spite of varying illumination. Coal, recognized as coal, looks black even in bright sunlight. Snow, perceived as snow, looks white even in shadow. Actually the snow in shadow may be darker than the coal in sunlight. If both objects are viewed through tubes, which obscure the clues to their nature as objects and reveal only small circular patches of the two surfaces, then the illuminated coal will appear much brighter than the shaded snow.

Discrete displacement of the retinal image will, with the right speeds and spacings, give rise to the visual experience of continuous movement. The motion picture makes use of this principle of apparent movement (*see* VISION: *Space Perception: Visual Perception of Movement*). Actually the interpretation of the discrete displacement as continuous movement is often a reconstitution of an original stimulus. A moving object is seen clearly only when the eyes move with the object, allowing the image momentarily to remain stationary on the retina. Thus discrete retinal displacement is the rule in perceiving continuous movement, and the perception of continuity of movement is really a reconstitution of the original continuity.

Auditory localization also illustrates how the stimulus situation is reconstituted in perceiving. A sound that originates in the median plane between the two ears affects both ears equally and is heard not as a double sound, one on the right and another on the left, but as a single sound localized correctly in the median plane. A sound from the right, however, coming earlier and louder to the right ear is localized at the right. Thus, in general, any sound that comes to both ears but is either earlier or louder at one ear will be localized as coming from the side of that ear (*see* HEARING: *Localization of Sounds*).

The general rule is that perception, insofar as it is adequate, tends to reconstitute the characteristics of the stimulus object. Many of these principles were worked out in Gestalt psychology although such basic facts as singleness of vision with two eyes have been recognized since antiquity.

Perception of Relations.—For the most part perception is relativistic rather than absolute. An object has no perceived size except as it is compared with another object. Precise judgments of tonal pitch, of visual brightness, and even of hue are possible only by reference to some standard. Accurate perception is always the perception of a relation.

It is well known that the perception of pitch is relative and that a melody or harmony depends on the relations among the musical notes and not on their absolute pitches. In the same way the visual perception of brightness is relative. If a man or other animal learns to choose the brighter of two grays, he will take a given gray when it is combined with a darker one and reject it when it is combined with a lighter one. Human adults, children, apes, dogs, rats, and bees all react in this relativistic manner.

The visual perceptions of up and down, of right and left, are relative. It has been known since Johannes Kepler (1604) that the optical image of the external world is inverted, up for down and right for left, in its projection on the retina of the eye, and the question used to be raised as to why we see right side up when the retinal image is upside down. Actually the image itself, being relative, is not distorted, for in it up is the opposite of down and right the opposite of left, whichever way the image is turned. It is, however, to this inverted image that the appropriate behaviour becomes attached by association, so that one reaches down to touch an object that is projected upon the top of the retina. Sometimes an experimental subject wears for a week a system of lenses that reverses this already inverted retinal image; then, since the image is now right side up, the world at first looks upside down. Presently, however, as the associations with behaviour become reversed, the inverted image seems to turn right side up again. When the lenses are removed the associations must again be reversed by experience.

Unconscious Discrimination.—Whether a discrimination is

to be regarded as conscious or unconscious depends almost entirely upon the definition of consciousness (*q.v.*). It is usual, however, to regard an accurate discrimination as unconscious when it leaves no memory trace of its occurrence, when the perceiver cannot say minutes or even seconds afterward whether he perceived or what he perceived. Familiar, well-habituated discriminations fall in this class, as do all rapid discriminations. A man can perceive a familiar designated object quickly when it lies on a table with 99 other strange objects, and he can pick out the designated object again and again from different sets of strange objects, quickly and accurately. He must indeed "see" the other objects in order to reject them and continue his rapid search for the specified object, but he cannot afterward tell much about these other objects. This hurried negative discrimination of wrong objects, discriminated in order to reject them, is practically unconscious—for they do not stick in memory.

There have been experiments in which a discrimination has been determined or aided by clues of which the discriminator declares he was fully unaware. In the same way judgments can be passed without the judge being aware of the motives and prejudices that influence his thought.

There is also the case of contradictory perception which occurs with hypnotism. (*See* HYPNOSIS.) For example, the hypnotist may suggest to the hypnotic subject that they two are alone in the room, although actually there is a third person present. The subject then becomes "blind" to the third person and acts consistently as if he were not there. Nevertheless, the subject never collides with the third person, never tries to sit where the third person is sitting. If the hypnotist suggests that the subject take the chair occupied by the "invisible" person, the subject will find excuses and reasons for not doing what is, in fact, impossible for him to do. In this case it appears that the subject "sees" the man to whom he is blind so that he may know not to "perceive" him.

Social Perception.—This term, which came into vogue in the late 1940s, is used to designate either: (1) such perceptions of social phenomena as the perception of anger or danger; or (2) those perceptions that are understood by reference to their social determinants.

The first class of social perceptions presents no new problems or principles. It consists of perceptions of social meanings in which the determinants and even the sensory cores may be unreportable by the perceiver and in that sense are unconscious. Thus a man may perceive anger in another man without knowing what bits of behaviour or facial expressions form the basis for his perception. Nor is this case different from the perception of the constant apparent size of a receding object when the observer does not know that he is unconsciously taking perceived distance into account.

Of the other class of social perceptions it has been said that the perceived pattern of the external world always mirrors the pattern of the needs of the perceiver. There are many well-known subjective determinants of perception, and by no means do they all operate to create illusion, for true knowledge of the apparently real world is one of the fundamental needs of the organism. Perceptual mechanisms tend to reconstitute the perception in such a manner as to increase the accuracy with which perception represents external objects and other events. Stereoscopic perception of depth, the object constancies, and the perception of continuous movement with cinematic discontinuity are all cases in point.

Organisms have, however, many other needs besides knowledge of the truth. Illusion may be created by the projection of wishes into perception. "If she be not fair to me, what care I how fair she be." The Thematic Apperception Test (*see* PSYCHOLOGICAL TESTS AND MEASUREMENTS: *Tests of Personality and Temperament*) samples the needs of a subject or patient by having him describe what he sees in a series of pictures that can be given many interpretations. Sometimes children see desired objects as larger than undesired ones when all objects are of the same size; this tendency to subjective distortion has been measured in experiments that provide a set of neutral comparison objects.

Social determinants operate like any of the other determinants of perception. They may work, for instance, in a defensive manner, as when a person, given sufficient time to perceive a rapidly exposed word, nevertheless fails to perceive it because it is an unwelcome-word, one that embarrasses or shames him. Perceptual defense, as it is called, is an escape mechanism by which the organism avoids, either completely or partially, an intolerable experience. This case belongs with the contradictory perceptions of the hypnotic state, for presumably the respondent must first have "seen" the word in order to be able to exclude it from his immediate memory.

See HALLUCINATION; ILLUSION; PARAPSYCHOLOGY; PSYCHOLOGY; PSYCHOLOGY, HISTORY OF; *see* also references under "Perception" in the Index.

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(E. G. BOR.)

PERCEVAL, an important hero in Arthurian romance and Grail winner in the oldest extant account of the Quest for the Holy Grail, *Le Conte del Graal* or *Roman de Perceval*, written between 1179 and 1191 by Chrétien de Troyes (*q.v.*). He is not mentioned as one of Arthur's knights in Geoffrey of Monmouth's *Historia regum Britanniae*, or in Wace's poetic version of it, although the name Peredur, which in medieval Welsh literature is equated with Perceval, is mentioned in an early Welsh poem *Y Gododdin* (*see* WELSH LITERATURE).

Perceval first appears as one of Arthur's knights in a list of names at the beginning of *Erec*, the 12th-century romance by Chrétien de Troyes, and he is promoted to the rank of hero in Chrétien's last romance, *Le Conte del Graal*. Here his chief characteristic is an uncouth innocence, a variant of the "Great Fool" theme, and this remains his dominant characteristic in Arthurian romance. In Chrétien's poem, Perceval's father and brothers having been killed in pursuit of chivalry, he is brought up by his mother in isolation from the world and in complete ignorance of knighthood. He meets some knights by chance, plies them with naïve questions and then determines to become a knight. His ignorance is shown by his strange behaviour during his journey and on his arrival at Arthur's court, but a great destiny is prophesied for him by a damsel and a court fool. He visits the Grail Castle where he is received by the Fisher King who has been maimed by a spear thrust through his thighs. There Perceval sees a strange procession of a squire bearing a lance, two squires carrying ten-branched candlesticks, a damsel holding a *graal* which gives forth great light, and another damsel with a silver platter, but he fails to ask the question which would have healed the Fisher King and restored the Waste Land. It is only after leaving the Grail Castle that he learns of the disastrous consequences of his silence, first from a damsel, his cousin, and then from a hideous damsel. He sets out to find the Grail, and in the rest of the romance this quest for the mysterious vessel is associated with Perceval's education in chivalry. He has a lady, Blancheflor, but unlike Lancelot (*q.v.*) his chivalry is not inspired by human love but is given a more spiritual motivation. As he seeks for the Grail, so he gradually learns the true meaning of chivalry and its close connection with the teachings of the Church. Chrétien never finished the romance, although a number of continuations were

written, but it seems likely that had he done so, Perceval would have returned to the Grail Castle and broken the spell by asking the question about the Grail.

Three other works appear to be based on Chrétien's poem, although there is some uncertainty as to their exact relationship with it. These are the *Parzival* of Wolfram von Eschenbach (*q.v.*), the Welsh *Peredur* in the *Mabinogion* (*q.v.*), and the 14th-century Middle English rhymed romance, *Sir Perceval of Galles*. Perceval's character remains fairly consistent throughout Arthurian romance, although his position in the hierarchy of Grail winners changes. He is still the principal hero of two other French Grail romances, both of the 13th century, the *Didot Perceval* and the *Perlesvaus*, a long and complicated romance which relates the adventures of Gawain, Lancelot, and Perceval (Perlesvaus) in the Quest for the Grail. However, in *La Queste del Saint Graal* of the Vulgate cycle, the version which was to be the most widely read and to have the greatest influence on later works such as the prose *Tristan* (*see* TRISTAN) and Sir Thomas Malory's *Morte Darthur*, Perceval is only one of three knights (the others being Galahad and Bohort) to achieve the Quest and is superseded by Galahad as chief Grail winner and as the knight entitled to the "Siege Perilous," the seat at the Round Table reserved for the knight successful in the Grail Quest. Perceval seems to have been displaced by Galahad for two reasons. First, to link the Grail Quest closely to the story of Lancelot, and to give it its true significance, the Grail winner in the *Lancelot* prose cycle is made Lancelot's own son Galahad; second, the Grail theme itself has here been given a more austerely theological significance which demands a new Grail winner without Perceval's past, one whose genealogy could be traced back to David and whose very name Galahad has been linked with the biblical place name, "Gilead," one of the mystic appellations of Christ. Perceval, however, both in the Vulgate-cycle Quest and in Malory still plays an important part. He preserves that quality of childlike innocence, already to be found in Chrétien's Perceval, and it is this which protects him from temptation and sets him apart from the other knights. Unlike Galahad he is not allowed to look into the Grail, but he sees in visions many of its mysteries and never returns to ordinary earthly life.

Perceval figures as the hero of Wagner's last opera, *Parsifal* (1882), in which, after various adventures, he heals the wounded Grail Guardian with the sacred spear and restores the service of the Grail to its former glory.

See also ARTHURIAN LEGEND; GRAIL, THE HOLY; GAWAIN.

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PERCEVAL, SPENCER (1762–1812), English statesman and prime minister from 1809 until his assassination in 1812, was born in London on Nov. 1, 1762. He was the second son of the 2nd earl of Egmont. Educated at Harrow and at Trinity College, Cambridge, he was called to the bar by Lincoln's Inn in 1786 and became a king's counsel in 1796. In the same year he entered Parliament as member for Northampton and supported the administration of Pitt. In 1801, on the formation of the Addington government, he was appointed solicitor general, and from 1802 till Pitt's death in 1806 he was attorney general. When the king dismissed the Grenville ministry in March 1807, Perceval, an ardent opponent of Catholic emancipation, became chancellor of the exchequer and chancellor of the duchy of Lancaster under the duke of Portland, whom in 1809 he succeeded in the premiership. On May 11, 1812, Perceval was shot dead in the lobby of the House of Commons by a madman named John Bellingham, a bankrupt with a grievance against the government who had vainly applied to the prime minister for redress. Bellingham, though insane, was hanged on May 18.

See D. Gray, *Spencer Perceval* (1963). (A. AL.)

PERCH, either of two closely related, edible, freshwater bony fishes: the common perch (*Perca fluviatilis*), generally distributed over northern Eurasia, and the yellow perch (*P. flavescens*), found in eastern North America. Together with the pike perches and darters they comprise the Percidae, a family of typical spiny-rayed fishes. Perches inhabit rivers and lakes but thrive best in waters with a depth of more than three feet; in large lakes they frequently descend to 300 ft. or more. The European form occurs in Scandinavia as far north as the 60th parallel; but the northern limit of the American species is about the 55th parallel. The species exhibit many variations in shape, some specimens being high-backed, others low and long-bodied. A rich greenish brown, with golden reflections, covers the back and sides, which are ornamented with five or seven dark crossbands. A large black blotch occupies the membrane between the last two spines of the dorsal fin; the pelvic, anal, and lower parts of the caudal fins are bright vermilion.

L. M. CHACE FROM THE NATIONAL AUDUBON SOCIETY

YELLOW PERCH (PERCA FLAVESCENS)

Perches are carnivorous and voracious. They are highly esteemed as food in inland regions. Exceedingly prolific, perch begin to spawn when three years old, depositing, in April or in the first half of May, the 10,000 to 40,000 eggs, which are extruded in long, netlike narrow bands on water plants. Perch often become so numerous and crowded that none has enough food and all remain small; they are then undesirable for food.

Many spiny-rayed fishes belonging to a variety of closely related families are called perch, as surf perch (Embiotocidae) and some sea bass (Serranidae); distantly related families of the order Percopsiformes are also called perch, as trout perch and pirate perch. *See* FISH; *see* also references under "Perch" in the Index.

(C. HU.)

PERCHE, a district of northern France, on the borders of Normandy, lies mainly in the east of the *département* of Orne, with extensions into the adjacent *départements* of Eure, Eure-et-Loir, and Sarthe. Perche consists of hilly country, with summits between 700 and 1,000 ft. (213 m. and 304 m.), enclosing the upper basin of the Huisne tributary of the Sarthe and forming the watershed between it and eastward drainage to the Eure and Loir. It is a district of pastoral farming, chiefly concerned with breeding cattle and dairying and especially famous for its breed of draft horses (Percheron). It lies north of the limit of viticulture, but cider-apple orchards are a ubiquitous feature of its hamlets and scattered farmsteads. Mortagne and Nogent-le-Rotrou are the chief market towns and in the Middle Ages were at different times capitals of the County of Perche. (AR. E. S.)

PERCHTA: *see* BERCHTA.

PERCUSSION INSTRUMENTS, the name given to those musical instruments from which sound is produced principally by striking. They are divided into two main classes which sometimes overlap: idiophones, in which sound is produced by striking or clashing together hard substances—wood, metal, etc.—and membranophones, in which sound is produced by vibrating a stretched skin. There are separate articles on all the main percussion instruments or classes of instruments in use in the modern orchestra or dance band; this article traces the development of early instruments, and also describes some unusual and interesting examples of instruments of this type used in folk music or in ancient civilizations. (*See* also ORIENTAL MUSIC; CHINESE MUSIC; JAPANESE MUSIC; INDIAN MUSIC; AFRICAN MUSIC.)

The first stage in the making of music and the development of musical instruments began when primitive man stamped on the ground or slapped his own body to produce rhythmic sound. The sounds produced varied in tone according to whether the heels or toes were used in stamping or whether bony or fleshy parts of the body were struck in slapping. With this preinstrumental music is associated the stamped pit, a hole dug in the ground and covered at the top or midway down with a lid of bark. The earliest known prehistoric instrument, found always associated with the stamped pit in Paleolithic excavations, is the slung rattle, which

BY COURTESY OF (LEFT) THE CINCINNATI ART MUSEUM; (RIGHT) JAMES BLADES

EARLY CHINESE PERCUSSION INSTRUMENTS: (LEFT) BARREL DRUM, NAILED HEAD; (RIGHT) WOODEN FISH (TEMPLE BLOCKS), ONE SHOWING CARVED HANDLE, THE OTHER SHOWING "MOUTH" SLIT IN BOTTOM

was shaken or hung from the ankle, arm or neck of the dancer. It consisted of several shaking pieces: nutshells, seeds, hooves, teeth or similar hard objects. The gourd rattle (a gourd containing such hard objects) became an important instrument in ritual and to mark time for dancing. Like other primitive instruments it was believed to possess magical power. As a nursery toy, its modern equivalent soothes and amuses children. Under the name maraca (*see* below) it is an important instrument in the modern Latin-American dance orchestra.

Primitive Drums.—Next in chronological order are the slit drum and the membrane drum found in Neolithic excavations. In its earliest form the slit drum was a hollowed tree trunk, the fashioning of the cavity giving the drum two distinct tones, one on each side of the opening. The original instrument was stamped upon, rammed with long sticks or struck with cudgels, the tone produced being of considerable resonance and carrying power. Existing specimens measure up to 20 ft. in length and 7 ft. in width. The size of the instrument diminished as it developed. In the modern orchestra, the slit drum is found in the form of the Chinese wood block, a small percussion instrument with a clear, penetrating tone.

The drum became indispensable in primitive life. Credited with powers of magic and having numerous other functions, it was held to be the most sacred of instruments, and was therefore developed in several forms. The early membrane drum, which was struck with the bare hands, consisted of a section of hollowed tree trunk covered at one end with reptile or fish skin. Later, the end was covered with the skin of hunted game or of cattle, and sticks were used for striking the drum, which was played in an upright or slanting position, according to its length. The double-headed drum came later, and, with the advent of pottery, the clay drum, an earthenware vessel taking many shapes—goblets, cups, etc. Various methods were used for fastening the skins, some of which are still in use. The skin might be secured to the single-headed drum with pegs, nails, glue, buttoning or neck lacing with cord, while the skins of the double-headed drum were directly cord-braced (*i.e.*, laced through the holes of the skin).

Each of the early civilizations furnishes evidence of the development of the drum. A vase from Adab (*c.* 3000 B.C.) and other objects found in Mesopotamia at this period illustrate the shallow or frame drum and small cylindrical drums being played in horizontal and vertical positions. A drum (nailed head) as tall as the two players is depicted on a Sumerian vase of the same period. Early Egyptian artifacts show a drum with the skins stretched by a network of thongs, and provide evidence of the use of clappers and concussion sticks. Struck together, the latter were used to scare birds, as a musical instrument to accompany ritual dances and to provide rhythm for work in the fields and at the stamped wine press. An ancient tomb of the Egyptian kings in the catacombs of Eleithya, near Thebes, depicts a group of performing women, one of whom holds a curved concussion stick in each hand.

The origin of the hourglass drum is obscure. A waisted drum, narrower in the middle than at the ends and little longer than it is wide, is seen on one of the Bharatat reliefs, the oldest Indian temple reliefs (2nd century B.C.). The instrument is suspended from an ape's shoulders, and is being played with two sticks by the animal. The Indian clapper drum (*damaru*), a small drum which is similar in shape to the hourglass, has one or two cords fixed in such a manner that they strike the skins when the instrument is moved to and fro. An hourglass drum with movable pitch (*kalengo*) is still used in Nigeria. Leather thongs stretch from end to end, connecting the two membranes. The drum is held in the hand or under the arm, the player squeezing the cords or releasing the pressure to alter the pitch. The *kalengo* is played with the hands or a curved flat-ended stick. It is used by the Yoruba for their *Sakara* dances and signaling. Skilled players are able to make the drum follow their own tonal language and to interpret it. The manufacture of an important drum involves considerable ceremony, and its use is observed with time-honoured customs. In east Africa, the drum is considered holy and the drumyard a place of refuge. The coronation drums are struck with sticks made of human tibias, and offerings such as cattle are made to the royal instruments. Complex rhythms characterize the playing of African drums.

The barrel and shallow nail drum are associated with India and the far east. The wooden frame of the shallow Chinese drum is lacquered red, as a symbol of happiness, and the skins emblematically adorned with the dragon and phoenix. The drum is normally suspended on a stand, the player striking the centre with leather-knobbed sticks, named male and female. A spring is fixed inside certain types of shallow drums of Chinese origin. The spring strikes the inner side of the skins when the outer surfaces are struck. Giant drums were used in Asia in war. The drums and players (who were madmen recruited from prisons) were secured to wagons drawn by oxen, and placed at the head of battle formation. The frenzied performers pounded their instruments unceasingly with heavy clubs and whips. The strength of the noise from the opposing sides often proved a decisive factor in the conflict. The giant drum of the Chinese called *Hiuen-Kou* is said to have been invented for use in the imperial palace in 1122 B.C. This instrument was a barrel drum with nailed heads, upward of four inches in diameter and depth. It oscillated on a specially prepared stand and had a smaller drum on each side.

The wooden fish (China and Japan) is a form of slit drum expertly carved to resemble a mythical fish. The instrument is hollowed out through a ventral slit representing the creature's open mouth, lacquered red and gold and is struck with a heavy painted stick similarly coloured. It is beaten to attract the attention of the divinity, and is tolled in slow tempo by mourners at a funeral service. In modern times the wooden fish is found in many sizes in western orchestras under the name of temple block. It often replaces the coconut shells used to imitate the sound of

horses' hooves, and it adds humour to numerous situations on film and radio such as the sound of a popping champagne cork.

The *tablā* player, who is a prominent musician in Indian chamber music, performs on two drums, the *bayan* and *daina*. The *bayan* is a small kettledrum (metal shell) with skin stretched by means of leather thongs. The *daina* has the shape of a truncated cone, is made of wood and is painted in multicoloured stripes. The skin is stretched by leather thongs which are tightened by movable wooden dowels. Circular patches of a substance resembling hard rubber are affixed to the vellum of each drum. The skins are struck with the hand, finger tips, or side of the thumb and vibrated by friction, the ingenious rhythms being enhanced by the different tones obtained from various parts of the vellums. A skilled *tablā* player ranks as a virtuoso. Nakers is the name given in medieval times to small hand-drums with bowl-shaped bodies made of metal —precursors of the orchestral timpani. *Naqqāra* is the Arabic name for similar instruments, which came to Europe as the result of the Crusades. Nakers are often mentioned in medieval literature, and depicted in the Louterell Psalter of the early 14th century, where a pair is seen suspended in front of the player by a strap round the waist, a stick being held in each hand. In Holbein's wood engraving "Dance of Death" Death is seen beating a drum with a thighbone. The instrument is similar in appearance to and positioned like the medieval naker.

Bongoes are small Cuban drums, bucket-shaped wooden vessels with strong vellum heads which are struck with the fingers and thumb. They form part of the Latin-American orchestra and modern dance bands and consist of a pair of drums of different size and pitch, normally tuned a fifth apart. The instruments are fixed together, and held between the knees or affixed to a stand. Timbales, the French name for kettledrums, is a term loosely applied to instruments in the form of large bongoes in the Latin-American orchestra. They are a pair of drums mounted on a stand and played with sticks. Often the player also performs on a cowbell or paila; the latter was originally an upturned bucket but was later made in the form of a metal plate. (*See* DRUM; MUSIC, PRIMITIVE; MUSIC IN ANCIENT CIVILIZATIONS.)

Percussion Groups.—Marrow bones and cleavers is the name given to the traditional music of the butchers of England and Scotland, for which the meat vendors of the old Clare market, London, were long famous. The players produced a musical effect from their implements by a skilful manipulation of their knives (cleavers), and an assortment of marrow bones. A complete octave, rendering the effect of a peal of bells, was produced from the cleavers, and rhythmic features were provided by striking the bones and also drums. Important weddings brought these players considerable remuneration both for their attendance and their abstention. On being informed that the "orchestra" intended to serenade the couple, the father of the bride would seldom refuse the gratuity in advance to escape the infliction. The marrow bones and cleavers can be observed in use in plate VI of Holbein's series "The Wedding of the Industrious Apprentice to His Master's Daughter" (1538). An early use of percussion instruments in domestic music making is seen in Bottom's remark in *A Midsummer Night's Dream* ". . . I have a reasonable good ear in music. Let's have the tongs and the bones." A domestic instrument associated with the marrow bones and cleavers was the saltbox. It was beaten with a rolling pin in such a manner as to produce varying sounds, and was used to provide a rhythmic accompaniment to an instrumental ensemble. The verse in Bonnell Thornton's burlesque "Ode to St. Cecilia's Day" (1763), which so amused Dr. Johnson, describes the method of performance.

> In strains more exalted the salt-box shall join,
> And clattering and battering and clapping combine;
> With a rap and a tap while the hollow side sounds,
> Up and down leaps the flap, and with rattling rebounds.

The steel band originated in Trinidad; the instruments consisted at first of trash can (dustbin) lids, and later, of oil drums. It is believed that these domestic appliances replaced various bamboo instruments, and that the authorities prohibited their use on feast days in view of their possible use as weapons during periods of unrest. Dents are skilfully fashioned in metal receptacles of varying size, and the base of the depression struck with a mallet. The pitch of the note is determined by the diameter and depth of the indentation. The steel band in commercial entertainment has a considerable musical attraction, the range of the instruments covering four chromatic octaves.

Bell Instruments.—The Turkish crescent (*chapeau chinois* or jingling johnny) is an instrument introduced into the military bands of Great Britain and elsewhere about 1800, at the time of the popularity in western Europe of Janissary music. The crescent is an upright pole surmounted by a tent-shaped construction and metal headpiece, composed of a crescent and other symbols, from which points and elsewhere on the pole hang small bells and

BY COURTESY OF (FAR LEFT, RIGHT) THE METROPOLITAN MUSEUM OF ART, (FAR LEFT) GIFT OF MISS ALICE GETTY, 1946, (RIGHT) THE CROSBY BROWN COLLECTION OF MUSICAL INSTRUMENTS, 1889; (BOTTOM CENTRE) THE MUSEUM OF PRIMITIVE ART. PHOTOGRAPHS, (LEFT) M. MORROW, (TOP CENTRE) JAMES BLADES

FORERUNNERS OF MODERN PERCUSSION INSTRUMENTS: (FAR LEFT) BARREL DRUM FROM INDIA WITH CORD-TENSIONED CONSTRUCTION; (LEFT) TUBULAR DRUM FROM BORNEO; (TOP CENTRE) INDIAN TABLĀ CONSISTING OF TWO DRUMS, (LEFT) BAYAN AND (RIGHT) DAINA, (BOTTOM CENTRE) WOODEN SLIT DRUM FROM NEW GUINEA; (RIGHT) HOURGLASS DRUM FROM THE SUDAN

jingles. Plumes made from horsetails further ornament the instrument, the bells and jingles of which are shaken in rhythm.

The sistrum is an instrument of percussion of definite pitch (occasionally found in Italian scores) consisting of a series of small mushroom-shaped bells, mounted in pyramid-fashion on a handle. The compass of the instrument ranges from one to three octaves, with the bells mounted diatonically in a single row, or chromatically in two rows. (*See* SISTRUM; GLOCKENSPIEL; BELL.)

The tubaphone was a popular solo instrument in the military band repertoire during the early part of the 20th century. It consisted of a series of short metal tubes arranged in a frame in two rows. Similar in design and sound to the orchestral glockenspiel, it was played in the same manner.

The jingles are a spray of bells, or metal pieces, smaller than the normal sleigh or harness bells.

Percussion Instruments in the Orchestra.—"Slap-Stick" is a device used in the orchestra to produce the sound of the crack of a whip and consists of two pieces of wood, joined in a V-shape by hinging at the base, or partway up to form a handle.

Maracas are Latin-American percussion instruments used in pairs in the rumba band. Each maraca is a gourd, or substitute, fixed to a handle filled with dried seeds which rustle when the instrument is shaken, or alternatively produce a clicking sound when the gourd is tapped with the forefinger. (*See* above). Claves are round sticks of hardwood six to eight inches in length, descendants of the primitive concussion sticks (*see* above). In the Latin-American dance orchestra rhythm is marked by the claves which the player strikes in a recurring pattern. One piece of wood, held over the upturned fingernails of one hand, is struck with the other, held lightly in the manner of a drum stick. Bones are a percussion instrument used in the 19th-century British or American Negro minstrel band. Two pieces of a rib bone of an animal are held between the fingers and clicked together. The cabaça is a Latin-American instrument consisting of a calabash shell surrounded with a network of beads. The handle of the cabaça is held in the right hand with the bowl of the instrument resting in the palm of the left hand. Rotation of the handle causes the resonant bowl to turn within its network of beads, producing a gentle rasping sound.

The guiro (known also as scraper or reso-reso) is a calabash gourd, or short length of bamboo stem into which is plowed a series of deep grooves in regular formation. Sound is produced by drawing over the grooves a thin strip of bamboo, or similar rigid object. Stravinsky wrote a part for the "guero" in the original score of *Le Sacre du printemps* but later deleted it. The guiro forms an integral part of the modern rumba band.

See also MUSICAL INSTRUMENTS and references under "Percussion Instruments" in the Index.

See Curt Sachs, *The History of Musical Instruments* (1940); Francis W. Galpin, *Old English Instruments of Music* (1932). (J. BL.)

PERCY, a family whose deeds are prominent in English history. It was founded by WILLIAM DE PERCY (*c.* 1030–96), a follower of the Conqueror, who bestowed on him a great fief in Yorkshire and Lincolnshire. The register of Whitby abbey, which he founded anew, and in later days the heralds, were responsible for exaggerating the origin and pedigree of the family. By Emma, daughter of Hugh de Port, a great Hampshire baron, William was father of several sons, of whom ALAN the eldest succeeded him. His grandson WILLIAM (d. 1175) was the last of the house in the direct line, and left two daughters and coheiresses, Maud countess of Warwick, who died childless, and Agnes. Agnes de Percy had married Jocelin, brother of Queen Adelaide, second wife of Henry I, and from this marriage descended the second house of Percy (which name it assumed), till its own extinction in the male line five centuries later (1670). By it was brought into the family the great Petworth estate in Sussex, which Jocelin had obtained from his sister. His son RICHARD (*c.* 1170–1244) was one of the 25 barons appointed to enforce the observance of Magna Carta and in 1216 was an active supporter of Louis of France against King John.

HENRY DE PERCY (1273–1314) was one of Edward I's most active agents in the subjugation of Scotland until the success of Robert Bruce drove him out of Turnberry castle, and made him withdraw into England. Summoned to parliament as a baron in the time of Edward I, he later, as one of the lords ordainer, supported the baronial opposition to the personal rule of Edward II. Hitherto the family had been mainly connected with Yorkshire, but Henry gave its fortunes a new direction by his purchase of lands in Northumberland from Antony Bek, bishop of Durham, among them the great lordship of Alnwick, which became the principal seat of the family. Henceforth the Percys, now the greatest landowners in Northumberland, became the principal guardians of the northeastern border against the Scots, and successive members of the family served regularly as wardens of the marches.

Henry's son, another HENRY (*c.* 1299–1352), did splendid service to his sovereign by defeating and taking prisoner David II, king of Scotland, at the battle of Neville's Cross (1346).

To him succeeded his son, another HENRY PERCY (1322–1368), a feudal baron like his predecessors, who fought at Crécy during his father's lifetime and whose brother THOMAS PERCY (1333–1369) was bishop of Norwich from 1356 to 1369. Henry's son, HENRY PERCY, 1st earl of Northumberland, father of the famous Hotspur, SIR HENRY PERCY (*q.v.*), was killed at Bramham Moor in 1408, his title and estates being forfeited after his rebellion in 1405. Henry V formally restored them in 1416 to this earl's grandson, HENRY (1394–1455), then a prisoner with the Scots, whose liberation he procured. For the later history of the family *see* NORTHUMBERLAND, EARLS AND DUKES OF. (C. D. R.)

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PERCY, SIR HENRY, called HOTSPUR (1364–1403), eldest son of Henry, 1st earl of Northumberland, was born on May 20, 1364. He saw active service when he was 14 at the siege of Berwick. After 1384 he served almost continuously as warden of either the East or the West March toward Scotland, and his zeal in border warfare won him the name of Hotspur from his opponents. In popular story and ballad he is known as one of the heroes of Otterburn or Chevy Chase. In the summer of 1388 the Scots sent a small body under the earls of Douglas, March, and Moray to invade Northumberland. The earl of Northumberland dispatched his sons Sir Henry (knighted in 1377) and Sir Ralph against the enemy. In hand-to-hand fighting before the walls of Newcastle, Douglas is said to have won Hotspur's pennon, which he swore to fix upon the walls of Dalkeith. The Scots then retreated to Otterburn where Hotspur, bent on recovering his pennon, attacked them on Aug. 19. Douglas was slain in the battle, though not (as is stated by the chronicler Thomas Walsingham) by Hotspur's hand. Hotspur was captured by Sir John Montgomerie, and his brother Ralph by Sir John Maxwell. Hotspur was released on the payment of a heavy ransom, to which Richard II contributed £3,000.

In July 1399 Hotspur and his father were the first magnates to join Henry of Lancaster (afterward Henry IV) on his landing in England, and played an important part in his successful usurpation. They were well rewarded for their support. Hotspur was appointed warden of the East March and captain of Roxburgh Castle, and received a series of offices and grants which made him virtual governor of northern Wales. With the young prince, Henry (afterward Henry V), he led the Welsh campaign of 1401, and in May was able to report considerable success in pacifying the North Welsh, and the recovery of Conway Castle. In the autumn of 1402 a Scots invasion of northern England led by the earl of Douglas was met by Northumberland and Hotspur, and the Scots were heavily defeated at Homildon Hill (Sept. 14). Thereafter the Percys became, in the words of the chronicler Adam of Usk, "too much puffed-up," and their relations with the king worsened. Roxburgh had already been taken from Hotspur in March 1402 and given to the earl of Westmorland. In disputes over the captives taken at Homildon Hill, the king refused to allow Hotspur to

retain Douglas as his personal prisoner. Nor would Henry permit him to ransom his brother-in-law, Sir Edmund Mortimer, from the hands of the Welsh rebels. Financial grievances inflamed these differences. The Percys were unable to secure payment of much of the money owed them for their charges in the north and in Wales, and were impatient of Henry's genuine financial difficulties. By 1403 it was clear that the king could not be so easily dominated as they had hoped, and, with the precedent of king-making still fresh, they determined to replace him on the throne.

In July 1403 Hotspur raised the standard of rebellion in Cheshire, where Richard II had won for himself a special loyalty. Henry was accused of having broken his promises, of murdering Richard II, and of excluding from the throne Richard's legitimate heir, the young earl of March, to whom Hotspur was related through his wife, Elizabeth Mortimer. The king's speedy action prevented Hotspur's occupying Shrewsbury and joining his Welsh ally, Glendower, and on July 21, 1403, Hotspur, accompanied by his uncle, Thomas Percy, earl of Worcester, and the earl of Douglas, with a force of Cheshire men, was forced to give battle outside Shrewsbury. Hotspur was killed, the earls of Douglas and Worcester were captured, and the rebel army dispersed. Worcester was executed two days later. Percy's body was buried at Whitchurch, about 16 mi. N of the battlefield, but was disinterred two days later to be exhibited in Shrewsbury. The head was cut off and fixed on one of the gates of York.

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PERCY, THOMAS (1729–1811), English man of letters and bishop of Dromore, whose ballad collection *Reliques of Ancient English Poetry* (1765) stimulated research into ballad poetry and inspired the romantic movement. He was born at Bridgnorth, Shropshire, April 13, 1729. He went to Christ Church, Oxford, and held livings at Easton Maudit (1753) and Wilby (1756), both in Northampton, for many years. In 1763 he edited the poems of the earl of Surrey and published *Five Pieces of Runic Poetry From the Islandic Language*. The *Reliques* were based on an old manuscript he rescued from a friend's house, where parts of it had been used to light the fire. He edited them at William Shenstone's suggestion and, although some doubted their authenticity and many scoffed at their primitive style, they became increasingly popular and profoundly influenced Scott, Wordsworth and Coleridge. The standard edition is by H. B. Wheatley (1876). In 1770 Percy published *Northern Antiquities*, a set of translations including one (from a Latin version) of the Icelandic *Edda*, which thus became available to English readers for the first time. In his preface he makes a scholarly distinction, unusual for his period, between the various branches of the Celtic and Teutonic peoples. His *Ancient Songs*, chiefly on Moorish subjects, translated from Spanish, were edited by D. Nichol Smith (1932).

Percy became domestic chaplain to the duke of Northumberland (1770) and, through his influence, dean of Carlisle in 1778 and bishop of Dromore in Ireland in 1782. He died there on Sept. 30, 1811.

See A. C. C. Gaussen, *Percy, Prelate and Poet* (1908); *The Percy Letters*, ed. by D. Nichol Smith and C. Brooks, 5 vol. (1944–57).

PERDICCAS, the name of three kings of Macedonia who reigned respectively in the 7th century B.C., *c.* 450–413, and 365–359, and of one of Alexander the Great's generals (*c.* 365–321); the last is the subject of this article.

Son of Orontes and a descendant of the princes of Orestis, one of the Macedonian provinces, Perdiccas served with distinction in Alexander's campaigns. At the time of Alexander's death (323) he had acquired a leading position at the court and in the army. He led the aristocratic party which supported the claim of the unborn child of Roxana, Alexander's widow, to the succession. After the compromise under the terms of which a joint kingship and a division of the powers of regency were arranged, Perdiccas exercised a wide authority in Asia as "supreme general" and soon began to act as if he meant to make himself master of the whole empire. This attempted usurpation was strongly resisted by the regional governors Ptolemy in Egypt and Antigonus in Phrygia and by Perdiccas' colleagues in the regency, Craterus and Antipater. In 322 Perdiccas conquered Cappadocia and installed as satrap his most reliable and efficient subordinate, Eumenes (*q.v.*) of Cardia. Antigonus refused obedience and fled to Europe, where he persuaded Antipater and Craterus that Perdiccas must be destroyed. Leaving Eumenes to hold Asia Minor against Craterus and Antigonus, Perdiccas marched against Ptolemy. But when he failed to force the Nile mutinous officers led by Peithon and Seleucus murdered him (321).

See F. Geyer in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. xix, 590–614 (1937). (R. H. Si.)

PERDIX (also known as Polycaste), in Greek mythology, a woman of Athens, whose son, Talos, studied with her brother, Daedalus. The boy invented the saw and the draftsman's compass, whereupon Daedalus in an envious rage threw him from the Acropolis. Perdix hanged herself, and the Athenians dedicated a shrine to her beside the Acropolis. According to Ovid (*Metamorphoses*), Perdix was the name of the boy; on his fall he was changed into a partridge (Gr. *perdix*) by Athena. (T. V. B.)

PEREDA, JOSÉ MARÍA DE (1833–1906), Spanish writer, the acknowledged leader of the modern Spanish regional novelists, a realist in the tradition of Cervantes and the picaresque writers. Born at Polanco near Santander on Feb. 6, 1833, of a family noted for its fervent Catholicism and its traditionalism, Pereda looked an authentic hidalgo. His first literary effort was the *Escenas montañesas* (1864), starkly realistic sketches of the fisherfolk of Santander and the peasants of the Montaña. There followed other sketches and early novels of pronounced controversial spirit, such as *El buey suelto* (1878), a counterpart to Balzac's thesis in *Petites misères de la vie conjugale; Don Gonzalo González de la Gonzalera* (1879), a satire on the revolution of 1868 and a eulogy of the old patriarchal system of government; and *De tal palo tal astilla* (1880), a protest by a rigid Catholic against the liberal religious tendencies advocated by his friend Benito Pérez Galdós in his novels *Doña Perfecta* and *Gloria*.

With the exception of *Pedro Sánchez* (1883), where Pereda describes the disillusion of a 19th-century Gil Blas from the Montaña in the troubled political arena of the capital, and *La Montálvez* (1888), a satirical description of Madrid society, all his novels have a Montaña background.

Pereda's best work, one of the finest Spanish novels of the 19th century, was *Sotileza* (1884), an epic of the Santander fisherfolk and a genuine novel of customs. The author's avowed aim was to paint the life of the old Santander fisherman with its virtues and its defects, and he has done this with great sympathy and realism. A masterpiece of characterization is the portrait of Sotileza, the haughty and enigmatic fishergirl.

Pereda resembles Thomas Hardy in his regionalism and Dickens in his love for the "good old days," but in his virile realism, tinged with a fund of human sympathy, he is thoroughly Castilian. He was not a good psychologist nor a good story-teller, but he possessed the gift of creating human characters, particularly of the humbler variety, and, with his mastery of rich and flexible language, he excels, above all, as a painter of nature, in all its aspects. Pereda died at Santander on March 1, 1906.

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PÈRE DAVID'S DEER, a large, rare Asian deer, unknown in nature within historic time, that differs from all other deer in shedding its antlers twice, rather than once, each year. It is *Elaphurus davidianus*, the only species of its genus. Presumably its original home was in northern China, and fossil remains have been found in Japan. It is now found only in confinement on estates and in zoological gardens. This unusual deer stands more than three and one-half feet at the shoulder. The pelage is tawny red in summer, becoming uniformly grayish in winter; the under parts, rump, area around the eyes, and muzzle are whitish. Fawns are spotted with white. The antlers, up to three feet long, fork shortly above the burr, the front prong branching once and the

hind prong extending backward, unbranched. The long, bushy tail, reaching the hocks, is another unique feature of this deer.

Description of this deer was based on specimens obtained in 1866 through a French missionary, Père Armand David, from the Imperial Hunting Park 3 mi. S of Peking. The park was enclosed originally by a 45-mi. brick wall. Fortunately, before the Peking herds were destroyed around 1900, translocations to various European estates had already been made. The largest herd resides at Woburn Abbey, Bedfordshire, Eng. *See* also DEER.

BY COURTESY OF NEW YORK ZOOLOGICAL SOCIETY

BUCKS AND DOE OF PÈRE DAVID'S DEER (ELAPHURUS DAVIDIANUS)

(H. K. B.)

PEREGRINATIO ETHERIAE (PILGRIMAGE OF ETHERIA), the anonymous incomplete Latin account of her travels in the Middle East written by a nun from western Europe for her colleagues at home toward the end of the 4th century A.D. It is important for the information it gives about religious life and the observances of the church year in the localities visited, which include the chief holy places of the Old and New Testaments in Egypt, Palestine and Syria. There is a detailed description of the daily and annual liturgical activities at Jerusalem. Discovered in 1884 by J. F. Gamurrini in an 11th-century manuscript at Arezzo, the account was first attributed to Silvia, the sister of Rufinus, but in 1903 it was shown that the author was a Spanish nun called Etheria or Aetheria (variants are Egeria and Eucheria). The date of the account, which depends on internal evidence, lies between 363 and 540; most scholars agree that within this period the most likely date is during the last years of the 4th century. *See* also CHURCH YEAR: *Jerusalem.*

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PEREGRINUS PROTEUS (2nd century A.D.), Greek Cynic philosopher celebrated for his spectacular suicide. According to Lucian, whose letter "On the Death of Peregrinus" is the main source of information about him, he was suspected of parricide in his youth and had to emigrate from his native city of Parium in Mysia. He later took up residence in Palestine, but his influence in the Christian community there led to his being arrested. On his release he left Palestine and became estranged from the Christians. In Egypt he met the Cynic philosopher Agathobulus, whose views he combined with what he had learned from Christianity (*see* CYNICS). He next went to Rome, but was expelled by the prefect for insulting the emperor Antoninus Pius. After leaving Rome he went to Greece, where he was at first well received, but compromised his popularity by disparaging the public benefactor Herodes Atticus. He then announced his intention of cremating himself and finally did so on a funeral pyre during the Olympic Games of A.D. 165, in the presence of many spectators, among whom was Lucian.

Though Lucian's account of Peregrinus represents him as an opportunist and an exhibitionist, not all ancient authors agree, and modern scholars are inclined to think of him as sincere, however abnormal, in his enthusiasms. The influence of Oriental religion is suggested by the manner of his death. He assumed the name Proteus himself, in allusion to the ever-changing Proteus of mythology.

See Lucian, "The Death of Peregrine," *Works*, vol. iv, Eng. trans. by H. W. and F. G. Fowler (1905); also K. von Fritz, "Peregrinus," Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, Halbband 37 (1937).

PEREIRA, NUNO ÁLVARES (1360–1431), called THE HOLY CONSTABLE, one of the outstanding Portuguese military leaders of his time, victorious throughout a long career of warfare, was born at Bonjardim, near Sertã, on June 24, 1360, the illegitimate son of Álvaro Gonçalves Pereira, prior of the Order of the Hospital of St. John of Jerusalem. On the death of King Ferdinand (October 1383), he came forward at once as a supporter of the master of Avis, the future King John I (*q.v.*), in defense of Portugal's independence against the claims of Ferdinand's heiress Beatriz, who had been married to John I of Castile. His talent soon became manifest, and it was his army that defeated the Castilians in the Battle of Atoleiros (April 6, 1384). Further heroic actions won him appointment to the office of constable of the kingdom in 1385. The victories at Aljubarrota (Aug. 14, 1385) and at Valverde (Oct. 15 or 16), which demonstrated Portugal's military superiority over Castile and assured the nation's independence, were largely due to his resolute conduct in leadership and in action; and he took part in the subsequent fighting against the Castilians until the peace of Oct. 30, 1411. Finally he gave all his support to the expedition that captured Ceuta from the Moors in 1415. His sovereign heaped honours upon him, giving him the countship of Ourêm, Barcelos, and Arraiolos, with extensive lands and properties. By his wife, Leonor de Alvim, the constable had a daughter, Beatriz, who was married to John I's legitimated son Afonso and so became the ancestress of the house of Braganza (*q.v.*). Pereira, who had had a Carmelite house built in Lisbon in fulfillment of a vow, entered it himself as Friar Nuno de Santa Maria in 1423. He died there on April 1, 1431. Pope Benedict XV beatified him on Jan. 23, 1918. (V. R. R.)

PEREIRA DE SOUZA, WASHINGTON LUIZ (1869–1957), president of Brazil, was born at Macaé, Rio de Janeiro, Oct. 26, 1869. He was reared in and identified politically with the state of São Paulo. A career politician for over 30 years, he held numerous public offices, including those of mayor of the city of São Paulo and of state governor (1920–24). His most lasting contribution as president was the initiation of an ambitious highway construction program, which was expanded by his successors. Under the political system of the time his election as president in 1926 had been assured by his predecessor. However, in the revolution of 1930, led by Getúlio Vargas, the old system collapsed. Pereira de Souza was deposed and exiled to Europe three weeks before completing his term. He was thus the last president of the so-called "old republic." He returned to Brazil in 1947 and died in São Paulo on Aug. 4, 1957. (R. E. P.)

PEREKOP, an isthmus in the Ukrainian Soviet Socialist Republic, U.S.S.R., between the Karkinitski Gulf of the Black Sea and the Sivash, or Putrid Sea, which links the Crimea to the mainland. At its narrowest it is only four miles across. As the only land route to the Crimea, until the rail causeway across the Sivash was built in 1873, the isthmus for long had great strategic significance. An earthen bank and ditch across it at the narrowest part are of prehistoric date and are believed to have given the name of Taphros ("ditch") to a nearby Greek colony. In the 13th century Perekop, with the rest of the Crimea, passed to the Tatars. Their khan, Mengli Ghirai, in the late 15th century renewed the dike and erected fortifications, including a new fort, Or-kapu, on the site of Taphros, where the village of Perekop now stands. The isthmus has been the scene of many battles, notably the Russian onslaughts in 1736 under B. K. Minikh, in 1738 under P. P. Lassi, and in 1771 under Prince V. M. Dolgoruki. In 1920 the Red Army under M. V. Frunze defeated Gen. P. N. Wrangel there, and during the German advance of 1941 and retreat of 1944 there were fierce engagements at Perekop. A road, a railway, and an irrigation canal now enter the Crimea by the isthmus.

(R. A. F.)

PERETZ, ISAAC LEIB (1852 or 1851–1915), Yiddish and Hebrew man of letters, especially remembered for his sketches of Hasidic life whose rich spirituality he portrays with sympathy and understanding, was born in Zamosc, Pol., on May 18, 1852, or May 20, 1851. A brilliant student, he acquired a traditional Jewish education before turning to secular studies partly under the guidance of his father-in-law. A disciple of the movement of enlightenment, *Haskalah*, he wrote poems in Yiddish and Hebrew criticizing Jewish customs, meanwhile earning a livelihood as an attorney at law. Compelled to leave his native town in 1889 because of a conflict with the authorities, he became a clerk in the offices of the Jewish congregation in Warsaw, but was imprisoned for some months in 1899 for socialist activities. During the last

ten years of his life he became the recognized leader of the Yiddishist movement, whose aim—in opposition to the Zionists—was to create a complete cultural and national life for Jewry in the Diaspora with Yiddish as its language. A prolific and versatile writer of poems, short stories, dramas, allegories, satires, humourous sketches and *feuilletons*, Peretz was partly instrumental in raising the standards of Yiddish literature to a high level. Although scathingly critical of the traditional modes of Jewish life and the bitter inequalities of the wider social order, he also recognized the nobility of spirit so frequently shrouded by a poverty-stricken and ugly environment. His stories, which are largely concerned with humble lives, are episodic but keenly penetrating, while his sympathy for the poor and friendless is moving and sincere. He died in Warsaw on April 3, 1915.

BIBLIOGRAPHY.—Collected edition of Hebrew works (1899–1901), of Yiddish works (1901), of Hebrew works with Hebrew trans. of Yiddish works (1947–57); Russian trans. (1902–03). (D. PA.)

PEREYASLAV-KHMELNITSKI (formerly PEREYASLAV), a town in Kiev *oblast* of the Ukrainian Soviet Socialist Republic, U.S.S.R., stands on the right bank of the river Trubezh, 6 mi. (10 km.) above its confluence with the Dnieper and 45 mi. (72 km.) SE of Kiev. One of the oldest Russian towns, Pereyaslav (sometimes known as Pereyaslav Russki or Pereyaslav Yuzhni) was first mentioned in 907. In the 11th century the town flourished and was made the seat of a princedom by Yaroslav the Wise for his third son. There were princely and episcopal kremlins at that time, and the commercial town was enclosed by ramparts 3,500 yd. (3,200 m.) long, parts of which survive. In 1096 the town was besieged by the Cumans (Polovtsy) and in 1239 it was sacked by the Tatars. Thereafter the town passed to Lithuania and later to Poland but, after the failure of a Cossack uprising in 1648, the Cossacks under Bogdan Khmelnitski (Bohdan Chmielnicki; *q.v.*) met at Pereyaslav in 1654 and acknowledged the supremacy of the tsars. After the Revolution the town's name was expanded to honour Khmelnitski. Modern Pereyaslav (1959 census, 14,361) is a small market town of only local significance. (R. A. F.)

PÉREZ, ANTONIO (1540–1611), secretary of Philip II of Spain, whose career presents one of the earliest examples of a now familiar phenomenon, that of a man who is driven to treason by a system of political absolutism in which he himself has played a prominent part. He was born at Madrid, the illegitimate son of Gonzalo Pérez, secretary of the emperor Charles V, and was legitimated in 1542. Charming, intelligent, and, through his father, well connected, Pérez quickly rose in the service of Philip II, becoming the king's secretary (1568) and secretary of several of the royal councils. A long line of historians, dramatists, and novelists have speculated on Pérez's supposed liaison with Doña Ana de Mendoza, the one-eyed princess of Eboli and widow of Philip's favourite, Ruy Gómez de Silva, although it is very unlikely that their relationship was anything but a political alliance.

The upstart secretary was hated by many of the grandees and by his rivals in the Spanish civil service. The king's favour was unstable, and to safeguard himself, Pérez intrigued with all parties: with Philip II's half brother Don John of Austria and his secretary, Juan de Escovedo, against the king; with the king against Don John; perhaps even with the Netherlands rebels against both. When Don John, then governor-general of the Netherlands, sent Escovedo to Spain in 1577 to plead for his plan to invade England and liberate and marry Mary Stuart, queen of Scots, Pérez feared the exposure of his own intrigues. He persuaded the suspicious king that Escovedo was Don John's evil genius and was plotting treason. The king gave his consent to the murder of Escovedo and Pérez organized his assassination on March 31, 1578.

Philip II never forgave Pérez for having forced his hand. On July 28, 1579, he had Pérez and the princess of Eboli arrested. For eleven years, Pérez remained in prison and all efforts to extract a full confession and all incriminating documents from him failed. In April 1590 he escaped from Madrid to Aragon and placed himself under the protection of the Aragonese courts. Now, for the first time, he accused the king of the murder of Escovedo. Philip thereupon tried to have Pérez handed over to the Inquisition, but the populace of Saragossa twice rioted (May and September 1591) and prevented this move. Philip considered it rebellion and sent a Castilian army into Aragon (October 1591).

Pérez fled to France in November. He spent the remainder of his life at the courts of France and England, carrying on his polemic against Philip II and contributing to the "black legend" about the king. After Philip II's death (1598), Pérez lost what little influence he had had. He failed to obtain a pardon from Philip III and died in poverty in Paris, on Nov. 3, 1611. His *Relaciones*, of which there are many editions, was published in 1598.

See G. Marañón, *Antonio Pérez*, 2 vol. (1947), abridged edition translated into English by C. D. Ley (1954); K. O'Brien, *That Lady* (1946), a typical novel on the subject. (H. G. KO.)

PÉREZ DE AYALA, RAMÓN (1880–1962), eminent Spanish novelist, poet, and critic, was born at Oviedo on Aug. 9, 1880. He studied at Jesuit colleges and the University of Oviedo, traveled widely, wrote poetry, and indulged in journalism. The ruin and suicide of his father made him turn to writing as a profession—so successfully that he was elected to the Royal Spanish Academy in 1928. A man of liberal, cosmopolitan outlook, Ayala worked for the establishment of the second republic and represented it as ambassador to Great Britain from 1931 to 1936. He lived in Argentina for some years, but returned to Spain in 1954. His first novels, more or less autobiographical and realistic, were *Tinieblas en las cumbres* (1907), *A.M.D.G.* (1910)—a grim picture of Jesuit education—*La pata de la raposa* (1912; English translation, *The Fox's Paw*, 1924), and *Troteras y danzaderas* (1913), a satirical presentation of Madrid literary and bohemian life.

Three short tragic *novelas poemáticas* (1916) marked the transition to Ayala's more stylized mature manner with its use of myth and symbolism. *Belarmino y Apolonio* (1921), by many considered his masterpiece, portrays with great comic force two rivals: the cobbler-philosopher whose preoccupation with language ultimately reduces him to silence, and the cobbler-dramatist, a garrulous extrovert. *Luna de miel, luna de hiel* (1923) and its sequel *Los trabajos de Urbano y Simona* (1923) describe a young couple's emergence from sexual innocence into maturity. His last major work, in two parts, *Tigre Juan* and *El curandero de su honra* (1926; Eng. trans., *Tiger Juan*, 1933), is a reworking of the Don Juan and honour themes. His intellectual power, literary craftsmanship, sensitive use of language, and fine ironical humour make him one of Spain's foremost novelists. He died in Madrid on Aug. 5, 1962.

See F. Agustín, *Ramón Pérez de Ayala* (1927); N. Urrutia, *De Troteras a Tigre Juan* (1960). (H. B. HL.)

PÉREZ DE HITA, GINÉS (1544?–1619?), Spanish writer, is known for his authorship of the *Historia de los bandos de Zegríes y Abencerrajes o Guerras civiles de Granada* (modern edition by P. Blanchard-Demonge, 1913–15), the first Spanish historical novel and last important collection of Moorish border ballads, which punctuate the narrative like the lyrics in contemporary pastoral novels. The chivalrous Abencerrages (*q.v.*) of the first part (1595), which depicts the political disintegration of the kingdom of Granada preceding its fall, established the stereotype of the romantic Moor of European literature; the second part (1619), describing the campaign of 1568–71 against the Moriscos, in which the author served, is marked by compassion for the vanquished and a generous anger at Christian excesses.

See P. Festugière, in *Bulletin Hispanique* (1944). (F. S. R.)

PÉREZ GALDÓS, BENITO (1843–1920), the greatest Spanish novelist since Cervantes. He was interested in the entire nation at a time when regionalism was prevalent; he looked forward to a more prosperous, free, and enlightened Spain. He revealed to Spaniards the meaning of their recent history and the forces which were making modern Spain, and also showed them their own national psychology through his masterly creation of a wide range of characters.

Born at Las Palmas in the Canary Islands, on May 10, 1843, Galdós went to Madrid in 1862 to study law, but soon abandoned

the university for journalism. His youthful articles showed cautious liberalism in politics and intransigent opposition to the intolerant religious trends of the times. The same attitudes appeared in his early novels, the first being *La fontana de oro* (1870).

Galdós saw that the Spain of the 1870s was the outcome of events of the Napoleonic Wars, an epoch neglected by Spanish historians. He began in 1873 to publish a series of historical novels —*Episodios nacionales*—which retold Spain's history from the Battle of Trafalgar (1805) to the death of Ferdinand VII (1833). For background material he used memoirs, old newspaper articles, and eyewitness accounts; thus his novels were vivid and accurate historically, and they achieved a great popular success. By 1879 he had completed two series—each of ten volumes—and he then renounced the historical novel for the contemporary scene.

He had already brought out four contemporary novels, beginning with *Doña Perfecta* (1876). In them the reforming spirit of his early period still prevailed. But after 1880 a new tone was struck, one of tolerant acceptance of Spain's idiosyncracies, of identification of the author with Spain, which he now chided benignly and admonished only indirectly for its faults.

The new series, somewhat influenced by French naturalism, began with *La desheredada* (1881) and reached its culmination with *Fortunata y Jacinta* (4 volumes, 1886–87), Galdós' masterpiece and one of the monuments of world literature. Galdós had become the novelist of Madrid, displaying a phenomenal knowledge of the city which is the epitome of all Spain, and he had also become the analyst of the Spanish character. The realism which dominated this period gradually admitted more and more elements of spirituality, at first questioning their value—*Ángel Guerra* (3 volumes, 1890–91)—later accepting the forces of the spirit as an integral part of reality—*Nazarín* (1895) and *Misericordia* (1897).

In 1892 Galdós produced *Realidad,* his first acted drama. Despite his denials, this work and his subsequent plays owed something to the current interest in Ibsen. Galdós never handled the dramatic form with the same sureness as the novel; his career as a playwright was one of alternating stormy successes, often for fortuitous causes—*e.g., Electra* (1901) which expressed the progressive, anticlerical mood of a section of Spanish opinion and so achieved a spectacular success for political rather than literary reasons—and of equally startling failures.

Galdós' financial difficulties caused him to resume the *Episodios nacionales,* beginning a third series in 1898. He went on to produce a fourth and part of a fifth series so that by 1912 he had written 26 more historical novels, bringing his account of Spanish history down to 1877 and retelling events of which he himself had been a witness. But this period of Galdós' life was one of gradual decline. Financial difficulties made him suspicious of others; political activity in the republican cause disillusioned him; finally, gradual loss of eyesight culminated in total blindness (1912). His last works, four plays (1914–18) and a novel (1915) show a withdrawal and a weakening of creative energy. He died in Madrid, Jan. 4, 1920.

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PÉREZ JIMÉNEZ, MARCOS (1914–), military leader and president of Venezuela (1952–58), was born April 25, 1914, in Michelena. He became a professional soldier, receiving a commission from the Venezuelan Military Academy in 1934. His political activities began in 1944, and he took part in the *coups d'état* that overthrew the government on Oct. 18, 1945, and Nov. 24, 1948. After the second coup he served as a member of the military junta that ruled Venezuela. In December 1952 he became provisional president by designation of the armed forces—an appointment confirmed by the Constituent Assembly of 1953, which elected him to a five-year presidential term (1953–58). Pérez' administration continued the reformist programs standard in Venezuela since 1936, but failed to keep pace with increasing national needs. To maintain his regime he depended on popular apathy and armed forces support. Extravagance, corruption, police oppression, and mounting unemployment created conditions of dissatisfaction in the armed forces and among the people. Military malcontents attempted a *coup d'état* on Jan. 1, 1958, and the subsequent armed forces crisis enabled civilian discontent to find expression. Pérez was forced out of office on Jan. 23, 1958, and a civilian-military junta took control. He fled the country but was extradited by the U.S. in 1963 to stand trial for embezzling government funds. (R. L. GE.)

PERFUME, a composition whose fragrance gratifies the sense of smell and which is commonly associated with personal adornment. A perfume is difficult to define; the expression "a pleasant smell" is inadequate; a well-cooked dinner provides a pleasant smell but not a perfume in the generally accepted meaning of the word. More appropriate as a definition would be "a blend of materials, each with its own particular odour, resulting in one over-all and pleasant impression." It is preferable to use the word "blend" as distinguished from "mixture," which suggests something that might result from haphazard additions and might easily give an unpleasant odour impression. Expensive materials can be mixed in an inexpert manner to produce an odour with little appeal; on the other hand, quite pleasing perfumes can be made by the expert blending of inexpensive raw materials.

The nature of odour perception is not completely understood, although it is known that odorous substances must be capable of undergoing some degree of vaporization. An odorous chemical, whether liquid or solid, must change to the gaseous state and travel through the air to the nose. The sensory nerve system consists of (1) the receptor organ, where the odorous molecules are received; (2) the nerves, which transmit the response; and (3) the receiving area of the brain, which interprets the message. (*See* SMELL AND TASTE: *Sense of Smell.*)

Perfumery is commonly associated with handkerchief perfumes, toilet waters, cosmetics, and soaps, but perfumes are employed in many industrial products, including detergents, polishes, leather, rubber, etc. The psychological effect of a perfume is undeniable: it appeals to the senses in the same way as does a country scene, a fine painting, a pretty girl, or a piece of music.

HISTORY

The story of perfume touches on medicine, mythology, religion, and anthropology, and its raw materials have been gathered from all parts of the world. One of its earliest associations was with man's offering of pleasant odours to his gods by the burning of incense (the word perfume comes from the Latin *per fumum,* "through smoke"). The art of perfumery may well have been practised 25,000 years ago by the Indo-European races. Early Chinese records mention incense, and China's early and important contribution to perfumery was musk. Odorous products from 3,000 to 5,000 years old have been found. An Egyptian papyrus of 2000 B.C. refers to myrrh.

Perfumery appears to have been handed down from the Chinese, Hindus, Egyptians, Israelites, Carthaginians, Arabs, Greeks, and Romans. During the reign of the Pharaohs in Egypt, perfumes were used for a variety of purposes. The Bible makes numerous references to perfumery materials, including frankincense, myrrh, spicy balm, aromatic substances, musk, hyacinth, almonds, cinnamon, calamus, and cassia. Actual formulas for perfume are quoted in Exodus 30:23–25 and 30:34–35. From the 4th century B.C. perfumes were used in Greece in medicine and for pleasure. The mythology of the Greeks speaks of many fragrances and their scientists studied the art of perfumery. Interest in the essential oils was certainly shown in Egypt, Persia, and India. (Probably the first oil to be distilled was turpentine in the 4th or 5th century B.C.) Queen Cleopatra of Egypt used perfume to charm Julius Caesar and Mark Antony, and the Romans brought back many perfumery materials from Greece, Palmyra, and Arabia. Fats were used in ancient Greece and Rome to extract oils from roots and flowers. Perfumery was probably brought to Britain first by the Romans and again by the Anglo-Saxons, and in the Middle Ages returning crusaders reintroduced perfumes from the East. The first authentic description of essential oils is ascribed to Arnaldo de Vilanova, a Catalan physician, in the

period A.D. 1240–1311. From the fall of Rome to the Renaissance, the development of perfumery was mainly carried on by the Arabs and the Persians, who produced spices and gums and built up an important foreign trade. Between the 9th and the 12th centuries, the Arabs knew of distillation. The discovery of alcohol as a vehicle for perfumes was probably made in the 14th century and the first toilet water was based on rosemary ("Hungary water").

The revival of the arts during the Renaissance awoke a fresh interest in perfumery in Italy and France. Many books on perfumery were written during the 16th and the 17th centuries and the earliest formula for a lavender water is said to have been published in 1615. In the 17th and 18th centuries pharmacists and botanists and some early students of applied chemistry investigated essential oils and methods of distillation. Toward the end of the 18th century the production of essential oils and flower oils began to flourish in France. One of the first characteristic types of "flower water" was orange flower water introduced by the duchess of Neroli. This flower water, also known as neroli, forms an important part of eau de cologne and was introduced by Johann Marie Farina about 1725. From 1725 to 1850 perfumes changed from the fresh colognes to the more floral types. In 1850 the fancy or sophisticated perfumes of France made their appearance. Originally, they were based on tinctures of benzoin, vanilla, vetiver, patchouli, etc. The closing decades of the 19th century saw the advent of synthetic chemicals in perfumery and these made possible a greater variety of odour effects. Investigations since then have been associated with J. B. A. Dumas (1800–84), P. E. Marcelin Berthelot (1827–1907), W. A. Tilden (1842–1926), O. Wallach (1847–1931), and E. Charabot (1870–1938).

Another minor revolution came in the perfumery field when heavy flowery notes were modified with amyl (isoamyl) salicylate and methylnonylacetaldehyde. This vogue, still popular, was followed by perfumes with the accent on green, woody, and animal notes, as typified by sandalwood, vetiver, musk, and civet. Just before World War II, it became fashionable to accentuate the green notes; styralyl acetate (phenylmethyl carbinyl acetate) in particular found favour for this purpose. Great Britain is greatly influenced by Paris in its choice of perfumes, although certain floral types are very popular; *e.g.*, lavender, rose, and lily of the valley. In the Netherlands hyacinth and lilac are popular. About 1945, the French fashion houses brought in the "new look," a throwback to 1900, and perfumes likewise revived the powdery notes of the 1900 period—vanillin, orris, opopanax, etc. Spain and South America appear to remain loyal to their heavy spicy notes, while the best sellers in the United States have been based on the heavy exotic flowers idiom, although many of the famous French perfumes are also appreciated. (*See* also COSMETICS AND COSMETOLOGY: *Historical Development;* ESSENTIAL OIL: *History;* DISTILLATION: *Historical Note.*)

RAW MATERIALS

Perfumery raw materials may be divided into three main groups: (1) the essential oils and products isolated from these oils; (2) products of animal origin; and (3) synthetic chemicals.

The Essential Oils.—An essential oil (*q.v.*) consists of complex mixtures of volatile liquid and solid chemicals. These oils occur in various parts of plants and in some cases quite different types of oils are found in various parts of the same plant; *e.g.*, orange oil from the peel, petitgrain oil from the leaves, and neroli from the flowers of the orange tree. Typical examples are: *flowers* (jasmin, rose, mimosa, violet, ylang-ylang, orange blossom); *flowers and leaves* (lavender, rosemary, violet); *leaves and stems* (geranium, cinnamon, patchouli, petitgrain); *barks* (cinnamon, cassia); *woods* (sandalwood, cedarwood, rosewood); *roots* (vetiver, angelica); *rhizomes* (orris, ginger); *fruits* (orange, lemon, lime, bergamot); *seeds* (aniseed, nutmeg); *resinous exudations* (myrrh, benzoin, styrax).

It is uncertain whether the essential oils are present as a result of photosynthesis or whether they are simply by-products of plant metabolism. One earlier theory suggested that two simple chemicals, namely acetone and acetaldehyde, could be formed from carbon and water. These two chemicals can react to produce the important material citral and from citral many chemicals found in essential oils can be formed. A physiological synthesis from sugars has also been postulated. However, it now seems likely that acetic acid is the basic unit. Three molecules of this chemical may be converted biogenetically into senecioic acid with a loss of the carboxyl group. This provides the basic five-carbon isoprene unit. Fairly straightforward reactions can now be visualized which will yield the terpenes and derivatives such as myrcene, geraniol, and linalool. Evidence for alternative biological routes has also been found, *e.g.*, in the synthesis of the sterols.

Constitution.—All essential oils consist of a complex mixture of chemicals and this is true even in the case of those that contain a preponderance (*i.e.*, 80–90%) of one constituent. The great bulk of the constituents of the oils belong to a group of organic compounds known as the terpenes (*q.v.*), which include hydrocarbons of the formula $(C_5H_8)_n$ and their oxygenated derivatives. These compounds are peculiar in that most of them may be regarded as being derived by the fusion of isoprene units. Thus two isoprene units when fused yield the monoterpene (*e.g.*, limonene) structure, while three give the sesquiterpene (*e.g.*, cadinene) skeleton.

Hydrocarbons such as these can give rise to a large number of oxygenated derivatives; *e.g.*, alcohols and their esters, aldehydes and ketones. Some of the more important of these are geraniol, citronellol and terpineol, citral and citronellal, and, finally, camphor.

Besides the terpene family, a number of other organic compounds frequently occur in essential oils. These include a number of aliphatic aldehydes and also aromatic compounds including phenols such as eugenol.

Methods of Extraction.—The essential oils are separated from the plant by steam distillation and by extracting with volatile solvents such as benzene, lythene (a low-boiling, purified fraction of petroleum), and, in some cases, alcohol and butane. Two other methods are extraction with fats (enfleurage method) and a simple pressing of the oil from peels, as, for example, with lemon oil. Although certain oils will not withstand the somewhat harsh treatment of steam distillation, many oils (including most of the root, wood, bark, and leaf oils) are processed in this way.

In many cases the trees are cut down and the wood, etc., is taken to a local distillation unit, the oil obtained then being sent to central bulk depots before final distribution. For years the distillation units were crude vessels; the wood, leaves, etc., were placed in the vessels, water was added and the vessels were heated by fire. Water and oil distilled over and the oil was separated. The modern tendency is for processing plants to be erected where it is possible to inject steam into the vessel and where extraction can be performed under modern conditions.

Extraction by volatile solvent in most cases gives a bigger yield and extracts the oil in a more gentle fashion than does steam distillation. In some cases, leaves, petals, mosses, etc., are simply stirred in a large vessel with the solvent and, when the extraction is complete, the solution is passed through a filter and the solvent distilled away. In another method, batteries of percolators, each with a capacity of about 100 gal., are fitted with perforated trays on which the flowers are placed. At one end of the series is a solvent tank and at the other end a vacuum still. The solvent runs slowly through the various percolators and finally reaches the vacuum still, where it is distilled away and returned to the solvent tank, the perfume remaining in the retort. The process is repeated many times until the flowers are exhausted of their perfume. The product left behind contains insoluble waxes in addition to the perfume oil and at this stage is known as a "concrete." On treatment with alcohol and ultimate removal of the alcohol, the "absolute" is obtained. Jasmin flowers yield about 0.3% and roses about 0.24% of concrete. In some cases the petals are pressed to break up the cells and under these circumstances the yields are often higher.

In the enfleurage extraction method, the petals are placed on glass trays (chassis) upon which a layer of specially purified animal fat has been spread. The trays are stacked together so that

the petals are contained between two layers of fat and then are left for about 24 hr., during which time the volatile oils are absorbed by the fat layer. Petals are replaced by fresh ones every day until the fat is saturated with the flower oil. Extraction of the mass (the pomade) with alcohol separates the fat and yields the floral absolute.

Enfleurage extraction is particularly valuable in the case of certain flowers, *e.g.*, jasmin and tuberose, that continue to produce perfume after picking, for only by the gentle process of enfleurage is it possible to extract the maximum yield of oil from the petal. With most other flowers, the production of essential oils ceases on picking and therefore a more drastic extraction process, such as with hot fat, gives the maximum oil yield. Hot fat extraction has, however, been almost entirely superseded by solvent extraction. The enfleurage process does not remove all the oil from the petal and valuable oil is also lost in the traces of fat adhering to the exhausted petal. The exhausted petals are therefore normally solvent-extracted so that they yield the so-called absolutes of chassis.

As previously mentioned, oils are often distilled under very rough conditions. The collecting of the wood, leaves, etc., constitutes a great deal of work and time, and often one ton of vegetable matter will yield only a few pounds of oil. As the various small producers have to send their oils to central bulking depots, the oils that eventually arrive in the large collection centres (*e.g.*, a seaport) have passed through many hands. Thus much time, labour, and transport, to say nothing of supervision, is required to produce an essential oil.

The following chemicals are isolated from the essential oils, usually by distillation in a commercially pure state, and are employed in perfumery: geraniol and citronellal from citronella oil (Java, Formosa, and Chinese grades); citral from lemon-grass oil; eugenol from clove oil; linalool from bois de rose (rosewood) oil; and safrole from sassafras oil. In many cases the natural isolates are reprocessed to produce other important perfumery chemicals; *e.g.*, geraniol is converted to citronellol, citronellal to hydroxycitronellal, citral to ionone, eugenol to isoeugenol and vanillin, linalool to linalyl acetate, and safrole to isosafrole and heliotropin.

Products of Animal Origin.—Most of the animal products are used only in high-class handkerchief perfumes and in the form of alcoholic tinctures. They include musk from the musk deer, ambergris from the sperm whale, civet from the civet cat, and castoreum from the beaver.

Synthetic Chemicals.—There is a tendency to regard the synthetics in perfumery as "poor relations" of the natural products but this is completely unrealistic as an essential oil may cost much less than a synthetic. Further, the enormous number of man-made chemicals available to the perfumer make this group not only of great importance now but of even greater significance for the future. In addition, many of the important natural isolates have been synthesized and are available in large quantities; these products include citral, geraniol, linalool, and derivatives made from them. Important milestones in the development of synthetic perfumery chemicals include the synthesis of phenylethyl (phenethyl) alcohol by B. Radziszewski in 1876, musk xylol and musk ambrette by A. Baur in 1891, ionone by F. Tiemann and P. Kruger in 1893, hydroxycitronellal and undecalactone in 1905, and amyl cinnamic aldehyde in 1927 (synthesis published in 1927 although the chemical had been available previously).

The synthetic chemicals offer a wide selection of odour characteristics, ranging from those with typical floral effects to odours unknown in nature. Many thousands cover many types and strengths. Chemically, they include hydrocarbons, alcohols, esters, aldehydes, acetals, ketones, ethers, amino compounds, nitro bodies, lactones, phenols, and, in many cases, chemicals containing more than one of the foregoing groups.

Odour effects of a chemical depend upon many factors, *e.g.*, the presence of one or more active odour groups (osmophore), the position of the group, the presence and position of other groups in the molecule, the size of the molecule, and its vapour pressure. Literally hundreds of thousands of odorous chemicals are theoretically possible and many thousands have been prepared.

Certain of the synthetic chemicals possess odours that are distinctly floral in character; the chemicals and their odours include isoamyl salicylate (clover), amyl cinnamic aldehyde (jasmin), anisaldehyde (*p*-anisaldehyde; hawthorn), citronellol (rose), benzyl acetate (jasmin), cyclamen aldehyde (cyclamen), geraniol (rose), heliotropin (heliotrope), hydroxycitronellal (lily of the valley, lilac), ionone (violet), phenylethyl alcohol (phenethyl alcohol; rose), and terpineol (lilac).

Of special interest is a range of chemicals made with castor oil as the starting material. These include the above-mentioned amyl cinnamic aldehyde; undecalactone (peach odour), and *gamma*-nonyl lactone (coconut odour).

PREPARATION AND USE

The Architecture of a Perfume.—Is perfumery an art or a science? Without science little progress would have been made in perfumery. The scientist has given perfumery its raw materials, whether won directly from nature or produced by chemical synthesis; he adds continually to the vast store of raw materials and indicates the way in which they may be used in finished products. However, perfumery is an art and not a science: It is not enough to say science has provided an analysis of, say, rose oil; artistic creation is the key to the production of a successful rose perfume and no ordinary application of scientific data will achieve this end. Scientific blending of perfumery ingredients is not yet possible, but research indicates that it may become so.

It is not entirely fanciful to compare perfumery with music and painting. All three arts commence with a basic idea, the painter beginning with his background sketch, the musician with his theme or motif, and the perfumer with his skeleton or primary accord. Around and into these ideas are blended the harmonizing colours, sounds, and odours. The painter seeks to balance his light contrasts so that even the sharp edge of a table blends naturally into the scene. Balance in music is accomplished by the judicious harmonizing of instruments, or orchestration, and achieves accord by the use of different keys to avoid repetition.

The perfumer adds to his primary accord his harmonizing or blending odours. His equivalent of key variation and shading is his "layer blending," *i.e.*, his harmony of "top notes," "middle notes," and "back notes." The comparison may be pursued, for example, in the selection of one outstanding ingredient, whether sound, colour, or odour, and in the building up of the work around this basic subject. In music the concerto places emphasis on one instrument with orchestral accompaniment; in painting, a colour, say blue, is selected and laid shade on shade; and so in perfumery it is possible to select one odiferous body, for instance, amyl salicylate, patchouli, or even a rose or jasmin accord, and to build a perfumery concerto around it. Even a strong ingredient, difficult to use, may successfully be made the central odour of a perfume. Perfumery is more analogous to music than to any of the other arts, if only on account of the intangible nature of music and perfumery.

Such a description of perfumery implies that perfumers are artists, and it is true that a good perfumer must be aesthetically sensitive. It is, however, a hard fact that perfumers must practise their art against a commercial background, and sheer intuition is not a sufficient guarantee of success. After all, there is a low limit to the number of people who can be given the opportunity to spend their time in free experiment and the creation of new perfumes without at the same time contributing something to their application and indicating the nature of future requirements in the form of new ingredients. Ideally, the successful perfumer should have, as well as artistic sense, a sound background of organic, inorganic, and physical chemistry. If he is concerned with perfumes for cosmetics or soap, then he must possess an intimate knowledge of these subjects. Further, the perfumer has some thousands of raw materials to employ, he is concerned with the hazards his creation must eventually face, and, in addition, he often has to identify ingredients from a complex blend, and this calls for an intimate knowledge of large numbers of separate items. Finally, most perfumers must be able to give a critical assessment of the purity of the many raw materials with which they are concerned.

Manufacture.—The actual mixing together of the various ingredients of a perfume is not a complicated process. Once the formula has been established and the raw materials checked and accepted, then little remains but to stir them together into one homogeneous mixture. However, perfumery materials may be expensive and in many cases subject to deterioration if harshly treated. Further, a perfume will often consist of liquids, solids, and resinous products, which means that some special technique must be adopted to ensure a perfectly uniform mixture.

The size of batch production will to some extent decide the type of mixing vessel to be employed. Although glass may be used in the case of small production, stainless-steel vessels are normally employed. In most cases, the batch is mixed by high-speed propeller-type stirrers. The nonliquid portion of the formula is placed in the vessel and to this is added the relatively high-boiling ingredients. The contents of the vessel are thoroughly stirred until solution is effected. Under certain circumstances it is possible to introduce heat (up to 50° C) to speed up the rate of solution. The more volatile constituents are added when the mixture is cold and the whole is thoroughly stirred. The finished mixture is pumped from the vessel through a filter system to the storage vessels. It is essential that contact with copper and iron be avoided during all stages of production, as these metals may have adverse effects on the perfume constituents.

Use of the Finished Perfumes.—*Alcoholic Solutions.*—The word "perfume" is generally understood to mean the product sold in an attractive container for use on handkerchief, dress, or body. Such an item is an alcoholic solution of a complicated mixture of odorous ingredients. In a handkerchief perfume the odour ingredients may occur to an extent of 5% to 20%. In a toilet water (lavender water or eau de cologne) the amount may vary between 2% and 10%. The concentrated perfume is dissolved in alcohol, usually in glass-lined vessels, and allowed to mature for several months, after which the solution is filtered and bottled.

With the expensive type of perfume, use is made of tinctures (alcoholic solutions) of certain products. Thus tinctures of musk and ambergris are added at a late stage of manufacture. There are two reasons for this special treatment: in the first place, these materials are very expensive and, secondly, they require an individual alcoholic extraction and cannot be added to the original concentrated perfume.

Nonalcoholic Solutions.—Important as the alcoholic perfumes may be, in terms of tonnage they represent only a small portion of the odorous products sold in the world. Soap alone accounts for a large amount of the perfume used. In fact, many of the commercial products used in the 1960s contained perfume in some form. Cosmetics account for a large share of the more expensive perfumes used but huge amounts of inexpensive perfumes are used in the detergent industry. The rubber, leather, textile, plastic, and insecticide industries also make use of perfume.

The selection of a perfume for a specific product requires knowledge of the chemical and physical properties of the perfumery ingredients and of the product itself. There are two distinct aspects to be considered. In the first place, the odour of a chemical may be modified when placed in a new medium; *e.g.*, the odour of a perfume perceived in concentrated form or in alcoholic solution may be quite different when present in soap or detergent. Powders also exert a great effect on odorous materials; the effect is often selective, so that certain odours in a perfume may be accentuated in a base such as talc, while others may be considerably reduced. This can result in a complete unbalancing of the original odour effects. The second effect that may occur affects stability of both perfume and product. For instance, soaps may have an adverse effect on a perfume. Colour may develop or the perfume may deteriorate because of the alkaline nature of the soap. On the other hand, a perfume may itself exert an adverse effect on a product. The perfume may combine with ingredients in the product to produce unwanted colour or it may change the consistency of a product; *e.g.*, a perfume may reduce the stability of a cosmetic emulsion or change the original consistency in some way.

See also references under "Perfume" in the Index.

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PERGA (Greek PERGE; modern MURTANA in the *il* of Antalya, Turkey), an ancient city of Pamphylia, situated about 8 mi. (13 km.) inland from the Mediterranean at the junction of a small stream (Sarisu) with the Cestrus (Aksu Cayi). It was a centre of native culture, as contrasted with Greek, which was predominant in Attaleia (Antalya), and a great seat of the worship of "Queen" Artemis, here represented as a human-headed cone, a purely Anatolian nature goddess.

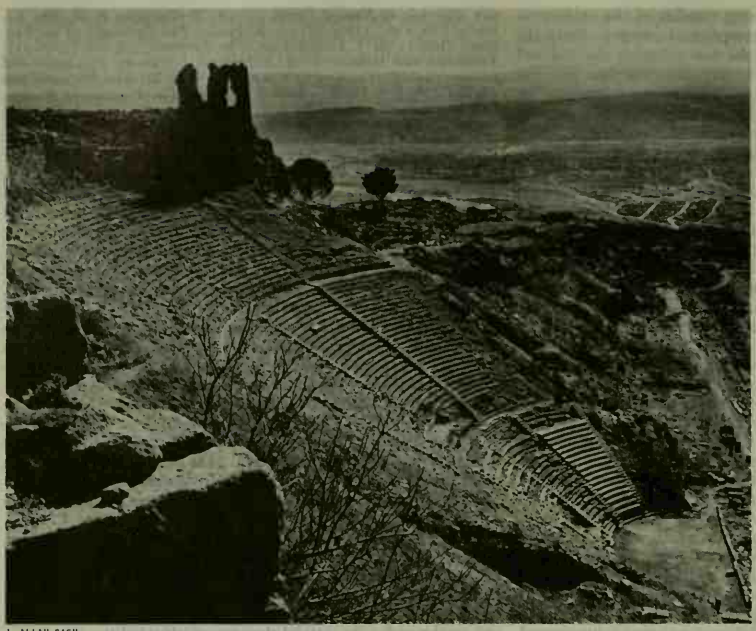
In Perga, Paul and Barnabas began their first mission in Asia Minor (Acts 13:13). A difficult mountain route into Phrygia began at Perga, and Alexander used it for his invasion of inner Asia Minor. Long the metropolis of Pamphylia Secunda, Perga was superseded in Byzantine times by its port, Attaleia, which became a metropolis in 1084. The extensive ruins all lie in the plain south of the acropolis. The walls, which are well preserved, are of late Roman or Byzantine reconstruction. The most notable monument is the theatre outside the walls on the southwest. Nearby is a fine stadium, while within the walls are ruins of two basilicas, baths, and the agora. (WM. C. B.)

PERGAMUM (PERGAMUS; modern BERGAMA in the *il* of Izmir, Turkey), an ancient Greek city in Mysia situated 16 mi. (26 km.) from the Aegean Sea on a lofty isolated hill (about 1,000 ft. [300 m.]) on the north side of the broad valley of the Caicus (modern Bakir) River. The peak of the hill served as a fortress and residence for the Attalid dynasty which ruled the city in the 3rd and 2nd centuries B.C. The residential part of the city was on the lower slopes of the hill, on ground now mostly occupied by the modern town. In the time of the Roman Empire the city was situated in the plain below.

Pergamum is known to have been in existence in the 5th century B.C., but practically nothing is known of its early history. As the capital of the Attalid dynasty it developed during the 3rd and 2nd centuries B.C. into a flourishing city. Though formally autonomous, it was completely under the control of the kings, who even regulated the functions of the minor magistrates.

Excavations, begun in 1878 under the auspices of the Berlin Museum, besides unearthing many artistic treasures, have enabled archaeologists to reconstruct the plan of the most important areas of the Hellenistic city. Cut into the western slope of the hill there stood a theatre. Above this lay the principal temple of the city, that of Athena Nicephorus, its courtyard set about with porticoes, with, on one side, the library (in fame second only to that of Alexandria). To the south lay the great altar of Zeus with its richly decorated frieze, a masterpiece of Hellenistic art and one of the wonders of the ancient world. A part of this altar and its surviving reliefs, restored and mounted, now stands in the Pergamon Museum in Berlin. On higher ground there was in Roman times a temple dedicated to the emperors Trajan and Hadrian (earlier probably the site of a temple of Zeus); the royal palace, the barracks, the storehouses, and the military arsenal stood close by. Below the altar of Zeus a street descended at a very steep incline to the central part of the city. Here lay what may be termed the civic buildings (as opposed to the royal structures of the upper city): a large market place, a gymnasium, and temples of Hera and Demeter. Roman remains include an amphitheatre, a theatre, and a racetrack. Outside the city to the southwest there was a temple of Asclepius, associated in the 2nd century A.D. with the activity of the famous physician Galen, who was a native of Pergamum.

Of the structures in the upper part of the Hellenistic city it would appear that the military buildings, the palace, and some of the religious monuments in their early form were erected in the 3rd century B.C. by the first rulers of the Attalid house. But a far-reaching program of rebuilding and new building was carried



J. ALLAH CASH

RUINS OF THE HELLENISTIC THEATRE AT PERGAMUM

through by the later kings Eumenes II and Attalus II, and it was chiefly their work that made the city famous for its architecture and its art (in spite of its library it never rivaled Alexandria in scholarship). Eumenes II built a very strong wall for the city and enlarged its area; he was also responsible for the development of the civic buildings referred to above. The work of the earlier king Attalus I, though overshadowed by the achievements of his successors, should not be overlooked. The kings after Attalus I are known to have collected many works of art from Greece to adorn the temples and courtyards of the city; these were additional to the numerous works of sculpture, painting, and decoration commissioned from resident artists.

Pergamum has a history of continuous occupation. Under the Byzantine Empire it was refortified. It passed into Muslim hands early in the 14th century. It is still an administrative and commercial centre of importance with a population in 1960 of 21,689. Its population in the time of the Roman Empire has been estimated at about 200,000.

See also ATTALID DYNASTY; ATTALUS; EUMENES; GREEK ARCHITECTURE; GREEK ART; and references under "Pergamum" in the Index.

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PERGOLESI, GIOVANNI BATTISTA (1710–1736), Italian composer, whose intermezzo *La serva padrona* was one of the most celebrated stage works of the 18th century, was born at Jesi, near Ancona, on Jan. 4, 1710, the son of a surveyor. His family name was Draghi but, having moved to Jesi from Pergola, the family was called Pergolesi or Pergolese, meaning "of Pergola." Pergolesi first studied music locally. From 1726 he attended the Conservatorio dei Poveri at Naples, where his masters included D. Matteis, G. Greco, L. Leo, and F. Durante and where he earned a high reputation as a violinist. In 1731 his oratorios *La conversione di S. Guglielmo d'Aquitania* and *La morte di S. Giuseppe* and his opera *Salustia* were performed at Naples but with little success. In 1732, when he had become acquainted with the work of A. Scarlatti, he was appointed *maestro di cappella* to the prince of Stigliano at Naples and produced a Neapolitan *opera buffa*, *Lo frate 'nnammorato*, which was well received. In December of the same year his Mass, commissioned as a thanksgiving for delivery from an earthquake at Naples, was also performed with success. In August 1733 his most important stage work was first produced. This was not his *opera seria*, *Il prigionier superbo*, which received the cool reception usually reserved for his serious operas, but the gay little intermezzo *La serva padrona*, on a libretto by G. A. Federico, inserted between the acts. In February 1734 Pergolesi was appointed deputy *maestro di cappella* of Naples and in May went to Rome to direct the performance of his Mass in F. In October 1734 he produced another *opera seria* at Naples, *Adriano in Siria*, with the intermezzo *Livietta e Tracollo*. On his return to Rome his best *opera seria*, *L'Olimpiade*, met with no more success than his Neapolitan ventures. His comic opera *Flaminio* was well received in Naples in 1735; but his health was now failing, and in February 1736 he left Naples for the Capuchin monastery at Pozzuoli, near Naples. There he managed to finish his last work, the celebrated *Stabat Mater*. He died in extreme poverty at the age of 26 and was buried at the cathedral at Pozzuoli on March 17, 1736.

When Pergolesi died his fame had scarcely penetrated beyond Rome and Naples, but later in the century his reputation grew enormously. After the posthumous success of *La serva padrona* and particularly after its performance in 1752 in Paris, where it led to the *guerre des boufons* (*see* OPERA: *18th-Century Developments*), forgers became busy producing spurious Pergolesiana, and a number of works bearing the composer's name are either known to be by other composers or are of doubtful authenticity. These include some of the works ascribed to Pergolesi by Igor Stravinsky in the arrangements he made for his ballet *Pulcinella*, produced by Sergei Diaghilev in 1920. Pergolesi's serious style is best illustrated in his *Stabat Mater*, his ability to wield large choral and instrumental forces, in his Masses, and his gift of comic characterization in *La serva padrona*.

His works, *Opera omnia*, were edited by F. Caffarelli in 27 volumes (1939–42). They include some works of doubtful authenticity, such as the six concertinos for strings published at The Hague about 1730 by C. B. Ricciotti and the trio sonatas which in some early manuscripts are ascribed to D. Gallo.

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PERI, JACOPO (1561–1633), Florentine singer and the first composer of opera. Born in Rome on Aug. 20, 1561, of noble stock, he studied with C. Malvezzi in Florence and entered the service of the Medici about 1590. He became a member of Count Bardi's *Camerata*, the learned coterie that attempted to reconstruct the authentic presentation of ancient Greek drama; they held that the plays were sung throughout, and their desire to find a form of

music completely subservient to the words and the dramatic action led them to abandon traditional polyphony and to experiment with recitative—a lightly accompanied, naturalistic speech-song for voice and continuo alone. Ottavio Rinuccini's *Dafne*, a pastoral play modeled on T. Tasso and G. B. Guarini, was set to music in this style by Peri (with some contributions from Count Corsi) and performed with great success in 1597. The music of *Dafne*, the first opera, is almost entirely lost, but Peri's next work (a setting of Rinuccini's *Euridice*) was printed and survives; it was commissioned for the wedding of Maria de' Medici and Henry IV of France on Oct. 6, 1600. *Tetide* (1608) and *Adone* (1620), written for Mantua, apparently remained unperformed and are now lost. Marco da Gagliano's *Flora* (Florence, 1628), for which Peri wrote and sang the part of Clori, survives. From 1609 to 1625, Peri composed or collaborated on ten ballets, *feste*, masquerades, and interludes for the Florentine court; none of these found a printer and most have disappeared. Further short pieces in manuscript and printed collections, together with *Euridice* and the fine continuo madrigals of *Le varie musiche* (1609), show Peri as a sensitive composer, remarkable as much for his control as for his daring. He died in Florence on Aug. 12, 1633.

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PERIANDER (ruled *c.* 627–586 B.C.), the second tyrant of Corinth (*q.v.*). In contrast with his father, Cypselus, the founder of the dynasty, he is generally represented by Greek writers as a cruel despot, the tyrant par excellence. Much of this tradition probably derives from the Corinthian nobility, with whom he appears to have dealt harshly. The firmness and activity of his government are beyond dispute. It is said that under him the commercial prosperity of Corinth was so great that he could rely for revenue on tolls on goods entering Corinthian ports. To promote and protect Corinthian trade he established colonies at Potidaea in Chalcidice and at Apollonia in Illyria; he is said to have built the carriageway (*dialkos*) across the Isthmus of Corinth and to have planned a canal through it. In Greece proper he conquered Epidaurus and annexed Corcyra. He cultivated friendly relations with Thrasybulus, tyrant of Miletus, and maintained a connection with the kings of Lydia and of Egypt; his nephew and successor, Psammetichus, was so called after the Egyptian pharaoh Psamtik. Periander arbitrated in the struggle in northwestern Asia Minor between Athens and Mytilene, and awarded Sigeum to Athens.

Periander was also a patron of literature, for it was by his invitation that the poet Arion came to Corinth from Lesbos. He was reckoned one of the Seven Wise Men of Greece and was the reputed author of a collection of maxims in 2,000 verses.

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PERICARDIUM, DISEASES OF. The serous sac (pericardium) containing the heart may become the seat of inflammation (pericarditis) just as the cardiac valves and heart muscle may during the course of such acute diseases as rheumatic fever. (For anatomy, *see* COELOM AND SEROUS MEMBRANES.) The normal shiny appearance is lost; the membrane becomes congested; and inflammatory serum exudes into the cavity. In this stage the visceral and parietal layers grate upon one another with each heartbeat and give rise to a "friction rub" over the front of the chest which can be heard with the stethoscope and may be perceptible to the hand. As more inflammatory exudate collects, the surfaces are separated and friction disappears. Thereafter the course of the disease varies as the inflammation advances or recedes. The accumulation may become so extensive that it seriously impedes cardiac action; and if the pericarditis accompanies or follows pneumonia the fluid may become purulent. In either event exit must be given to the fluid surgically.

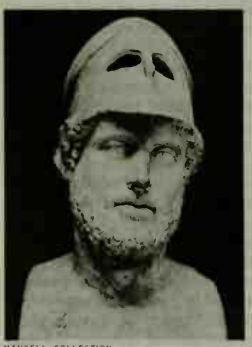
If the disease recedes the roughened pericardial surfaces again come into contact through absorption of the exuded fluid and friction reappears. Fibrous adhesions form between the pericardial layers over a greater or smaller area; sometimes they become universally adherent and the cavity is obliterated. Occasionally when the covering of the heart and the lining of its sac become firmly adherent one to another, the mechanical function of the heart is disturbed and congestive heart failure results. Calcium may be deposited in the pericardium, making the diagnosis much easier by its appearance in X-rays of the chest. For this condition there are highly successful surgical procedures.

Exudation of fluid into the pericardial cavity, apart from inflammation, occurs in certain diseases of the kidney; however, in these cases, which are often unaccompanied by symptoms, it is a serious omen. In rupture of the heart or in certain varieties of aneurysm the pericardial sac is suddenly filled with blood. Distress is extreme, and death from mechanical interference with the action of the heart occurs after a few seconds.

Another condition that occasionally results in accumulation of fluid in the pericardial sac is myxedema (hypothyroidism). This condition can be completely alleviated by the administration of thyroid extract. Tumours of the pericardium are very rare and are nearly always benign. They may cause mechanical difficulty in the heart's activity. *See* also HEART, DISEASES AND DEFECTS OF; HEART AND LUNG, SURGERY OF. (W. S. L.-B.; E. B. BY.)

PERICLES (*c.* 495–429 B.C.), Athenian statesman, largely responsible for the full development in the later 5th century of both the Athenian democracy and the Athenian Empire.

Background.—Pericles was the son of distinguished parents. His father, Xanthippus, a member of the leading house of a powerful Attic clan, probably the Buzygae, was an outstanding figure in the generation of the Greco-Persian Wars. His sympathies were then with the democratic group in the state, and he led the prosecution in the trial of Miltiades. In 485/484 he was ostracized by the people, who gave their favour to Themistocles, but he was recalled on the eve of the Persian invasion, commanded the Athenian squadron at Mycale, and conducted the siege of Sestos. Nevertheless he was rapidly displaced by Miltiades' son, Cimon (*q.v.*); for the conservative group, led by the Areopagus Council, became dominant in the state after 478. The mother of Pericles, Agariste, was a niece of Cleisthenes, leader of the very wealthy Alcmaeonid clan, who had reformed the constitution in the democratic interest in 508–507 and had shown an unrelenting hostility toward Sparta. Pericles thus had an immediate entry into the ranks of the aristocrats and of the democratic group, "the people's faction," as it was called, and to his inherited assets of wealth and reputation he added an obviously able mind, a convincing integrity of character, and fine powers of oratory. By 465 when he was 30 years old, he shared the leadership of the democratic group with an older statesman, Ephialtes.



MANSELL COLLECTION

BUST OF PERICLES, FOUND AT TIVOLI, A ROMAN COPY FROM A MID-5TH-CENTURY B.C. MARBLE HERM, IN THE BRITISH MUSEUM

Pericles grew up in a period of confidence. The Greek states had defeated the mighty power of Persia, and Athens had become the acknowledged leader of a great alliance. The older generation, whose views are represented at their finest by Aeschylus (d. 456), had a deep faith in the orthodox religion of the Greeks; but the younger generation contained men of adventurous mind who preferred a more intellectual philosophy. Pericles combined a serene confidence with an original mind. His friends included Anaxagoras of Clazomenae, a rationalist who attributed the movements of the universe to physical processes activated by "mind"; Zeno of Elea, whose speculations on time, space, and movement gave rise later to the atomic theory of Leucippus; Damon of Athens, musician and philosopher, who inspired some of the tenets of the democratic

group; and Phidias of Athens, who sculpted the finest statues of Zeus, the god of the Greeks, and of Athena, the patroness of Athens. Pericles was, like them, progressive in his attitude to philosophy, music, and art, and he was a political theorist as well as a practical politician.

The Development of Democracy.—In 465 Athens stood at a crossroads. The policy of the Areopagus Council—hostility to Persia, friendship with Sparta, and cooperation with the allies in the Delian League—had culminated in Cimon's decisive victory over Persia at the Eurymedon River, and it was possible for Athens to continue the same policy. An alternative line of reasoning was that the defeat of Persia made it no longer necessary to be friendly with Sparta and to cooperate with the allies; a more strictly Athenian policy might now be pursued, but not so long as the Areopagus Council and Cimon were at the helm of the state. In 465 Athens inclined toward the second policy in attacking one of the strongest allies, Thasos, which had justifiably refused to give Athens a share in its possessions. At this time Ephialtes and Pericles opened a series of prosecutions against leading members of the Areopagus Council, who were tried in the people's courts. Some of these were successful, but a charge of corruption, laid against Cimon by Pericles, failed, probably in summer 462. A trial of strength occurred when Sparta appealed for help against the Messenians and the Spartan serfs, the helots. Ephialtes, describing Sparta as Athens' rival in the struggle for power, advocated refusal, but Cimon recalled the days of Spartan and Athenian cooperation against Persia and persuaded the assembly to send help. The issue was decided at home when Cimon and the hoplites of the army were overseas on service. Then Ephialtes and Pericles obtained a majority in the assembly to rescind many powers hitherto held by the Areopagus Council and to transfer them to the democratic Council of Five Hundred (the boule; *q.v.*) and to the people's courts. When Cimon returned, the people confirmed their choice of the democratic leaders by ostracizing him in the spring of 461. A month or two later Ephialtes was assassinated, and Pericles found himself the surviving leader of the democratic group.

Pericles was a firm believer in the sovereignty of the people, which was directly expressed in the majority vote of the citizens in the assembly and of a section of them in the people's courts. On his proposal the assembly removed further powers from the Areopagus Council, and the people's will was now untrammeled except by the rules of procedure (which required, for example, a preliminary recommendation by the boule) and by respect for established law and precedent. During the next ten years most offices of state were made open to any citizen, whatever his financial position might be; state judges were instituted to supervise local courts and curtail local influence; and on Pericles' own proposal Athenian citizenship was granted only to men of Athenian parentage on both sides. Thus the privileged circle of citizenship was closed, and within it equality of political opportunity under the democracy was safeguarded. Thus in 462–454 the foundations of the Periclean type of democracy were firmly laid, and there is no doubt Pericles himself played the leading part in the development.

The Policy of Expansion.—In the field of foreign affairs Pericles had less experience in 461. As a general he was far surpassed first by Cimon and then by Tolmides, Myronides, and others, but as an orator in the assembly he was able to influence the foreign policy of the state. In the hour of Sparta's weakness the Athenians allied themselves with Sparta's enemies Argos and Thessaly, and then with Megara against Sparta's loyal ally Corinth; and they delivered a strong offensive against Epidaurus, Corinth, and Aegina in 458. Next year the Spartan army, weakened though it was, joined forces with the Boeotians and marched toward Attica. Pericles distinguished himself in the ensuing battle at Tanagra, the only occasion in his lifetime when the Athenian army faced a Spartan army in battle. The verdict was slightly in favour of Sparta; the Spartan army marched home through the territory of Megara, and the point was established that Athens had little or no hope of defeating Sparta on land. Boeotia, however, was exposed to attack by the Athenians, who overran the cities and set up a number of "democratic" governments. In the same year, 457, Pericles achieved his desire to conquer Aegina, "the eyesore of the Piraeus," as he called it, and he completed the task entrusted to him by the assembly, the building of the Long Walls from Athens to the Piraeus which made the city almost impregnable and ensured access to the sea. The Athenian navy raided the coasts of the Peloponnese, occupied Naupactus as a base in the Corinthian Gulf, and under Pericles' command in 455 won over most of Acarnania. The spectacular success of Athenian arms, except in the all-important trial of military strength with Sparta, seemed to justify the adventurous foreign policy of the democracy, even if it involved some rough handling of the allies in the Delian League. (*See* also DELIAN LEAGUE.)

Simultaneously, however, Athens engaged in a major war in Egypt against Persia. It is not known whether Pericles favoured this course, but he certainly learned from it to avoid a war on two fronts. At first all went well; an allied fleet, to which Athens contributed only a small squadron, won a victory on the Nile and the Egyptians expelled the Persians. But the Persians returned to the attack in strength and captured the entire expeditionary force in 454. This disaster shook Athens' position as a sea power and as leader of the allies in the Delian League. The people turned to Pericles in this crisis. He took command of the western fleet and brought it to the Piraeus; he was given charge of the "allied treasury," which the Athenians transferred from Delos, thus depriving the allies and making themselves masters of great financial reserves; he desisted from operations against the Peloponnese and then obtained a truce through the good offices of Cimon, who was recalled, on the proposal, probably, of Pericles. The truce lasted to 446. Meanwhile Pericles concentrated on recovering a number of allied states which had seceded from the Delian League and on preparing for an offensive against Persia; in 450 Cimon led a fleet of 200 ships to victory in Cyprus and died shortly afterward. Negotiations were opened with Persia, and peace was concluded in 449/448 with defined spheres of interest.

The Athenian Empire.—Although Pericles left negotiations with Sparta and war with Persia to Cimon, he outmaneuvered him at home and carried through two radical policies. He confirmed the people's loyalty to the democracy by enlarging the number and the powers of the people's courts and by introducing a system of state pay, which benefited the poorer citizens especially and enabled them to fulfil political and judicial functions. Second, he converted the Delian League from an alliance to an empire by reducing to dependent status those states which had revolted and by planting outposts of Athenian citizens, known as cleruchies, at strategic points on "allied" territory. His methods involved political, military, and judicial intervention, but he was probably correct in seeing that otherwise the Delian League would dissolve and leave Greece weaker in facing Persia. His main concern, as always, was the aggrandizement of Athens, and he tried to isolate Sparta by a diplomatic offensive, probably in 448. He invited all Greek states to attend a panhellenic conference at Athens, where it was planned to celebrate the end of the Greek war with Persia, terminate all internal wars in Greece, and proclaim the freedom of the seas for all Greek ships. But the members of the Spartan alliance refused the invitation, and no conference was held.

Even with Persia at peace and the empire under control, Pericles just saved Athens from disaster in 446–445. The oligarchs whom Athens had exiled from Boeotia, Locris, and Euboea combined to defeat an Athenian army and liberated the whole of Boeotia from Athens. Then Euboea revolted, and while Pericles led an army thither the Megarians rose and killed the Athenian garrison. Pericles hurried back to find a combined army of Peloponnesians, Megarians, and Boeotians invading Attica under the command of a Spartan king. The army suddenly withdrew. Pericles, it was believed, had bribed the Spartan king. Negotiations were opened for a settlement. During them Pericles reduced Euboea to obedience. In winter 446–445 the Thirty Years' Treaty was concluded: it was a pact of nonaggression between two blocs of power —Athens and its empire and Sparta and its allies—and any dispute was to be settled by arbitration. Of disputed territories the Athenians were allowed to keep Naupactus, Aegina, and Euboea. The extrication of Athens from its dilemma in 454, the formation of the Athenian empire, the strengthening of the democracy, and the

securing of peace with Persia and Sparta were primarily due to Pericles, who had shown the highest gifts of diplomacy, foresight, and forcefulness.

The "Periclean Age."—Respite from war enabled Pericles to picket the empire more securely. Cleruchies were planted at Histiaea and Chalcis in Euboea, at Brea on the Thracian coast, and in the Chersonese. Athens still demanded tribute. With it Pericles maintained a standing fleet of 60 triremes to police the seas and launched a great building program to which the Parthenon and the Propylaea on the acropolis, the temples of Athena and Hephaestus and Ares in the agora, and those of Poseidon at Sunium and Nemesis at Rhamnus still bear witness. The policy of exploiting the so-called allies was challenged by Thucydides, son of Melesias, a relative of Cimon, who claimed that the Athenians had no right to use the allies' money in decking Athens out "like a harlot with jewels and statues and temples." In 443 the people chose between imperialism and cooperation: Thucydides was ostracized. Opposition to Pericles was thereafter expressed not in the assembly but in pamphlets such as the *Constitution of Athens,* falsely attributed to Xenophon and often referred to as "The Old Oligarch," composed *c.* 431. Opposition in the empire came to a head in winter 441/440, when Samos, one of the few allies still possessing a fleet, refused to accept arbitration by Athens in a quarrel with Miletus.

Pericles attacked at once and successfully. He imposed a heavy fine on Samos, removed a hundred hostages, set up a "democratic" government, and left Athenian commissioners and a garrison to support it. But the Samians, in collusion with the nearest Persian satrap, rebelled once more, and Byzantium rose in sympathy. Pericles had to deploy 200 ships and conduct a siege for nine months before the Samians capitulated on condition that they lost their fleet and walls, paid the cost of the war, and gave hostages to Athens. An example had been made of the strongest surviving "ally," and the peace treaties with Sparta and Persia had held firm during this dangerous operation.

Pericles also enlarged the area of Athens' influence between 445 and 435. Good relations with Egypt brought Athens gifts of grain; alliances were renewed with Rhegium in Italy and Leontini in Sicily; Thurii was founded in south Italy as a colony under Athenian leadership for volunteers from any Greek state; operations in the Ambraciote Gulf brought an alliance with Acarnania; a colony for Athens and its allies was founded at Amphipolis on the Strymon River in Thrace; and a strong fleet, commanded by Pericles, toured the Black Sea, planted colonies, and brought new accessions to the empire.

The constant activity of Athens was viewed with alarm by Sparta and its allies. At first Pericles was careful to observe the principles of the balance of power under the Thirty Years' Treaty by leaving the western seas to Corinth and keeping the Aegean free to Greek traders. But in 435 a quarrel started between Corinth and Corcyra, which endangered Corinth's sea power in the west. In 433 both states sent embassies to Athens. Advocates of peace advised the Athenians to keep clear of the quarrel, but Pericles persuaded the assembly to make a defensive alliance with Corcyra, and Athenian ships fought against Corinthian ships that autumn. In 432 Pericles proposed and carried a decree excluding Megara from all Athenian ports; and a colony of Corinth in the Aegean, Potidaea, ordered to dismantle its defenses, refused, hoping for help from Corinth and Macedonia. The nature and timing of these actions show Pericles determined to apply severe pressure on Sparta's allies, even at the risk of a general war. In 432 the Spartans took up the challenge: "If Athens," they said, "would retract, then peace would continue"; the alternative was war. Pericles advised the people not to yield, and hostilities began in 431.

The zenith of Pericles' career was in 445–431, the so-called Periclean Age. The balance of power with Persia and Sparta which gave Athens an assured peace and a growing prosperity was primarily due to his intelligent statesmanship and lasted as long as he wished it to last. Some of the wealth which accrued to Athens was expended at his direction on the magnificent temples and festivals, the fortifications and the fleet, and the policing of the seas. The democracy was developed and led by him. The large and enlightened middle class provided unusual stability under a constitution which entrusted all powers of direct government to the people, and Pericles' ideal of a liberal democracy with no social or financial barriers (as expressed by Thucydides the historian) came as near to actuality as was possible in an exclusive citizen body resting on a basis of slavery. Pericles was the pivot on which the constitution turned. He was elected each year by the whole people as their chosen general for 14 years in succession. His integrity, ability, and experience enabled him to dominate the assembly and impose his will alike in domestic and foreign policy. He inspired the citizens with his unqualified loyalty to Athens and with his ambitions for its future.

Peloponnesian War and Death.—Pericles was confident of defeating Sparta (*see* PELOPONNESIAN WAR) by a strategy of defense by land and offense by sea, causing a war of attrition in which a naval offensive would impoverish Megara, Corinth, Sicyon, and others, split the Spartan alliance, and force Sparta to a humiliating peace, whereas Athens had capital reserves, unassailable sea power, and an empire for supplies. For two years his strategy succeeded. He was chosen in 430 to deliver the funeral speech for the dead of the first year of the war and to command a raiding force of 150 triremes. Then plague struck Athens. One-third of the best troops died, including two sons of Pericles. He was deposed and fined by the demoralized citizens. They elected him general again in 429, but he died before the end of the year. Whereas his successors failed, Thucydides the historian believed Pericles would have led Athens to victory with that certainty of judgment and power of command which he had always shown. Posterity has been more impressed by the advanced democracy and the intellectual culture which he had created.

Pericles had a high forehead (the Attic comedians called him "squill-headed") and a composed, dignified expression which can be seen in a copy of a bronze head by Cresilas at the British Museum (no. 549). In private life Pericles associated himself with the progressive intellectuals, both thinkers and artists, some of whom suffered in the people's courts. He was a close friend of Sophocles, whose plays had something of Pericles' own serenity, confidence, and refinement. He formed a lifelong attachment to a courtesan, Aspasia (*q.v.*), who rivaled him in intellectual and cultural interests. His son by her, also called Pericles, was one of the generals at the Battle of Arginusae who were condemned to death in a mass trial by the democracy in 406.

See also GREECE: *History: The Great Wars in Greece;* and references under "Pericles" in the Index.

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PERIDOTITE is a dark, heavy, igneous rock containing at least 10% olivine; other iron- and magnesia-rich minerals, generally pyroxenes; and not more than 10% feldspar. Most peridotites are coarse-grained and granitoid, although some are coarsely porphyritic. Peridotite occurs in four main geologic environments: (1) interlayered with iron-, lime-, and magnesia-rich rocks in the lower parts of tabular-layered igneous complexes or masses; (2) as irregular masses, rich in olivine $(Mg,Fe)_2SiO_4$, with or without related gabbro, in alpine-type mountain belts; (3) in volcanic pipes (the variety known as kimberlite); and (4) as dikes and irregular masses with rocks exceptionally rich in potash and soda. The layered complexes are believed to have been formed in place by selective crystallization and crystal settling from a previously intruded fluid or magma; the remaining types seem to have ranged from fluid magmas to semisolid crystal mushes at the time of emplacement. Nearly all peridotite is more or less altered to serpentine (*q.v.*) and cut by many irregular shear surfaces.

Peridotite is the ultimate source of all chromium ore and naturally occurring diamonds, and of nearly all chrysotile asbestos. It is one of the main host rocks of talc deposits and platinum

metals and formerly was a major source of magnesite. Some varieties of serpentine (verd antique) are used as building and ornamental stone, and fresh dunite (pure olivine rock) is used in parts of glass furnaces. In warm humid climates peridotite and serpentine have weathered to soils and related deposits (*see* LATERITE) which, though now worked on a relatively small scale, are enormous potential sources of iron, nickel, cobalt, and chromium. (T. P. T.)

PÉRIER, CASIMIR PIERRE (1777–1832), French banker and statesman who exercised a decisive influence on the political orientation of the July Monarchy, was born at Grenoble on Oct. 21, 1777. He was the son of the manufacturer and financier Claude Périer (1742–1801), who dealt in national property (real estate) and became one of the first directors of the Banque de France. After service with the staff of the French Army in Italy (1798–1801), Casimir Périer returned to France and, together with his brother Antoine Scipion, founded a new bank. By 1814 Périer was one of the most important bankers in Paris; and he then had some part in the financial negotiations between the fallen emperor Napoleon, the French provisional government, the victorious Allies, and the Bourbon dynasty. Under the Restoration, when the duc de Richelieu's government in 1817 relied chiefly on foreign banks, especially the Amsterdam House of Hope and the London House of Baring, for the floating of a loan, Périer proposed on the contrary that French banks should play the preponderant role in it. Elected to the Chamber of Deputies to represent first Paris (from 1817) and then Troyes (from 1827), he sat with the moderate opposition of the left.

On the revolution of July 1830, which made Louis Philippe king of the French, Périer was elected president of the Chamber. He promptly made himself the spokesman of the "party of resistance," that is, of the right, in opposition to his rival Jacques Laffitte (*q.v.*). On March 13, 1831, he succeeded Laffitte as president of the Council of Ministers (premier) and minister of the interior. He thereupon set himself to restore order: the National Guard was brought into action against the demonstrations of the opposition in Paris; and later the Army put down the silkworkers' insurrection in Lyons (November–December 1831).

Périer pursued his own line in foreign affairs. Determined to resist the spread of revolution, he declined to intervene on behalf of the Polish insurgents against Russia. But he dispatched a naval squadron to Lisbon to force the absolutist government of Dom Miguel to compensate French merchants for damage (July 1831); he sent an army to defend the new kingdom of the Belgians against the Dutch (August 1831); and he ordered the occupation of the Adriatic port of Ancona by a French brigade, so as to check Austrian predominance in the Papal States (February 1832). Despite this active policy, he had to face continual attacks from the left and from the Legitimists; and his authoritarian manner sometimes alienated Louis Philippe also. Périer died in Paris on May 16, 1832, during the cholera epidemic. (JE. V.)

PERIGEE, in astronomy, that point in the orbit of a satellite, natural or artificial, which is nearest to the earth (Gr. *peri,* "near," *ge,* "the earth"). The perigee of the sun's apparent orbit and the earth's perihelion (*q.v.*) are so related that they differ 180° in longitude, the first being on the line from the earth toward the sun, and the second from the sun toward the earth.

PÉRIGNON, DOMINIQUE CATHERINE, MARQUIS DE (1754–1818), French army officer who made his name during the French Revolutionary Wars and became one of Napoleon I's marshals, was born at Grenade, near Toulouse, on May 31, 1754, of a family of lawyers. Having retired from the royal army, he was elected to the Legislative Assembly in 1791 but soon resumed active service. In 1793, when the Spaniards invaded Roussillon, he did well in the confused fighting there; and in 1794 he led the centre of Gen. J. F. Dugommier's army of the Eastern Pyrenees, which expelled the invaders and advanced into Catalonia. When Dugommier was killed (Nov. 18), Pérignon assumed command and took Figueras ten days later and Rosas in Feb. 1795. Under the Peace of Basel (July 1795), he went as the French Republic's ambassador to Madrid (1796–98). In 1799 he commanded a wing in Italy and was wounded and taken prisoner by the Russians at Novi (Aug. 15). Released, he was made a senator of France in 1801.

Pérignon was well treated by Napoleon, who made him a marshal (1804), governor of Parma (1806), and comte (1808). From 1808 he served in Naples. Adhering to the Bourbons on Napoleon's downfall, he was named a peer of France (1814) and appointed commanding officer first at Toulouse (1815), then in Paris (1816). Created marquis in 1817, he died in Paris on Dec. 25, 1818.

PÉRIGORD, an ancient *pays* (district) of southern France, corresponding to the bulk of the modern *département* of Dordogne (*q.v.*), with part of Lot-et-Garonne. It was bounded north by Angoumois, northeast by Limousin, east by Quercy, south and southwest by Agenais, and west by Bazadais, Bordelais, and Saintonge. The name was derived from that of the Gallic tribe of the Petrocorii or Petragorici, whose capital became Périgueux (*q.v.*). Sarlat, Bergerac, and Nontron were also important places. Counts of Périgord are recorded early in the 6th century A.D. and in 778. After a period in which the countship was attached first to that of Angoulême (*c.* 866–*c.* 963), and then to that of La Marche, it became a separate entity again *c.* 1006. Apart from quarrels with the bishops of Périgueux, the counts played their part in the troubled affairs of Aquitaine; and with the formal reduction of Aquitaine to Guienne in 1259 Périgord became an area of disputed suzerainty between the French and the English crowns (*see* GUIENNE; HUNDRED YEARS' WAR). Confiscated from the feudal dynasty of counts (1399), Périgord was granted to Louis de France, duc d'Orléans, but Charles d'Orléans sold it to the House of Blois-Penthièvre in 1438. Transferred to the House of Albret by marriage (1470), it was subsequently inherited by the crown of Navarre, and so was finally united with the French crown by Henry IV (1589). Under the *ancien régime* it was included in the province of Guienne and the *intendance* or *généralité* of Bordeaux.

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PÉRIGUEUX, a town of southwest-central France, *préfecture* of the *département* of Dordogne (former capital of the medieval province of Périgord Blanc), and an episcopal see, lies on the right bank of the Isle River, 120 km. (75 mi.) ENE of Bordeaux by road. Pop. (1962) 36,585.

Its two nuclei are the Cité and Puy-Saint-Front districts. The former occupies the site of the Roman town of Vesunna to the southwest; the latter, the medieval town to the east, surrounds the cathedral of Saint-Front. The modern town spreads to the west and northwest of Puy-Saint-Front. The cathedral of Saint-Front is a domed church of the Aquitanian school, built *c.* 1125–50. It has the shape of a Greek cross, with five lofty domes; and the in-

BY COURTESY OF THE FRENCH GOVERNMENT TOURIST OFFICE, CHICAGO

THE CATHEDRAL OF SAINT-FRONT IN PÉRIGUEUX, BUILT ABOUT 1125–50

terior is very bare. Its somewhat Byzantine appearance is due to wholesale restoration in the 19th century by Paul Abadie (the architect of Sacré Coeur in Paris). There is a Romanesque bell tower and 13th–14th-century cloisters are on the south side. At the northern edge of Puy-Saint-Front is the Musée du Périgord, with prehistoric and archaeological exhibitions as well as later secular and ecclesiastical art. In the Cité is the 12th-century church of Saint-Étienne, which was the cathedral until 1669 despite severe damage in 1577 during the Wars of Religion.

Northwest of this is a Roman arena of the 3rd century A.D.; and southwest stands the Château Barrière (12th–15th century) built on the boundary wall of the Roman *civitas*. Farther south, across the railway, is the so-called Tour de Vésone, believed to have been part of a Gallo-Roman temple to the goddess Vesunna.

Originally, Périgueux was the settlement of a Gaulish tribe, the Petrocorii, who called it Vesunna after a local spring which became their tutelary deity. When the barbarians came it shrank to a small encampment, the *civitas Petrocoriorum*—hence the modern forms, Cité (the part of the town where the *civitas* was situated) and Périgueux. A medieval town, Puy-Saint-Front (after St. Fronto or Frontonius, the apostle of Périgord in the 2nd century and Périgueux's first bishop) grew up between the 5th and 14th centuries around an abbey, burned down in 1120 and later replaced by the cathedral of Saint-Front. Périgueux struggled against the English throughout the Hundred Years' War, although they held it from 1361 to 1369. It suffered severely under Protestant occupation (1575–81) during the Wars of Religion. Amnestied by Louis XIV in 1654 for its part in the Fronde, it settled thereafter into an era of peace; but it had still to defend its privileges from the encroachment of centralized bureaucracy.

Under the Revolution, Périgueux continued as capital of a *département* covering exactly the same area as Périgord. From the July Monarchy (1830) onward many improvements were made and the town received new impetus under the Second Empire and the Third Republic. It is now one of the most attractive towns in southwestern France.

Périgueux is a road and rail junction, especially northeast for Limoges and southwest for Bordeaux. It is about 300 mi. (482 km.) from Paris by road and rail. There is an airport 5½ mi. (8.8 km.) E at Bassillac. Motor coach tours are organized for visitors wishing to see the surrounding countryside.

Internationally known for its pâté de foie gras, truffles, and wines, Périgueux is also an important hog market. Vegetable preserving is also carried on; and industries include the manufacture of hardware, cutlery, chemicals, textiles, and leather goods.

PERIM (Arabic MAYUN), an island and British possession in the Bab al Mandeb Strait about 100 mi. (160 km.) W of Aden. Pop. (1960 est.) 500. Area 5 sq.mi. (13 sq.km.). Perim is volcanic in origin, bare and strewn with boulders, and rather flat, with its highest point (214 ft. [65 m.]) in the south. It has a good small harbour on the southwest, with an entrance 860 yd. (786 m.) wide, and a small airfield. Perim, called Diodorus in the *Periplus*, was explored by Affonso de Albuquerque, who set up a cross there in 1513 and called it Vera Cruz. It was occupied by the French in 1738, and by the British in 1799. It was abandoned shortly after as waterless but reoccupied in 1857, just prior to the cutting of the Suez Canal, as a coaling and cable station. Both activities ceased in 1936. Included in Aden Colony in 1937, it was separated in 1963 by the Perim Order in Council. The High Commissioner of Aden is the legislative authority for Perim, while administration is in the hands of a commissioner for Kamaran and Perim. (W. H. Is.)

PERINTHUS: *see* HERACLEA.

PERIODICAL. This term, which was once applied to all publications appearing at regular intervals, is now used by librarians and others to designate all such serials except newspapers (*q.v.*).

Early Periodicals.—The forebears of the literary periodical in the 17th century were the book notices inserted by publishers in the early newsbooks. By 1646 such notices, accompanied by short critical comments, were appearing with some regularity; about 1650 they began to be grouped together and to form a regular feature of the newsbook or paper. Of far greater importance than the book notice was the digest or abstract journal, of which the pioneer was the *Journal des sçavans* (later *Journal des savants*), first issued in Paris on Jan. 5, 1665, by Denys de Sallo and continued in a series unbroken except for a short period of suppression from 1797 to 1816. Though original material began to appear in it after the issue of the first few numbers, its primary aim was to give summaries of all important books published in Europe, together with obituaries and bibliographies of prominent writers and reports on important philosophical, literary and scientific matters. The *Journal des sçavans* was closely followed by the *Philosophical Transactions (Acta philosophica)* of the Royal society of London (March 1665), the first abstract journal in English, designed to record "the present undertakings, studies and labours of the Ingenious in many considerable parts of the world." Italy followed with the short-lived *Giornale de' letterati* (Rome, 1668–81)—another journal with the same title was published at Parma from 1668 to 1690 (with a break between 1679 and 1686)—and the *Galleria di Minerva* (Venice, 1696–1717); in Germany the *Acta eruditorum*, published in Latin, appeared in Leipzig from 1682 to 1731. Christian Thomasius' *Monatsgespräche* (1688) was the first periodical in the German language.

Meanwhile the book advertisements in the newsbooks had developed into regular catalogues—of which the *Mercurius librarius* (1668–70) or *Term Catalogues* was the most noteworthy—though these were but "dry things, scarce able to raise in men that gust and appetite for learning" that the *Weekly Memorials for the Ingenious* (1681–83) hoped to foster by means of the critical notes that it attached to each title. This periodical was the precursor of the critical review; it was shortly followed by the *Universal historical bibliothèque* (1686) which announced its intention of printing reviews of important books, and for the first time invited contributions from scholarly critics.

In 1690, Samuel Wesley, father of John and Charles, joined John Dunton in launching the *Athenian Gazette* (later the *Athenian Mercury*, ended 1697), the forerunner of *Notes and Queries* and *Answers*, which attempted a kind of information service on all literary and scientific matters about which its readers might ask. Daniel Defoe was one of the contributors. In 1692 Dunton began to issue supplements dealing with natural history and natural phenomena. Dunton's later journal, *The Compleat Library* (1692–94), virtually the successor of the *Athenian Mercury*, was the first periodical of importance to allot, in the manner now customary in learned journals, definite proportions of its space to original contributions and to book reviews.

Side by side with these attempts to popularize learning were the periodicals of amusement, of which *Mercurius Jocosus* (1654) was one of the earliest, and Donneau de Vizé's *Mercure galant* (Paris, 1672–1820) the most successful. Modeled on the latter, but more serious in content, was P. A. Motteux's *Gentleman's Journal* (1692–94), which contained essays, verses, letters and stories. Edward Ward's *London Spy* (1698–1700), with lively sketches of London manners and customs, was one of a number of short-lived journals whose contents were mainly humourous, vulgar or obscene.

GREAT BRITAIN

If the 17th century saw the establishment of the abstract journal or digest, the learned journal, the critical review and the periodical of amusement, the 18th century produced in the essay periodical its own characteristic contribution to English journalism. This form, itself one of the most important manifestations of 18th-century English literature, constituted the first attempt to create an organized popular opinion in matters of literary taste and manners in general. Richard Steele issued the *Tatler* in 1709–10; and a dozen similar publications appeared in the same year, at least half of them imitating the title as well as the form. Joseph Addison contributed to the *Tatler* and, with Steele, ran its successor the *Spectator* (1711–14) and also the *Guardian* (1713). Swift and Bolingbroke wrote political articles for the *Examiner* (1710–14); the *Spectator* and the *Guardian* replied on behalf of the Whigs, the latter finding itself in no way cramped in this

respect by its early profession of freedom from political controversy.

The Stamp act of 1712 struck a hard blow at the essay periodicals—the *Spectator's* sales dropped from about 4,000 copies to 1,600—but the very severity of the act is striking evidence of their success in forming public opinion not only in the literary but also in the political sphere.

Meanwhile a series of literary reviews—the *History of the Works of the Learned* (1699–1712), the *Memoirs of Literature* (1710–17) and others—carried on the tradition of the *Weekly Memorials for the Ingenious* and the publications of John Dunton. The first Irish review, *A Literary Journal* (Dublin, 1744–46), falls within this period. Of importance was the *Monthly Review* (1749–1844). The first magazine or miscellany of modern type was Edward Cave's *Gentleman's Magazine* (1731–1907), modeled on Motteux's *Gentleman's Journal* of 1692; Samuel Johnson joined the staff in 1738. *The London Magazine or Gentleman's Monthly Intelligencer* (1732–85) was the most formidable of a large number of rivals to the *Gentleman's Magazine;* others were the *Scots Magazine* (1739–1826); the *North Briton,* edited by John Wilkes (1762–63); the *European Magazine and London Review* (1782–1826); and the *Monthly Magazine* (1796–1843). The most noteworthy development of the last few years of the century was the specialized periodical—*Archaeologia* (1770), *Curtis's Botanical Magazine* (1787), the *Philosophical Magazine* (1798) and the *Farmer's Magazine* (1800–25) being among the more important examples, and the first three the longest-lived.

The 19th Century.—To Edinburgh is due the first high-class critical journal, the *Edinburgh Review* (1802–1929), established by Sydney Smith, Henry Brougham and Francis Jeffrey and issued in the buff and blue colours of the Whig party that it supported. Among its more eminent contributors were Carlyle, William Hazlitt and Macaulay. Its brilliant Tory competitor, the *Quarterly Review* (1809), was begun by the London publisher John Murray at the instance of Sir Walter Scott, who, though at first contributing to the *Edinburgh,* soon found himself dissatisfied with it. George Canning, Robert Southey, Lord Salisbury and Gladstone were all contributors to the *Quarterly,* and Scott himself reviewed in it. The third of the famous 19th-century periodicals was *Blackwood's Magazine* (1817), with contributions from Scott, John Lockhart, John Galt and many others. The *Edinburgh* ceased publication with the end of its 250th volume; the *Quarterly* and *Blackwood's* were still current at mid-20th century.

Of other quarterlies may be noted the *Westminster Review* (1824–1914), *Mind* (1876) and a large number of denominational reviews. Among the monthlies and weeklies were the *Christian Observer* (1802–77), the *Monthly Repository* (1806–38), the *Athenaeum* (1828, later combined with *New Statesman and Nation*), the *Spectator* (1828), the *Fortnightly Review* (1865–1950, monthly from 1866), the *Contemporary Review* (1866) and the *Nineteenth Century* (1877, called *Twentieth Century* after 1950). W. T. Stead's *Review of Reviews* (1890–1936) introduced a new development in printing criticisms of work published in other reviews. The *Times* (London) began to issue its *Literary Supplement* in 1902.

The 19th century also produced a flood of popular magazines. John Limburd published the *Mirror* (1822–49) as a twopenny illustrated magazine. A decade later came *Chambers's Journal* (1832), long conducted by the John Chamberses, father and son; the *Penny Magazine* (1832–46), published by Charles Knight; and the *Saturday Magazine* (1832–44), issued by the Society for Promoting of Christian Knowledge. Charles Dickens' *Household Words* (1850–59) was followed by his *All the Year Round* (1859–95); the latter was continued by the novelist's son. Leading sixpenny monthlies were the *Cornhill Magazine* (1860–1939), initially edited by Thackeray and the first to publish serial fiction regularly; *Fraser's Magazine* (1830–82), which published much early Thackeray and some of the best of Thomas Carlyle; and *Temple Bar* (1860–1906), first edited by G. A. Sala. *Notes and Queries* (1849) has long interested the curious antiquary. Nor were the interests of women forgotten: the *Queen* (1861) and the *Lady* (1885) were destined for long lives.

The 20th Century.—The late 19th century saw the birth of the illustrated magazine proper, and the 20th saw its great development. Many magazines had already inserted full-page illustrations and woodcuts in the 1860s, but none of these approached what is now accepted as an illustrated magazine. The continually changing attitude of the public is clearly shown by Sala's statement in *Temple Bar* that, with due regard to the interests of his readers, he preferred to give them 16 extra pages of print rather than an illustration or two. The *English Illustrated Magazine* (1883–1913) may perhaps be considered the parent of illustrated monthlies.

Innumerable publishers forthwith adopted the view of Sir George Newnes that a magazine should give "wholesome and harmless entertainment to crowds of hard-working people craving for a little fun and amusement," by providing light literature and illustrations. The *Strand Magazine* (1891–1950) was designed to "contain stories and articles by the best British writers and special translations of the chief foreign authors." No limit was to be put to illustration. It was a bold move, and even the publishers felt that they were embarking "upon the wildest extravagance in furnishing no fewer than a hundred and ten illustrations in a single number." This was before the general adoption of process engraving, and woodcuts were still in use. The success which followed was phenomenal. In a different category must be placed the illustrated weeklies in which the illustrations counted for more than the letterpress; of these the *Illustrated London News* (1842) was the pioneer. The *Sphere* began in 1900, the *Tatler* in 1901; *Picture Post* (1938–57) was the most striking example at mid-20th century.

Besides illustrations, 20th-century magazines are notable for variety of specialization in the professions, industries, trades, religion, arts and letters, sports, etc. *Radio Times* (1923), which reached a spectacular 9,000,000 circulation by mid-century and continued to rise, was an outstanding example. There were many prosperous motion-picture periodicals, and many devoted to women's interests; the weekly *Woman* (1937) had over 3,000,000 circulation before the end of its second decade.

The outbreak of World War II wrote finis to the files of many periodicals; in 1939 death came to the literary *Criterion* (1922), Sir John Squire's *London Mercury* (1919), and the monthly *Windsor* (1895).

Shortage of paper supply continued to cripple magazine publication for some years after the end of the war.

Children's Magazines.—Another outstanding feature of the late 19th century was the development of literature for the young. Since the spread of education had inspired the production of encyclopaedias and dictionaries expressly intended for the comprehension of children, it is not surprising that periodicals for boys and girls should also have assumed an important role. The best magazines contained a mixture of fiction, science and practical suggestions to young people in a variety of crafts and hobbies. Most prominent of the 19th-century juveniles were *Chatterbox* (1866–1934), *Little Folks* (1871–81), the *Boy's Own Paper* (1879–1904) and the *Girl's Own Paper* (1880). *My Magazine* (1914–33) is a later example.

The so-called "comics" descended upon Britain in mid-20th century like the locusts upon Egypt of old.

Historical and Scientific Magazines.—Though specialized journals began to make their appearance in the late 18th century, it was not until the end of the 19th that any very great expansion of their numbers took place. Mention must be made, however, of a few outstanding earlier examples, such as the *Lancet* (medical; 1823); the *Provincial Medical and Surgical Journal* (1840–52), followed by *British Medical Journal* in 1857; the *Economist* (1843); and *Nature* (general science; 1869). After 1880 every science, art, profession and trade began to issue its own periodical or periodicals until no field of activity, however highly specialized, was unrepresented. It must be sufficient here to list only a few: the *Law Quarterly Review* (1885), the *English Historical Review* (1886), the *Library* (1889), the *Studio* (art; 1893), *Man* (anthropology; 1901), the *Hibbert Journal* (theology and philosophy; 1902).

FRANCE

The *Journal des sçavans*, the first number of which appeared on Jan. 5, 1665, is acknowledged to be the parent of modern periodical literature. About 1663, François Eudes de Mézeray obtained a privilege for a regular literary periodical, but the idea came to nothing; and the credit for having produced the first periodical must go to Denys de Sallo, who at the time was regarded as a genius and inventor for having framed the scheme. Its intention and scope is given in the *Encyclopédie méthodique:* "Il a été inventé pour le soulagement de ceux qui sont ou trop occupés ou trop paresseux pour lire les livres entiers" ("It has been invented for the relief of those who are either too busy or too lazy to read whole books").

The severe literary and political censorship enforced in France was directly responsible for the introduction of the literary periodical into the Netherlands, where no fewer than 31 first-rate journals were issued within the century 1680–1780 by French Protestant refugees.

In this manner appeared Pierre Bayle's *Nouvelles de la république des lettres* (1684–1718), one of the principal successors of the *Journal des sçavans;* and Jean Le Clerc's *Bibliothèque universelle et historique* (1686–93)—to mention only two. A few years later, the *Mémoires pour l'histoire des sciences et des beaux-arts*, commonly known by the name of *Journal de Trévoux* (1701–67), was brought out at Paris under the auspices of the Jesuits. Their primary object was to defend religion from attack, and it was probably for this reason that the journal incurred the displeasure of Voltaire. For 30 years the printers of the little town of Trévoux were kept busy, until it became more convenient to transfer the headquarters of the journal to Paris.

Meanwhile the *Spectator* and *Tatler* were appearing in England; but the French were cautious in adopting the essay periodical, though an incomplete translation of the *Spectator* appeared in Amsterdam in 1714. It was not until 1722 that Marivaux made his unsuccessful attempt to rival the Englishmen by issuing his *Spectateur français* (1722). The *Spectateur suisse* (1723), *Le nouveau Spectateur* (1758) and others came after but were of little value. *Le Pour et contre* (1733–40), edited by the Abbé Prévost and full of anecdote and miscellaneous information, was similar in form to the English reviews.

Another periodical of high rank of the 18th century was the *Journal encyclopédique* (1756–93), founded by Pierre Rousseau, who carried on his work for many years under the protection of the count of Horion, minister of the prince bishop of Liège. When the latter died, Rousseau was compelled to transfer the journal from Liège to Bouillon on account of the philosophical articles it contained, but permission was given him to establish his presses there. Voltaire, Diderot and others contributed to the Paris *Gazette littéraire* from 1764 to 1766. During the revolutionary period, and until the abolition of the censorship in 1828, most periodicals were suspended or suppressed.

Specialized journals began in the latter half of the 17th century and continued in quantity. *Revue des deux mondes* (1829–1944) reached its greatest importance as a fortnightly in mid-19th century, when leading literary figures were contributors. It was succeeded by *Revue: littérature, histoire, arts et sciences des deux mondes* (1948). Other 20th-century reviews are *Nouvelle revue* (1879), *Mercure de France* (1890), *Revue de Paris* (1894) and *Les Oeuvres libres* (1921). *L'Illustration* (1843–1944) was long a world-famous picture magazine. *Paris-match* (1949) quickly gained circulation leadership among French weeklies by brilliant illustration and timely, informative text. Periodicals devoted to women's interests and fashions have also been very successful, as the monthly *Marie-Claire* (1954). Children's periodicals have been popular, as *Le Magasin d'éducation et récréation* (1864–1905), which published Jules Verne and was illustrated by Gustave Doré and J. L. E. Meissonier. "Comics" grew in favour, reaching a distribution of over 20,000,000 monthly at mid-20th century.

GERMANY

The *Acta eruditorum* (Leipzig, 1682–1731), the earliest of German periodicals, was not only limited in its choice of subjects to mathematics, physics and botany, but was also handicapped by the use of the Latin language. Nevertheless, such German men of science as Leibniz and the botanist Michael Ettmüller, combined to make the *Acta* a central meeting ground where the results of their researches might be read. The *Acta* had many imitators. Soon after the English periodicals of Addison and Steele had reached Hamburg, the Germans taking these, especially the *Spectator* and the *Guardian*, as models, brought out *Der Vernünftler* (1713), *Die lustige Fama* (1718) and *Discoursen der Maler* (1721). J. C. Gottsched's *Die vernünftigen Tadlerinnen* (1725–26) was the first women's journal. In 1759 C. F. Nicolai introduced his *Briefe, die neueste Literatur betreffend* to the world, and enlisted as collaborators Lessing and Moses Mendelssohn; it lasted six years. The *Frankfurter gelehrte Anzeigen* (1772–90), a successor of the *Franckfurtische gelehrte Zeitungen* (1736–71), followed a few years later and is chiefly interesting because Goethe wrote for it as a young man; the *Jenaische allgemeine Litteratur-Zeitung*, of which Goethe may be said to have acted as editor in chief, was issued in 1804–41. C. M. Wieland's *Der Teutsche Merkur* (1773–89) stands out as a literary periodical of the first importance, as does also the *Allgemeine Literatur-Zeitung* (1785–1849).

The periodicals issued in the various German states during the next 60 years displayed an ever-increasing political consciousness, and some indeed, such as the *Hallische Jahrbücher* (1838–43), received government support. The *Jahrbücher für wissenschaftliche Kritik* (1827–46), first published by J. F. Cotta, was a noteworthy publication of this period. By the end of the period politics had almost ousted literature from German reviews.

The revolution of 1848 was disastrous to the periodical press, and very few journals survived it. Developments in the later part of the 19th century followed much the same course as in England. Among the best-known journals of this time are the *Deutsche Rundschau* (1874), *Historische Zeitschrift* (1859), *Neue Rundschau* (1889), *Die Literatur* (1898–1942), *Deutsche Vierteljahrsschrift* (1923), *Erkenntnis* (1930–39).

The National Socialist revolution produced a further wave of suppressions, and the division of Germany into zones of occupation in 1945 resulted in many changes and gradual resumption of publication. By the 1950s some 4,000 periodicals were in course of publication. Among reviews were *Deutschland Review* (1949, Hamburg), *Die Besinnung* (1946, Nürnberg) and *Revue* (1948, Munich). *Spiegel* (1947, Hamburg) was a popular weekly; and among picture magazines were *Heute* (1945–51, Munich) and *Zeit und Bild* (1947, Frankfurt).

OTHER COUNTRIES

Canada.—The first monthly in eastern Canada was the *Novia Scotia Magazine* (1789–92), and in Canada proper the *Canadian Magazine* (Montreal, 1823–25). In addition to these were the bilingual *Quebec Magazine* (1791–93), a quarterly; and several others entirely in French: *L'Abeille canadienne* (1818–19), *La Bibliothèque canadienne* (1825–30; continued as *L'Observateur* [1830–31]) and the *Magasin du Bas-Canada* (1832). The *Literary Garland* had a longer life (1838–51) than most of those that preceded it, and was for some time the only English magazine published in Canada. A series of interesting French-Canadian reviews followed; the foremost, *La Revue canadienne* (1864–1922), contained the best writings of contemporary French-Canadian men of letters.

Maclean's Magazine (1896) has long been the best known general magazine in Canada. It is published from Toronto, the country's magazine capital, whence are issued also the *Canadian Home Journal* (1904); and *Chatelaine* (1928), the leading Canadian women's journal. Some U.S. periodicals have large circulations in Canada.

Australia and New Zealand.—The *Australian Magazine* was published in Sydney in 1821–22, and was followed by the *South Asian Register* (1827), the *Australian Quarterly Journal* (1828) and a second *Australian Magazine* (1838). The *Sydney University Magazine* (1855 and 1878–79), continued as the *Sydney University Review*, was of some importance and of literary value. Australian

periodicals are strongest in the weekly field. Greatest of general popular weeklies is the *Bulletin* (1880), founded in Sydney by J. F. Archibald, which became important in the development of the country's literature and art. Largest circulation in the commonwealth was claimed in the late 1950s by the *Australian Women's Weekly* (1933), which had publication offices in all the leading cities and was said to enter one-third of Australian homes.

The Netherlands.—Apart from the journals of French origin already described, the earliest periodicals in the Netherlands were the *Examinator* (1719–20) and *Den Amsterdamschen Hermes* (1722–23). In 1837 *De Gids* was founded as the organ of liberalism and at the same time of a new movement in literature and it remained an important review. *Haagsch Maandblad* (1924) is a literary monthly, and *Erasmus* (1933) an important scientific journal. There are many technical and class periodicals. The official *Radiogids* has a wide circulation.

Italy.—Conditions in Italy were long unfavourable to the growth of periodicals. Politics was not a safe subject for free comment, and the church interfered much in matters of science and literature as well as religion. Nevertheless, the *Journal des sçavans* had its imitator in Rome when Cardinal Ricci began to print *Giornale de' letterati* (1668–81); and Venice, always in the forefront in literary activities, issued the *Galleria di Minerva* (1696–1717). The rivalry, however, of both the academies and the princes acted as a continual curb, and the outlook of editors and writers remained circumscribed for a long period. G. Baretti, in *La Frusta letteraria* (1763–65), so mercilessly attacked the writers of Italy and even the ruling princes that after two years of precarious existence the *Frusta* was suppressed. *Il Caffé* (1764–66) was much influenced by French ideas. Important modern reviews have been *Nuova Antologia* (1866), Benedetto Croce's *La Critica* (1903–44), *Scientia* (1907), *La Rassegna italiana* (1918), *Rinascita* (1944) and *Italia contemporanea* (1953). *Scena Illustrata* (1865) is one of the oldest of illustrated monthlies. *Epoca* (1944) is a popular illustrated weekly.

Portugal.—*Jornal Enciclopedico* (1779–92) and *Jornal de Coimbra* (1812–20) were the chief early Portuguese reviews. *Panorama* was largely historical and literary; Alexandre Herculano's historical tales were published in it. Most 19th-century journals were short-lived; but *Instituto* (1852) had a long life as a literary and scientific review, and *Naturalia* (1936) enjoyed wide acceptance.

U.S.S.R.—In Russia the Academy of Sciences led the way by the issue of *Yezhemyesyatchniya Sochineniya* ("Monthly Works") (1755–64); and four years later the first private undertaking, the *Trudolyubivaya Pchela* ("Industrious Bee") (1759) with critical essays and translations from the *Spectator*, appeared. Few periodicals appeared in Russia until the 19th century, when the most representative magazines were the *Vestnik Evropy* (1802–30), edited by the historian N. M. Karamzin; the *Biblioteka dlya Chteniya* (1834–65), the first to obtain any commercial success; the *Sovremennik* (1836–66), founded by Pushkin; the *Russky Vestnik* (1856–1906), edited by the well-known publicist M. N. Katkov; the *Vestnik Evropy* (1866–1919), a continuation of the earlier *Vestnik*, to which the novelist Turgenev contributed; *Russkaya Misl* (1880–1927); *Letopis* (1915–17), edited by Maksim Gorki. The Bolshevik revolution produced a great upheaval and was responsible for an enormous output of periodicals of all kinds, but without any real freedom of the press. *Novyi Mir* ("New World") (1925) was one of the more important reviews of the Soviet regime. The Soviet publication system calls for the production of a journal in every major field of industry, technology, art. *Literaturnaia Gazetta* (1929) was the leading literary journal. Two periodicals were published from Moscow in English, German and French as well as in Russian—*Soviet Literature* (1932) and *Soviet Woman* (1945).

Scandinavian Countries.—The northern countries of Europe —Sweden, Norway and Denmark—have never lagged behind in the production of literature. The earliest periodical in Sweden was *Swänska Argus* (1732–34), a journal similar to the *Spectator*. Of modern magazines the following are worth mentioning: *Ord och Bild* (1892); *Nordisk Tidskrift* (1878), which prints historical and philosophical articles; *Nya Sverige* (1907–28), a conservative review; and the weekly *Idun* (1888). The first Norwegian periodical was *Ugentlige Korte Afhandlinger* (1760). *Samtiden*, begun by Gerhard Gran in Bergen in 1890 and moved to Oslo a decade later, was long the leading Norwegian journal. *Nye Tidender om lærde Sager* (1720–1837) was the earliest critical journal in Denmark. Leading 20th-century monthlies were *Tilskueren* (1884–1939), *Gads Danske Magasin* (1906), *Danske Magasin* (1952).

Spain.—In Spain the periodical came much later than in France, and it was in the beginning dependent on its French prototype. Political and religious censorship was as severe as it was in Italy. The earliest periodicals date from the middle of the 18th century, the best known being *Efemérides barometricomedicas matritenses* (1743–47) edited by Fernández Navarrete; the *Diario de los literatos de España* (1737–38); and *Memorial literario* (1784–1808).

Three early 19th-century periodicals are worth noting—*Miscelánea de Comercio* (1819), *Artes y literatura* (1819–21) and *El Censor* (1820–22). The influence both of the censorship and of the foreign periodical declined greatly during the regency of Maria Cristina (1833–41). Of a large number of reviews which began in the mid-19th century, mention may be made of the *Revista Ibérica* (1861–63), the *Revista de Cataluña* (Barcelona, 1862–63) and the *Revista de España* (1868–95). *España moderna* (1889–1914), *La Lectura* (1901–20), *Revista de Occidente* (1923–36; first edited by Ortega y Gasset) and *Gaceta literaria* (1927–32) were among the more important periodicals of the first quarter of the 20th century. The outstanding weekly was *Blanco y negro* (1891–1936). The *Revista hispano-americana de ciencias, letras y artes* (1921–36) was one of the better-known reviews of Latin-American interest published in Spain. Many Spanish periodicals fell victims to the strict censorship imposed by the Franco regime. *Mundo Hispánico* (1948) was a later monthly.

Switzerland.—The *Nova litteraria helvetica* (1703–15) of Zürich is the earliest literary periodical which Switzerland can show; followed by the *Bibliothèque italique* (1728–34) and the *Bibliothèque britannique* (1796–1815), both published at Geneva. The *Bibliothèque universelle* (1816) and *Revue suisse* (1838) amalgamated in 1858 as the *Bibliothèque universelle et revue suisse*. Among later periodicals may be mentioned *Revue mensuelle* (1897–1926); *Zwingliana* (1897); *Archives de psychologie de suisse romande* (1901) edited by Flournoy and Claparède; *Untersuchungen zur neueren Sprach- und Literaturgeschichte* (1903–12); *Revue de Genève* (1920–24); and *Schweizerische Monatshefte* (1921). In the second half of the 20th century, leading monthlies were *Atlantis* (1929), *Schweitzer Journal* (1935) and *Gegenwart* (1939); and leading weeklies were *Schweitzer familien-Wochenblatt* (1881), *Patrie suisse* (1884), *Schweitzer illustrierte Zeitung* (1912) and *Weltwoche* (1933).

India.—The first Indian magazine was the *Oriental Magazine, or Calcutta Amusement* (1785–86). Several periodicals were conducted, usually for brief periods, by western missionaries. The *Hindustan Review* (1900, Patna) was founded and long edited by Sachschudananda Sinha, at Allahabad. The *Indian Review* (1900, Madras) was established by G. A. Natesan. In the course of India's economic development of the mid-20th century, a large number of professional, technical and industrial periodicals sprang up.

South Africa.—The *South African Journal* (1824, Cape Town) was the pioneer journal of this region. The periodicals of South Africa are chiefly centred in Cape Town and Johannesburg, and are largely trade and industrial journals of 20th-century growth.

Japan.—The Meiji restoration of 1868 brought a renaissance of culture and popular education in Japan and marked the beginning of magazines as distinct from newspapers. In the early 20th century the leading figure in the publication of Japanese magazines was Noma Seiji, whose nine periodicals nearly all had reached circulation in six figures. Many of the country's leading magazines survived World War II; and by the end of the occupation in 1952 there were more than 2,000 periodicals in course of publication, including popular miscellanies, women's journals, an interesting class of light literary reviews, magazines for youth and periodicals devoted to the stage, screen, radio, television and sports.

There was a large group of small magazines devoted to verse. Weekly news magazines issued by leading newspapers had large circulations. Outstanding class periodicals were *Shufu No Tomo* ("Woman's Friend," 1917), *Yoiko No Tomo* ("Child's Friend," 1924) and *Shin Eiga* ("New Movies," 1938).

China.—The Christian missionaries William Milne, Robert Morrison and Liang A-fa established the first successful Chinese general magazine, under the title *Tsachihshu Maiyueh Tungchichuan* ("Chinese Monthly Magazine"). Printed in Malacca, it was circulated in Chinese territory (1815–22). The first to be published in China itself came from Canton in 1833, was moved to Singapore four years later and published there for a decade; it was called *Tunghsiyankao Maiyueh Tungchichuan* ("Eastern-Western Monthly Magazine") and was founded by Charles Gutlaff, a missionary, but in 1837 it was taken over by the Society for the Diffusion of Useful Knowledge, a British institution. Various and numerous periodicals offering religious, philosophical, literary and scientific matter were published in the chief Chinese cities in the 19th century; but it was not until the period of Liang Ch'i-ch'ao and his fellow reformers and publicists, beginning in the second decade of the 20th century, that modern periodicals came into wide circulation. Liang himself was editor, usually for brief periods, of eight different periodicals. Among long-lived magazines were *Tung-fang Tsa-chih* ("Eastern Miscellany," 1904) and *Chiao-yü Tsa-chih* ("Educational Miscellany," 1908). The Communist revolution of 1949 resulted, after a few years, in wider distribution of periodicals than formerly; but these were controlled by the government and highly propagandist.

Central and South America.—Early gazettes and journals in Central and South American countries often partook of the nature of magazines, being miscellaneous in character; but not until the 20th century did periodicals as such flourish. By that time colour printing had been well developed, and illustrated weeklies and monthlies were widely popular. The largest Cuban magazine was the attractively illustrated *Bohemia* (1911), a weekly. In Mexico the leader was *La Familia* (1931), a fortnightly. In Brazil were two outstanding magazines in the Portuguese language—*Eu Sei Tudo* (1920), a general monthly; and *Vida Domestica* (1920), a women's journal. Argentina had many more magazines than any other South American country, as well as wider readership. *Maribel* (1932), rotogravure weekly miscellany, boasted at mid-20th century a larger circulation than any other South American magazine, though *Para Ti* (1922), also of Buenos Aires, a women's weekly, was a close second. (C. T. H. W.; F. L. K.; F. L. Mt.).

UNITED STATES

The first American magazines were two Philadelphia, Pa., publications that dated their first numbers Jan. 1741. Actually first to appear was Andrew Bradford's *American Magazine*, followed in three days by Benjamin Franklin's *General Magazine*. The former lasted three months and the latter six. About 100 magazines were founded in the Colonies, most of them very short-lived. Outstanding were three Philadelphia periodicals—the *Pennsylvania Magazine* (1775–1776), edited by Thomas Paine; the *Columbian Magazine* (1786–92), called the *Universal Asylum* in its last two or three years; and Mathew Carey's *American Museum* (1787–92). Also important were Isaiah Thomas' *Royal American Magazine* (1774–75) and *Massachusetts Magazine* (1789–96); and Thomas and James Swords' *New-York Magazine* (1790–97).

More than 500 periodicals were published for shorter or longer periods in the first quarter of the 19th century; nearly 100 were being issued in 1825. There was marked development in weekly miscellanies supported by literary coteries in many cities and towns; in periodicals for women and children; in religious journals and those devoted to such reforms as antislavery and temperance; in medical, legal and agricultural journals; and in theatrical and comic papers. This class journalism increased rapidly and by mid-19th century there were about 600 periodicals.

Outstanding monthlies were *Godey's Lady's Book* (1830–98, Philadelphia), famous for its stenciled coloured fashion plates; *Graham's Magazine* (1826–58, Philadelphia), which began as the *Casket;* the *Southern Literary Messenger* (1834–64, Richmond, Va.); and the *Knickerbocker Magazine* (1833–65, New York city). Chief quarterlies were the *North American Review* (1815–1940), which developed from the *Monthly Anthology* (1803–11, Boston, Mass.) and had a famous line of editors, including Jared Sparks, Edward Everett, James Russell Lowell, Henry Adams, and George B. M. Harvey; *The Dial* (1840–44), famous transcendental magazine edited by Margaret Fuller, Thoreau and Emerson; and *De Bow's Review* (1846–80, New Orleans, La.). Notable weeklies were the *Youth's Companion* (1827–1929), a family periodical with a long line of famous contributors; and the *Saturday Evening Post,* founded in 1821, but brought to its later preeminence as a popular weekly after its purchase by Cyrus H. K. Curtis in 1897.

A New Era, 1850.—A new era began with the founding of *Harper's New Monthly Magazine* in New York city in 1850, with copious woodcut illustration, 144 pages and English fiction serials. A worthy competitor came in 1870, *Scribner's Monthly*, later the *Century* (1881–1930). *Scribner's Magazine* (1887–1939) was another quality illustrated monthly. By 1890 these richly illustrated general magazines surpassed anything of the kind ever before known in any country. The *Atlantic Monthly*, Boston, without illustrations, began its distinguished literary career in 1857, under Lowell's editorship. William Dean Howells, Thomas Bailey Aldrich, Walter Hines Page and Ellery Sedgwick were among its editors. Other famous monthlies of the latter 19th century were the *Galaxy* (1866–78), New York; *Overland Monthly* (1868–1935), San Francisco, whose first editor was Bret Harte; *Forum* (1886–1940), New York; *Lippincott's Magazine* (1868–1916), Philadelphia; and *Frank Leslie's Popular Monthly*, New York, which began in 1876 and from 1906 to 1956 was published as the *American Magazine*. Three prominent New York weeklies were *Harper's Weekly* (1857–1916); *The Nation*, founded by Edwin Lawrence Godkin in 1865; and *Outlook* (1870–1935), which began as *Christian Union* under Henry Ward Beecher's editorship. By 1870 there were about 1,200 periodicals in the United States, close to 2,400 in 1880, and nearly 3,000 by 1890.

In the 1890s came the high-class illustrated monthlies selling for 10 or 15 cents in place of the 35 cents asked by the "quality" magazines. The only one of this spectacular group to survive was the *Cosmopolitan,* founded in 1886 by John Brisben Walker; others were *McClure's Magazine* (1893–1933), *Munsey's Magazine* (1889–1929) and *Everybody's Magazine* (1899–1929). These, with the *Arena* (1889–1909), of Boston, and the weekly *Collier's* (1888–1957), were leaders in the muckraking which exposed corruption in municipal government, finance, etc., throughout the decade 1902–12. Leading muckrakers for *McClure's* were Lincoln Steffens, Ida M. Tarbell and Ray Stannard Baker, who later took over the ailing *Frank Leslie's Popular Monthly* and renamed it the *American Magazine*.

Later Magazines.—The *Reader's Digest,* a pocket-size magazine containing condensations of articles from other periodicals, was founded in 1922 and by mid-century had attained the largest circulation of any serial publication ever known, said to be about 21,000,000 monthly, including editions distributed in most foreign countries and printed in several foreign languages. *Time*, a weekly news magazine founded in 1923 by Briton Hadden and Henry R. Luce, met with much success and had a considerable effect on the art of reporting. *Newsweek* (founded 1933) was the most successful of its followers. In 1936 Time, Inc., launched a weekly picture magazine whose title, *Life*, was purchased from the satirical weekly (founded 1883) which had just suspended publication. Another picture magazine, the fortnightly *Look*, was founded in 1937. In the 1960s both had circulations of about 7,000,000. (*See* also PHOTOJOURNALISM.) *The New Yorker,* founded in 1925 by Harold Ross, though smaller in circulation (about 440,000 in the 1960s), had great influence on fiction writing, reporting, and cartooning. Prominent among U.S. periodicals in the 20th century were illustrated magazines for women, such as *Ladies' Home Journal* (founded 1883), *Harper's Bazaar* (founded 1867), *Woman's Home Companion* (1873–1957), *Good Housekeeping* (founded 1885), *Vogue* (founded 1892) and *Better Homes and Gardens* (founded 1922).

Most U.S. general periodicals are circulated largely by subscription, the price usually being lower than the cost of publication; such magazines therefore depend for their financing upon advertising revenue. (An exception was the *Reader's Digest*, which until 1955 did not accept any advertising.) With the advent of other advertising media, particularly television, the proportion of advertising budgets spent for printed media tended to decline. This loss of revenue, combined with changes in reading habits, increasing production expenses, and increases in postage rates, created serious problems for many large-circulation general magazines. *See* also LITTLE MAGAZINE and references under "Periodical" in the Index.

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(F. L. MT.)

PERIODIC LAW. Dmitri I. Mendeléyev discovered in the mid-19th century that the chemical elements show a periodic recurrence of properties when they are arranged in a certain order, which is approximately the order of increasing atomic weight. The statement of this fact, which has been of inestimable value in the development of the science of chemistry, is called the periodic law; and a tabular arrangement of the elements which brings those with similar properties into juxtaposition is called the periodic table or periodic system of the elements.

It was recognized during the second decade of the 20th century that the order of elements in the periodic system is that of their atomic numbers, the integers which are equal to the positive electrical charges of the atomic nuclei expressed in electronic units; and in recent years great progress has been made in explaining the periodic law in terms of the electronic structure of atoms and molecules. This clarification has increased the value of the law, which is used as much today as it was at the beginning of the 20th century, when it expressed the only known relationship among the elements.

History of the Periodic Law.—The classification of the chemical elements is a comparatively recent problem, for it was not until about the beginning of the 19th century that the two kinds of chemical substances, elements and compounds, were clearly differentiated. The early years of the century witnessed a rapid development in analytical chemistry—the art of distinguishing different chemical substances—and the consequent building up of a vast body of knowledge of the chemical and physical properties of both elements and compounds. This rapid expansion of chemical knowledge soon necessitated classification, for on the classification of chemical knowledge are based not only the systematized literature of chemistry but also the laboratory arts by which chemistry is passed on as a living science from one generation of chemists to another. The elementary substances are few in number, about 100, with distinctive properties, whereas compound substances are extremely numerous, with properties correspondingly diversified and often overlapping. It thus occurred that the classification of elements lagged many years behind that of compounds, and, in fact, no general agreement had been reached among chemists as to the classification of elements for nearly half a century after the systems of classification of compounds had become established in general use.

J. W. Döbereiner in 1817 showed that the combining weight of strontium lies midway between those of calcium and barium, and some years later he showed that other such "triads" exist (chlorine, bromine and iodine; and lithium, sodium and potassium). J. B. A. Dumas, L. Gmelin, E. Lenssen, Max von Pettenkofer and J. P. Cooke expanded Döbereiner's suggestions between 1828 and 1854 by showing that similar relationships extended further than the triads of elements, fluorine being added to the halogens, and magnesium to the alkaline-earth metals, while oxygen, sulfur, selenium and tellurium were classed as one family and nitrogen, phosphorus, arsenic, antimony and bismuth as another family of elements.

Attempts were subsequently made to show that the atomic weights of the elements could be expressed by an arithmetical function, and in 1862 A. E. B. de Chancourtois proposed a classification of the elements based on the new values of atomic weights given by Stanislao Cannizzaro's system of 1858. De Chancourtois plotted the atomic weights on a helical curve such that corresponding points differed by 16, the approximate atomic weight of oxygen. This curve brought closely related elements onto corresponding points, and he suggested in consequence that "the properties of the elements are the properties of numbers," a remarkable prediction in the light of modern knowledge.

In the following year, 1863, J. A. R. Newlands proposed a system of classification of the elements in the order of atomic weights, the elements being assigned ordinal numbers from unity upward and divided into seven groups having properties closely related to the first seven of the elements then known: hydrogen, lithium, beryllium, boron, carbon, nitrogen and oxygen. This relationship was termed the law of octaves, by analogy with the seven intervals of the musical scale.

TABLE I.—*The Short-Period Form of the Periodic System of the Elements*

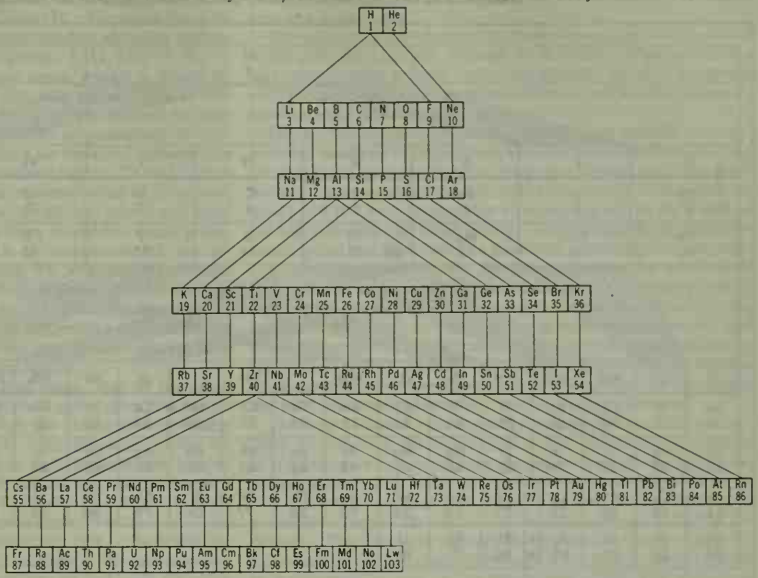
Group O	I		II		III		IV		V		VI		VII		VIII
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	
	H 1														
He 2	Li 3		Be 4		B 5			C 6		N 7		O 8		F 9	
Ne 10	Na 11		Mg 12		Al 13			Si 14		P 15		S 16		Cl 17	
Ar 18	K 19	Cu 29	Ca 20	Zn 30	Sc 21	Ga 31	Ti 22	Ge 32	V 23	As 33	Cr 24	Se 34	Mn 25	Br 35	Fe 26, Co 27, Ni 28
Kr 36	Rb 37	Ag 47	Sr 38	Cd 48	Y 39	In 49	Zr 40	Sn 50	Nb 41	Sb 51	Mo 42	Te 52	Tc 43	I 53	Ru 44, Rh 45, Pd 46
Xe 54	Cs 55	Au 79	Ba 56	Hg 80	57–71*	Tl 81	Hf 72	Pb 82	Ta 73	Bi 83	W 74	Po 84	Re 75	At 85	Os 76, Ir 77, Pt 78
Rn 86	Fr 87		Ra 88		Ac 89		Th 90		Pa 91		U 92		Np 93		Pu 94, Am 95, Cm 96

*Lantbanum and the lanthanons.

Then in 1869 Mendeléyev, as a result of an extensive correlation of the properties and the atomic weights of the elements, with special attention to valency, proposed the periodic law, by which "the elements arranged according to the magnitude of atomic weights show a periodic change of properties." Lothar Meyer had independently reached a similar conclusion, published after the appearance of Mendeléyev's Russian paper and of an account of it in German.

Mendeléyev's periodic table of 1869 contained 17 columns, with two nearly complete periods (sequences) of elements, from potassium to bromine and rubidium to iodine (*see* Table III), preceded by two partial periods of seven elements each (lithium to fluorine and sodium to chlorine), and followed by three incomplete periods. In his 1871 paper Mendeléyev presented a revision of the 17-group table, the principal improvement being the correct repositioning of 17 elements. He, as well as Lothar Meyer, also proposed a table with eight columns, obtained by splitting each of the long periods into a period of seven, an eighth group containing the three central elements (such as iron, cobalt, nickel; Mendeléyev also included copper, instead of placing it in group I), and a second period of seven. The first and second periods of seven were later distinguished by use of the letters "a" and "b" attached to the group symbols, which were the Roman numerals.

TABLE II.—*The Periodic System of the Elements With Periods Demarcated by the Noble Gases*



With the discovery of the noble gases helium, neon, argon, etc., by Lord Rayleigh and Sir William Ramsay in 1894 and the following years, Mendeléyev and others proposed that a new "zero" group to accommodate them be added to the periodic table. The "short-period" form of the periodic law, with groups 0, I, II, . . . VIII, became popular, and remained in general use until recent years.

A new table, devised in 1895 by J. Thomsen, was interpreted in terms of the electronic structure of atoms by Niels Bohr in 1922. In this table, Table II, there are periods of increasing length, each extending from one noble gas to the next noble gas; the table thus contains a period of 2 elements, two periods of 8 elements, two periods of 18 elements, a period of 32 elements and an incomplete period. The elements in each period are connected by tie-lines with corresponding elements in the following period. The principal disadvantage of this periodic table is the large space required by the period of 32 elements and the difficulty of tracing a sequence of closely similar elements along the slanting tie-lines. A very satisfactory compromise, shown in Table III, is to compress the period of 32 elements into 18 spaces by omitting the 14 rare earths, or lanthanons, which are indicated below. This form of the periodic table is the work of T. Bayley (1882).

The great value of the periodic law was made evident by Mendeléyev's success in 1871 in finding that the properties of 17 elements could be correlated with those of other elements by moving the 17 to new positions from those indicated by their atomic weights. This change indicated that there were small errors in the previously accepted atomic weights of several of the elements, and large errors for several others, for which wrong multiples of the combining weights had been used as atomic weights. Mendeléyev was also able to predict the existence and many of the properties of the undiscovered elements eka-boron, eka-aluminum, eka-silicon, now identified with the elements scandium, gallium, germanium, respectively. Similarly, after the discovery of helium and argon, the periodic law permitted the prediction of the existence of neon, krypton, xenon and radon. Moreover, Bohr pointed out that element 72 would be expected, from its position in the periodic system, to be similar to zirconium in its properties rather than to the rare earths; this observation led G. de Hevesy and D. Coster in 1922 to examine zirconium ores and to discover the missing element, which they named hafnium.

Many of the elements in the Mendeléyev and Lothar Meyer periodic tables of 1871 were required by their properties to be put in positions somewhat out of the order of atomic weights. Most of these displacements have been rectified by redeterminations of the atomic weights; three, however, remain, and are real. In the three pairs of elements argon and potassium, cobalt and nickel, and tellurium and iodine, the first element of each pair has the greater atomic weight, but the earlier position in the periodic system. The solution of this difficulty had been indicated by Newlands, who had assigned the successive ordinal numbers to the elements arranged approximately according to atomic weight.

Ernest Rutherford's experiments on the scattering of alpha particles by the nuclei of heavy atoms led to the determination of the nuclear electrical charge. The ratio of the nuclear charge to that of the electron was noted to be roughly one-half the atomic weight. In 1911 A. van den Broek suggested that this quantity, the atomic number, might be identified with the ordinal number of the element in the periodic system. This suggestion was brilliantly confirmed in 1913 by H. G.-J. Moseley's measurements of the wave lengths of the characteristic X-ray spectral lines of many elements. There is no longer any uncertainty about the position of any element in the ordered series of the periodic system. All of the elements from 1 to 103 are now known, and it is to be expected that new elements beyond 103 will be made by nuclear reactions.

The small significance of the exact atomic weight of an element to its position in the periodic system is shown by the existence of isotopes of every element, atoms which have the same atomic number but different atomic weights. The chemical properties of the different isotopes of an element are essentially the same, and all of the isotopes of an element occupy the same place in the periodic system.

The detailed understanding of the periodic system has developed along with the quantum theory of spectra and the electronic struc-

TABLE III.—*The Long-Period Form of the Periodic System of the Elements*

																	H 1 He 2
0	I	II	III	IV	V	VI	VII	0									
He 2	Li 3	Be 4	B 5	C 6	N 7	O 8	F 9	Ne 10									
Ne 10	Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17	Ar 18									
0	I(a)	II(a)	IIIa	IVa	Va	VIa	VIIa	VIII			Ib	IIb	IIIb	IV(b)	V(b)	VI(b)	VII(b)	0
Ar 18	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Kr 36	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Xe 54	Cs 55	Ba 56	La 57	* Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Rn 86	Fr 87	Ra 88	Ac 89	* Th 90	Pa 91	U 92												

*Lanthanons	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
**Actinons	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lw 103

ture of atoms, beginning with the work of Bohr in 1913. Important forward steps were the formulation of the general rules of the old quantum theory by W. Wilson and A. Sommerfeld in 1917, the discovery of the exclusion principle by W. Pauli, Jr., in 1925, the discovery of the spin of the electron by G. E. Uhlenbeck and S. Goudsmit in 1925, and the development of quantum mechanics by W. Heisenberg and E. Schrödinger during the same year. The development of the electronic theory of valence and molecular structure, beginning with the postulate of the shared electron pair by G. N. Lewis in 1916, also played a very important part in explaining the periodic law.

Mendeléyev stated that a natural law acquires scientific importance only when it yields practical results in elucidating unexplained phenomena, in disclosing unrecognized occurrences and in evoking verifiable predictions. The periodic law has been found to be very useful indeed in the simplification of the science of chemistry through the classification of the elements; in the determination of the correct multiples of equivalent weights to be taken as the atomic weights of elements; in indicating errors in atomic weights; in the prediction of the existence and properties of new elements; and especially as a basis for chemical reasoning and prediction in the planning of experimental work. Its value has increased with increasing understanding of the law and its basis in the electronic structure of atoms.

Survey of the Elements in Relation to the Periodic System.—The long-period form of the periodic system, Table III, is used as the basis of the discussion that follows. This table has the great advantage over the short-period form, Table I, in that it does not confuse the user by placing in the same group such dissimilar elements as the halogens and manganese and its congeners. It is also more useful and in some respects more satisfactory than Table II, the periodic system with groups demarcated by the noble gases. In particular, the condensation of the very long period, cesium, 55, to radon, 86, by the omission of the rare-earth metals permits the closely related elements such as copper, silver and gold to be placed close together in a compact column.

The long-period form of the periodic system of the elements, Table III, contains all the chemical elements that have been discovered or made; they are arranged, in the order of their atomic numbers, in seven horizontal periods, with the rare-earth metals (cerium, 58, to lutecium, 71) and the actinons (thorium, 90, to lawrencium, 103) indicated separately below. The periods are of varying lengths. First, there is the hydrogen period, consisting of the two elements hydrogen, 1, and helium, 2. Then there are two periods of eight elements each: the first short period, from lithium, 3, to neon, 10; and the second short period, from sodium, 11, to argon, 18. There follow two periods of 18 elements each: the first long period, from potassium, 19, to krypton, 36; and the second long period, from rubidium, 37, to xenon, 54. The very long period of 32 elements, from cesium, 55, to radon, 86, is condensed into 18 columns by the omission of the 14 lanthanons (which are indicated separately below), permitting the remaining 18 elements, which are closely similar in their properties to corresponding elements of the first and second long periods, to be placed directly below these elements. The last period, extending from francium, 87, to lawrencium, 103, is incomplete. The properties of these elements indicate that this period is a second very long period of 32 elements. The elements from thorium to uranium are indicated in the table in two places: first, below the elements hafnium to tungsten respectively, to which they show considerable similarity in properties; and second, below the corresponding lanthanons.

The six noble gases, helium, neon, argon, krypton, xenon and radon, occur at the ends of the six completed periods and consti-

tute the 0 group of the periodic system. For convenience, this group is repeated at the left side of Table III. The seven elements lithium to fluorine and the seven corresponding elements sodium to chlorine are placed in the seven groups, I, II, III, IV, V, VI and VII, respectively. Each of these seven groups is joined by tie-lines with two elements of the first long series. The 17 elements from potassium, 19, to bromine, 35, are distinct in their properties, and might well be considered to constitute 17 subgroups of the periodic system. Largely for historical reasons (the use of the short-period form of the periodic system, Table I), however, it is customary to describe them as constituting 15 subgroups, the three consecutive elements iron, cobalt and nickel and their congeners in the succeeding periods being placed in a single group, VIII. The elements potassium, 19, to manganese, 25, are assigned to subgroups Ia, IIa, IIIa, IVa, Va, VIa and VIIa respectively; and the elements copper, 29, to bromine, 35, are assigned to subgroups Ib to VIIb, respectively. (In some modern versions of the periodic system, the members of subgroups a and b in groups III and above are the reverse of the arrangement shown here. There is no one standard form of the system.)

It is customary to consider the first group, that of the alkali metals, as including, in addition to lithium and sodium, the metals of subgroup Ia (potassium, etc.), but not the much less similar metals of subgroup Ib (copper, etc.). Also the second group, the alkaline-earth metals, is considered to include beryllium, magnesium, calcium, strontium, barium and radium, but not the elements of subgroup IIb. The properties of the elements do not indicate unambiguously whether the boron group might be better considered to include the subgroup IIIa or the subgroup IIIb. The other four groups include the corresponding "b" subgroups: the carbon group, IV, consists of carbon, silicon, germanium, tin and lead; the nitrogen group, V, includes nitrogen, phosphorus, arsenic, antimony and bismuth; the oxygen group, VI, includes oxygen, sulfur, selenium, tellurium and polonium; and the halogen group, VII, includes fluorine, chlorine, bromine, iodine and astatine. The proposed inclusion of potassium and its congeners with lithium and sodium as group I is indicated in the table by representing the subgroup by the symbol I(a), and similarly for II(a), IV(b), V(b), VI(b) and VII(b). The ambiguity for group III, which is considered by about equal numbers of authorities to include scandium and its congeners, on the one hand, and gallium and its congeners, on the other, is not resolved in this table.

Hydrogen is indicated by tie-lines to be related to both the alkali-metal group and the halogen group. In its chemical properties it is not closely similar to either the alkali metals or the halogens. However, it is assigned the oxidation number $+1$ in its compounds such as HF, and -1 in its compounds such as LiH; and it may hence be considered as being similar to a group I element and to a group VII element, respectively, in compounds of these two types, taking the place first of Li and then of F in LiF. Hydrogen is, in fact, the most individualistic of the elements: no other element resembles it in the way that sodium resembles lithium, chlorine resembles fluorine, and neon resembles helium. It is a unique element, the only element that cannot conveniently be considered a member of a group.

Ten of the elements of each long period are called the transition metals. There are usually taken to be scandium, 21, to zinc, 30 (the iron-group transition metals); yttrium, 39, to cadmium, 48 (the palladium-group transition metals); and hafnium, 72, to thallium, 81 (the platinum-group transition metals).

The periodicity in properties of the elements arranged in order of atomic number is strikingly shown by the consideration of the physical state of the elementary substances and such related properties as the melting point, density and hardness. The elements of group 0 are gases that are difficult to condense. The alkali metals, in group I, are soft, metallic solids with low melting points. The alkaline-earth metals, in group II, are harder and have higher melting points than the adjacent alkali metals. The hardness and melting point continue to increase through groups III and IV, and then decrease through groups V, VI and VII. The elements of the long periods show a gradual increase in hardness and melting point from the beginning alkali metals to the centre of the period (cobalt, rhodium, iridium), and then a fairly regular decrease to the halogens and noble gases.

The valence of the elements is closely correlated with position in the periodic table, the elements in the principal groups having maximum positive valence (oxidation number) equal to the group number; and maximum negative valence equal to the difference between eight and the group number.

The general chemical properties described as metallic or base-forming, metalloid or amphoteric, and nonmetallic or acid-forming are correlated with the periodic table in a simple way: the most metallic elements are to the left and to the bottom of the periodic table; and the most nonmetallic elements are to the right and to the top (ignoring the noble gases). The metalloids are adjacent to a diagonal line from boron to polonium. A closely related property is electronegativity, the tendency of atoms to retain their electrons and to attract additional electrons, as shown by ionization potential, electron affinity, oxidation-reduction potential, the energy of formation of chemical bonds with other elements and other properties. The electronegativity depends upon position in the periodic table in the same way as nonmetallic character, fluorine being the most electronegative element and cesium (or francium) the least electronegative (most electropositive) element.

The sizes of atoms vary regularly through the periodic system. Thus the effective bonding radius in the elementary substances in crystalline or molecular form decreases through the first short period from 1.52 Å (angstrom unit $= 10^{-8}$ cm.) for lithium to 0.73 Å for fluorine, then rises abruptly to 1.86 Å for sodium, and gradually decreases through the second short period to 0.99 Å for chlorine. The behaviour through the long periods is more complex: the bonding radius decreases gradually from 2.31 Å for potassium to a minimum of 1.25 Å for cobalt and nickel, and then rises slightly, and falls to 1.14 Å for bromine. The sizes of atoms are of importance in the determination of co-ordination number, and hence of the composition of compounds. The increase in atomic size from the upper right corner of the periodic table to the lower left corner is reflected in the formulas of the oxygen acids of the elements in their highest states of oxidation, as shown in Table IV.

TABLE IV.—*Formulas of Oxygen Acids of Elements in Their Highest Oxidation State*

$H_2Be(OH)_4$	H_3BO_3 $HAl(OH)_4$	H_2CO_3 H_4SiO_4 H_2GeO_4 $H_2Sn(OH)_6$	HNO_3 H_3PO_4 H_3AsO_4 $HSb(OH)_6$	H_2SO_4 H_2SeO_4 H_6TeO_6 and H_2TeO_4	$HClO_4$ HIO_4 and H_5IO_6

The smallest atoms group only three oxygen atoms about themselves; the next larger atoms, which co-ordinate a tetrahedron of four oxygen atoms, are in a diagonal belt; and the still larger atoms, which form octahedral oxygen complexes (stannic acid, antimonic acid, telluric acid, paraperiodic acid), lie below and to the left of this belt. It is only the chemical and physical properties of the elements that are determined by the extranuclear electronic structure; these properties show the periodicity described in the periodic law. The properties of the atomic nuclei themselves, such as the magnitude of the packing fraction and the power of entering into nuclear reactions, are, although dependent upon the atomic number, not dependent in the same periodic way.

The Electronic Structure of Atoms as the Basis of the Periodic System.—The noble gases, helium, neon, argon, krypton, xenon and radon, have a striking chemical property—that of forming few chemical compounds. It would be surmised that this property depends upon their possession of especially stable electronic structures. During the development of modern atomic physics and the theory of quantum mechanics, a precise and detailed understanding has been obtained of the electronic structure of the noble gases and other atoms that explains the periodic law in a thoroughly satisfactory manner.

The Pauli exclusion principle states that no more than two electrons can occupy the same orbit (or, in wave-mechanical language, orbital) in an atom, and that these two electrons in the same orbital must be paired; that is, must have their spins opposed. The orbitals in an atom may be described by a total quantum number,

n, which may assume the values 1, 2, 3, . . . ; and an azimuthal quantum number, l, which may assume the values 0, 1, 2, . . . , $n - 1$. There are $2l + 1$ distinct orbitals for each set of values of n and l. The most stable orbitals, which bring the electron closest to the nucleus, are those with the smallest values of n and l. The electrons that occupy the orbital with $n = 1$ (and $l = 0$) are said to be in the K shell of electrons; the L, M, N, . . . shells correspond respectively to $n = 2, 3, 4, \ldots$. Each shell except the K shell is divided into subshells corresponding to the values 0, 1, 2, 3, . . . of the azimuthal quantum number l; these subshells are called the s, p, d, f, . . . subshells, and they can accommodate a maximum of 2, 6, 10, 14, . . . electrons.

The approximate order of stability of the successive subshells in an atom is indicated in Table V. The most stable shell, the K shell, is completed at helium, with two electrons. The L shell is then completely filled at neon, with atomic number 10. The atoms of the heavier noble gases do not, however, have a completed outer shell, but instead have completed s and p subshells; *i.e.*, an outer shell of eight electrons, called an octet of electrons. The d subshells and f subshells are also filled with electrons after the less stable orbitals are occupied.

The electron occupancy of the shells in the noble gas atoms is:

Electrons in		K	L	M	N	O	P	Q	shell
He	2:	2							
Ne	10:	2	8						
Ar	18:	2	8	8					
Kr	36:	2	8	18	8				
Xe	54:	2	8	18	18	8			
Rn	86:	2	8	18	32	18	8		
	118:	2	8	18	32	32	18	8	

The numbers 2, 8, 18 and 32 correspond to filling the s; s and p; s, p and d; and s, p, d and f subshells, respectively.

The first period of the periodic table is complete at helium, when the K shell is filled with two electrons. The first and second short periods represent the filling of the 2s and 2p subshells (completing the L shell at neon), and the 3s and 3p subshells (at argon), leaving the M shell incomplete. The first long period begins by the introduction of electrons in the 4s orbital. Then at scandium the five 3d orbitals of the inner M shell begin to be occupied. It is the successive occupancy of these five 3d orbitals by their complement of ten electrons that characterizes the ten elements of the iron-group transition series. At krypton the M shell is complete and there is an octet in the N shell. The second long period, of 18 elements, similarly represents the completion of an outer octet and the next inner subshell of 10d electrons.

The very long period of 32 elements results from the completion of the 4f subshell of 14 electrons, the 5d subshell of 10 electrons, and the 6s, 6p octet. The filling of the 4f orbitals corresponds to the sequence of 14 lanthanons, and that of the 5d orbitals to the 10 platinum-group transition metals.

The next period, which is incomplete, involves the 5f subshell of 14 electrons, the 6d subshell of 10 electrons, and the 7s, 7p octet. The filling of the 5f orbitals corresponds to the actinons, the elements beginning with thorium, 90.

The successive periods of the system hence correspond to the introduction of electrons into the following orbitals:

The very short period, H, He.	2 elements. 1s.
The first short period, Li to Ne.	8 elements. 2s, 2p.
The second short period, Na to Ar.	8 elements. 3s, 3p.
The first long period, K to Kr.	18 elements. 3d, 4s, 4p.
The second long period, Rb to Xe.	18 elements. 4d, 5s, 5p.
The very long period, Cs to Rn.	32 elements. 4f, 5d, 6s, 6p.
The incomplete period, Fr to 118.	32 elements. 5f, 6d, 7s, 7p.

There are advantages to replacing the K, L, M, . . . shells by a different grouping of the subshells, in which those with nearly the same energy are grouped together, in close correlation with the periodic system. The new set of shells is the following:

The helium shell.	2 electrons. 1s.
The neon shell.	8 electrons. 2s, 2p.
The argon shell.	8 electrons. 3s, 3p.
The krypton shell.	18 electrons. 4s, 4p, 3d.
The xenon shell.	18 electrons. 5s, 5p, 4d.
The radon shell.	32 electrons. 6s, 6p, 5d, 4f.
The eka-radon shell.	32 electrons. 7s, 7p, 6d, 5f.

(*See* CHEMISTRY: *Inorganic Chemistry: Group VIII, the Rare Gases.*)

The Properties of the Elements of the Main Groups.—The periodicity of properties of the elements is caused by the periodicity in electronic structure. The noble gases are chemically unreactive or nearly so because their electronic structures are stable—their atoms hold their quota of electrons strongly, have no affinity for more electrons, and have little tendency to share electrons with other atoms. An element close to a noble gas in the periodic system, on the other hand, is reactive chemically because of the possibility of assuming the stable electronic configuration of the noble gas, by losing one or more electrons to another atom, by gaining one or more electrons from another atom, or by sharing electrons. (*See* VALENCE.) The alkali metals, in group I, can assume the noble-gas configurations by losing one electron, which is loosely held in the outermost (valence) shell, to another element with greater electron affinity, thus producing the stable singly charged positive ions. Similarly the alkaline-earth metals can form doubly charged positive ions with the noble-gas electronic configurations by losing the two loosely held electrons of the valence shell; the positive ionic valences of the elements of the first groups are hence equal to the group numbers. The elements just preceding the noble gases can form negative ions with the noble gas configurations by gaining electrons; the negative ionic valences of these elements are equal to the difference between eight and their group numbers. The covalence of an atom is also determined by its electron number and the stable orbitals available to it. An atom, such as fluorine, with seven electrons in its outer shell can combine with a similar atom by sharing a pair of electrons with it, thus achieving the noble-gas configuration, with three unshared pairs and one shared electron pair in the valence shell.

The properties of elements in the same group of the periodic system are, although similar, not identical. The trend in properties from the lighter to the heavier elements may be attributed to changes in the strength of binding of the outer electrons and especially to the increasing size of the atoms.

The Transition Elements.—The nature of the three transition groups can be discussed by taking the iron group as an example, since the other two groups are similar.

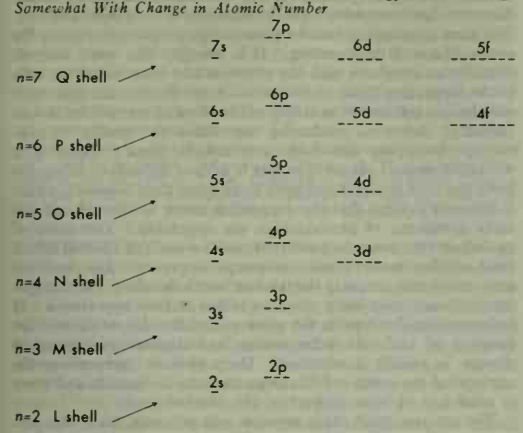
In potassium and calcium the valence electrons, outside of the argon shell, occupy the 4s orbital. Additional valence electrons, in scandium, titanium, etc., enter not the 4s subshell but the 3d subshell, which is then completely filled, along with 4s, in zinc. The elements potassium, calcium, scandium, titanium, vanadium, chromium and manganese have maximum oxidation numbers that range from one to seven, in that order, corresponding to their successive positions following argon. The atoms titanium to manganese are, however, not similar to the corresponding atoms carbon to fluorine or silicon to chlorine in the short periods because they are not directly followed by a noble gas, whose stable structure they might achieve by gaining or sharing electrons. Instead, these atoms have a strong tendency to form bipositive or terpositive ions by losing two or three electrons, the remaining valence electrons occupying the 3d orbitals, which for these positive ions are more stable than the 4s orbital.

The elements copper, by losing one electron, and zinc, by losing two, can form the ions Cu^+ and Zn^{2+} with a completed M shell of electrons. If the 4s and 4p orbitals were much less stable than the 3d orbitals, instead of about equally stable, this electronic configuration would be similar to the neon configuration; and nickel would be a noble gas, copper an alkali metal and zinc an alkaline-earth metal. The actual, different properties of nickel, copper and zinc result from their power of using the 4s and 4p orbitals in forming chemical bonds. Nevertheless, the effect of the 18-shell configurations (of Cu^+, Ag^+, Au^+) is evident in the normal valences of the elements of subgroups Ib, IIb, IIIb, IVb, which are equal to the group numbers.

These elements may also assume other valences, one or two greater (by losing additional electrons, leaving the 3d subshell incomplete) or two less (by having the 4s orbital occupied by an unshared electron pair).

It is convenient to consider ten of the elements in each long

TABLE V.—*Representing Qualitatively the Relative Stability of Successive Electron Orbitals in Atoms; the Relative Energy Values Change Somewhat With Change in Atomic Number*



period or very long period to be transition elements, corresponding to the introduction of ten electrons in a d subshell. There is some arbitrariness in the selection of these elements, because the sharp differentiation of s, p and d subshells for the outer electrons of an atom in a molecule or crystal is not possible; these subshells are precisely defined only for a system with spherical symmetry; *i.e.*, for a system containing only one nucleus.

Although the selection is arbitrary, it is convenient to consider the elements titanium to gallium inclusive as the first transition elements; zirconium to indium as the second; and hafnium to thallium as the third.

The Lanthanons.—The existence of a long series of very closely related elements, the lanthanons or rare-earth elements, has been clarified by the development of the understanding of the electronic structure of atoms. With increase in the atomic number of the elements the seven 4f orbitals become increasingly stable, until, at lanthanum, 57, or cerium, 58, these orbitals begin to be occupied. In the terpositive gadolinium ion, 64, the 4f subshell is half-filled, with one electron in each of the seven orbitals; and in the lutecium ion, 71, it is completely filled with its complement of 14 electrons.

The lanthanons thus comprise the 14 metals from cerium to lutecium, with the same electronic structure except for the variation from 1 to 14 in the number of 4f electrons. Often lanthanum, with the same electronic structure but with no 4f electrons in the terpositive ion, is also included among the lanthanons, increasing their number to 15.

The 4f orbitals are deep within the atoms—there is a stable noble-gas shell of eight 5s and 5p electrons outside, as well as, in the neutral atoms, two valence electrons in the 6s orbital and perhaps one in a 5d orbital. Because the 4f orbitals are in an inner shell, the properties of the atom or ion are changed only slightly by changes in the number of electrons that occupy them; hence the lanthanons are closely similar to one another in physical and chemical behaviour. This similarity was made strikingly evident by the great difficulty of separating them from the complex mineral mixtures in which they occur in nature, which caused their discovery to be spread over a period of more than a century.

The lanthanons all have +3 as their principal oxidation state, corresponding to the loss of the three valence electrons to more electronegative atoms. Cerium, praseodymium and terbium also occur in oxidation state +4, and samarium, europium and ytterbium in oxidation state +2.

The Actinons.—The only important general question about the periodic system to which the answer remains doubtful concerns the nature of the last period. Because thorium is more closely similar to hafnium than to cerium in many of its properties, and uranium is more closely similar to tungsten than to neodymium, it has been thought that the uranium elements constitute the beginning of a transition period similar to the two long periods, and involving the occupancy of the 6d subshell. However, G. T. Seaborg has pointed out that the properties of the transuranium elements suggest that these elements are members of a second series of the lanthanon type, with occupancy of the 5f orbitals beginning at thorium. It is true that uranium is unlike the lanthanons in that the +6 oxidation state is the most stable of its oxidation states (+6, +5, +4, +3); but neptunium, instead of being similar to rhenium, is reported not to have a stable +7 state; instead, neptunium and plutonium are said to have the same oxidation states as uranium, but with a general shift in stability toward the lower oxidation states.

An answer to this question can be given by the consideration of the stability and nature of the electronic orbitals involved. Although d orbitals contribute to the formation of strong covalent bonds, inner f orbitals are not useful in this way, as is shown by the small tendency of the lanthanons to form covalent compounds. The fact that uranium does form covalent compounds shows that the 6d orbitals are stable enough to be used for this purpose; and the stability of the +6 oxidation state shows that the 5f orbitals of uranium are not sufficiently stable to attract any of the six valence electrons very strongly. Hence the uranium period differs from the immediately preceding period in that the 5f orbitals are less stable relative to the 6d orbitals than are the 4f relative to the 5d orbitals. However, with increase in atomic number the 5f orbitals will increase in stability more rapidly than the 6d orbitals, and ultimately the 5f orbitals will be filled. It is likely that this process has begun at neptunium; and presumably it is completed at element 103, which is similar to lutecium in structure and properties, with probably a greater tendency to the formation of covalent compounds.

The 6d, 7s and 7p subshells are thus successively occupied, with element 118, eka-radon, as the next noble gas, though probably able to form some chemical compounds. The 14 elements from thorium to lawrencium are called the actinons.

Thus this great generalization, the periodic law, which first showed its value through Mendeléyev's prediction of the existence and properties of undiscovered elements, is again being put to the same use, the undiscovered elements of present interest being those that have greater atomic number than the known elements. The undiscovered elements will be sought not in nature's minerals, but in preparations made by man.

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PERIODONTAL DISEASES are diseases of the soft tissues around the teeth. Periodontal tissue includes both the (1) gingiva, or gum, the tissue that surrounds the neck of a tooth; and (2) the dental ligament, or attachment membrane, the soft tissue that surrounds the root of a tooth.

The free edge of the gingiva surrounds the neck of a tooth like a collar and slopes away on the outside to become continuous with the oral tissue covering the bony process of the jaw. This outer surface of the gingiva is firm, pink, and slightly stippled (rough). As the healthy gingiva completely surrounds the neck of a tooth, a shallow sulcus, or crevice, lies between the border of the gingiva and the line of attachment to the tooth surface. The remaining inner surface of the gingiva is normally attached to the roots of the teeth and is continuous with the deeper periodontal tissue. (*See* also TEETH: *Human Dental Anatomy*.)

The health of the gingiva is largely dependent upon the practice of regular daily hygienic care by proper tooth brushing and the use of dentifrices and mouth rinses. A surface covering of epithelium protects the soft tissue from injury and infection. Beneath the epithelium is another tissue, the connective tissue,

which is well supplied with blood vessels. Protective blood cells gather rapidly in the event of injury or infection to heal the soft tissue and resist the infecting agent, but when there is continuous irritation in the gingiva, inflammation results. This brings about the beginning of gingivitis, the simplest and commonest periodontal disease.

Gingivitis.—Gingivitis begins as a mild inflammation that causes bleeding gums. It is seldom painful and therefore frequently overlooked or neglected. It is usually a chronic condition brought about by a low-grade infection in the gums associated with constant mechanical irritation or irritation by dental calculus, food packing between two adjacent teeth, the retention of food, and soft deposits around the gum line. The commonest cause of all is the lack of brushing of the teeth. Inflammation in the gingiva gradually extends into the deeper periodontal tissues, loosening them from their normal attachment to the roots of the teeth. This eventually causes a pocket to form along the root surface beneath the collar of gum tissue, producing the beginning of a periodontal pus pocket, once called a pyorrhea pocket. Vincent's infection, a gingivitis commonly called "trench mouth," is an acute and painful form of gingivitis caused by specific microorganisms. It may be contagious, at least during the most active period of infection.

Hyperplastic gingivitis, or inflammatory enlargement of the gingival tissue, often is associated with certain systemic disturbances, such as diabetes, blood diseases, metal poisoning, and nutritional deficiencies. A more fibrous type of gingival enlargement, known as fibrous gingival hyperplasia, is frequently associated with hormone disturbance during adolescence or pregnancy. Another form of hyperplasia appears as a side effect in the use of diphenylhydantoin sodium in the treatment of epilepsy; this is a very firm, painless, but disfiguring type of fibrous hyperplasia.

All these types of gingivitis are amenable to treatment and can be cured by the removal or correction of the cause. This includes thorough removal of calculus deposits, correction of mechanical irritation, control of infection, and practice of daily home care.

Periodontitis.—Periodontitis, like gingivitis, is a progressive inflammation. It involves the deeper tissues surrounding and attached to the roots of the teeth. As the pocket deepens, the support of the tooth is weakened by loss of surrounding bone. Food residue and bacteria accumulate and stagnate in the pocket. Pus is formed and discharged from the pocket opening into the mouth. Eventually the tooth loosens because of the loss of its bony support. Sometimes an acute infection occurs in a deep periodontal pocket, causing much pain followed by swelling of the surrounding tissue. This is a periodontal abscess. It is not associated with the commoner abscesses that are found at the root tip when there is infection in the root canal.

Periodontitis is curable if treated early. The pockets should be curetted and irrigated, and the roots made smooth. Very often the overlying unattached soft tissue wall of the pocket must be removed surgically to eliminate the pocket. Personal dental hygiene on the part of the patient also is important. (*See* also ORAL SURGERY.)

Gingivosis and Periodontosis.—These degenerative diseases are difficult to explain and to control.

Gingivosis is a rather uncommon and painful condition sometimes found on the labial surface of the gingiva. The surface of the epithelium seems to peel or slough away because of degeneration of the underlying connective tissue, leaving a raw surface. The cause is unknown.

The cause of periodontosis, affecting the deeper periodontal tissues, also is not entirely clear. It seems to have several causes, probably being associated with some systemic disturbance that interferes with nutrition in this local tissue, causing it to break down. Periodontosis is characterized by drifting or separating teeth and by the sudden formation of pockets of considerable depth. There are seldom any calculus deposits on the affected teeth or any bleeding until a late stage of development. Injury from the occluding forces as the teeth are brought together results in destruction of the supporting bone and loosening of the teeth.

Tissues that are continuously subjected to severe stress may be affected by certain systemic factors that reduce the ability of the tissues to function and to repair the damage of daily wear and tear. The gums may appear healthy even though deeper tissue along the root surfaces is degenerating. It is thought that some internal disturbance interferes with the nutrition and function of the cells in the supporting tissue of the teeth. Some diseases interfere with metabolism and lower the ability of the blood to nourish the tissues properly. Inherited tendencies may affect the quality of constantly developing new bone and muscle tissue. Teeth with weakened support cannot take part in normal occlusion. When the teeth begin to separate and drift away from their normal position it becomes evident that the supporting tissue is affected and the early symptoms of periodontosis are appearing. The onset of periodontosis cannot be predicted, and no one can foretell which teeth will become involved in a susceptible person. The condition most commonly occurs in the third or fourth decade of life, but systemic diseases may bring about an earlier or later appearance. If inflammation develops in the gingivae and the deeper tissues, the progress of both the inflammatory and degenerative forms of disease is greatly accelerated. Deep pockets form along the surfaces of the roots and discharge pus into the mouth, and there is great loss of bony support of the affected teeth.

The anterior teeth often separate and protrude, while the posterior teeth move from their normal positions and are brought into abnormal relation with posterior teeth of the opposing jaw. This often subjects those teeth to abnormal biting stress and hastens their loss because of injury to the surrounding periodontal tissues. In the later stages of periodontosis, both the degenerative and the inflammatory symptoms become combined in a condition known as periodontitis complex.

In its early stages periodontosis can be alleviated and often cured by correcting an unbalanced diet and instituting very thorough home care of the teeth and gums. When the teeth begin to drift, retaining appliances are installed. Surgical removal of pockets is essential to remove diseased tissue and restore healthy underlying bone upon which new soft tissue can grow.

Traumatism.—The teeth normally are held firmly within a bony socket surrounded by very dense and strong tissue fibres of the periodontal attachment, or ligament. Although the teeth may seem immovable, there is a slight movement when pressure is applied horizontally. Normal periodontal attachment tissue varies in thickness from 0.1 to 0.3 mm.; if the root of a tooth moves more than half that distance under pressure, the periodontal tissue will be crushed against the bony socket.

When the teeth are brought into occlusion the cusps of the teeth of one jaw should fit into the grooves of the teeth in the opposing jaw in cusp-to-groove contact. Many factors interfere with this ideal arrangement, causing malocclusion, which results in abnormal horizontal stress upon some tooth or teeth. Constant horizontal stress may force a tooth to move and eventually loosen it in its socket. The effect of this causes traumatic injury in the supporting tissue. This has been known as traumatic occlusion but is more correctly called traumatism.

Periodontal Atrophy.—Atrophy is a wasting away or shrinking of tissue. Periodontal atrophy is classed as a degenerative condition, although it is not classed as a disease. Receding gums with a healthy colour and a normal attachment to the crown or root of a tooth are evidence of shrinkage and not of disease. When teeth have no occluding contact or function, the attachment tissue on the root surface undergoes a degenerative change, just as does almost any other unused muscle or organ. This is called disuse atrophy. Another form of atrophy, occurring late in life, is called senile atrophy. Atrophic changes in the gingival tissue may occur at any time after middle life. Brushing the teeth crosswise may cause toothbrush trauma to the gingiva and early recession of the gingival border of the gums, although it does not result in periodontal disease. (ER. D. C.)

Bruxism.—Bruxism is a voluntary or involuntary nonfunctional movement of the lower jaw. It is expressed as either occasional or habitual grinding, clenching, or clicking of the teeth at any time of day or night. Many individuals who have this habit

are unaware of it. Although the major cause of bruxism is psychological, there may be local, systemic, and occupational factors. In children, the cause may be of a developmental nature. Acts of bruxism vary in type, frequency, duration, intensity, and direction of force. Though not always destructive, the major effects are primarily wear of the teeth and loss of the bone structure that supports the teeth. Traumatism and disturbances in the joints of the jaw may develop. Bruxism should be suspected in all cases of periodontal disease. (S. C. Na.)

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PERIOECI (Greek Perioikoi, "dwellers around") had a specialized meaning in several ancient states, notably in Laconia, where it designated the free but voteless inhabitants ruled over by the Spartan aristocracy. Their origin is disputed, some ancient writers maintaining that they were the older Achaean inhabitants conquered by the invading Spartans, others that, like the Spartans themselves, they were Dorians. They lived in numerous cities of varying size, with a large measure of local independence but excluded from Spartan citizenship and subject to the supervision of the ephors and probably also of governors called harmosts. Sparta depended heavily on their military service: at Plataea in 479 B.C. an equal number of Spartans and *perioeci* fought in separate units; by the Peloponnesian War they fought together, and at Leuctra in 371 the army consisted mainly of *perioeci* with a Spartan cadre. Trade and industry, forbidden to Spartan citizens, were open to them. They were generally content with their status, and after 370 only the northern frontier areas, Arcadian by race, fell away from Sparta. In the Roman period the *perioeci* mostly formed separate states.

In Crete, on the other hand, this name was used for the serfs who tilled the land round each separate city. Elsewhere the political meaning, if any, depends on the circumstances, but the literal geographical sense is always important. (A. As.)

PERIPATETICS, the name given in antiquity to members of the school of Aristotle and their successors. The name was derived from the Peripatos, a covered walk in the Lyceum in Athens, where Aristotle began to teach in the year 335 B.C., on his return from Macedonia. Previously, he had attended the school of Plato in the Academy (up to Plato's death in 348–347 B.C.); it was in the Peripatos that he completed his transformation of the Platonic teaching, abandoning the doctrine of transcendent ideas and adopting in its place an empirical attitude to reality as manifested in nature and in history. This led to the most comprehensive encyclopaedic system of thought that was ever known in antiquity. (*See* Aristotle.)

Aristotle's immediate successor as leader of the school was Theophrastus (*q.v.*). Neither he nor Eudemos of Rhodes (*q.v.*) made any radical change in the teaching; they concentrated rather on the development of individual aspects. Theophrastus, however, tried to strengthen the systematic unity of the whole, giving further development to nearly every part of Aristotle's doctrines. But the increasing decline of the metaphysical elements, together with the expansion of empirical methods, was preparing the way for the coming independence of the specialized subjects. Soon the Peripatos could hardly any longer be called a school of philosophy, since it had lost even its unity of ethical teaching and was disintegrating into a number of separate disciplines. Dicaearchus and Aristoxenus (*qq.v.*), abandoning the cardinal principle of Aristotelian metaphysics, renounced belief in the immortality of the soul. Furthermore, Dicaearghus ceased to subscribe to the contemplative ideal of life preached by Theophrastus; and Aristoxenus confronted the ethics of Plato and Aristotle with a so-called Pythagorean theory reconstructed from traditional sources.

Further proof of how soon the school lost its philosophical unity is supplied by Clearchus of Soli who, like Aristoxenus and Dicaearchus, may still have been a personal disciple of Aristotle. In opposition to the other two, he clung to the idea of the soul's immortality. However, he attempted to prove this not through the dialectic methods of Plato and Aristotle but by means of popular tales about states of ecstasy, which he tried to link to primitive shamanistic traditions. In his treatment of ethical questions Clearchus seems to adhere to a general ideal of "moderation" which was not bound to any particular philosophical premisses. Thus in his treatise *Peri Bion*, in which he explains his attitude toward hedonism, the Aristotelian idea of the coexistence of several equally justified ways of life seems to have been forgotten.

A characteristic of this disintegration is the increasing number of specialized treatises on the natural sciences. Some such treatises written by Theophrastus are extant, and we know at least the titles of certain monographs on zoology, on physiology and on medicine by Strato of Lampsacus and by Clearchus. Strato moreover, in his physics, separated himself entirely from the teleological principles of Aristotle, approaching more nearly to the atomic theories of Democritus. According to the scientific qualifications of each investigator, this specialization in the sciences proved to be sometimes an advantage and sometimes a drawback: thus some Peripatetics contributed to the development of empirical disciplines of considerable stature, while others produced a number of works on the miraculous intended only for entertainment.

The achievements of the Peripatos are equally uneven in the field of the humanities. The foundation had been laid by Aristotle, who gathered material for his teaching on statecraft from political history, studied the philosophy of his predecessors as a basis for his own theories and discovered in ancient poetry important and vital examples for his own ethics. Here again the various branches became increasingly independent as time went on. Thus Demetrius Phalereus, who ruled as Macedonian governor in Athens from 317 to 307 B.C., wrote on Athenian constitutional history as well as on his own political activities. In their commentaries on the poets, the Peripatetics were able to refer back to old traditions that had begun with the explanations of Homer by the Rhapsodists; and their biographies of the poets were based on popular books on the life of Homer or Hesiod, from which they often borrowed the fictional embellishments. Aristotle, Dicaearchus, Demetrius Phalereus and Chamaeleon (a representative of the first generation of disciples) are all attested to have written works on Homer; and lyric and dramatic authors were equally favourite subjects for dissertations. The Peripatos notably stimulated the Alexandrian grammarians from Zenodotus to Aristarchus, whose editions and interpretations of the classical texts preserved that literature for posterity.

A new period in the history of the Peripatetics began in the 1st century B.C., when Andronicus of Rhodes (*q.v.*) published the long-neglected works of Aristotle and thus aroused interest in the philosophical tradition proper to the school. With Andronicus there came into being a way of interpreting the main writings of Aristotle which was to last as long as the Roman empire, reaching its climax with Alexander of Aphrodisias (*q.v.*). Admittedly Alexander interpreted Aristotle in a nominalist sense, maintaining that the universal was a mere abstraction from the particular (whereas Aristotle had in fact given it ontological priority, though conceding that our knowledge may spring from the particular). Alexander's interpretation, as Strato's long before him, involved opposition to Platonism at a time when other exponents were attempting on the contrary to smooth out as far as possible the differences between the teachings of Plato and the teachings of Aristotle.

As a synthesis of the two philosophies was actually brought about soon after Alexander's time by Plotinus, Aristotelian thought came to exert an influence in Neoplatonism (*q.v.*). This survived long after the school of the Peripatetics had perished. (F. Wi.)

PERIPATUS, a genus of remarkable wormlike Arthropoda (*q.v.*) belonging to the class Onychophora. The name is often loosely applied to all members of this class, which at one time were believed to be intermediate between Annelida (segmented worms) and Arthropoda (insects, spiders, crabs).

See Onychophora.

PERISCOPE, an optical instrument used in land and sea warfare and submarine navigation to enable an observer to see his surroundings while remaining under cover, behind armour or submerged. Technicians engaged in nuclear research employ extremely long periscopes to observe the functioning of nuclear reactors from a safe distance.

A periscope always includes, among its optical elements, two mirrors or reflecting prisms to change the direction of the light coming from the scene being observed: the first reflects it down through a vertical tube and the second diverts it horizontally so that it can be viewed conveniently. There is usually a telescopic optical system, which may be very complex, which gives magnification, provides as wide an arc of vision as possible and includes a crossline or a reticle pattern which establishes the line of sight to the target. There may also be devices or accessories for estimating the range and course of the target, and for photographing through the periscope.

The simplest type of periscope consists of a tube at whose ends are two mirrors which are parallel to each other but at 45° to the axis of the tube. This device produces no magnification and does not give a crossline image for gun-sighting use. The arc of vision is limited by the simple geometry of the tube—the longer or narrower the tube, the smaller the field of view. Periscopes of this type found very wide use in World War II in tanks and other armoured vehicles, as observation devices for the driver, gunner and commander. When fitted with a small auxiliary gunsight telescope at the side of the tube, the tank periscope can also be used in pointing and firing the guns. By employing tubes of rectangular cross section, approximately 7 in. by 2 in., wide horizontal fields of view can be obtained—large vertical fields are not necessary in surface combat. The vertical displacement of the line of sight is of the order of one foot. Sometimes solid prisms of glass or plastic are used in place of the end assemblies consisting of a mirror and two sealing windows. The periscopes and their swivel mounts are designed and constructed so as to be as water- and dust-tight as possible. The top mirror assembly or prism may be detachable, and readily replaceable with a spare unit in case it is shattered by enemy gunfire or is otherwise damaged.

Turret Periscopes.—Periscopes are installed in the gun turrets and armoured conning towers of battleships and cruisers in order that the gunnery officer can sight on the target and, if desired, can bring the guns to bear on it, when the turret is in "local control." The shape and construction of the turret may necessitate a periscope length of as much as 10 ft., for unobstructed vision. A simple instrument of the two-mirror type would have much too narrow an angular field of view; so a telescopic optical system is always employed. This may be thought of as having the effect of placing the observer's eye much closer to the top end of the periscope, thereby greatly increasing his arc of vision. It also makes possible magnification, which is necessary because the guns fire at long ranges. A crossline reticle can easily be included for gun-sighting use.

A typical optical system for such a periscope is shown schematically in fig. 1, in which the outline of the instrument is indicated also, for reference. The function of each optical part, described in order, is as follows: the upper sealing window *A*, through which light enters from the target scene; the head mirror or prism *B*, which reflects the incoming light down the periscope tube; the objective lens *C*, a cemented achromatic doublet lens which brings the light to a focus; a plano-convex collective lens *D*, located at this focus, and upon which the crossline or other reticle pattern may be etched; a pair of similar achromatic doublet lenses *E* and *F* which erect the image; the lower deflecting prism *G*, which turns the light into a horizontal path; the sealing plate *H*, at the lower end of the main periscope tube; one or more colour filters *I*, for haze and glare reduction, usually interchangeable red, yellow, polarizing and clear plates; the eyepiece, which consists of two doublet lenses, a so-called field lens *K* and an eye lens *L*. If it is desired to be able to illuminate the reticle for night use, the crossline may be etched on the lower sealing plate *H* rather than on the collective lens *D*. The sealing plate must then be located at the second focal point, *J*. The reticle markings may include several short vertical lines equally spaced on each side of the vertical crossline; these are used in estimating the deflection error of the projectiles. Moving parts outside the sealed main portion of the periscope are the interchangeable colour filters and the eyepiece which can be adjusted in focus to suit the individual observer.

This optical system can be thought of as consisting of two astronomical telescopes. The upper one is made up of lenses *C*, *D* and *E*. It provides little magnification but transfers the target image and field of view down the periscope tube to lens *F*, which is the objective lens of the second telescope; *K* and *L* constitute its eyepiece. This second astronomical telescope magnifies the image in the ratio of the focal lengths of the objective and eyepiece. It also erects the image, which has been inverted in both the up-and-down and left-to-right senses by the first telescope.

The mirror or reflecting prism at the upper end of the periscope tube is so arranged that it can be tilted by means of a mechanism that is actuated by a handwheel located near the eyepiece; the line of sight may thus be carried through as much as 30° above and below the horizontal. The entire periscope can be rotated in its mount about its vertical axis through 360°, so as to scan the horizon. In order to prevent fogging of optical surfaces and the consequent loss of vision, the interior of the periscope must be thoroughly dried, filled with dry air or nitrogen and sealed tightly against the atmosphere. Gas inlet and outlet valves are ordinarily provided for this purpose.

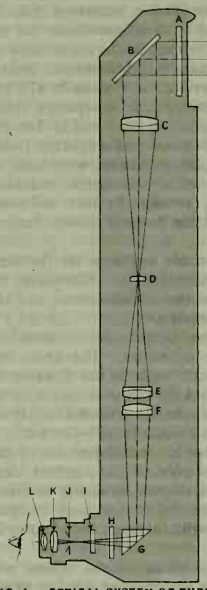

FIG. 1.—OPTICAL SYSTEM OF TURRET PERISCOPE USED IN WARSHIPS (*see* TEXT)

A typical turret periscope will have an optical magnification of approximately 10 and an angular field of view of 4° to 6°. The brilliance of the image seen by the observer depends on the over-all light transmission of the instrument and on the size of the exit pupil; *i.e.*, the beam of light that emerges from the eye lens. Conditions imposed on the optical design usually permit a fairly large exit pupil, say 5 mm. in diameter, which is sufficient for day use. For night use, however, the emergent beam of light should entirely fill the pupil of the observer's eye for maximum brightness of image. This necessitates an exit pupil of 7- to 8-mm. diameter, which usually entails larger diameter optical elements throughout, with a concomitant increase in over-all size, weight and cost of the instrument. The percentage of light transmitted by an optical instrument can be greatly increased by coating all air-to-glass surfaces of the various lenses and prisms with so-called reflection-reducing films. The use of such films in the optical system of fig. 1 will increase its light transmission from around 30% to more than 50%, a gain of almost 100%. Also, the image rendition is improved in that crisper, clearer images are obtained and ghost images and flare spots are eliminated. This technique of coating optical surfaces came into wide use in military optical instruments during World War II.

Submarine Periscopes.—Periscopes used in submarines are similar in principle to the turret periscopes of warships but differ from them in certain important respects because of the following special conditions which are imposed: the submarine periscope must be much longer, and the top few feet of its length must be greatly reduced in diameter. The periscope must be capable of being raised and lowered into the hull of the submarine; it should

have available both low and high optical magnifications.

The over-all length of a periscope may exceed 40 ft., and a large fraction of this length will be exposed, outside the hull of the submarine, at maximum extension of the periscope. Great forces are exerted on the tube in dragging it through the water when the submarine is underway submerged. Thus, the tube must be large enough to give sufficient rigidity without offering too much resistance to motion through the water; a diameter of from 6 to 8 in. is usually selected, depending on the length. This tube must be made of a corrosion-resistant material and must be very carefully machined for perfect roundness, straightness and uniformity in diameter, since it must permit both rotation about its vertical axis and raising and lowering of the periscope in the long watertight gland through which it enters the hull of the submarine. Near the upper end of the periscope tube is a tapered portion above which is a narrow tube 2 or 3 ft. in length, surmounted by a slightly larger head which contains the entrance window and the elevating prism.

The diameter of this tube is made as small as possible, often less than 2 in., to reduce the probability of its detection by enemy observation and to cut down the size of the wake or "feather" caused when the submerged submarine is in motion with its periscope elevated into observing position.

All of the joints in the periscope tube, the sealing of the upper window and the packing of the stuffing box at the hull line must be made tight enough to withstand the considerable hydrostatic pressures encountered when the submarine submerges. Rotation of the periscope is usually accomplished by the observer, who grasps two folding handles at the lower end; proper adjustment of the stuffing box permits this rotation without allowing sea water to leak into the submarine.

The periscope is raised, or is lowered into a well extending into the hull of the boat, by push-button-actuated electrical hoisting equipment controlled by the observer.

Two magnifications are usually provided, 1½ and 6. The first gives the observer the impression of normal viewing, the extra power over unity being necessary to overcome the psychological effect of "tunnel vision." The field of view associated with the 1½ power is in the range 32°–40°, depending on other design considerations. Use of the higher power enables the observer to see greater target detail, but restricts the field of view to 8°–10°, one-fourth of the low-power values of angular field, but one-sixteenth the areas.

The magnification change is effected by rotating one of the folding handles at the lower end of the periscope. Rotation of the other handle moves the line of sight through angles between 10° depression below horizontal and 45° elevation, by tilting the head prism. The wide use in World War II of aircraft to hunt down enemy submarines, however, made it necessary to provide "high-angle" or sky-searching periscopes capable of viewing at such elevations as to be able to scan the entire sky, from horizon to zenith.

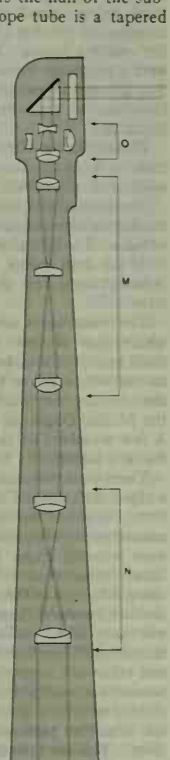

FIG. 2.—UPPER PORTION OF LONG, NARROW-TUBE SUBMARINE PERISCOPE (NOT TO SCALE)

The exit pupil diameter of standard submarine periscopes is 4–5 mm. This is sufficient for day use, but not for the best performance at night, when a value of 7 mm. is needed. In order to obtain this larger light-gathering power, the size of the lenses near the head prism must be increased. Therefore, it is impossible to retain the very small diameter of the upper portion of the periscope tube.

Certain schools of thought maintain, however, that too much emphasis has been placed on, and too high a price paid for, keeping this dimension so small. The light transmission of the most complicated periscopes may be around 15%, which is undesirably low. Treatment of the air-to-glass surfaces of all the lenses and prisms with reflection-reducing films raises the transmission by as much as 200%, according to the number of surfaces involved. The resulting gain in image brightness is very noticeable and is particularly valuable during nighttime, dawn and dusk, the most favourable periods for submarine torpedo attacks.

The reticle lens has engraved upon it special telemeter scales which make possible a rough calculation of the distance of a target vessel, based on an estimate of its length or height. More accurate ranges can be determined by the special stadimeters usually built into or attached to submarine periscopes.

The optical system of a submarine periscope may be essentially that of fig. 1, except that the focal lengths and spacing of the lenses are adjusted to give a magnification of 6. However, for very long periscopes in which the narrowest possible top portion is desired, which severely restricts the diameter of the upper lenses, this optical system will not provide the observer with sufficient field of view. A solution to these difficulties is illustrated in fig. 2. In a location corresponding to above lens *C* of fig. 1 there are added two complete astronomical telescopes, *M* and *N*, each consisting of two or three lenses. The telemeter scales are then engraved on a plano-convex lens in the uppermost astronomical telescope, rather than on lens *D* of fig. 1.

In order to provide the lower magnification of 1½ and still retain a wide field of view and sizable exit pupil, additional lenses must be added at the top end of the complete telescopic system. This is usually done as illustrated in fig. 2, by bringing into the line of sight a small four-power reversed Galilean telescope *O* which consists of two achromatic lenses, the upper of which is diverging and the lower converging. The higher magnification of 6 is obtained when these lenses are swung to the side. The provision of movable lenses and the necessary controls in this already crowded portion of the tube calls for very careful mechanical design. The periscope just described employs the most complicated optical system used in any common military instrument.

See also SUBMARINE.

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(S. S. B.)

PERISSODACTYL, any of the hoofed mammals of the order Perissodactyla, which includes horses, tapirs, rhinoceroses, and their extinct relatives.

GENERAL FEATURES

Structure.—The most characteristic feature of these animals is the structure of the feet. In perissodactyls the axis of the foot passes through the middle toe, whereas in artiodactyls, the other large group of hoofed animals, the axis passes between the third and fourth toes. The outer toes tended to disappear during the evolution of hoofed animals, leaving perissodactyls with an odd number of functional toes (hence the common term odd-toed ungulates) and artiodactyls with an even number (even-toed ungulates). Other features more or less characteristic of perissodactyls are the general tendency for the premolar teeth to resemble molars ("molarization" of the premolars), the presence of a full set of incisor teeth (absent in the upper jaw of most artiodactyls) and the presence of a third trochanter on the femur. The stomach is simple, and there is a large caecum at the juncture of the large and small intestines. All living perissodactyls lack a gall bladder. (*See* ARTIODACTYL.)

Origin and Evolution.—The living perissodactyls are only a remnant of a once-flourishing group that reached the peak of its evolutionary history in Middle Tertiary times, about 30,000,000

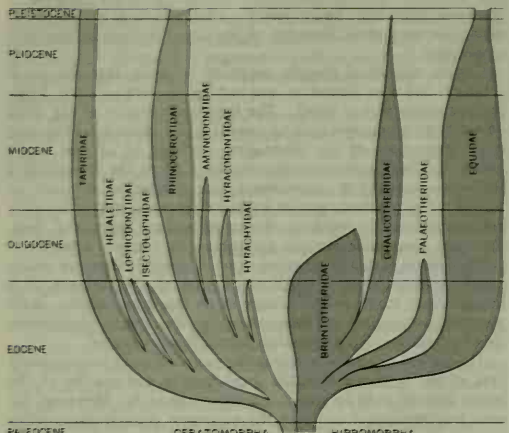

FIG. 1.—EVOLUTION OF THE PERISSODACTYLS. WIDTH OF BAND INDICATES RELATIVE ABUNDANCE OF SPECIES IN EACH BRANCH

years ago, when its members were the dominant hoofed animals in most of the world, occupying about the same position among the animals of that era that deer, antelope, and oxen do today. After the Middle Tertiary they declined rapidly. Most of the families died out completely, and there can be little doubt that the whole order is on the verge of extinction today. The reasons for the decline of the perissodactyls and the rise of the artiodactyls are unknown. At the peak of their development the perissodactyls seem to have been highly evolved and intelligent animals.

The ultimate ancestors of the perissodactyls undoubtedly were among the Condylarthra, a primitive stock of Paleocene mammals that gave rise to most of the later hoofed mammals. The direct ancestors of the perissodactyl stock must have resembled *Hyracotherium*, the ancestral four-toed horse, which lived in the Early Eocene, about 50,000,000 years ago. *Hyracotherium* was primitive in most respects, but its legs were slender and adapted for running. Almost at its beginning the perissodactyl stock divided into two major lines, the Hippomorpha, or horselike perissodactyls, and the Ceratomorpha, or rhinoceroslike perissodactyls. Both lines evolved rapidly, and before the end of the Eocene the perissodactyls had reached the peak of their radiation, with no fewer than 12 families represented. By the end of the Eocene, about 35,000,000 years ago, they had already passed their peak. Only nine families survived into the next epoch, the Oligocene, and four of these died out before the end of the epoch. Only three families are extant today.

SURVEY OF THE ORDER

Hippomorpha

The suborder Hippomorpha is divided into four families: Palaeotheriidae, Equidae, Brontotheriidae, and Chalicotheriidae.

Paleotheres (Palaeotheriidae).—These were the closest relatives of the true horses, and their remains are known only from Europe and Asia. For a time the evolution of the paleotheres in Europe paralleled the evolution of the true horses in North America. Unlike the horse line, the paleothere line was relatively short lived; the last paleotheres died in the Early Oligocene, more than 30,000,000 years ago.

The paleotheres were rather tapirlike browsing animals with low-crowned cheek teeth and short stout legs ending in three toes. The earliest species were small, but some of the later species were as large as rhinoceroses. The best-known genus is *Palaeotherium* (meaning "ancient beast"), which occurs in abundance in gypsum deposits within the city of Paris. These Parisian fossils were studied in detail by the great French anatomist Cuvier in the early 19th century, giving *Palaeotherium* the distinction of being one of the first fossil mammals so studied.

Horses (Equidae).—The fossil record of the horses is the best known of all mammals. It begins in the Early Eocene, about 50,000,000 years ago, with *Hyracotherium*, the eohippus (*q.v.*) or dawn horse. *Hyracotherium*, known from North America and Europe, was very close to the ancestral type of the perissodactyl stock, being a small mammal with a primitive skull, the primitive mammalian number of 44 teeth, and the cheek teeth low crowned for crushing leaves. From this beginning the horse stock underwent a progressive evolution accompanied by a great deal of splitting up into numerous branches, especially during the Miocene. Only one of these branches leads to the modern horses. (*See* EQUIDAE.)

Titanotheres (Brontotheriidae).—The titanotheres or brontotheres left a fossil record nearly as complete as that of the horses, making this one of the best-known groups of fossil mammals.

The titanothere family is remarkable for its short life and for the degree of evolution that took place in this relatively brief period of time. The first titanotheres appeared in the Early Eocene along with the first horses, and the family was completely extinct in North America by the Early Oligocene, about 55,000,000 years later.

The titanotheres were essentially a North American group. The whole span of their history is represented in North American fossil beds; the huge bones of these beasts are particularly abundant in the White River Oligocene beds of South Dakota. Late in their history they pushed into Asia, where the group survived into the Middle Oligocene after all American forms had disappeared. A few members of the titanothere family ranged as far west as Eastern Europe.

There were two main trends in the evolution of the titanotheres: a rapid drift toward large size and a tendency to develop bizarre bony knobs on the nose. In other respects the titanotheres remained relatively primitive throughout their history. The earliest were scarcely larger than a dog, and lightly built, whereas the latest forms were as large as elephants. *Brontotherium* stood about 8 ft. high at the shoulders. The cheek teeth remained square and low crowned throughout all the history of the family. There was only slight molarization of the premolars, suggesting that throughout their history the titanotheres were browsers on leaves and other soft vegetation. In the latest giant species the molars became extremely large, contrasting with the premolars, which remained relatively small. In the first titanotheres the forefeet had the primitive perissodactyl number of four toes, the hind feet three. This toe formula was retained in all the later forms. In the larger and heavier species the skeleton was adapted to supporting great weight: the pelvis flared out; the legs were columnar; and the feet were broad and short. The thoracic vertebrae were char-

BY COURTESY OF (LEFT) PRINCETON UNIVERSITY MUSEUM OF NATURAL HISTORY FROM A DRAWING BY ROBERT BRUCE HORSFALL, (CENTRE) THE CHICAGO NATURAL HISTORY MUSEUM, (RIGHT) THE AMERICAN MUSEUM OF NATURAL HISTORY FROM A DRAWING BY CHARLES R. KNIGHT

FIG. 2.—RESTORATIONS OF EXTINCT PERISSODACTYLS: (LEFT) HELALETES, (CENTRE) HYRACOTHERIUM WITH YOUNG; (RIGHT) HYRACODON

acterized by long spines for supporting the weight of the heavy head.

The titanotheres diverged into several lines in the course of their evolution. One line, represented by *Manteoceras*, led to the giant-horned titanotheres. In another line, the dolichorhines (long-headed titanotheres), the skull became very long and horns were never developed. In still another branch, the telmatheres, there were no horns, but the canine teeth became large and tusk-like.

(LEFT) MARY ELEANOR BROWNING—PHOTO TRENOS, (CENTRE, RIGHT) YLLA—RAPHO GUILLUMETTE

FIG. 3.—LIVING PERISSODACTYLS: (LEFT) HORSE (EQUUS CABALLUS); (CENTRE) SOUTH AMERICAN TAPIRS (TAPIRUS TERRESTRIS); (RIGHT) AFRICAN BLACK RHINOCEROS (DICEROS BICORNIS)

Chalicotheres (Chalicotheriidae).—Compared with the titanotheres, the chalicotheres were a long-lived group; the last chalicothere died in the Pleistocene, only a few thousand years ago. At no time during their long history were they very numerous; they never underwent the spectacular evolution that characterized the titanotheres.

The first chalicotheres were small creatures similar to the other primitive perissodactyls of Eocene times. During the Oligocene and Early Miocene these developed into bizarre animals that have no counterpart among living mammals. The hooves of the earliest chalicotheres evolved into huge claws on both front and hind feet; the body was short; and the front legs were longer than the hind legs so that the animal sloped from front to rear like a giraffe. They were most ungainly looking animals, and it is difficult to imagine what their habits were. The teeth, like those of the titanotheres, were low crowned and square, adapted to crushing soft food. From North America the chalicotheres spread into Eurasia. The best-known chalicothere is the North American *Moropus*, which was the size of a large horse.

Ceratomorpha

The suborder Ceratomorpha is typified by the modern tapirs and rhinoceroses. The group is divided into eight families: the Isectolophidae, Helaletidae, Lophiodontidae, Tapiridae, Hyrachyidae, Hyracodontidae, Amynodontidae, and Rhinocerotidae. Only two of these, the Tapiridae and Rhinocerotidae, have living representatives.

The isectolophids, helaletids, and lophiodonts were early and not very successful side branches of the tapir stock. Nearly all died out before the end of the Eocene. They were mostly small slender creatures, generally similar to the other primitive perissodactyls, although *Lophiodon* of the Late Eocene of Europe was as large and heavy as a rhinoceros.

Tapirs (Tapiridae).—In many ways the living tapirs are primitive perissodactyls, very similar to the common ancestors of all perissodactyls. This is in part because they have retained the habits of the early perissodactyls: they live in forests and still browse on leaves and soft vegetation instead of grazing on harsh grasses. The back is curved instead of being straight as in fast-running perissodactyls. The cheek teeth are low crowned, have a simple pattern, and lack a cement covering. The last three premolars are strongly molarized, as in the horses. The only striking specialization of the tapirs is the development of a short flexible proboscis. (*See* also TAPIR.)

True tapirs first appeared in the Oligocene, probably as descendants of one of the more primitive Eocene groups; some students think they may have descended from the helaletid *Heptodon*. The earliest known true tapir is *Protapirus*, found in North America and Europe. *Protapirus* was similar to modern tapirs, even having a tapirlike proboscis, and the further evolution of the group involved mostly an increase in size. Fossil tapirs are relatively rare, as is true of all forest-dwelling animals.

Rhinoceroses (Rhinocerotidae).—The rhinoceroses and their relatives (hyrachyids, hyracodonts, and amynodonts) have the most complicated history of any group of the perissodactyls. The living rhinoceroses are the only survivors of this large assemblage, and several species of these are on the verge of extinction. There can be no doubt that this group of perissodactyls, once numerous and successful, is about to disappear forever. (*See* also RHINOCEROS.)

The earliest known rhinocerotoid is *Hyrachyus*, a small slender creature the size of a large dog, rather similar to the earliest horses in appearance. *Hyrachyus* lived in North America in Eocene times. In the Late Eocene the hyrachyid stock gave rise to two lines that continued the further evolution of the rhinocerotoids. One of these lines was the hyracodonts or "running rhinoceroses," typified by *Hyracodon* of the North American Oligocene. These were long-necked, slender-legged animals, with three toes in front and three behind. None of them had horns. They probably paralleled the early horses in their habits, and may in fact have competed with them. The running-rhinoceros line died out at the end of the Oligocene. A second branch of the hyrachyid stock was the amynodonts, represented by *Amynodon* and *Metamynodon*. The amynodonts were heavy-bodied, short-legged animals about the size and build of a hippopotamus. They had no horns, but the canine teeth were large and daggerlike. The premolar teeth never became molariform. Their bones are usually found in river-channel deposits, and it is likely that their habits were similar to those of the river-loving modern hippopotamus.

The known history of the true rhinoceroses begins in the Oligocene, but these earliest-known forms were probably derived from the running-rhinoceros stock at some time during the Eocene. The rhinoceroses, in contrast to the running rhinoceroses, tended toward large size very early in their history. The premolar teeth rapidly became molarized, as in the horses, but the incisors formed a special chisellike cropping tool. Some, but not all, of the later species developed horns on the nose; these are not true horns, however, being composed entirely of matted hairs. Although the true rhinoceroses seem to have originated in North America, most of their evolution took place in the Old World.

One of the early true rhinoceroses was *Caenopus* from the Oligocene of North America, a heavy-bodied hornless creature standing about 5 ft. high at the shoulders. From this and other early species the rhinoceroses radiated into several phyletic lines during the Oligocene and Miocene. Thus *Teleoceras* and its relatives were remarkably short-legged animals, apparently with amphibious habits similar to those of the modern hippopotamus. The elasmotheres were giant rhinoceroses, with a large horn on the forehead instead of on the nose, that lived in Eurasia in the Pleistocene. The Asiatic baluchitheres were the largest of the rhinoceroses, and *Baluchitherium* itself was the largest land mammal that ever lived. It stood about 18 ft. high at the shoulders, had a head about 4 ft. long, and was hornless.

The direct ancestors of the modern rhinoceroses appeared in the Late Miocene. The modern species belong to several different groups with slightly different ancestries. The one-horned Indian rhinoceros (*Rhinoceros*) most closely resembles the ancestral form. The two-horned Sumatran rhinoceros (*Ceratorhinus*) is apparently related to the woolly rhinoceros depicted in the cave paintings of Stone Age man. The two-horned rhinoceroses of Africa, the black (*Diceros*) and white (*Ceratotherium*), represent a separate branch.

CLASSIFICATION AND DISTRIBUTION

The following classification is one of several taxonomic outlines. An asterisk (*) indicates an extinct group.

Suborder Hippomorpha
- Superfamily Equoidea
  - Family Palaeotheriidae* (Eocene: Asia; Eocene-Oligocene: Europe).
  - Family Equidae—horses (Eocene-Pleistocene: North America; Eocene-Recent: Europe; Miocene-Recent: Asia; Pliocene-Recent: Africa; Pleistocene: South America; worldwide in domestication).
- Superfamily Brontotherioidea*
  - Family Brontotheriidae* (Eocene-Oligocene: North America, Asia, Europe).
- Superfamily Chalicotherioidea*
  - Family Chalicotheriidae* (Eocene-Miocene: North America; Eocene-Pliocene: Europe; Eocene-Pleistocene: Asia).

Suborder Ceratomorpha
- Superfamily Tapiroidea
  - Family Isectolophidae* (Eocene: North America, Asia).
  - Family Helaletidae* (Eocene-Oligocene: North America, Asia).
  - Family Lophiodontidae* (Eocene: Europe, Asia).
  - Family Tapiridae—tapirs (Eocene-Pleistocene: North America; Oligocene-Pleistocene: Europe; Miocene-Recent: Asia; Pleistocene-Recent: South America).
- Superfamily Rhinocerotoidea
  - Family Hyrachyidae* (Eocene: North America, Asia).
  - Family Hyracodontidae* (Eocene: Asia; Eocene-Oligocene: North America).
  - Family Amynodontidae* (Eocene-Oligocene: North America; Eocene-Miocene: Asia; Oligocene: Europe).
  - Family Rhinocerotidae—rhinoceroses (Eocene-Pliocene: North America; Eocene-Pleistocene: Europe; Eocene-Recent: Asia; Miocene-Recent: Africa).

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(D. D. D.)

PERITONITIS, is an acute or chronic, localized or generalized inflammation of the peritoneum. Before the development of aseptic surgery in the latter half of the 19th century, almost all patients who underwent abdominal surgery developed peritonitis and died; consequently, such surgery was seldom attempted. Even with the improvements brought about by aseptic surgery, about 33% of all peritonitis cases terminated in death, although a much greater amount of abdominal surgery was attempted. With the advent of sulfonamides, antibiotics, and improved surgical and therapeutic techniques in the 1940s, the peritonitis mortality rate dropped to between 5% and 10%, and early in the second half of the 20th century, the incidence of peritonitis in abdominal surgery was only about 2%. Infection following surgery was, however, no longer the main cause of peritonitis.

Acute peritonitis commonly arises as a result of extension of infection from an appendix that has been permitted to become gangrenous in appendicitis and to perforate, discharging infected fecal material into the abdominal cavity. It may also follow the perforation of a gastric or duodenal ulcer; the bursting of abscesses or cysts into the abdominal cavity; or the extension of gonorrheal infection of the uterus in the female. It may arise as a complication of abdominal surgery, usually when a leak develops after the intestines are sutured together following the removal of a segment for cancer or some other disease. The escape of bile from the gallbladder or a bile duct into the peritoneal cavity may produce a rapidly fatal acute peritonitis.

At onset of the inflammation, the peritoneum loses its shiny appearance, becoming rough, granular, and markedly congested. An exudate begins to flow into the peritoneal cavity; it is at first thin and turbid, later becoming thick and purulent with increasing amounts of fibrin. The intestines become glued together and adherent to the omentum, abdominal wall, and other abdominal organs. The inflammation of the peritoneum is usually due to the aerobic and anaerobic bacteria commonly present in the intestinal tract, which overcome the resistance of the peritoneum when constantly replenished, as from a leak in the bowel, or from infected foreign material such as food or a bit of necrotic appendix.

Acute peritonitis usually begins with a chill, vomiting, and pain in the abdomen with extreme tenderness so that pressure, even of the bedclothes, cannot be borne. The patient lies on his back with the knees drawn up to relax the abdominal muscles; the breathing becomes rapid and shallow and is performed by movements of the chest only, the abdominal muscles remaining quiescent, which is not the case in healthy respiration. The abdomen becomes swollen as a result of gaseous distention of the intestines, and there is usually constipation. The pulse is rapid and feeble, and the temperature rises to 104° or 105° F (40° or 40.56° C). There is a complete absence of intestinal peristalsis. A cold, clammy sweat appears on the forehead, and the eyes are withdrawn into the orbits. The expression is one of great anxiety, but the mind remains clear even when death approaches.

Death results from the cessation of movements in the intestinal tract so that gastric and duodenal secretions accumulate in the stomach and are lost to the body as a result of vomiting. The continued escape of the digestive secretions produces a progressive demineralization, dehydration, and alteration in the chemical composition of the blood. The secretion of urine decreases and finally stops. When these disadvantageous factors are combated by decompression of the stomach and intestines by suction tubes and intravenous administration of salt solution, many patients make a remarkable recovery. It is probable that paralysis of the intestines, secondary to the infection of the peritoneal cavity, is more important as the cause of death in generalized peritonitis than is invasion of the bloodstream by bacteria or the absorption of poisonous materials from the peritoneal cavity.

The treatment of generalized peritonitis consists in the administration, systemically, of drugs such as penicillin, streptomycin, chlortetracycline (Aureomycin), or sulfadiazine; and a surgical operation designed (1) to remove from the peritoneal cavity foreign material that serves as a nidus, or focus of infection, (2) to close perforations of the intestinal tract, and (3) to provide drainage. Decompression of the intestinal tract by tubes introduced through the nose into the stomach, with constant suction, is of great value. Blood transfusions and intravenous administration of physiological solutions of sodium chloride and other salts are very helpful.

(L. R. Dt.)

PERIWINKLE, in zoology, any small marine snail belonging to the family Littorinidae. They are widely distributed shore (littoral) snails, chiefly herbivorous, usually found on rocks, stones or pilings between high and low tide marks; a few are found on mud flats and some tropical forms are found on the prop roots of mangrove trees. Of the approximately 80 species in the world, ten are known from the western Atlantic. The common periwinkle, *Littorina littorea*, may be found in great abundance on the rocky shores of northern Europe and northeastern North America. It is the largest, most common and widespread of the northern species. It may reach a length of 1½ in., is usually dark gray and has a solid spiral (turbinate) shell that readily withstands the buffeting of waves.

Formerly, periwinkles were an important source of food, particularly for the poorer classes in the British Isles, France and the Netherlands. In 1858 the London market consumed 76,000 bu. Since that time periwinkles have been considered a delicacy by many people and are still consumed in large quantities. In Europe they are frequently sold by street vendors, particularly in seaside towns. In France, where they are known as *vignot* or *vignette*, the snails are usually boiled in a small amount of heavily salted water (the salt tends to loosen the animal from the shell). The meat is then either made into periwinkle soup or served with butter or a variety of sauces.

The breeding habits of periwinkles are quite variable. *Littorina saxatilis*, which lives high up on rocks and is often out of water for long periods of time, holds its eggs in a brood sac until the young are fully developed, at which time they emerge as tiny crawling replicas of the adult.

The common periwinkle was introduced into North America at Halifax, Nova Scotia about 1857 and has spread as far south as New Jersey. It is very common on the rocky shores of New England, and also occurs on shallow muddy bottoms, along the banks of tidal estuaries and among the roots and blades of marsh grass

where the water is only moderately salty.

All species in the Littorinidae are important as a favourite food of many shore birds, particularly ducks.

In many sections of the southern United States the term periwinkle or penny-winkle is applied to any small fresh-water snail.

See also MOLLUSK; SNAIL; SHELLS AND SHELL COLLECTING.

See J. C. Bequaert, "The Genus *Littorina* in the Western Atlantic," *Johnsonia* 1, no. 7, pp. 1–27, pl. 1–7 (1943); C. M. Yonge, *The Sea Shore* (1949). (R. D. T.)

PERIWINKLE, in botany, the name given to various plants of the genus *Vinca*, of the dogbane family (Apocynaceae). The name periwinkle is possibly taken from *pervinka*, the Russian name of the flower, which in turn is derived from *pervi*, "first," as it is one of the first flowers of spring. The lesser periwinkle (*V. minor*), with lilac-blue flowers, ¾ in. across, an evergreen, trailing perennial, has run wild throughout eastern North America. It is native to Europe and is found in the British Isles. The similar greater periwinkle (*V. major*), with purplish-blue flowers, 1 to 2 in. across, native to continental Europe, has become naturalized in England. The Madagascar periwinkle (*V. rosea*) is of world-wide distribution in the tropics.

ROCHE

PERIWINKLE (VINCA MINOR), A CREEPING PLANT OFTEN USED AS GROUND COVER UNDER TREES OR IN STONY AREAS

PERIYAR, a river and lake of southern India. The river rises in the Cardamom Hills and flows westward for about 140 mi. through the state of Kerala into the Arabian Sea. Its source is in a wet part of the country with a long rainy season, and it flows across well-watered terrain where no irrigation is required. The upper valley was accordingly dammed, and from the large irregular-shaped Periyar Lake thus formed the water was taken by a tunnel for more than one mile through the mountains to the dry eastern side in the state of Madras. There the water from the lake irrigates a large area in the vicinity of Madurai. This has been a successful operation since 1895, and one of the later projects of independent India was the development of hydroelectric power from the lake. The Periyar hydroelectric scheme, with a planned output of 105,000 kw., was commissioned in 1958. (L. D. S.)

PERJURY, in a general sense and by etymologic origin, means lying under oath. The common definition of perjury as a criminal offense is an intentional misstatement of material fact made under oath or affirmation in a legal proceeding before a tribunal authorized to conduct the proceeding. Related offenses under modern penal codes deal with "false swearing" under other circumstances, and with non-sworn falsification in official matters.

As a transgression of spiritual significance, it was formerly in England subject only to religious sanctions administered by ecclesiastical authorities. In the 17th century in England the Court of Star Chamber began to punish the giving of false sworn testimony as a secular offense akin to obstruction of justice. Anglo-American legislation thereafter defined and expanded the offense of falsification in official matters. It was broadened to include false sworn testimony not only before judges but also in legislative and adminlstrative hearings. Either by further enlargement of perjury, or by special enactments on "false swearing," falsification of affidavits was made punishable. Penal sanctions were extended to falsification on "affirmation" as well as oath, so that the statutes would apply to those unwilling to be sworn. In the 20th century, criminal law in this area, departing entirely from the oath concept, expanded in a variety of statutes penalizing any written or even oral, misrepresentation in official inquiries or proceedings.

A classic requirement of the law of perjury is that the falsification be "material." With few exceptions, the legislatures and the courts have refused to treat trivial or irrelevant lies as felonies. Usually it is said that anything "capable of influencing the tribunal on the issue before it" is material. But the scope of perjury has sometimes been restricted by stringent and arbitrary interpretations. Thus a New York case held that it was not perjury falsely to testify in a divorce suit that the husband had committed adultery with X on one occasion, when the divorce complaint charged only the commission of an adulterous act with X on another occasion, since only the latter was material in the suit (*People* v. *Teal*, 196 N.Y. 372, 89 N.E. 1086 [1909]). In reaction against such decisions, some codes have eliminated materiality as an element of the offense. Examples of this approach are seen in the *Indian Penal Code*, par. 193; *Canadian Criminal Code*, par. 99(a) and 112; and the *Model Perjury Act* recommended by the commissioners on uniform state laws in 1952. More commonly, the materiality requirement has been retained for felonious perjury but eliminated for "false swearing," a statutory misdemeanour. The American Law Institute approved this solution in 1957.

To establish perjury the prosecution must prove that the statement was false and known to be so. Furthermore, it is commonly provided that the testimony of a single uncorroborated witness shall not suffice to prove falsity. On the other hand, it has been held that a person may be convicted of perjury regardless of the objective truth of the statement made, if, true or false, he did not believe it. In such case, it is said, he falsely represented his own belief.

A special problem of some importance in the law of perjury is whether a person commits the offense by lying under oath in a criminal or other proceeding directed against him. Under some legal systems, of or derived from continental Europe, defendants and other litigants are not sworn or the perjury statute has a restricted application to them. It is thought to be unfair or unrealistic to impose penal sanctions on a witness who is so obviously under pressure to give an account favourable to himself. On the same principle, in a minority of English-speaking jurisdictions, including England and the state of Georgia, the defendant in a criminal case may make an unsworn statement. Generally, however, U.S. law makes no such distinctions in favour of defendants, who, if they choose to testify, may be prosecuted for perjury. In consequence, there have been cases where a person has been tried for crime, acquitted and subsequently convicted of perjury based upon his sworn denials of guilt in the earlier trial; an example is *State* v. *Leonard*, 236 N.C. 126, 72 S.E. 2d 1 (1952). In a contrasting case, *United States* v. *Williams*, 341 U.S. 58 (1951), the defendant was convicted of perjury for false self-exculpating testimony in a prior trial in which, nonetheless, he was convicted of the crime charged.

The opportunity to question a supposed culprit under oath as to alleged misconduct in the remote past has also been used to secure from him sworn denials which can then be prosecuted as perjury, notwithstanding that prosecution for the original offense would be barred by the statute of limitations. It has been argued that this violates the spirit of limitations provisions, which are intended to prevent prosecution where lapse of time, death of witnesses and dimming of recollection make it difficult to determine the truth. (*See* comment on the prosecution of Alger Hiss, 40 *J. Crim. Law* 344 [1949]; Note, 102 *U. Pa. Law Rev.* 630, 649 [1954]).

The outer limits of the area in which the criminal law may be usefully or safely employed to repress lying are reached when legislatures undertake to penalize unsworn oral misrepresentation to any sort of official; *e.g.*, a policeman or an individual legislator making informal inquiries. In *King* v. *Manley* (1933), 1 K.B. 529, the English court of criminal appeal affirmed conviction of a woman who falsely reported that she had been robbed, thus effecting a "public mischief" by wasting police time and public money in investigating false leads. A few statutes go so far as to punish any false statement relating to an alleged offense. The American Law Institute in 1957 tentatively approved provisions on this subject in its *Model Penal Code* which would cover the offense of Manley, but would reach other oral misrepresentation to law enforcement officials only if it falsely implicates another person in crime. The danger sought to be avoided is that people might be subjected to criminal prosecution for denying their

own guilt; *e.g.*, when stopped by a policeman for a traffic offense or for denying knowledge of a crime under investigation, out of fear, friendship or mere reluctance to become involved.

See also OATH AND AFFIDAVIT.

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(L. B. S.)

PERKIN, SIR WILLIAM HENRY (1838–1907), English chemist, the discoverer of aniline dyes (*i.e.*, synthetic dyes prepared from coal tar), was born in London on March 12, 1838. He attended the City of London School and in 1853 entered the Royal College of Chemistry and studied under August W. von Hofmann, to whom he later became an assistant. He devoted his evenings and vacations to private investigations in a rough home laboratory, and was inspired by one of Hofmann's papers to undertake the synthesis of quinine. In the course of his experiments in 1856 he oxidized impure aniline with potassium dichromate and obtained a black product from which he was able to extract a bluish substance with excellent dyeing properties. This was the first aniline dye to be prepared, and it subsequently became known as aniline purple, tyrian purple, or mauve. A patent for the process of manufacturing the dye was taken out in 1856, and in 1857, with the aid of his father and an older brother, Thomas, Perkin set up works at Greenford Green, near Harrow, for the commercial production of mauve.

In 1858 he and B. F. Duppa synthesized glycine, the first amino acid to be prepared artificially, and in 1861 they synthesized tartaric acid. Perkin also had an important share in the development of artificial alizarin, which entirely replaced the red dye of the madder root. C. Graebe and C. T. Liebermann in 1868 prepared the substance synthetically from anthracene, but their process was not practicable on a large scale. In 1869 Perkin patented a commercially feasible process that secured for his Greenford Green works a monopoly of alizarin manufacture for several years. He also carried out investigations on other dyes and on flavouring materials, in the course of which in 1868 he synthesized the first artificial perfume, coumarin (*q.v.*), the odoriferous principle of woodruff and the tonka bean. He also investigated the constitution of salicyl alcohol, or saligenin.

About 1874 Perkin abandoned manufacture and devoted himself exclusively to research. In 1878 he discovered the Perkin reaction for the preparation of unsaturated acids (*e.g.*, cinnamic acid), which depends on the condensation of aromatic aldehydes with the salt of a fatty acid. Later he made a comprehensive study of the relation between chemical constitution and the rotation of the plane of polarization of light in a magnetic field and calculated the magnetic rotatory power of various elements and radicals.

Perkin was elected a fellow of the Royal Society in 1866 and was awarded the Royal Medal of the society in 1879 and the Davy Medal in 1889. He was knighted in 1906, on the 50th anniversary of his discovery of mauve.

He died at Sudbury near Harrow on July 14, 1907.

See also CHEMICAL INDUSTRY; COAL TAR.

See also R. Meldola, *Jour. Chem. Soc.*, p. 2214 (1908); R. Meldola, A. G. Green, and J. C. Cain, *Jubilee of the Discovery of Mauve and of the Foundation of the Coal-Tar Colour Industry by Sir W. H. Perkin*, Perkin Memorial Committee (1906).

PERKINS, WILLIAM (1558–1602), one of the most noted English Puritan theologians and preachers, whose "sermons were not so plain but that the piously learned did admire them, nor so learned but that the plain did understand them," was born at Marston Jabbett, in Warwickshire. As many another Puritan divine, he was a graduate and a fellow (1584) of Christ's College, Cambridge. He was appointed lecturer in the Church of Greater St. Andrews, and it was there that he became famous for his powerful, learned and persuasive sermons.

Perkins was one of the few Puritan divines who attempted to write a systematic theology, and his was the most successful. He was widely quoted not only by Puritans but by non-Puritan Anglicans as well. Theologically, his *Golden Chain* represents a point of view very similar to that of John Calvin, but it was not simply an English version of Calvin's *Institutes*. Perkins prepared a catechism, wrote a powerful treatise defending the Church of England against Roman Catholicism (*The Reformed Catholike*, 1597), and produced numerous other writings.

Many of the key Puritan leaders such as William Ames and John Robinson were his students. In the 17th century, Perkins' theology probably was more widely read than that of any other Puritan. He died in 1602 and was interred in St. Andrew's church.

(JE. C. B.)

PERLIS, a state of the federation of Malaysia (*q.v.*), is the smallest and most northerly of the Malayan states with a seaboard on the Andaman sea. It is a constitutional sultanate. Until 1909 the state was a dependency of Thailand and then became one of the unfederated Malay states and a British protectorate; it was temporarily annexed by Thailand in 1942, but became a British protectorate again in 1945 until Malaya's independence in 1957. Area 310 sq.mi. Pop. (1961 est.) 101,357.

A large part of Perlis is a closely cultivated and densely settled plain formed by short erratic streams from the steep range in the northeast which combine into the Sungei Perlis river. To its north is the Nakawn (Sithammarat) range of cave-ridden limestones forming the boundary with Thailand. The eastern boundary is among similar mountains and barely 18 mi. from the sea, Malaya there being at its narrowest. The Perlis plain merges into freshwater swamp southward where it borders Kedah state.

Perlis has 49,000 ac. under paddy, the growing of which is the main occupation, the rice yield being the highest among the federation states. The coarse alluvium and erratic streams present frequent problems of water shortage for wet farming, so that regular crops of dry paddy are sown.

Malays form 78% of the total population and about 2,000 Chinese live in two or three mining villages outside the caves in the northern limestone range, within which irregular but rich pockets of alluvial tin have collected, the annual output being only about 220 tons.

Kangar is the state capital (pop. [1957] 6,064) and the sultan's residence is at Arau nearby. Kangar is a dispersed, open settlement, rather a village than a town. Kuala Perlis is an open settlement of fishermen who live in stilted houses built over the river mouth. It is inaccessible except by water. Inland and well away from the coastal swamps runs the Malayan railway, the single track of which crosses into Thailand at Padang Besar, the Malayan customs station, but the traffic has little economic significance for Perlis which has negligible exports. (E. H. G. D.)

PERLITE (PEARLSTONE), a natural glass generally of composition equivalent to granite with concentric cracks, such that the rock breaks into small pearllike bodies or "pebbles," and formed by rapid cooling of viscous lava or magma. A rhyolite (*q.v.*), it is commonly gray or greenish but is known to occur in shades of brown, blue and red. The lustre is pearly to waxy. Prior to about 1950 perlite was virtually unknown in commerce; but in the second half of the 20th century great deposits were worked in New Mexico, Nevada, California and other western states. Production outside the United States increased very slowly. When crushed perlite is rapidly heated to its softening temperature (*c.* 1,500°–2,000° F.), the contained water is converted to steam to form multitudes of tiny bubbles within the softened particles. The perlite is thus "popped" or suddenly expanded up to 20 times its original volume. This frothy glass may be considered an artificial pumice. Because of its very low density, heat-treated perlite is a substitute for sand in lightweight wall plaster and concrete aggregate. Due to its porous nature the material is ideal for heat and sound insulation and the manufacture of insulating wallboard and acoustic plaster. Other uses include lightweight ceramic products, filters and fillers.

The spherical or perlitic cracks which characterize this rock are generally considered to be due to contraction of the cooling glass. Some studies indicate the cracks form in response to hydration. The concentric arrangement of cracks causes small pellets of glass to separate from the rest of the rock. These "pebbles" may range up to an inch across but are usually the size of lead shot. They may appear as spherules widely distributed through

a sort of matrix, or they may be so closely packed as to mutually interfere and form polygon-shaped pellets somewhat resembling dried peas. The pearly lustre is attributed to reflections from the thin air films formed along the concentric fractures.

Some perlites are of intrusive origin (dikes), but others constitute major portions of lava flows. These glassy rocks may grade into nearly completely crystalline volcanic types. Like obsidian (*q.v.*) they may carry large crystals (phenocrysts) of quartz, alkali feldspar, and plagioclase and in some cases biotite or hornblende. Where phenocrysts are abundant the rock passes into vitrophyre. Crystalline bodies (*see* SPHERULITE; CRYSTALLITE) may also abound, and curved or wavy trains of these are common evidence of flowage of the viscous molten material.

Microscopically some of the small glass pellets show slight double refraction indicating a strained condition in the material, and doubly refracting glass at the contact with phenocrysts suggests strain due to differential contraction.

The chemical composition, index of refraction, and specific gravity of perlite are similar to those of obsidian. The water content, however, is considerably higher (generally 3%–4%), much having been added subsequent to consolidation. (*See* PITCHSTONE.)

Devitrification or conversion of the glass to a microscopically fine crystalline aggregate is usually initiated spontaneously along cracks or at the surfaces of phenocrysts and spherulites. Some minutely crystalline rocks show well-developed perlitic structure and undoubtedly represent completely devitrified perlite. The localization of spherulites along curved and concentric bands in certain glass-free rocks suggests a devitrified perlite with spherulitic growth along the perlitic cracks.

For chemical analyses of perlite and related glassy rocks, *see* PITCHSTONE. (C. A. CH.)

PERM, an *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., formed in 1938, covers an area of 62,780 sq.mi. (162,600 sq.km.) and had a population (1959) of 2,992,876. The *oblast* lies on the western flank of the central Urals, extending from the crestline in the east, across the broad basin of the middle Kama to the Upper Kama uplands in the west. The northwest corner is occupied by the Komi-Permyak National Okrug (*q.v.*). The climate is continental, with a January average temperature of −17° C. (1° F.) and a July average of 17° C. (62° F.). Rainfall is from 20–22 in. a year in the west to 24–25 in. on the Urals. Almost the whole *oblast* is thickly forested with taiga of spruce, fir, pine and birch. Along the rivers are extensive flood plain meadows.

In 1959 a high proportion (59%) of the population were urban dwellers. There are 22 towns and 47 urban districts, the largest being Perm (629,118), the administrative centre, Berezniki (106,119), Solikamsk (82,874), Lysva (72,989), Kungur (64,796), Chusovoi (60,658), Kizel (60,687) and Krasnokamsk (54,715). This large urban population reflects the *oblast's* position as part of the Urals industrial area. Like the remainder of the Urals it is exceptionally rich in minerals. Most important are the huge deposits along the Kama of salt and potassium (among the largest in the world), which are the basis of the chemical industry of Berezniki, Solikamsk and Perm. Iron ore, copper and chromite supply the metallurgical and engineering industries found in most of the larger towns, especially Chusovoi and Lysva. Perm *oblast* is the northern end of the Second Baku oil field, drilled chiefly in the Chusovaya valley. Coal, fire clays and glass sands are also exploited. The forests supply paper, pulp and other timber-working industries. The northerly latitude and poor podsol soils give agriculture a minor role, except for intensive market gardening round the towns. Rye, potatoes and wheat are the main crops. There are several large power stations, notably the Kama hydroelectric plant, north of Perm city. (R. A. F.)

PERM (known as MOLOTOV from 1940 to 1957), a town and the administration centre of Perm *oblast* in the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on both banks of the Kama, 12 mi. below the Chusovaya confluence and about 700 mi. E.N.E. of Moscow. Pop. (1959) 629,118, making it the 17th town of the U.S.S.R.

In 1723 V. N. Tatishchev founded a copper-smelting works where the little stream Yegoshikhi joined the Kama at a small village, Bryukhanovo, founded in 1568. In 1781 the settlement of Yegoshikha became the town of Perm, although another town, Perm the Great (Perm Velikaya, now Cherdyn), had existed 150 mi. upstream since the 14th century.

Perm's position on the navigable Kama, leading to the Volga, and on the great Siberian highway (established in 1783) across the Ural mountains led to its development as an important trade and manufacturing centre. As industrialization proceeded in the Urals, especially after the Revolution, Perm grew considerably. Railways now focus on it from Solikamsk and the Kama chemicals region, from the Tura valley and Sverdlovsk in the Urals mining and metallurgical regions, and from Kirov in the west. Considerable transshipment takes place at Perm's busy river port. The town extends for 25 mi. along the high river banks. Its wide range of metallurgical and engineering industries produce equipment and machine tools for the petroleum and coal industries, agricultural machinery and telephones. There are large shipyards and an aircraft factory. A big refinery depends on petroleum from the immediate neighbourhood and oil is also piped from Almetyevsk. The chemical industry makes fertilizers, and timber working and flour milling are also carried on. Power is supplied by the 500,000-kw. hydroelectric plant just above the town.

Perm has the A. M. Gorky State university (founded 1916) and also has mining, pedogogical, pharmacological and medical institutes. Among its cultural institutions are opera and drama theatres and an art gallery with a noted collection of wood carvings. The town gives its name to the Permian geological series, first identified in this locality. (R. A. F.)

PERMAFROST, any part of the earth's mantle, including bedrock and all types of surficial materials, at any depth, maintaining a temperature of 0° C. or lower continuously for two or more years. Unfrozen ground is included as well as that commonly referred to as permanently frozen or, more correctly, perennially frozen ground.

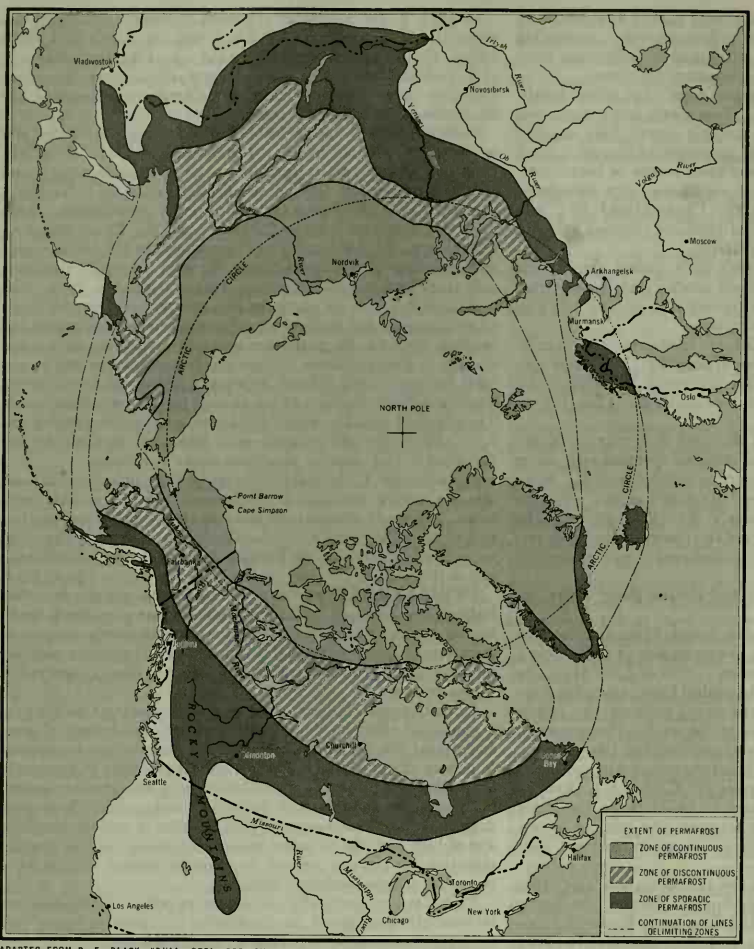
Permafrost and the geomorphic processes associated with it have a significant effect on the development and distribution of plant and animal life in areas where it occurs; its practical importance to human affairs is that it presents special problems in essentially all engineering projects. Its distribution is not precisely known but more than one-fourth of the earth's surface bears it in some degree. It is a phenomenon of high latitudes in both hemispheres and of high altitudes of major mountain systems, this relationship reflecting the primary control by climatic regimes typified by a perennial, negative radiation balance.

Permafrost is essentially continuous in polar regions, becomes increasingly interrupted in distribution at lower latitudes and occurs only sporadically toward its geographic limits. The continuous zone occupies an area of about 2,950,000 sq.mi. in the northern hemisphere and the entire 6,000,000 sq.mi. of Antarctica in the southern hemisphere. The discontinuous zone and sporadic zone include about 2,860,000 and 2,820,000 sq.mi., respectively, exclusive of alpine areas which may total 1,000,000 sq.mi.

Permafrost is thickest in the ice caps of Antarctica and Greenland where depths of several thousand feet are attained. Ground permafrost in the continuous zone generally ranges from 800–1,200 ft. in northern Alaska and 1,000–1,500 ft. in Siberia. Depths of about 2,000 ft. and 1,050 ft., respectively, have been measured at Nordvik, Sib., and Cape Simpson, Alaska. Estimates based on extrapolation of temperature profiles near Point Barrow, Alaska, indicate thickness of 670 ft. near the ocean shore and 1,330 ft. eight miles inland. In the discontinuous zone thickness is generally between 200–400 ft. and in the sporadic zone usually less than 100 ft.

Composition may be organic or inorganic; water, usually in the form of ice, furnishes the cementing medium of all otherwise unconsolidated materials. Well-drained deposits of gravels devoid of ice are termed dry permafrost. Within frozen ground brines with salt concentration several times greater than sea water qualify as permafrost but are unfrozen.

Ice occurs in many forms and variable amounts in ground



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EXTENT OF THE ZONES OF PERMAFROST

permafrost and often exceeds all other materials in quantity. It is present as crystals of diverse size and shape, as grains, films, veins and lenses, and as large masses either horizontally or irregularly disposed or as vertically oriented, downward tapering wedges.

The origin of permafrost probably dates from the Pleistocene Epoch, although that of the continuous zone is in equilibrium with present climates and all materials added to the surface become part of the permafrost body. In the sporadic zone isolated bodies of permafrost are in large part relicts of historical climates. Such fossil permafrost, often deeply buried beneath surficial deposits, is long-enduring but is gradually reduced under conditions resulting in annual net transfer of heat to depth.

The production, preservation or dissipation of permafrost depends upon a complex of climatic factors (solar radiation, sky radiation, back radiation, winds, vapour pressure, precipitation, cloudiness), properties of surface (vegetation, albedo, snow, standing water), and physical properties of substrate components (organic and inorganic types, texture, structure, density, specific heat, thermal conductivity and diffusivity, thermal gradients). Both formation and preservation are enhanced by long, cold winters with low snowfall and clear skies and summers that are short, dry, cloudy and cool.

Overlying all frozen permafrost is a layer of variable thickness subject to thaw in warm seasons. This layer, called the active layer, may penetrate only the surface mat of vegetation or may extend to depths of a few inches to several feet. In continuous permafrost, thaw averages only one to two feet over large areas. The upper limit of frozen ground beneath the active layer, the permafrost table, is deepest on well-drained gravels lacking vegetation cover and topographically exposed to maximum insolation. Minimum thaw occurs in peats and fine-textured inorganic materials of low, poorly drained sites protected from the sun by topography, vegetation or snow cover. Sporadic bodies of permafrost are often buried by perennially thawed ground overlain by the seasonally frozen active layer. Such unfrozen layers, as well as islands of thawed ground surrounded by permafrost, are called (Russian) *talik*.

Aggradation and degradation of frozen ground produce characteristic landscape features and influence the course and techniques of man's activities. Extreme stresses and pressures induce heaving, thrusting, splitting, cracking, stirring and slumping of substrate materials. Stress is often relieved by polygonal arrays of vertical contraction cracks which become filled with ice. Repeated cracking and ice growth lead, in time, to development of ice-wedges several feet wide and many feet deep. Sand-wedges are formed similarly in conditions of great aridity.

Pressures deform sediments, inject fluid muds into voids and raise fine materials vertically to the ground surface or force them into the active layer. Forces of complex nature produce such surface features as mud spots or silt boils, frost blisters, ice mounds, and pingos. Pingos, hills composed largely of ice, originate in swampy lowlands and attain heights exceeding 200 ft. and diameters of several hundred feet. Noteworthy examples occur on the Mackenzie River delta, Can.

Thaw and gravity movements (creep, flow, solifluction, mass caving and slumping) of saturated materials across the water-lubricated permafrost table of all slopes are important geomorphic processes shaping arctic landscapes. Thaw and subsidence produce thaw lakes, cave-in lakes, thermokarst topography, beaded streams and surface expression of ice-wedge polygons.

This instability of surfaces is destructive to vegetation and interferes with orderly processes of soil formation. Low mounds, ridges and other relief structures differentiate biological assemblages largely by improving drainage and related environmental conditions. Plant remains contribute large annual increments of organic material to permafrost which constitutes a long-term cold-storage repository of both plant and animal fossils. This natural

refrigeration is employed for food preservation by man by the simple expedient of excavating cellars in the frozen ground.

Where permafrost occurs, procurement of potable water supplies, disposal of waste, mining, well drilling, and road, airstrip and building construction pose critical engineering problems. Avoidance of sites most subject to frost action and preservation of frozen ground by maintaining natural insulation and protection against transfer of heat from structures to the ground prevent costly damages or total loss of structures.

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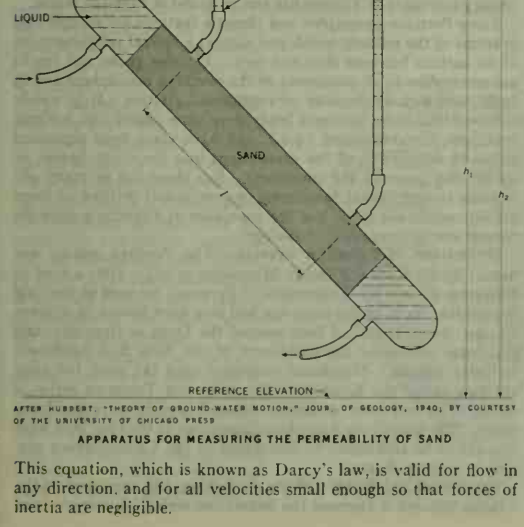
PERMANENT COURT OF INTERNATIONAL JUSTICE: *see* INTERNATIONAL COURT OF JUSTICE.

PERMEABILITY (FLUID). The permeability of a solid with respect to fluids is a measure of the facility with which fluids can penetrate or flow through the solid. Thus, of two solids, that one is the more permeable through which, under identical conditions, the greater quantity of a given fluid will pass in a fixed time. Solids owe their permeability to the existence of an internal porosity comprising a three-dimensional network of intricately branching and interconnecting channels. (*See* also GROUND WATER; HYDROLOGY.)

Darcy's Law.—The fluid permeability of a solid is defined and measured in terms of a flow experiment analogous to that illustrated in the accompanying figure. Here a liquid is made to flow through a porous solid into which two manometers along the same flowline have been tapped. It is found experimentally (and can also be deduced theoretically) that the volume of liquid, q, crossing the unit gross area normal to the flowlines in unit time is given by

$$q = (Nd^2)(\rho/\mu)(-g\partial h/\partial l)$$

in which N is a dimensionless shape factor and d a length parameter characterizing the geometry of the solid, ρ and μ are the density and viscosity of the fluid, g the acceleration of gravity, and $\partial h/\partial l$ the rate of increase with distance in the flow direction of the manometer height h with respect to a reference elevation.



AFTER HUBBERT, "THEORY OF GROUND WATER MOTION," JOUR. OF GEOLOGY, 1940; BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

APPARATUS FOR MEASURING THE PERMEABILITY OF SAND

This equation, which is known as Darcy's law, is valid for flow in any direction, and for all velocities small enough so that forces of inertia are negligible.

Of the three groups of factors on the right-hand side of the above equation, the first, Nd^2, depends only on the pore geometry of the solid; the second, ρ/μ, is a property of the liquid; and the third, $-g(\partial h/\partial l)$, is the impelling force acting upon each unit of mass of the liquid. In the past, various combinations of these factors have been taken as a measure of permeability, but opinion and usage have gradually converged toward agreement that the term "permeability" shall pertain to a property of the solid only.

Of these factors, only the first, Nd^2 (often expressed by the symbol k), satisfies this condition, and it is accordingly taken as a proper measure of the permeability of the solid. Transposing the equation, the permeability of the solid is given by

$$k = Nd^2 = -\frac{q\mu}{\rho g(\partial h/\partial l)}$$

and its dimensions are $[L^2]$ (length)^2.

Units of Permeability.—Hence, in any consistent system of measurement in which one of the fundamental units is that of length, the unit of permeability is the square of the unit of length—for example, the square centimeter or the square foot.

For granular solids, if the mean grain diameter is taken as the characteristic length d, the factor N has an order of magnitude of 10^{-4}. Hence the permeabilities of clastic sediments, ranging from fine silts, with mean grain diameters of 10^{-4} cm., to coarse sands, with mean grain diameters of 10^{-1} cm., vary from about 10^{-12} to 10^{-6} sq.cm. Since the useful range of permeabilities of most sedimentary rocks is from about 10^{-12} to 10^{-8} sq.cm., there would be some advantage in having a practical unit defined by 1 practical unit $= 10^{-12}$ sq.cm.

Inconsistent units in wide current use are the Meinzer unit (5.42×10^{-10} sq.cm.) and the darcy (0.987×10^{-8} sq.cm.).

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PERMEABILITY, MAGNETIC. The force between two magnetic poles varies as the product of the strengths of the poles, and inversely as the square of the distance between them. It depends also on the nature of the intervening medium. In the (centimetre-gram-second) electromagnetic system of units, unit pole is defined as one which repels an equal pole at a distance of one centimetre in empty space with a force of one dyne. Let F be the force between two poles of strengths m_1, m_2 at a distance r apart. Then, in a vacuum, $F = \frac{m_1 m_2}{r^2}$. More generally, $F = \frac{m_1 m_2}{\mu r^2}$. The constant μ depends on the medium, and is known as the permeability. The permeability may also be defined as the ratio of the magnetic induction B to the magnetizing force H; the induction being a measure of the magnetic force which would be exerted on unit pole placed in a narrow crevice in the medium, perpendicular to the direction of the magnetic force.

Thus $\mu = B/H$. The conception of permeability is due to Michael Faraday, who spoke of it as "conducting power for magnetism," and the term was introduced by William Thomson (later Lord Kelvin) in 1872.

Substances are divided into two main magnetic classes: diamagnetics, with the permeability μ less than 1; and paramagnetics with μ greater than 1. In diamagnetics the directions of the magnetization and the magnetizing force are opposite, in paramagnetics the same. For most substances the permeability differs very little from 1, and does not vary with the magnetizing field. A few paramagnetic substances, below certain critical temperatures, are ferromagnetic, having magnetic properties resembling those of iron. The permeability of ferromagnetics (which include iron, nickel and cobalt and some of their alloys) is a

function of the magnetic force, and generally depends on the previous history of the specimen. The permeability may be very large; the maximum for some generator steels and for iron-nickel alloys being greater than 100,000. A knowledge of the permeability characteristics of iron and iron alloys, in particular, is of great technological importance. Material having a high permeability for definite ranges of magnetic force is generally required in the construction of electrical machinery.

See MAGNETISM: *General Description of Magnetism; Magnetization and Permeability Curves.*

PERMEAMETER, an instrument for measuring magnetic permeability and other magnetic characteristics of substances. *See* MAGNETISM: *Measurement of Magnetic Quantities: Common Methods: Yokes and Permeameters;* PERMEABILITY, MAGNETIC.

PERMIAN PEOPLES, used by ethnologists and linguists outside of the Soviet Union to designate collectively two groups who speak closely related languages belonging to the Finno-Ugric family: Udmurt or Votyak and Komi or Zirian (Ziryen; *see* SYRVENIANS). Some Soviet scholars also distinguish a third Permian branch, the Komi-Permyak, who constituted (1960s) 70% of the 200,000 inhabitants of the Komi-Permyak national *okrug* (*q.v.*); but this tripartite division seems based on political considerations alone, for Permyak is simply the southernmost dialect of Komi (*see* FINNO-UGRIC LANGUAGES).

The common ancestors of the Udmurt and Komi separated from the westbound Volga-Finns (Cheremis and Mordvin; *qq.v.*) during the 1st millennium B.C., and continued as a uniform speech community for about 1,500 years thereafter. This period is known to specialists as the Permian (it has no connection, of course, with the geological period of the same name). The Permian community split into two branches during the 9th century A.D.

Udmurt Peoples.—Udmurt was spoken in the 1960s by more than 600,000 persons in the Udmurt Autonomous Soviet Socialist Republic (*q.v.;* capital, Izhevsk, an industrial centre), in the area between the Vyatka and Kama rivers. The Udmurt, organized in strong clan relations, are almost entirely peasants; each village was governed by a council of clan elders (*ken'esh*), which even farm collectivization did not succeed in wiping out. The Udmurt came under Russian administration in 1587, and were slowly converted to Christianity after 1740 under the influence of Archbishop Veniamin, who set up a church near the old Udmurt capital, Glazov.

Komi Peoples.—Komi was spoken by about 400,000 people in the 1960s, in an immense area, from the neighbourhood of the Udmurt northward almost to the Arctic Sea, and on the Kola Peninsula. The Komi Autonomous Soviet Socialist Republic (*q.v.;* capital, Syktyvkar) is the largest of all such republics in European U.S.S.R. Komi society has been shaped to a great extent by geographic location and climatic conditions, by the type of economy suitable for the area, and by Russian influence in cultural and political life. The location is responsible for the people's isolation and tardy progress; the uninviting climate protected them from extensive colonization until after World War II. The agricultural form of economy that prevailed for centuries remained dominant, though by no means uniform. After 1932 the Ukhta-Pechora region was gradually transformed into a mining and industrial area, and into a fuel producer for Leningrad industries; the modern development of the area is synonymous with that of three big undertakings: the oil trust, the coal trust, and the Northern Pechora Railway. The principal focus of the new Arctic mining activities is Vorkuta. In its vicinity the Komi changed after World War II from owners of large reindeer farms into workers on state farms, along with many Russian settlers. *See* also PERM.

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(T. A. SB.)

PERMIAN SYSTEM, a geological term designating the uppermost system of rocks and the final period of the Paleozoic era (the era of ancient life)—a time believed to have begun about 235,000,000 years ago, and lasting about 25,000,000 to 35,000,000 years, as indicated in the accompanying geologic time chart.

Geologic Time Chart

System and Period	Series and Epoch	Distinctive Records of Life	1,000 Years
CENOZOIC ERA			
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	
	Paleocene	First placental mammals	70,000
MESOZOIC ERA			
Cretaceous		Extinction of dinosaurs	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
PALEOZOIC ERA			
Permian		Reptiles developed, conifers abundant	235,000
Carboniferous	Upper (Pennsylvanian)	First reptiles, coal forests	260,000
	Lower (Mississippian)	Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000
Ordovician		First primitive fishes	400,000
Cambrian		Marine invertebrates	500,000
PRECAMBRIAN TIME			
		Few fossils	3,500,000–4,000,000

General Conditions of Permian Time.—The Permian was a time of crisis in world history. During much of preceding and succeeding Paleozoic and Mesozoic time, the continental areas were low and widely flooded by shallow seas, and the climate was equable over much of the earth. During the Permian, wide areas of the continents were emergent, there were extensive mountain chains and harsh climatic contrasts, with widespread deserts and continental glaciers; conditions were thus not unlike those of our modern era. Plant and animal life underwent many changes toward the end of Permian time, all species and many genera disappearing, some families and orders declining, others increasing in prominence, bringing about a change from the characteristic Paleozoic life to the characteristic Mesozoic life. (*See* also PALEOBOTANY; PALEONTOLOGY.)

Nevertheless, one should not think of these critical times as a cataclysm; their distinctive features began and ended gradually. Many of the mountain chains, such as the Appalachians of North America, had been growing since middle Paleozoic time. Permian marine invertebrates were not impoverished by the harsher conditions, but exceeded in variety and number those of some earlier periods. Many genera persisted into the Triassic, and the evolutionary forebears of Triassic life can be found in Permian strata.

Some Permian geographic and climatic features are inexplicable in terms of the modern world, and suggest a radical rearrangement of its surface between then and now. Permian rocks and fossils are much alike in all continents of the southern hemisphere and in India, and include deposits of continental glaciers. It is widely believed that these southern lands were once joined into a single continent, Gondwanaland (*q.v.*), and have since been separated either by foundering of the connections into the ocean basins, or by drifting apart of the continents. But there are as many objections to continental foundering or continental drifting as there are arguments for them, and the anomalies of Permian geography remain one of the riddles of geology.

Definition of Permian System.—The Permian system was named by Sir Roderick Impey Murchison in 1841, after a visit to European Russia, for the province of Perm not far west of the Ural mountains; rocks of the same age had long been known in western Europe, where they had been termed the Dyas in Germany, and had been considered the basal part of the New Red Sandstone in Great Britain. Murchison originally used the term for what are now called the Kungurian, Kazanian and Tartarian series, a sequence of red beds, evaporite deposits and fossiliferous limestone. The underlying Artinskian limestones of the type area were thought to be equivalent to limestones of the Carboniferous system in western Europe.

Later work has shown that the Artinskian, and even part of the Uralian beneath it (termed the Sakmarian series) is younger than

BY COURTESY OF YALE PEABODY MUSEUM

FIG. 1.—LANDSCAPE OF CHARACTERISTIC PERMIAN ANIMALS AND PLANTS, DETAIL OF A MURAL BY RUDOLPH ZALLINGER

Plants: (upper left) trunk of *Lepidodendron*, a scale tree; (upper centre) group of *Walchia*, a conifer. "Fin-back" animals: (lower left) *Edaphosaurus;* (centre) *Dimetrodon;* (right) *Sphenacodon*

the typical Carboniferous farther west. Beds between typical Permian and Carboniferous were, for a time, designated as "Permo-Carboniferous," but this usage has passed out of favour, and general practice now is to extend the base of the Permian considerably below the base originally designated.

North American stratigraphers usually put the base of the Permian at the bottom of the Wolfcamp series and the zone bearing fossils of *Pseudoschwagerina*, a genus of the fusulinid family of Foraminifera (*q.v.*), which is about equivalent to the bottom of the Sakmarian in the U.S.S.R. It is thought that a boundary so placed can be recognized more readily than one at a higher level, and that it marks a significant stage in invertebrate evolution. European stratigraphers differ as to the classification of the Sakmarian, but some place it in the Carboniferous. On the other hand, the lower part of the German Dyas seems to be a continental equivalent of the Sakmarian and Wolfcamp.

The boundary of the Permian with the overlying Triassic can be drawn successfully in most marine sequences on the basis of characteristic invertebrate fossils, but its position is uncertain where the beds near the boundary are nonmarine and poorly fossiliferous—as they are in many places. In some areas the classification, as between Permian and Triassic, of formations and whole series has been much debated.

The classification of rocks in geologic systems is dealt with in GEOLOGY: *Historical Geology*. Additional information on the use of fossils in classifying and correlating deposits will be found in FOSSIL. *See* also SEDIMENTARY ROCKS; STRATIFICATION.

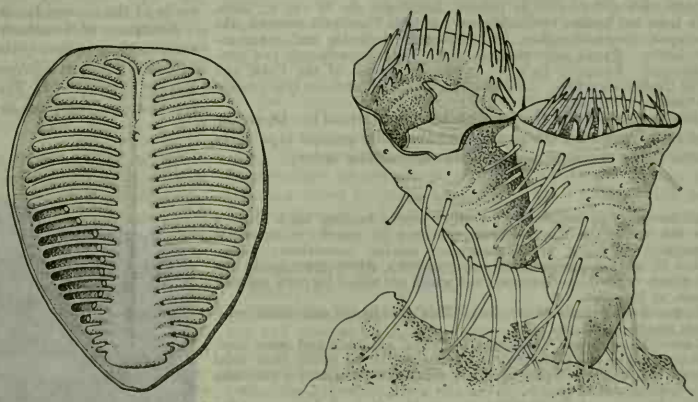
PERMIAN DEPOSITS

Deposits of Permian time are characterized by several distinctive assemblages, which reappear from one continent to another around the world. These types include:

(1) Red beds and other clastic rocks composed of fragments of pre-existing rocks, evaporites (gypsum, anhydrite, rock salt, potash minerals), dolomites and limestones. Red beds contain vertebrates (amphibians and reptiles) and plants, the limestones and dolomites an invertebrate fauna, mainly brachiopods, pelecypods and gastropods, relatively impoverished and without great diversity of genera and species. They were formed on extensive, flat, continental areas, partly on the surface of the land, partly in dessication basins, partly in shallow ephemeral seas, probably in a dry climate. Deposits of this type occur widely in the northern hemisphere, as in the U.S.S.R., Germany, Great Britain and the mid-continent region of North America.

(2) Marine deposits, in some areas of considerable thickness—shales, sandstones, and limestones, in places with thick reefs formed by lime-secreting organisms. Rocks of this type contain a large and diversified suite of marine invertebrates—fusulinids, bryozoans, brachiopods, pelecypods, gastropods, ammonoids, and the last of the trilobites. Such deposits are extensive in the southern part of the northern hemisphere and into the tropics—in Eurasia from the Mediterranean eastward to Indonesia in the ancient seaway called Tethys; in North America in western Texas, and Mexico.

(3) Volcanic rocks, mainly marine—lavas, pyroclastics and tuffs, with some nonvolcanic shales and limestones. Some beds contain marine invertebrates, such as fusulinids and brachiopods, and at some localities the fish *Helicoprion*. These deposits are characteristic of the most mobile parts of the geosyncline sur-



FROM CARL O. DUNBAR, "HISTORICAL GEOLOGY," JOHN WILEY & SONS, INC.

FIG. 2.—PERMIAN BRACHIOPODS (ACTUAL SIZE)

(Left) *Leptodus americanus*, showing skeletonized dorsal valve and corresponding flanges in spoon-shaped ventral valve; (right) *Prorichthofenia permiana*, two specimens showing position of growth

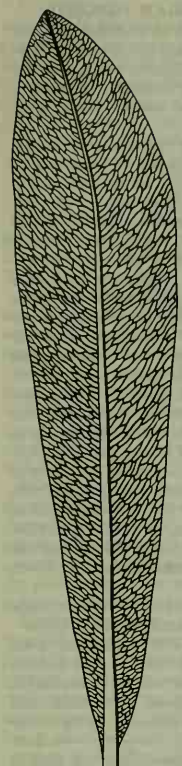


FIG. 3.—LEAF OF THE PERMIAN "TONGUE FERN" (GLOSSOPTERIS INDICA) THAT LIVED UNDER GLACIAL CONDITIONS

rounding the Pacific ocean, from California through British Columbia into Alaska, in Japan and New Zealand. An outlying volcanic sequence occurs at Las Delicias, Coahuila, Mex.

(4) Glacial and continental beds, generally with tillites near the base and a thick sequence of shales and sandstones above, with beds of coal. These deposits contain the distinctive seed fern, *Glossopteris*, and some reptiles. They are characteristic of wide areas in the continents of the southern hemisphere—southern Africa, eastern South America, Australia, Antarctica and peninsular India. Continental beds interfinger marginally in places with cold-water marine deposits containing the pelecypod *Eurydesma* and a few other invertebrates.

Permian of Europe.—Below are described some of the principal sequences of Permian rocks in the various continents, belonging to one type or another of the assemblages just listed.

The type Permian, in European Russia, lies in a broad basin that extends westward from the Ural mountains to Moscow. Thickness and nature of the rocks vary greatly across the basin, from thick clastic deposits on the east to thinner limestones on the west, but the general assemblage is of type 1, above. The following succession occurs (descending order):

EUROPEAN RUSSIA

Tartarian series.—Continental red beds, about 500 ft. thick, with many vertebrate fossils; upper part is Triassic.

Kazanian series.—In the west, marine limestone with invertebrate fossils, about 500 ft. thick, passing eastward into thicker nonmarine red beds.

Kungurian series.—Largely evaporites, with interbedded clays and marls; more than 2,500 ft. thick in the east, but thinning westward.

Artinskian series.—In the east, shales and sandstones, partly marine, partly continental, about 5,000 ft. thick, represented westward by upper part of limestones of Ufa plateau. Contains several zones of the fusulinid *Schwagerina*, as well as many ammonoids and brachiopods.

Sakmarian series.—In Ufa plateau, limestones 500 to 750 ft. thick, with large reef bodies, containing the fusulinid *Pseudoschwagerina*, the gastropod *Omphalotrochus*, the ammonoid *Artinskia* and other invertebrates. Passes eastward into much thicker sandstones and conglomerates. Formerly included in the Artinskian of the Urals and in the Uralian elsewhere. Lies on earlier Uralian limestones that contain the fusulinid *Triticites*.

In Germany, where the Permian has been termed the Dyas, the section is somewhat thinner, but of the same general type as in Russia. The sequence is as follows (descending order):

GERMANY

Zechstein (*Thuringian*).—At base, a copper-bearing black shale a few feet thick, the Kupferschiefer, overlain by 100 ft. of dolomitic limestone containing an impoverished marine invertebrate fauna. Above it, several thousand feet of evaporites, which give rise to the salt domes of northern Germany, and which are mined for rock salt and potash at Stassfurt.

Upper Rothliegende (*Saxonian*).—Red sandstones and shales with much interbedded lava.

Lower Rothliegende (*Autunian*).—Shales, red beds and some coal, containing *Walchia*, *Callipteris* and other plants. A much more local deposit than the two higher divisions, but locally attaining a thickness of several thousand feet.

The Permian of Great Britain resembles that of Germany. Its magnesian limestone appears to be the same as the dolomitic limestone of the lower Zechstein, and is likewise overlain by evaporites.

Permian of North America.—In North America the standard Permian section is that in west Texas, where most of the sequence is marine and highly fossiliferous (type 2, above), and attains a thickness of 10,000 ft. Best exposures are in the Guadalupe and Glass mountains lying, respectively, on the northwest and south sides of the Delaware basin, a depositional area of Permian time. There the sequence is as follows (descending order):

NORTH AMERICA

Ochoa series.—Evaporites, mainly anhydrite below and rock salt above, the latter containing workable potash-bearing layers. At top, a widespread thin dolomite (Rustler) with the only fossils in the series (brachiopods, gastropods, pelecypods). Overlain with hiatus by Upper Triassic, so relation to lowest Triassic is unknown.

Guadalupe series.—Marine sandstone, shale and thin limestone in Delaware basin, passing marginally in upper part into thick barrier reefs (Capitan limestone). Contains the fusulinids *Parafusulina* and *Polydiexodina*, the ammonoids *Waagenoceras*, *Timorites* and *Xenaspis*, and a rich and varied brachiopod fauna.

Leonard series.—Mainly black shale and thin-bedded limestone in Delaware basin (Bone Spring formation), passing marginally into limestone banks and small reefs. Contains the fusulinids *Schwagerina* and *Parafusulina*, the ammonoids *Perrinites* and *Medlicottia*, and numerous brachiopods, including *Dictyoclostus ivesi*.

Wolfcamp series.—In Glass mountains, shale with thin beds of limestone and conglomerate, but farther northwest a more solid body of limestone (Hueco). Contains the fusulinids *Pseudoschwagerina* and *Schwagerina*, the ammonoid *Artinskia*, the gastropod *Omphalotrochus*, and numerous brachiopods. Lies on Virgil series of Pennsylvanian (Upper Carboniferous), with *Triticites* and *Uddenites*, in places with angular unconformity.

North and northeast of the Delaware basin in the midcontinent area of central Texas, Oklahoma and Kansas, marine beds largely give place to red beds and evaporites; the Permian is of type 1.

Toward the northwest, also, the marine beds pinch out. At the Grand canyon in northern Arizona the Permian is about 2,000 ft. thick and consists, below the Triassic, of the Kaibab and Toroweap limestones, Coconino sandstone, Hermit red shale and Supai red beds. Only the Kaibab and Toroweap (with *Dictyoclostus ivesi* and *D. bassi*) are marine; the Coconino is an ancient dune deposit and the strata below are flood-plain deposits, with plant remains and reptile and amphibian tracks. Much of the sequence is of Leonard age, but the lower nonmarine beds include Wolfcamp equivalents.

Farther north, the Park City and Phosphoria formations form an interfingered set of deposits 200 to more than 1,000 ft. thick, which cover wide areas in contiguous parts of Utah, Wyoming, Idaho and Montana. They lie on Pennsylvanian, are overlain by early Triassic and cover a wide span of Permian time; parts are as old as the Leonard or Wolfcamp, but the main body, with the *Spiriferina pulchra* brachiopod fauna, is of Guadalupe age. The Park City and Phosphoria beds interfinger eastward with the red beds of the midcontinent area and are bordered on the west by volcanic rocks of the circum-Pacific belt.

Permian of Southern Hemisphere.—Permian rocks of the southern hemisphere belong mainly to type 4, above. The section in South Africa is representative and forms the lower part of the Karroo system. The Permian part of the Karroo varies from a few thousand feet thick in most of the region to nearly 15,000 ft. in

BY COURTESY OF CARL O. DUNBAR

FIG. 4.—EXAMPLE OF THE PERMIAN RECORD IN NORTH AMERICA, THE GUADALUPE MOUNTAINS IN WEST TEXAS, WHERE 1,300-FT. CLIFFS OF CAPITAN REEF LIMESTONE CAP 3,000 FT. OF DARKER PERMIAN SANDSTONE

the Cape mountains on the south. It consists of the following (descending order):

South Africa

Beaufort series.—Interbedded sandstones and shales, probably floodplain deposits, containing reptiles at many levels and a few *Glossopteris* in the lower part. Reptiles indicate that only lower part of series is Permian, the higher being Triassic.

Ecca series.—Mainly shale and mudstone, but with interbedded sandstone in places, and coal measures in the middle in Transvaal and Natal. Contains abundant *Glossopteris-Gangamopteris* flora.

Dwyka series.—In the south, thick tillites, with shales below and above, lying conformably on upper beds of the Cape system. Farther north, the series is missing entirely in places; in others, only the tillite is present, lying on a striated pavement of pre-Cape rocks. Upper shales contain sparse marine fossils in southwest Africa, including the pelecypod *Eurydesma* and the reptile *Mesosaurus*.

The tillites of the Dwyka are boulder-bearing clays which are moraines of a continental ice sheet; striae indicate that its centre was in Transvaal or farther north, from whence the ice moved south and southwest, the thick tillites on the south probably being a terminal moraine deposited at the edge of the continent. (*See* also Africa: *Geology.*) The Dwyka tillites record a climax of glacial conditions, but relations elsewhere indicate that the period of refrigeration was prolonged; in eastern Australia boulder beds of glacial origin are interspersed through more than 10,000 ft. of section.

Correlation of the Permian rocks of the southern hemisphere with those of the northern is difficult because the *Glossopteris* flora and cold-water marine fauna of the former extend but rarely into rocks of the latter region. Age of the tillites is especially disputed, geologists placing them variously entirely in the Carboniferous, entirely in the Permian or partly in both. In northern India (Salt Range and Kashmir) and in western Australia, tillites, cold-water marine beds and beds with *Glossopteris* flora are followed by beds with marine fossils which can be correlated with the Artinskian (Leonard) of the northern hemisphere, thus suggesting that the climax of glaciation was during Sakmarian (Wolfcamp) time. In other areas, where tillites extend through a greater thickness of strata, glaciation may have begun earlier and ended later than the Sakmarian. *See* also references under "Permian System" in the Index.

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PERNAMBUCO, a northeastern Atlantic state of Brazil. Area 37,946 sq.mi. (98,280 sq.km.); pop. (1960) 4,136,900. It comprises a comparatively narrow coastal zone, a high inland plateau and an intermediate zone formed by the terraces and slopes between the two. Its surface is much broken by the remains of the ancient plateau which has been worn down by erosion, leaving escarpments and ranges of flat-topped mountains, called *chapadas*, capped in places by horizontal layers of sandstone. The coastal zone is low, well-wooded and fertile. It has a hot, humid climate, relieved to some extent by the southeast trade winds. This region is locally known as the *matas* (forests). The middle zone, called the *caatinga* or *agreste* region, has a drier climate and lighter vegetation. The inland region, called the *sertão*, is high, stony and dry and frequently devastated by prolonged droughts (*sêcas*). The climate is characterized by hot days and cool nights and is generally considered healthful. There are two seasons, a rainy season from March to June and a dry season for the remaining months.

The rivers of the state include a number of small plateau streams flowing southward to the São Francisco river, and several large streams in the eastern part flowing eastward to the Atlantic. The largest of the coastal rivers are the Goiana, the Capibaribe, the Ipojuca, the Sirinhaém and the Una.

The state of Pernambuco is, for the most part, agricultural, the lowlands being devoted to sugar and fruit, with coffee in some of the more elevated localities; the *agreste* region to cotton, tobacco, Indian corn, beans and stock; and the *sertão* to grazing and in some localities to cotton. Sugar, molasses, rum (*aguardente* or *cachaça*), tobacco and fruit are largely exported. Coconuts, cacao, bananas, mangoes and other tropical fruits are produced in profusion, but the production of foodstuffs (beans, Indian corn, mandioca, etc.) is not sufficient for local consumption. Mangabeira rubber is collected to a limited extent, and piassava fibre is an article of export. Orchids are also collected for export in the districts of Garanhuns and Timbaúba. Cotton weaving and cigar making are leading manufacturing industries, after the large *engenhos* devoted to the manufacture of sugar and rum. The railways of the state concentrate at the port of Recife.

The capital of the state is Recife; pop. (1960) 788,569. There are a number of large towns in Pernambuco; the most important are: Bom Conselho, a town of the higher *agreste* region, Caruarú, Garanhuns, Goiana, Limoeiro, Olinda, the old colonial capital and episcopal see, Timbaúba and Vitória. These towns range in population from about 7,000 to more than 100,000.

Pernambuco, at its inception in 1526, was settled by Christovão Jacques, who founded a settlement on the Rio Iguarassú that was afterward abandoned. The first permanent settlement was made by Duarte Coelho Pereira at Olinda in 1530, and four years later he was granted a *capitania* of 50 leagues extending from the mouth of the São Francisco northward to that of the Iguarassú. Adjacent to this grant on the north was the *capitania* of Itamaracá, granted to Pero Lopes de Souza, which covered the remainder of the present state. The *capitania* of Pernambuco was ably governed and took an active part in the expulsion of the French from the trading posts established along the coast northward to Maranhão, and in establishing Portuguese colonies in their places. In 1630 Pernambuco was occupied by the Dutch and continued under their rule until 1654. Although an active guerrilla warfare was waged against the Dutch during a large part of that period, they did much to promote the agricultural and commercial interests of the colony, especially under the wise administration of Maurice of Nassau. As a result of their victory over the Dutch the people of Pernambuco developed a strong regional feeling and resentment of all foreign domination, including the Portuguese.

In 1817 Pernambuco was the scene of a revolutionary outbreak, which resulted in the temporary separation of the present states of Alagôas and Rio Grande do Norte, Ceará and Paraiba. There was another insurrection in 1822 when the Portuguese were expelled; and in 1824 dissatisfaction with the arbitrary proceedings of Dom Pedro I at Rio de Janeiro led to a separatist revolution for the formation of a new state, to be called the Federação do Equador. There was another outbreak in 1831 and frequent disorders to 1848, which culminated in another unsuccessful revolution. The population of the Pernambuco *sertão* became noted for its turbulent, lawless character, due partly to the distance from the coast where the bulk of the population is concentrated, partly to difficult means of communication and partly to the fact that this remote region became the refuge of criminals from the coast towns. (R. D' E.; R. E. P.)

PERNICIOUS ANEMIA: *see* Anemia; Blood.

PERNIK: *see* Dimitrovo.

PERÓN, JUAN DOMINGO (1895–), Argentine general and president (1946–55), led one of the most significant of Latin America's 20th-century revolutions. Born Oct. 8, 1895, in the province of Buenos Aires, Perón entered military school in 1911 (when the Argentine army was advised by a German military mission) and rose to captain in 1924. He had a minor part in the military-conservative revolution of 1930 which overthrew the democratically elected president, Hipólito Irigoyen, and which began a period of considerable political repression and increased

state authority. During these years Perón served as an observer with the Italian army (1938–39).

Popular dissatisfaction with the widespread social and economic injustice and with the corrupt regime of Pres. Ramón S. Castillo, together with profound divisions of opinion over Argentina's neutral position in World War II, formed the background for a *coup d'état* that overthrew Castillo in June 1943. An army clique which included Colonel Perón and which was known as the GOU (Group of United Officials) engineered this coup. The provisional governments during the following three years came increasingly under the domination of Perón, who at the outset shrewdly took the minor post of secretary of labour and social welfare. By 1945 he had added the offices of vice-president and war minister, and it was clear that he was bidding for undisputed power based on the support of the underprivileged labourers (the *descamisados,* or "shirtless ones") and on control of the army.

Ousted briefly from all his positions by a coup of the liberals (Oct. 1945), Perón, aided by the bold and loyal Eva Duarte (*see* below) whom he married on Oct. 26, 1945, emerged from a week's imprisonment on Oct. 17, 1945, and in a dramatic appeal to the people voiced his determination to lead them to victory in the pending presidential elections. After a campaign marked by violent repression of the rights of the liberal opposition by the Perón-controlled police and strong-arm squads, he was elected president in Feb. 1946 by a plurality of 250,000 out of approximately 5,000,000 votes.

Assuming office in June 1946, Perón set out on a course of nationalism, industrialization, statism, encouragement of anti-U.S. feeling and favouring of the proletariat. Basing his action on a doctrine of social welfare which he called *justicialismo,* Perón showered needed improvements upon the labourers in the form of wage increases and fringe benefits. He stimulated rapid industrialization and nationalized the banks, the railroads (which he purchased from the British in 1947) and other utilities, and financed public works on a large scale. Money and equipment for these costly innovations—and for the graft which corroded his regime—came from the foreign exchange accumulated by Argentina during World War II and from the profits of Instituto Argentino de Promoción del Intercambio (I.A.P.I.), a state trading institution which controlled agricultural production. Perón dictated the political life of the nation by his command of the army, the police, the labour unions and the Peronista party. He nearly eliminated constitutional liberties such as the free press, as demonstrated in his seizure of the newspaper *La Prensa* in 1951.

Re-elected by a slightly larger margin in 1951, Perón modified some of his policies, particularly his pell-mell industrialization, his disregard of agriculture and his anti-U.S. propaganda. He was overthrown by an army-navy revolt (Sept. 16–19, 1955) led by democratically inclined officers who reflected general discontent with inflation, corruption, tyranny, demagoguery and the anti-Roman Catholic policies that Perón had begun in 1954. The dictator fled to exile in Paraguay, eventually settling in Spain. He continued to influence Argentine political life through his numerous followers. His supporters, allowed on the ballot for the first time since 1955, polled about 35% of the vote in 1962, but the armed forces immediately annulled the election. In 1963 the Peronistas joined to form a united front with the Intransigent Radical party of former president Arturo Frondizi. When the military leaders disqualified many of the front's candidates for electors, both Perón and Frondizi urged their followers to cast blank ballots in the election as a protest. About 17% of the voters did so.

In December 1964 Perón made an attempt to enter Argentina, but his plane was turned back at Rio de Janeiro, and he returned to Spain. The indifference with which most Argentinians reacted to the incident was considered a blow to the Peronistas.

Eva María Duarte de Perón (1919–1952), wife of Juan Perón, was a powerful political figure in her own right. Born May 7, 1919, in a small town in the province of Buenos Aires, "Evita," as she was popularly known, moved to the city of Buenos Aires in the 1930s and played minor roles in motion pictures and on radio. She met Colonel Perón after the 1943 revolution that first brought him onto the national political scene, and she had much to do with organizing the labourers of Buenos Aires for the mass demonstration (Oct. 17, 1945) that marked his release from political imprisonment and cleared the way for his drive to the presidency. Evita and Perón were married the following week. When her husband assumed the presidency in June 1946, Evita devoted her boundless energy to extending his revolutionary dictatorship into areas peculiarly her own. She headed the feminine branch of the Peronista party, directed the Eva Perón Social Aid foundation (a vast fount of charity for the underprivileged, who did not observe that the funds came from the state and not from Evita personally), controlled the newspaper *La Razón,* in fact ran the ministry of health and in effect was the minister of labour, thus helping her husband control the labour unions, which formed a pillar of his authority. Her bid to become vice-president at the time of her husband's re-election (1951) was blocked by the army. She died July 26, 1952, in Buenos Aires.

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PÉROTIN (Perotinus) (d. 1238?) French composer of sacred polyphonic music who worked at Notre Dame in Paris toward the end of the 12th century and who now is believed to have been responsible for the introduction into Western music of writing in four parts. Nothing is known of his life. Though he is one of the composers of the time who did not remain anonymous, his identity remains in doubt. The name Pérotin, or Perotinus, is held to be a diminutive of Pierre, or Petrus, and it has been suggested that he was one of the figures of whom records have survived at Notre Dame, *Diaconus Petrus praecentor* (d. Paris, 1197) or, more probably, *Petrus succentor* (d. Paris, 1238). Early references to Pérotin are in a treatise by the 13th-century English theorist known as Anonymous IV (*c.* 1275), who refers to him as Perotinus the Great. These references are reproduced in E. Coussemaker's *Scriptorum de musica medii aevi,* vol. i (1864–76).

Until the middle of the 20th century research on the work of Pérotin as the founder of 12th-century polyphony remained in an elementary state. It is established, however, that he was the composer of two four-part polyphonic pieces, *Viderunt* and *Sederunt.* Another four-part composition, *Mors,* is also believed to be the work of Pérotin. Anonymous IV also attributes to him various vocal works for one and three voices. Armand Machabey and other medievalists showed that the four-part polyphonic works of Pérotin were revolutionary, since the religious music of the 12th century was almost entirely in the form of the two-part organum (*q.v.*). In the compositions of Pérotin the liturgical chant in the tenor is often heard not against one voice but against two or three voices, which provide highly decorative vocalizations. Among other achievements Pérotin enlarged upon the work of Léonin, who was his predecessor; he was also responsible for rhythmic innovations; and his works contain an early form of hocket, which was developed in the French motets of the following century.

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PEROVSKITE, essentially calcium titanate, orginally found in a chlorite schist at Achmatovsk in the Ural mountains and named after Count L. A. Perovski. Crystals are lustrous, yellow to brownish black, highly twinned cubes or octahedra (actually orthorhombic very nearly cubic symmetry). Common occurrences are as accessory constituents of basic or alkalic-basic igneous rocks or at metamorphic contacts of these rocks with limestones. The composition is $CaTiO_3$. Rare-earth elements, sodium, potassium and iron substitute for Ca, and niobium and tantalum substitute to a considerable extent for Ti in the natural mineral.

The name perovskite is also applied to an important crystal structure family, including calcium titanate ($CaTiO_3$) and related natural and synthetic compounds, all possessing similar pseudocubic or cubic structures. Element substitutions in natural perovskite suggested many of the chemical variations later shown to

be possible by synthesis. The importance of this family to the electrical industry was recognized with the discovery of ferroelectricity in barium titanate, $BaTiO_3$. Members of this family, including the titanates, zirconates and niobates, have become very important to the entire electronics industry, where they are used for their high dielectric constants and as transducers (transformers of electrical energy into mechanical energy) capable of withstanding high temperatures (*see* ULTRASONICS). (RU. R.)

PEROXYACIDS are oxyacids which contain one or more peroxide groups, –O–O–, or they may be regarded as oxyacids in which an OH^- group has been replaced by an –OOH group. They are formed by boron, carbon, titanium, zirconium, germanium, tin, nitrogen, phosphorus, vanadium, columbium, tantalum, sulfur, chromium, selenium, molybdenum and tungsten. Some are described under the corresponding elements; *e.g.*, peroxysulfuric acid and peroxydisulfuric acid under SULFUR. (J. B. Ps.)

PEROZ: *see* FIRUZ.

PERPENDICULAR PERIOD, in architecture, the final phase of English Gothic (*c.* 13th–17th centuries). The term was first used in 1817 by Thomas Rickman, who divided English Gothic into three stylistic phases: Early English, Decorated (or Curvilinear) and Perpendicular.

Perpendicular style is characterized by a predominance of vertical lines in the decorative work or traceries which appeared on windows and wall paneling (*see* TRACERY). The vertical lines were crossed by horizontal ones so as to form rectangular patterns which suggested the possibility of endless repetition. For this reason, Edmund Sharpe in 1851 introduced the term Rectilinear to characterize a style he believed to be a reaction to the Curvilinear. Although this belief was accepted for nearly a century, it is now known that the Curvilinear, which began in England in 1192 with the Eleanor crosses, was actually contemporaneous with the first Perpendicular design in the undercroft of St. Stephen's chapel in Westminster. Its stylistic continuation can be found a generation later in the eastern part of Gloucester cathedral (*c.* 1331–50). In structure, the Perpendicular tendency was toward the reduction of wall surface, the increase of window area, the continuity of vertical lines and supports and the lavish development of decorative vaulting ribs. Later, structural vaulting ribs were eliminated altogether and cut-stone traceried fan vaults were substituted (*see* ARCH AND VAULT).

Timber-trussed ceilings and roofs were developed to a point of great perfection and richness, as in Westminster hall, London (1395–99), and in countless simpler parish churches; *e.g.*, Chipping Norton, Holy Trinity, Hull. Also constructed in this style were many beautifully outlined and lavishly detailed church towers, usually square and without spires. Those of Gloucester cathedral (1450–57), Magdalen college, Oxford (1492–1505), the central tower at Canterbury (1495) and the west towers of York (1432–70) are typical. In decorative detail the Perpendicular style is marked by the introduction of the four-centred, or Tudor, arch, the covering of wall surfaces with ranges of traceried panels, chiefly rectangular, the general flatness of molding profiles, the enclosing of door and window arches within a rectangular hood mold and the replacement of an earlier naturalism in carved ornament by a rather dry and incisive though, at times, mechanical conventionalism. It was a style so vital that it yielded but slowly to the influx of Renaissance ideas, and, particularly in Oxford, its effect was felt in building well into the 17th century. *See* GOTHIC ARCHITECTURE: *Late Gothic; see* also references under "Perpendicular Period" in the Index.

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PERPETUAL MOTION is the action of a device that in theory will move by itself forever, without any supply of energy from outside. In some cases the motion is supposed to be independent of any external agent, but frequently the force of gravity plays an essential part in the scheme. More often, perpetual motion is taken to imply a machine which, once in motion, will produce external work for an indefinite period, either without any supply of energy or by drawing heat energy from the immediate surroundings. The possibilities of perpetual motion have fascinated many and retain great historic interest because, as a result of the vain quest for it, there grew up one of the great generalizations of physical science: the principle of conservation of energy (*see* ENERGY).

The U.S. Patent Office refuses to accept any patent application for perpetual motion without a working model, and "understands the term 'perpetual motion' to mean a mechanical motion creating energy, that is, a machine doing work and operating without the aid of any power other than that which is generated by the machine itself, and which, when once started, will operate for an indefinite time." The British Patent Office refuses any application that claims perpetual motion on the ground that this is obviously contrary to well-established physical laws.

Such devices as self-winding clocks or watches might appear to exhibit perpetual motion, but do not. Some are wound by the action of the wearer's movements on a small weight (*see* WATCH). Others have been devised to be wound by the variation of atmospheric pressure or temperature.

A mechanical device that would move perpetually without any supply of energy would violate the principle of conservation of energy. Although this fundamental law of science was not formally enunciated until the 19th century, many earlier workers realized that mechanical perpetual motion was a contradiction of nature; this was clearly stated by Thomas Savery (*c.* 1650–1715), who made the first commercially successful steam engine. Earlier (1586) the Dutch mathematician Simon Stevin (*q.v.*) based his demonstration of the laws of equilibrium on an inclined plane on the impossibility of perpetual motion.

By the first law of thermodynamics (*q.v.*) the law of conservation holds for changes of heat energy. This, however, would not prohibit the construction of a machine that should draw heat from, say, a large body of water, such as a lake, and convert it to work. This would amount to perpetual motion, since removal of energy to lower the temperature of a lake 1 mi. wide and 10 ft. deep by 1° C would supply heat corresponding to more than 10,000,000 horsepower hours, and heat from the sun and the surroundings would prevent the temperature of the lake from falling indefinitely. By the second law of thermodynamics, however, it is impossible to obtain a continuous supply of work by cooling a body to a temperature below that of the coldest of its surroundings. For example, the use of the heat of a boiler for doing work requires a colder body such as a condenser. This second law denies the schemes of a 20th-century school of perpetual motionists who claim somehow to use the heat of bodies at atmospheric temperature to produce a continuous supply of work.

The perpetual motionist of another modern school declares that he fully recognizes that work cannot be derived by any machine without a supply of energy of some kind, but that his machine, being supplied with energy, will produce a greater amount of energy. Such an inventor may claim that conservation of energy and the first and second laws of thermodynamics lack universal validity but that so far, for one reason or another, he has been unable to construct an engine to demonstrate this practically.

It has been suggested that if a substance could be found which cut off completely the action of gravity, it would be easy to achieve perpetual motion by holding a sheet of the substance beneath a weight being lifted and by removing the sheet while it fell. A similar scheme has been suggested as feasible if a substance could be found that would cut off completely the action of magnetism. These ideas neglect the work necessary to introduce and to remove the substance. Similarly, although a grounded conducting plate will cut off the attraction of an electrostatically charged body, a perpetual motion device has not been made on these lines with electric charges.

The words of the civil engineer Henry Dircks (1806–73) concerning claimants to perpetual motion, continue to be echoed. "A more self-willed, self-satisfied, or self-deluded class of the community, making at the same time pretension to a superior knowledge, it would be impossible to imagine. They hope against hope, scorning all opposition, with ridiculous vehemence, although centuries have not advanced them one step in the way of progress."

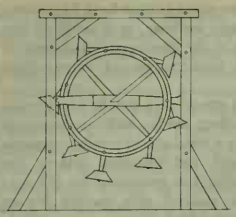

FIG. 1.—V. DE HONNECOURT'S OVERBALANCING WHEEL

The first recorded attempt to construct a perpetual motion machine apparently was that of Villard de Honnecourt (*q.v.*), an architect of the 13th century, who noted that skilful workmen often tried to contrive a wheel that would turn of itself. His crude sketch (fig. 1), offered as a solution to the problem, is the forerunner of a large number of different types of overbalancing wheel. The absence of perspective in this ancient picture makes the wheel appear in the same plane as the supporting frame, whereas actually it must be at right angles to it. The principle is clear, although not very well represented; the weights at the end of the hinged arms, which are on the ascending side of the wheel, are to lay flat against its circumference, while those on the descending side are to project. Actually, of course, however the weights and their attachments are designed, the moments of the gravitational forces about the wheel's axis will be the same.

A numerous class of machines that utilize the force of gravity on rigid solids includes many descendants of Honnecourt's wheel. Fig. 2 represents one described by Thomas Young (*q.v.*) in a lecture in which he denied the possibility of perpetual motion, saying: "To seek for a source of motion in the construction of a machine betrays a gross ignorance of the principles on which all machines operate." He pointed out that in every such overturning wheel, although some of the weights are more distant from the axis than others, there is always a correspondingly smaller number of weights on the side on which the wheel has the greater moment. Probably the most elaborate of such wheels, with 13 weights (each operated by a complicated system of levers, pulley wheels, and chains) was put forward in 1751, apparently by the printer Edward Cave (*q.v.*).

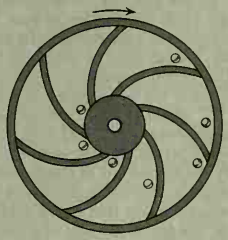

FIG. 2.—OVERTURNING WHEEL DESCRIBED BY THOMAS YOUNG

The most famous perpetual motion wheels were those of Edward Somerset, 2nd marquess of Worcester (1601–67) and of Johann Ernst Elias Bessler (1680–1745), generally known as Orffyreus. Worcester's wheel of 14 ft. diameter carried 40 weights of 50 lb. each. In *A Century of . . . Inventions . . .* (1633) he wrote that all the weights of the descending side of the wheel were always farther from the centre than those of the mounting side and yet that the numbers on both sides were equal. He did not claim that perpetual motion was the result, but said that Charles I, with various court personages, observed the trial and the behaviour of the weights (*c.* 1638–39), and concluded: "Be pleased to judge the consequence." This wheel was extensively discussed by authors from J. T. Desaguliers onward and in particular by Dircks, without definite conclusion. It seems that the wheel was started by hand, that the weights behaved as Worcester said, and that, having a large moment of inertia, the wheel continued to rotate without noticeable slowing during the brief period of its inspection, although coming to rest later.

Worcester's is the only contemporary record of his wheel, but there is a copious literature about that of Orffyreus, or rather about his last one, for he appears to have constructed more than one. In particular the Dutch physicist W. J. Gravesande (1688–1742) wrote a description of the externals of the wheel; the inventor would not permit him to see the inside. It was a drum about 12 ft. in diameter and 14 in. thick, consisting of a wooden framework covered with canvas. It turned on iron axes which Gravesande was convinced did not transmit the motion. He wrote that the wheel continued to rotate for two months (November 1717–January 1718) in a carefully locked room in the castle of Charles, landgrave of Hesse-Kassel. He spoke favorably of the invention but recorded that he had no opportunity of inspecting the working parts of the machine or of learning anything about the principles upon which it was constructed. It is stated that Orffyreus admitted that his wheel was set in motion by weights. A servant of the inventor later declared that she had effected the turning of the wheel from an adjoining room, but her word has been doubted. According to an apparently reliable account, Orffyreus broke his machine because of what he considered to be the impertinent curiosity of Gravesande. There is an atmosphere of charlatanry, mixed with a little madness, about the affair.

The overturning wheel rests on ignorance of the laws of mechanics. Another class, involving liquids, is based upon ignorance of the laws of hydrostatics and hydrodynamics. Waterwheels that hopefully would raise water to feed their own millstreams frequently occur in the history of the subject. John Wilkins, bishop of Chester, in his *Mathematicall Magick . . .* (1648) described a machine in which water was to be raised by an Archimedean screw kept in rotation by the falling of the raised water (*see* ARCHIMEDES, SCREW OF). His account is often quoted as if he believed this to be a solution of the problem of perpetual motion, but he wrote: ". . . upon trial and experience I found it altogether insufficient for any such purpose." Another device (fig. 3) founded on the erroneous belief that the pressure at a given distance below a large surface of liquid is greater than that below a small surface, was proposed (1686) by the Abbé de la Roque, proprietor of the *Journal des sçavans*, and subsequently by later inventors. The hope was that the water in the wider part would force up the water in the narrower part to produce continuous circulation. Most of the hydraulic schemes put forward up to the present are more elaborate but just as unsuccessful. Some involve capillary action; *i.e.*, surface tension (*q.v.*), as that (fig. 4) conceived by the artillerist Sir William Congreve (1772–1828). EFG represents an inclined plane that supports pulleys, an endless sponge band abcd, and jointed heavy weights in band ABCD. With the expectation that ab would become saturated with water while the weights were squeezing ad dry, the unfulfilled hope was that the extra weight in segment ab would produce continuous motion in the direction of the arrow.

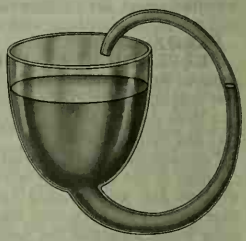

FIG. 3.—ABBÉ DE LA ROQUE'S HYDRODYNAMIC DEVICE

Wilkins classified the methods by which perpetual motion had been sought in his time as chemical, magnetic, and gravitational. As a chemical method he cited a reaction supposed to produce small particles which, if sealed in a vessel, would move continually. This, and self-moving liquids discussed by a few others, were never much pursued, probably because they were not adapted to drive machines. A magnetic method mentioned by Wilkins depended upon an implied sudden diminution of magnetic attraction at a certain point when a steel ball was attracted up an inclined plane by a lodestone; more complicated schemes involving magnetism were equally untenable, including designs that involve substances which cut off the magnetic field.

With the development of the Volta pile (*see* BATTERY), two piles could be arranged to attract a light ball from one to the other alternately. The amount of energy used is so small and its origin in the chemical action of the pile so little obvious, that it is surprising that more has not been heard of this method. Probably the fact that it was not adapted to make any kind of machine prevented projectors from putting it forward. In the Clarendon Laboratory at Oxford University

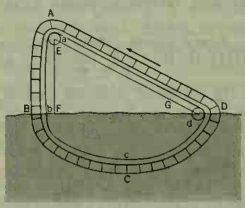

FIG. 4.—WILLIAM CONGREVE'S SPONGE AND WEIGHT MACHINE

there are two large piles, their upper ends, of opposite polarity, being connected by a wire and their lower ends each bearing a bell. A small brass ball suspended by a silk thread oscillates from one to the other, producing a sound. This has been operating since 1840, and probably is the most perpetual of all so-called perpetual motion devices, but in principle it is no different from an electric clock run by a battery (*see* ELECTROCHEMISTRY).

The availability of liquid air started a fresh crop of schemes for perpetual-motion engines that could do appreciable work. Liquid air obviously can be used as a boiler fluid to power an engine without a furnace of any kind. The trouble is that more energy is required to make the liquid air than can be derived from it.

There have been notable perpetual-motion frauds, one of the most celebrated being John W. Keely's motor which created a sensation in the U.S. about 1870. The inventor supported his claim with an abstruse theory that included such expressions as hydro-pneumatic-pulsating-vacuo-engine and etheric force. Using fraudulent demonstrations, Keely collected considerable sums of money in support of his project. He declared at one time that with one gallon of water he could propel a steamship from New York to Liverpool.

Modern techniques for obtaining power from atomic energy (*q.v.*) are sometimes cited as examples of perpetual motion, with the idea that they create energy from nothing. However, nuclear processes clearly consume atomic fuels, and in this sense are analogous to the burning of ordinary fuels.

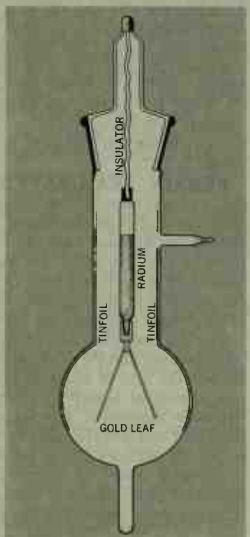

FIG. 5.—R. J. STRUTT'S RADIUM CLOCK

The first example of the use of nuclear energy to produce motion was in 1903, when R. J. Strutt (later fourth Baron Rayleigh) created a sensation with an apparatus called the radium clock. Two fine gold leaves, arranged as in the electroscope much used at that time in laboratories, hung from a thin-walled vertical glass tube containing radium, the whole being held by an insulating support inside an evacuated glass vessel (fig. 5). Attached to the inner walls of this vessel were two grounded tinfoil strips, so arranged that when the gold leaves became heavily charged and strongly repelled each other, they touched these strips and were discharged. As it lost beta particles through the thin glass, the radioactive preparation became charged, the leaves diverged, discharged, and collapsed; the process repeated indefinitely. The half-life of the radium fuel being about 1,620 years, the motion of the device may have seemed perpetual.

Strutt recorded that "Lord Kelvin was wildly enthusiastic about it and persisted in calling it my 'perpetual motion,' for at the time he advocated the view that radium drew its energy from the surroundings at the same temperature, contrary as he admitted to the second law of thermodynamics." However, it soon became firmly established that energy is released as the radium nucleus is transformed. The phenomenon is not perpetual motion produced by subtle design without a source of energy. The modern breeder reactor (*see* PLUTONIUM: *Uses*) constitutes an immensely more energetic version of Strutt's experiment.

The sun's radiant heat may be utilized by some direct method; the tides may be harnessed; or some other source of energy may be made to produce systematic mechanical motion for the service of man. But a machine to produce ordered motion by itself in complete isolation or to use the heat of its surroundings as a source of energy without a colder sink is so improbable that it is most likely to be impossible of realization.

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PERPETUITY, literally, means an unlimited duration; but in law it refers to a provision which is in breach of the rule against perpetuities. For more than seven centuries, Anglo-American law has assumed that social interest requires freedom in the alienation of property. (Alienation is, in law, the transferring of property by voluntary deed and not by inheritance.) When English land conveyancers in the late 16th century invented a form of conveyance designed to make land inalienable forever, the courts held it an invalid human attempt to rival the permanence of God. Thus they utilized the word "perpetuity" to describe such an invalid limitation, borrowing it from the Latin phrase *in perpetuum*, used constantly in the Scriptures with reference to God's eternal continuance (Ps. 103:9; Job 14:20).

The term perpetuity thus became, in law, the antithesis of freedom of alienation. It took little effort to extend the application of the word from present interests of perpetual duration to future interests which would prevent the alienability of the affected property for "too long" a time. The applicability of this regulation to future interests became clear by the end of the 17th century. The next century and a half (1687–1833) were spent by English courts in determining how long was "too long" for the purposes of this rule.

By this masterpiece of judicial legislation, the permissible period for the tying up of property became fixed at the lifetimes of human beings alive when the conveyance was made plus 21 years, plus one or more periods of gestation, to allow for the inclusion of persons conceived but not yet born at any of the times which were important in applying the permissible period. (*See* REAL PROPERTY AND CONVEYANCING, LAWS OF.) This period corresponded with the English marriage settlement, under which the land would be tied up until the eldest son of the marriage was of full age. The rule invalidated any interest in property, whether real or personal, which, when created, might take longer than this period to vest in the donee; it regarded possible, rather than actual events. This became the "common-law rule against perpetuities," and this rule, with slight modifications, now operates in England and in a very large percentage of the American states with respect to dispositions of both land and personal property. It serves simultaneously to assure the alienability of property by the end of a not inconveniently long period of time, and to set an outer limit on the power of the dead hand to control the future.

In 1830 the New York Legislature adopted statutes substantially shortening the permissible period and applying the rule's regulation not only to future interests but also to the duration of the most common form of private express trusts. This statutory innovation spread in varying degrees to 13 other states (Arizona, California, Idaho, Indiana, Kentucky, Michigan, Minnesota, Mississippi, Montana, North Dakota, Oklahoma, South Dakota, and Wisconsin) and the District of Columbia. The century following, however, witnessed a gradual abandonment of the New York leadership on this point, and even New York itself returned largely to the common-law permissible period in 1958. In England, in 1956, the Lord Chancellor's Law Reform Committee's Fourth Report recommended far-reaching reforms of the rule, including the substitution of actual events for possible events. Since the whole rule rests on social policy, exceptions to it based on social policies recognized as superior have gained acceptance as to perpetual trusts for burial lots, trusts for pension plans, charitable gifts, and some other less frequent types of conveyance.

BIBLIOGRAPHY.—A. J. Casner, *American Law of Property* (1952); J. C. Gray, *The Rule Against Perpetuities*, 4th ed. (1942); R. R. Powell, *Law of Real Property* (1949–58); J. H. C. Morris and W. B. Leach, *The Rule Against Perpetuities* (1956); Law Reform Committee, *Fourth Report*, Cmd. 18 (HMSO, 1956); R. E. Megarry and H. W. R. Wade, *The Law of Real Property*, 2nd ed. (1959).

(R. R. Po.; R. E. My.)

PERPIGNAN, a town of southern France, capital of the *département* of Pyrénées-Orientales and the seat of a bishopric, is situated on the Tet river, 15 mi. from the Spanish frontier and 7 mi. inland from the Mediterranean sea, in luxuriant fruit and wine country. It is dominated to the southwest by the Canigou massif (Mont Canigou, 9,137 ft.). Pop. (1962) 82,626.

Perpignan was one of the leading fortified towns of the Pyrenees. The citadel (17th–18th centuries) dominates it from the south; this incorporates the palace begun by the kings of Majorca (13th–14th centuries), a notable specimen of Catalan Gothic architecture. There is also the Castillet, a charming rose-brick château, mostly of the 14th century, which contains a folk museum. A fine complex of civic buildings testifying to Perpignan's commercial and administrative importance includes the Hôtel de Ville or town hall (13th–17th centuries) and the Loge de Mer (begun 1397). The chief religious monument is the 14th- to 15th-century cathedral of St. Jean. A notable museum is the Musée Rigaud in the 17th-century university building; it contains canvases by Hyacinthe Rigaud (1659–1743), a native of Perpignan.

Perpignan has a flourishing trade in fruit, wine and vegetables. There are also ceramic and other craft industries, including doll manufacture. The town's easy access to the Mediterranean beaches, thermal baths and mountains makes it a leading tourist centre; and by virtue of its good rail, sea (via Port-Vendres, 19 mi. S.E.) and air communications it is also a junction for travelers for southern Europe and north Africa. There are air routes to London, Paris and the Balearic islands.

The first mention of Perpignan occurs in the 10th century, when it was called Villa Perpiniani. It rose to importance on becoming capital of the medieval Spanish countship of Roussillon. The kings of Aragon held it from 1172 until 1278, and the kings of Majorca until 1344. It then passed between Aragon and France until 1475, when it was occupied by troops of the French king Louis XI, but it did not become permanently French until it was secured in 1659 by the treaty of the Pyrenees. (Y. H.)

PERRAULT, CHARLES (1628–1703), French writer of fairy tales and influential literary controversialist, was born in Paris, Jan. 13, 1628. After studying law, he began work under his brother Pierre but won some reputation about 1660 as a writer of burlesque verse and amourous poems. From 1663, when J. B. Colbert assumed the protection of literature and the arts, Perrault did important work under him, envisaging the establishment of a general academy such as Napoleon was later to set up in the Institut. Elected to the Académie Française in 1671, he died in Paris on the night of May 15–16, 1703.

Perrault is chiefly remembered for his charming fairy tales, *Histoires ou contes du temps passé* (with the alternative title *Contes de ma mère l'Oye*), published in 1697 but written, according to the abbé J. B. du Bos, sometime earlier, to amuse Perrault's children. The tales are notably free from the affectation and spurious naïvete that disfigure other fairy tales of the period. (*See* CHILDREN'S LITERATURE: *Fairy Tales and Fantasy.*) In his own time, however, Perrault was most important as the champion, in the Académie Française, of the "moderns" against the "ancients" (*see* ANCIENS ET DES MODERNES, QUERELLE DES). His poem *"Le Siècle de Louis le Grand,"* read to the Académie on Jan. 27, 1687, was an outspoken polemic that provoked Boileau to protest forcefully on the spot. Perrault, however, maintained his attitude in his *Parallèle des Anciens et des Modernes* (1688–92).

The most systematic and the most radical of the moderns, he believed that the human mind made continuous progress and that a nation's literature corresponded to its state of civilization, so that ancient literature was inevitably coarser and more barbarous than modern. Shocking to his contemporaries and to later critics, Perrault's extremism makes his thought a historic landmark in the revolt against the humanist tradition.

Three of his four brothers are also noteworthy: PIERRE (1611–*c.* 1680), an official in the revenue department who upheld the moderns against the ancients in the preface to his translation of Alessandro Tassoni's *La Secchia rapita* (*Le Seau enlevé*, 1678) and in *Critique des deux tragédies d'Iphigénie d'Euripide et de M. Racine* (unpublished); CLAUDE (1613–1688), a doctor of medicine whose activities as an architect were derided by Boileau in *L'Art poétique*, book iv (1674); and NICOLAS (1624–1662), a doctor of theology who inclined to Jansenism.

See P. Bonnefon, "Charles Perrault . . . ," three articles, *Revue d'histoire littéraire de la France* (1904–05), a most important study; also A. Adam, *Histoire de la littérature française au XVIIe siècle*, vol. iii and v (1952–56). (AE. A.)

PERRERS, ALICE (d. 1400), mistress of the English king Edward III, probably belonged to the Hertfordshire family of Perrers, although some sources state that she was of humble birth. She married Sir William Windsor, king's lieutenant in Ireland (1369–72) and governor there (1373–76). She entered the service of Edward's queen, Philippa of Hainaut, before 1366. Her intimacy with the king began about 1367. A few years after the queen's death (1369) Alice was given her robes and jewels. In May 1376 her removal from court was demanded by the commons in the Good parliament. It was alleged that she had drawn £2,000 or £3,000 a year from the royal coffers, and that she frequently sat on the judges' bench and "maintained" (supported) her friends in their lawsuits. A decree of banishment and forfeiture was passed against her. Although the bishops had sworn to excommunicate her if she returned, they remained passive when she was brought back to court later in 1376 by the king's brother, John of Gaunt. The parliament of Jan. 1377 reversed the sentence against Alice and she was with the king when he was dying (June 1377). After Edward's death she fled from court and the government seized more than £2,500 belonging to her; two chroniclers assert, however, that she took with her the rings from the dead king's fingers. In Dec. 1377 she was again condemned, this time before the lords, for defying the ordinance of 1376 and continuing to interfere with the course of justice. In 1378 she appealed against her conviction, on technical grounds, and the sentence was reversed in 1379.

PERRIN, JEAN BAPTISTE (1870–1942), French physicist, who was awarded the Nobel prize for physics in 1926 for his extensive studies on the motion (called Brownian movement) and distribution of small particles suspended in a liquid, was born at Lille, on Sept. 30, 1870. He was educated at the École Normale Supérieure in Paris and from 1898 to 1940 was professor of physical chemistry in the University of Paris. He was elected a member of the French Académie des Sciences in 1923 and was president in 1938. His researches were mainly concerned with colloids, Brownian movement and the determination of absolute molecular weights. He was the first to establish experimentally (1895) that cathode rays consist of negatively charged particles. His researches on Brownian movement gave experimental confirmation of Albert Einstein's theoretical studies in which it had been shown that such suspended particles should follow the gas laws even to the extent of giving a means of determining Avogadro's number (N), an important physiochemical constant, namely, the number of molecules in a gram molecule of any gas, the number obtained by Perrin being 6.8×10^{23}. His book, *Les Atomes* (1913; 3d ed., 1940), describing this work, became a classic. He died in New York city on April 17, 1942. (D. McK.)

PERRON, (CHARLES) EDGAR DU (1899–1940), Dutch man of letters and influential critic, was born at Meester Cornelis, Dutch East Indies, on Nov. 2, 1899, the son of a planter. In 1921 his family (which was of French origin) moved to Europe and settled in Brussels. Du Perron himself lived in Montmartre for some time, among the Paris artists, where he experimented with modernistic poems and stories. In his novel *Een Voorbereiding* (1927; "A Preparation") he gives an account of this period of apprenticeship. Later, with his friend Menno ter Braak (*q.v.*), he founded the publication *Forum* (1932–35) which turned against the exaggerated worship of beautiful form rather than distinctive content, and judged literature by standards of honesty and common sense.

Du Perron did much to publicize the works of André Gide and of his friend André Malraux, and translated into Dutch the latter's novel *La Condition humaine* which had been dedicated to him. His collected essays, *De smalle Mens* (1934), deal with the precarious position of the self-sufficient personality in the face of

the threatening collective attitude of left and right. His poems, collected in *Parlando* (1941), contain so-called *poesie parlante*, which achieves a new effect through the use of everyday words. Shortly before World War II du Perron spent a few more years in the Dutch East Indies, collecting material for his books on Multatuli published in *De Man van Lebak* (1937). He returned to the Netherlands and died at Bergen, Neth., on May 14, 1940. His collected works were published in 1954.

See G. H. 's-Gravesande, *E. du Perron* (1947); H. A. Gomperts, *Jagen om te Leven* (1949). (Gd. W. Hs.)

PERROT, SIR JOHN (*c.* 1527–1592), lord deputy of Ireland from 1584 to 1588, whose boldness in action provoked extremes of admiration or hatred and marred much of his work, was generally reputed to be the son of King Henry VIII. His mother was Mary Berkley, who later married Thomas Perrot. John Perrot, as he was named, was probably born at Harroldston, Pembrokeshire. He was attached to the household of William Paulet, 1st marquess of Winchester, and was knighted at the coronation (1547) of Edward VI. Though imprisoned by Mary I on a charge of harbouring heretics, he was soon released and was later granted the castle and lordship of Carew in Pembrokeshire. Early in the reign (1558–603) of Elizabeth I he was entrusted with the naval defense of south Wales. He was appointed lord president of Munster in Nov. 1570, and did much to pacify the province after the rebellion (1569) of James (Fitzmaurice) Fitzgerald. He withdrew to England in July 1583 and resigned his Irish office.

Sir John returned to Ireland as lord deputy in 1584. The end of the Desmond war (1579–83) provided the opportunity for the government to confiscate land for plantation by English settlers (*see* IRELAND: *History*). But the area made available was not utilized adequately and the colony acquired only a thin superstructure of English landlords. Perrot's work in regard to Connaught land titles was more satisfactory. He succeeded in inducing the great and small gentry to compound the services due to the crown by paying instead a fixed money rent.

Always ready for military action, Perrot opposed the renewed ambitions of Sorley Boy MacDonnell (*q.v.*), who was supported by the MacLeans from Scotland. He managed to restrict the use of Scots mercenaries by the Irish lords, but obtained the submission (1586) of Sorley Boy only by excessive concessions.

In the Irish parliament of 1585–86 much legislation introduced by Perrot was blocked in the house of commons. The English government rejected his advice to punish the opposition leaders and a compromise was provided which gave the Dublin government greater freedom in drafting legislation.

A plan of Perrot's to convert the revenues of St. Patrick's cathedral, Dublin, for a projected new university, precipitated a violent quarrel between him and Archbishop Adam Loftus of Dublin. Loftus successfully opposed the plan and then brought about Perrot's recall in 1588 on a charge of treasonable negotiations with Philip II of Spain. The correspondence is now known to have been forged, but he was found guilty and imprisoned in the Tower, where he died in Sept. 1592.

See Sir James Perrott, *Chronicle of Ireland, 1584–1608*, ed. by H. Wood (1933); C. McNeill, "The Perrot Papers," *Analecta Hibernica*, vol. xii (1943). (R. D. Es.)

PERRY, BLISS (1860–1954), U.S. writer, chiefly known as an essayist and critic, was born at Williamstown, Mass., Nov. 25, 1860. He graduated from Williams college in 1881 (A.M., 1883), continuing his studies at the universities of Berlin and Strasbourg. He was professor of English at Williams college, 1886–93; professor of oratory and aesthetic criticism at Princeton university, 1893–1900; professor of English literature at Harvard university, 1907–30; and Harvard lecturer at the University of Paris, 1909–10. He was editor of the *Atlantic Monthly*, 1899–1909. His autobiographical *And Gladly Teach* appeared in 1935. Perry died at Exeter, N.H., Feb. 13, 1954.

PERRY, MATTHEW CALBRAITH (1794–1858), U.S. naval officer, who concluded the first treaty between Japan and the United States, was born at South Kingston, R.I., April 10, 1794. He was commanding officer (1838–40) of the "Fulton II," first U.S. steam warship. In 1843 (with the honorary rank of commodore) he commanded a squadron that was sent to Africa, under the terms of the Webster-Ashburton treaty, to aid in suppressing the slave trade. During the Mexican War, Perry commanded a naval force that captured Frontera and Tabasco, thereby cutting off Mexico from Yucatan; and in March 1847, his unit carried out a bombardment that permitted the landing of troops at Veracruz.

In March 1852, Perry was appointed commander of a naval expedition to be sent to Japan to induce the government to establish diplomatic relations with the U.S. After studying the situation, Perry concluded that Japan's traditional isolation policy would be altered only if superior naval forces were displayed and if the Japanese officials were approached with a "resolute attitude." He decided "to demand as a right, and not to solicit as a favour, those acts of courtesy which are due from one civilized country to another. . . ." With two frigates and two sailing vessels he entered the fortified harbour of Araga on July 8, 1853. He refused to obey Japanese orders to leave and sent word that if the Japanese government did not delegate a suitable person to receive the documents in his possession, he would "go on shore with a suitable force and deliver them personally, be the consequences what they might." A high Japanese official was finally dispatched and, amid much ceremony, the U.S. documents were delivered. Perry then reported that he would return the following year, with a much larger naval force, to receive a reply to Pres. Millard Fillmore's request for a treaty.

In Feb. 1854 Perry reappeared in Edo (modern Tokyo) bay with more ships than before and on March 31 concluded the first treaty between the United States and Japan. The presents given by Perry to celebrate the occasion filled several boats and included a model railway, telegraph instruments, modern guns, telescopes and other items that served to impress the Japanese with the technological and scientific achievement of the west.

The treaty merely assured better treatment of shipwrecked seamen and permitted U.S. ships to obtain fuel and supplies at two Japanese ports. But it demonstrated the military government's inability to enforce its traditional isolation policy and thus contributed to the collapse of the feudal regime and to the modernization of Japan.

The success of the expedition made Perry a recognized authority on the far east. Through his writings and speeches he stressed the danger of British and Russian expansion and urged that the United States play a more active role in the orient. He died in New York city, March 4, 1858.

See also JAPAN: *History: The Opening of Japan.*

See the official record, *Narrative of the Expedition of an American Squadron to the China Seas and Japan* (1856); Edward M. Barrows, *The Great Commodore* (1935). (D. M. Br.)

PERRY, OLIVER HAZARD (1785–1819), U.S. naval officer who became a national hero when he defeated a British squadron in the Battle of Lake Erie during the War of 1812, was born on Aug. 23, 1785, at South Kingston, R.I. Appointed midshipman in 1799, he saw service in the Mediterranean and was commander of a gunboat flotilla when the War of 1812 began. In February 1813 he was sent to complete the building of the squadron at Erie, Pa.

On Sept. 10, 1813, Perry, with nine vessels, engaged Capt. Robert Heriot Barclay, who commanded six British warships. Perry was greatly superior in short-range firepower, but only slightly superior at long-range, and light wind prevented him from closing quickly with Barclay. After his flagship "Lawrence" had suffered heavy casualties and been reduced to a defenseless wreck, Perry transferred to the "Niagara," a sister-ship, and sailed into the British line firing broadsides, soon forcing its surrender. With U.S. control of Lake Erie thus regained, Perry sent his famous message to Brig. Gen. William Henry Harrison: "We have met the enemy and they are ours. Two ships, two brigs, one schooner, and one sloop." The battle had begun 8 mi. from Put-in-Bay and ended 14 mi. to the northwest, near West Sister Island.

Perry died at sea of yellow fever on Aug. 23, 1819, while returning from Venezuela.

See C. J. Dutton, *Oliver Hazard Perry* (1935); C. S. Forester, *The Age of Fighting Sail* (1956). (R. J. Do.)

PERRY is an alcoholic beverage made by fermenting pear juice. Mostly it is produced in those northern countries, of temperate climate, where it is easier to grow pears and apples than grapes. Dessert pears cannot be used for perry; the fruit must have "vintage" qualities, and where the soil is suitable for cider (*q.v.*) orchards it will also bear perry orchards successfully. In England, in Herefordshire, Worcestershire, Gloucestershire, and in parts of Monmouthshire, Somerset, and Kent, perry orchards flourish; they like best a sandy loam. In France only a little perry is produced in Brittany, but in Germany it is preferred to cider. Formerly there was a large production of perry in the eastern states of the United States.

Many English varieties of perry pears, such as Barland, Holmer, Huffcap, and Taynton Squash, can be traced to the end of the 17th century. The origin of some varieties, for instance Cheat Boy, Longland, and Blakeney, cannot be traced, but others can be dated to the 18th century (such as Buff) or to the early 19th century (Aylton Red). It was then that perry lost popularity; the orchards became derelict and were widely uprooted.

After World War II popular taste in Britain adopted sparkling perry, and pear juice is imported from Switzerland, as it possesses "vintage" quality when blended with English pear juice.

See R. Hogg, *The Apple and Pear as Vintage Fruits* (1886).

(C. C. H. F.)

PERSE, SAINT JOHN (pseudonym of MARIE RENÉ AUGUSTE ALEXIS LÉGER) (1887–), French poet and diplomatist, who was awarded the Nobel Prize for Literature in 1960. He was born at Saint-Léger des Feuilles, Guadeloupe, March 31, 1887, studied at the Universities of Bordeaux and Paris and in 1914 entered the diplomatic service. He went to China and was successively consul at Shanghai and secretary at Peking. In 1921 he attended the Washington Disarmament Conference as an expert on Far Eastern affairs. He was later secretary to Aristide Briand. In 1933 he was appointed secretary general of the Foreign Ministry, with the rank of ambassador. Dismissed from office in 1940, and deprived of French citizenship by the Vichy government, he went to the U.S., where he worked in the Library of Congress. He continued to live there after the liberation of France, although his French citizenship was restored and he retained an estate on the Riviera.

His early poetry, published before his diplomatic career gained momentum, includes *Éloges* (1904–08) and *Images à Crusoe* (1909), and shows the influence of Symbolism, though he later developed a more personal style. The language of his poetry, admired, especially by poets, for its precision and purity, is difficult, and he has made little appeal to the general public. His best known early work is the long poem *Anabase* (1925; Eng. trans. by T. S. Eliot, 1930). In the poems written in exile—*Exil* (1942), *Vents* (1946), *Amers* (1957), and *Chronique* (1960)—he achieved a more deeply personal note and, by some American readers, was regarded as an embodiment of the French national spirit: intellectual yet passionate, deeply conscious of the tragedy of life, a man of affairs with an artist's feeling for perfection and symmetry.

PERSEPHONE (Latin PROSERPINA), in Greek mythology the daughter of Zeus and Demeter, the goddess of agriculture, and wife of Hades, king of the underworld. In Homer, Persephone is queen of the underworld, and there is no mention of her relationship to Demeter. Hesiod, in his *Theogony*, is the first to relate that she was the daughter of Demeter and was carried off by Hades (*q.v.*). The Homeric Hymn to Demeter tells the story in full: Persephone was gathering flowers in the Vale of Nysa when she was seized by Hades and removed to the underworld. Her mother sought her in vain, sorrowing, and after nine days asked the all-seeing sun-god, Helios, if he knew what had happened. After learning the truth, Demeter ceased, in her misery, to be concerned with the harvest or the fruitfulness of the earth, so that widespread famine ensued. Zeus therefore intervened, commanding Hades to release Persephone to her mother. But Persephone had taken food in the underworld—a single pomegranate seed—so she could not be completely freed but had to remain one-third of the year with Hades, spending the other two-thirds with her mother.

One of the variants of the name Persephone is Persephassa, a form with a pre-Hellenic suffix that suggests that she was a pre-Hellenic deity, no doubt a goddess of the dead. If this is so, her connection with Demeter came later, when she was identified with Kore (the Greek word for "maiden"), the young grain-goddess and daughter of Demeter; Demeter and Kore were the leading goddesses in the Eleusinian mysteries (*see* MYSTERY), with which the Homeric Hymn to Demeter is connected. The story that Persephone/Kore spent four months of each year in the underworld was no doubt meant to account for the barren appearance of Greek fields in full summer (after harvest) before their revival in the autumn rains when they are plowed and sown.

Persephone also appears in the Orphic myth of Zagreus, her son by Zeus, who as a child was torn apart by Titans (*see* DIONYSUS). *See* DEMETER (with bibliography); *see* also references under "Persephone" in the Index.

PERSEPOLIS (Old Persian PARSA; modern TAKHTE-E JAMSHID), an ancient capital of the Achaemenian kings of Persia, situated about 32 mi. NE of Shiraz in Fars province, southwest Iran, not far from the point at which the small river Pulvar (Rudkhaneh-ye Sivand) flows into the Kor (Cyrus) river. The site is marked by a large terrace with its east side leaning on Kuh-e Rahmat ("the Mount of Mercy"). The other three sides are

FRANCES MORTIMER—RAPHO GUILLUMETTE

RUINS OF THE RESIDENTIAL PALACE OF DARIUS THE GREAT AT PERSEPOLIS; NEAR THE WEST TERRACE WALL, JUST SOUTH OF THE APADANA

formed by a retaining wall, varying in height with the slope of the ground from 14 to 41 ft.; on the west side a magnificent double stair in two flights of 111 easy stone steps leads to the top. On this terrace are the ruins of a number of colossal buildings, all constructed of a dark gray stone, often polished to the consistency of marble, from the adjacent mountain. The stones, of great size, cut with the utmost precision, were laid without mortar, and many of them are still *in situ*. Especially striking are the huge columns, 13 of which still stand in Darius the Great's audience hall, known as the apadana, the name given to a similar hall built by Darius at Susa (there are two more columns in the propylaeum or entrance hall of his son, Xerxes).

These ruins, for which the name "Sad-Sutun" ("the 100 Columns") can be traced back to the 4th century A.D., are now known as Takht-e Jamshid ("the Throne of Jamshid," a mythical Persian hero). That they represent the Persepolis captured and partly destroyed by Alexander the Great in 330 B.C. has been beyond dispute at least since the time (early 17th century) of the Italian traveler Pietro della Valle. It was not wholly deserted, for in the Apocrypha (II Macc. ix, 2) it is stated that the Seleucid king Antiochus IV (Epiphanes) during an incursion into Persia was repelled by the inhabitants of Persepolis shortly before his death (163 B.C.). In 1933 two sets of gold and silver plates recording in the three forms of cuneiform, Ancient Persian, Elamite and Babylonian, the boundaries of the Persian empire were discovered in the foundations of Darius' hall of audience. A number of inscriptions, cut in stone, of Darius I, Xerxes I and Artaxerxes III indicate to which monarch the various buildings are to be at-

tributed. The oldest of these on the south retaining wall gives Darius' famous prayer for his people: "God protect this country from foe, famine and falsehood." There are numerous reliefs of Persian, Median and Elamite officials, and 23 scenes separated by cypress trees depict representatives from the remote parts of the empire who, led by a Persian or a Mede, make appropriate offerings to the king at the national festival of the vernal equinox.

Behind Takht-e Jamshid are three sepulchres hewn out of the mountainside, the façades, of which one is incomplete, being richly ornamented with reliefs. About 8 mi. N.N.E., on the opposite side of the Pulvar, rises a perpendicular wall of rock, in which four similar tombs are cut, at a considerable height from the bottom of the valley. This place is called Naksh-e Rostam ("the Picture of Rostam") from the Sasanian carvings below the tombs, which were thought to represent the mythical hero Rostam. That the occupants of these seven tombs were kings might be inferred from the sculptures, and one of those at Naksh-e Rostam is expressly declared in its inscriptions to be the tomb of Darius I Hystaspes, concerning whom Ctesias relates that his grave was in a cliff face and could be reached only by means of an apparatus of ropes. Ctesias mentions further, with regard to a number of Persian kings, either that their remains were brought "to the Persians," or that they died in Persia. It is certain that Cyrus was buried at Pasargadae (*q.v.*), and if there is any truth in the statement that the body of Cambyses was brought home "to the Persians" it might be assumed that his burying place would be near that of his father. A rectangular ruin, however, containing several massive layers of stone of proportions identical with those forming the base of the tomb of Cyrus at Pasargadae, and taken from the same quarry, exists at Takht-e Gohar on the Pulvar, and may have been intended to serve as the tomb of Cambyses.

In order to identify the graves of Persepolis it should be borne in mind that it was the custom for a king to prepare his own tomb in his lifetime. This was certainly so in the case of Darius I, who in an inscription beside the entrance to his tomb describes his own character and states that God had given him two special qualities, namely wisdom and activity. The three other tombs at Naksh-e Rostam, besides that of Darius I, are probably those of Xerxes I, Artaxerxes I and Darius II. Xerxes II, who preceded Darius II, reigned for a very short time and could not have obtained so splendid a monument, still less could Sogdianus (Secydianus), who usurped his brother's throne and reigned for less than a year. The two completed graves behind Takht-e Jamshid would then belong to Artaxerxes II and Artaxerxes III. The unfinished one might be that of Arses, who reigned at the longest two years, but is more likely to be that of Darius III (Codomannus), who is one of those whose bodies are said to have been brought "to the Persians" (Arrian, *Anabasis*, iii, 22, 1).

Since Cyrus was buried in Pasargadae, which moreover is mentioned in Ctesias as his own city, and since, to judge from the inscriptions, the buildings of Persepolis commenced with Darius I, it was probably under this king, with whom the sceptre passed to a new branch of the royal house, that Persepolis became the capital of Persia proper. As a residence for the rulers of the empire, a remote place in a difficult alpine region was far from convenient, and the real capitals were Susa, Babylon and Ecbatana, Persepolis being visited mainly in the spring season. This accounts for the fact that the Greeks were not acquainted with the city until it was taken and plundered by Alexander the Great.

In 316 B.C. Persepolis was still the capital of Persis as a province of the great Macedonian empire. The city gradually declined during and after the Seleucid period, but the ruins remained as a witness to its ancient glory. It is probable that the principal town of the country, or at least of the district, was always in this neighbourhood. About A.D. 200 the city of Istakhr (Estakr, Stakr) was the seat of local governors. There the foundations of the second great Persian empire were laid, and Istakhr acquired special importance as the centre of priestly wisdom and orthodoxy. But from the stone ruins which still stand a few miles northwest of Persepolis, it is clear that Istakhr dates from Achaemenian times. The Sasanian kings (3rd–7th century A.D.) covered the face of the rocks in this neighbourhood, and in part even the Achaemenian ruins, with their sculptures and inscriptions in Pahlavi, and must themselves have built largely here, although never on the same scale of magnificence as their ancient predecessors. The Romans knew as little about Istakhr as the Greeks had about Persepolis, in spite of the fact that for 400 years the Sasanians maintained relations, friendly or hostile, with the Roman empire.

At the time of the Arab conquest Istakhr offered a desperate resistance. The city was still a place of considerable importance in the first century of Islam, although its greatness was soon to be eclipsed by the new metropolis Shiraz. In the 10th century A.D. it had become an insignificant place, as may be seen from the description of the Arab geographer al-Maqdisi (*c.* 985). In the mid-11th century it was razed by the Seljuk amir Qutulmish and its population was transferred to Shiraz. This fruitful region was covered with villages until the frightful earthquakes of the 19th century, and even in modern times it is, comparatively speaking, well cultivated. The "castle of Istakhr" played a conspicuous part as a strong fortress several times during the period of Arab ascendancy. It was the middlemost and the highest of the three steep crags which rise from the valley of the Kor, at some distance west or northwest of Naksh-e Rostam. *See* PERSIAN HISTORY; *see* also references under "Persepolis" in the Index.

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PERSEUS (*c.* 212–*c.* 165 B.C.), the last king of Macedonia (179–168), whose imperialist ambitions in Greece brought him into conflict with the Romans. He was the elder son of Philip V, probably by Polycrateia of Argos; insinuations of spurious or slave birth deserve no credence. While still young he commanded troops in his father's wars against Rome (199) and Aetolia (189). From 184 onward he intrigued against his brother Demetrius, representing him as coveting the succession through Roman favour, and in 181 persuaded Philip to execute him; the tradition concerning this is distorted in Polybius' pro-Demetrian account.

On succeeding (179) Perseus renewed his treaty with Rome and recalled debtors and exiles to Macedonia. He extended his influence in Thrace and Illyria, but made special efforts to win over the Greek world. He married Laodice, daughter of Seleucus IV, and gave his sister to Prusias II of Bithynia; he established excellent relations with Rhodes and resumed control of the Delphic amphictyony. In Aetolia and Thessaly, however, he encouraged the revolutionary party, and after subduing a revolt in Dolopia created widespread alarm by visiting Delphi with his army; an attempt to re-establish his influence in Achaea failed, but he made a treaty with Boeotia (perhaps 174). In alarm Eumenes II of Pergamum visited Rome (172) and by his incitement precipitated the Third Macedonian War (171–168). Helped by ineffective Roman strategy, Perseus during three campaigns held his enemy on his southern frontiers near Mt. Olympus; but in 168 niggardliness lost him the support of Genthius of Illyria, thus exposing his western flank, and a reinforced Roman army forced him to fight at Pydna. There his phalanx broke before the more flexible cohorts (*see* PYDNA, BATTLE OF), and Lucius Aemilius Paulus was victorious. Perseus was captured on the island of Samothrace and walked in Paulus' triumph (167). He died at Alba Fucens two years later.

Perseus' character was not unattractive, and alike as administrator, general and diplomatist he stands high. That he planned war with Rome is unlikely, though war was the logical outcome of his policy. His failure revealed his inability to reconcile the needs of Macedonia with the reality of Roman predominance.

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PERSEUS, in Greek mythology, the slayer of the Gorgon Medusa and the rescuer of Andromeda from a sea monster. The son of Danaë (*q.v.*) and Zeus, as an infant he was cast into the sea in a box with his mother by her father, Acrisius, king of Argos, to whom it had been prophesied that he would be killed by his grandson. After Perseus had grown up on the island of Seriphus, where the box had grounded, Polydectes, king of Seriphus, desired Danaë, and to rid himself of Perseus tricked him into promising to obtain the head of Medusa, the only mortal among the Gorgons (*see* GORGON). The story of his accomplishment of this task contains a series of folktale motifs.

Aided by Hermes and Athena, Perseus went to the end of the

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DETAIL FROM AN EARLY-5TH-CENTURY-B.C. ATTIC WATER JAR, SHOWING PERSEUS AND THE DECAPITATED MEDUSA, HER HEAD IN HIS BAG; ATHENA IS AT THE RIGHT. IN THE BRITISH MUSEUM

earth to obtain the help of the Graeae, sisters of the Gorgons. They were three hags who shared the use of one eye and one tooth which Perseus seized from them and would not return until they provided him with winged sandals (which enabled him to fly), the helmet of Hades (which conferred invisibility), a curved sword to decapitate Medusa and a bag in which to conceal the head. (According to another version, the Graeae merely directed Perseus to the nymphs of the north, who told him where to find the Gorgons and gave him the bag, sandals and helmet; Hermes gave him the sword, or sickle.) Armed with these, and with a shield from Athena, he set off on his task. Since the gaze of Medusa turned all who looked at her to stone, Perseus guided himself by her reflection in his shield and beheaded her as she slept. Safe from pursuit by her sisters because of his magic helmet, he returned to Seriphus and rescued his mother by turning Polydectes and his supporters to stone at the sight of Medusa's head.

A further legend inserted into Perseus' travels is that of his rescue of the Ethiopian princess Andromeda, when he was on his way home with Medusa's head. Andromeda's mother, Cassiopeia, had claimed to be more beautiful than the Nereids, so Poseidon had punished Ethiopia by flooding it and plaguing it with a sea monster. Andromeda's father, King Cepheus, had been informed by the oracle of Zeus Ammam that these ills would cease if he exposed Andromeda to the monster. Perseus, passing by on his winged sandals, saw her chained to a rock on the seashore awaiting the monster, and fell in love with her. After obtaining Cepheus' permission to marry her if he killed the monster, Perseus turned it to stone by showing it Medusa's head. This legend appears to be a fairy tale from the middle east. The rescue from the monster, which according to some early authorities took place at Joppa, near Lydda, may have been a source for the much later legend of St. George and the dragon.

After taking Andromeda to Seriphus and disposing of Polydectes, Perseus gave the Gorgon's head to Athena, who placed it on her shield, or aegis, and his other accoutrements to Hermes. He then took his mother back to her native Argos, where he accidentally struck Acrisius dead when throwing the discus, thus fulfilling the prophecy that he would kill his grandfather. He consequently gave up the kingship of Argos and founded Mycenae as his capital, becoming the ancestor of the Perseids, among whom was Heracles.

Perseus bearing the Gorgon's head or rescuing Andromeda was a favourite subject in painting and sculpture both ancient and Renaissance. Freud reinterpreted the Gorgon's head in terms of castration, and the English novelist Iris Murdoch used it for modern symbolism in *A Severed Head* (1961).

The chief characters in the Perseus legend, Perseus, Cepheus, Cassiopeia, Andromeda and the monster (Cetus), all figure in the night sky as constellations.

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PERSEUS, in astronomy, a constellation of the northern hemisphere, named after the Greek legendary hero. It contains a double cluster forming an interesting object for low-power telescopes. The second brightest star in the constellation is the famous eclipsing variable Algol (*q.v.*). A number of naked-eye stars—of which α Persei is the brightest—make up a loose cluster, which is located at a distance of about 400 light years from the sun. The double cluster itself is much more remote; its distance is of the order of 7,000 light years. The radiant, or apparent centre, of the Perseid meteor shower lies in Perseus.

PERSHING, JOHN JOSEPH (1860–1948), U.S. army officer, commander in chief of American troops in Europe during World War I, was born in Laclede, Mo., on Sept. 13, 1860. After graduation from the U.S. Military Academy at West Point, N.Y., in 1886 he participated in several Indian wars. In 1891 he became instructor in military science at the University of Nebraska, Lincoln, and later taught tactics at West Point. The Spanish-American War gave Pershing an opportunity for rapid promotion. He served with distinction in Cuba and then campaigned in the Philippines against the Moros of Mindanao. While a military attaché in Japan in 1905 he observed the Russo-Japanese War in Manchuria. Pres. Theodore Roosevelt recognized his distinguished service by promoting him to the rank of brigadier general in 1906, passing over 862 senior officers. Pershing served in the Philippines until 1913. He next gained attention as commander of the punitive expedition sent against the Mexican revolutionary Pancho Villa, who raided Columbus, N.M., in 1916.

After the United States declared war on Germany in March 1917, President Wilson selected Pershing to command the American Expeditionary Force (AEF). Pershing went to Europe in June and soon submitted a "General Organization Report" recommending an army of 1,000,000 men by 1918 and 3,000,000 by 1919. Early American planning had not contemplated a large army. The Allies had asked for financial, economic, and naval assistance, assuming the AEF could not be organized in time to provide assistance, but Pershing's recommendations prevailed, especially after Allied fortunes worsened during 1917. By early 1918 American plans called for concentrating an independent army on the western front. Pershing hoped it would spearhead a decisive offensive against Germany.

The exhaustion of the Allies, stemming from the setbacks of 1917, increased Allied dependence on U.S. arms. It also engendered pressure on Pershing to condone "amalgamation" of American troops by small units into European armies. The Allies wanted replacements for their depleted formations to resist expected attacks. Pershing adamantly opposed amalgamation and received support from his government, although he temporarily released his troops to the interallied commander, Ferdinand Foch, during the German offensives of March–June 1918. Pershing also opposed proposals to divert some U.S. troops to secondary theatres. The Supreme War Council, an interallied institution established to coordinate the political-military strategy of the Allies, continually recommended amalgamation and diversionary operations elsewhere than in France, but Pershing remained unmoved. These pressures subsided when the Allies assumed the offensive during the summer.

Pershing's army never became self-sufficient, but it conducted two significant operations. In September 1918 the U.S. forces as-

saulted the Saint-Mihiel salient successfully. Then, at Foch's request, Pershing quickly regrouped his forces for the Meuse-Argonne offensive, although he had originally planned an advance toward Metz. Incomplete preparations and inexperience slowed the Meuse-Argonne operations, but the interallied offensive in France destroyed German resistance and precipitated the Armistice of November. Pershing made some operational and logistical errors, but the creation of the AEF was a remarkable achievement.

Pershing returned to the United States with a great reputation and in 1919 received the rank of general of the armies, a title created in 1799 for George Washington but never held by him. Pershing's stern bearing and rigid discipline earned him the nickname "Black Jack." His determination and dedication gained him respect and admiration if not affection. Eschewing politics, Pershing remained in the Army and was appointed chief of staff, July 1, 1921. He held that post until his retirement in 1924. In 1931 he published a two-volume memoir, *My Experiences in the World War*. Pershing died on July 15, 1948, and was buried in Arlington National Cemetery. (D. F. Tr.)

PERSIA, the name used for centuries, mostly in European and other Western countries, for the kingdom of Iran in southwest Asia. It originates from a geographical region in southern Iran, adjoining the Persian Gulf, formerly known as Persis (*q.v.*) (Pars, Parsa; modern Fars). It was during the rule of the Persian Achaemenid dynasty that the ancient Greeks first came into contact with the inhabitants of Pars on the Iranian plateau. The name was gradually extended beyond the province of Pars to the entire kingdom which became known as the Persian Empire. Throughout their history the people of Iran have never used the name "Persia" for their homeland. They have always called it "Iran" (the land of the Aryans).

On March 21, 1935, the government of Iran officially requested other governments to adopt and use the name "Iran" instead of "Persia." However, as the name "Persia" was widely used by historians outside Iran and the country was better known under that name, in October 1949 the government of Iran announced that it would no longer insist on the use of "Iran" instead of "Persia."

For the ethnography of ancient Iran and an account of Persian history *see* Persian History. The geography, people, archaeology, administration, social conditions, and economy of the modern state are treated under Iran. (M. H. Ga.)

PERSIAN ART. Pictorial art flourished in Persia before Islam, for although no traces of frescoes or illuminations have come down to posterity from the Sasanian period (*c.* A.D. 224–651), it is known from other evidence that that great age of Iranian culture included painting among its many creative activities. Ernst Herzfeld traced to Sasanian models the motifs (dancing girls, huntresses, animal figures, floral decorations of various kinds) of the fragments of ornamental wall paintings which came to light in the course of excavations made at the caliph's palace at Samarra (9th century). At about the same time illumination must have come into favour at Baghdad, probably through the Manichees. Some knowledge of their book painting was gained through the discoveries made by Sir A. Stein and by the German expeditions to Turfan.

PAINTING AND CALLIGRAPHY

The Persian contribution to painting and calligraphy began in the Muslim era, and the form in which it first appeared was that of book production. The share of Persia in the development of this art in the Islamic countries dates from before the beginning of the Abbasid period (750). Toward the end of the 7th century in the two oldest centres of culture in Iraq—Basra and Kufa—beautiful Koran manuscripts in Kufic executed on parchment were common, though at first they had no extraneous decoration, but produced their effect solely by the heavy lapidary style of the archaic character. In the 8th and 9th centuries this branch of Islamic art reached its first period of splendour under the powerful stimulus imparted by the caliphs of Baghdad; and the masters of the Kufic who flourished at that time (*c.* 800) include not only a number of Arabs, but also the Persian Khoshnam of Basra. More important, however, was the part played by calligraphers of Iranian origin in the development of the various forms of the *naskhi*, the round correspondence character, which early began to take a dominant place beside the vertical script. The inventor of the decorative *thuluth*, which derived from this, is said to have been Ibrahim Segzi of Sijistan, and his pupil Ustad Ahwal Segzi has the reputation of having been the first, under the caliph al-Ma'mun, to elaborate and discuss rules of calligraphy. He in turn was the teacher of the celebrated Ibn Muqla, who brought the *naskhi* into general use in place of the Kufic and is regarded as the greatest authority on all the principles of the art. Ibn Muqla's school produced, among other famous pupils, Ibn al-Bawwab, Hasan al-Sirafi (d. 979), who was of Mazdaic origin, and the Buyid prince Fana-Khusru (d. 982), reputed to be a descendant of the Sasanian kings.

The Baghdad School.—The first extant works of the Baghdad school of painting date only from the 12th century, when the Seljuk period had already begun, but in their content and their artistic tendencies they go back unmistakably to older traditions, and continue with little change until the middle of the 13th century. They include scientific treatises (by Dioscorides, Galen and others) translated from the Greek by Nestorian scholars or based on ancient models, with explanatory illustrations; Arabic versions of the Bidpai fables (*Kalila* va Dimna) *wa-Dimna* which were imported from India; and the anecdotes of al-Hariri, then in great favour, in which the bold jests and witty conceits of Abu Sa'id of Serruj were illustrated. These three types of text were all equally well adapted to direct the artist to the study of nature and to emphasize the importance of problems of composition and colour, and the works of this school are veritably astonishing in their wealth of colour shading and their forcible depiction of their subjects. To what extent Persian masters are represented is not exactly known; but the circumstance that the *minai* pottery of Ray (Rhages) (*c.* 1200) borrowed the Baghdad style of painting suggests that the whole tendency had already spread from Mesopotamia to centres in Iran.

As early as about the 10th century, paper had supplanted parchment, not only in secular works but also in copies of the Koran and other religious texts, its manufacture having gradually spread from Samarkand to all the countries of Islam. Ornamental decoration of manuscripts, from which for religious reasons figures were excluded, also made continual strides, and soon the craft of the illuminators and gilders began to break away from that of the calligraphers and painters and to develop on its own lines. Kufic was now no longer used except in chapter headings and title pages; elsewhere the script employed was either one of the many variants of *naskhi*, or a decorative script representing a more graceful and stylistic development of the vertical character.

The Il-khan Period.—The Mongol invasion in the 13th century proved unexpectedly fortunate for the art of book production in western Asia. Hulagu and his successors not only took pains to promote it in every possible way, but also brought it into contact with the highly developed painting of the far east, and directed it toward new subjects, with the important effect of immensely enlarging the painters' outlook. The main tendency was now to the pictorial representation of historic events and legendary episodes, in world histories conceived on a large scale like Rashid al-din Fadlullah's and the principal result of acquaintance with the works of the Chinese masters of the Sung period was to enhance the feeling for landscape. In manuscripts of the early 14th century the strong foreign stimuli are seen combining with older traditions, and in course of time there developed a new Persian-Mongol style of painting which reached a high standard in the two capitals of the Il-khans, Baghdad and Tabriz. The profane texts were now no longer in Arabic, but generally in Persian, and the whole art of miniature painting was soon iranized when the great national epic of Firdausi and other poems, such as those of Nizami and Khwadju Kirmani, became increasingly common in illustrated and often sumptuous copies. New and effective uses were found for devices of composition, and, moreover, the arrangement of the verses in vertical columns, which could be broken up wherever desired, made possible a much more intimate and aesthetically satisfying conjunction of picture and text than had been known previously. Heroic

scenes from the *Shah-Nama*, sentimental themes from *Khosrau and Shirin, Laila and Majnun*, etc., were then for the first time expressed in characteristic forms.

Of Arabic texts there were at this period mainly the cosmography of Qazwini and a few astronomical treatises, which seem to have been produced with loving care in western Turkistan. To the Baghdad school of calligraphy belongs the credit of developing, about 1300, the lapidary style of the Kufic Korans into the round writing, and bringing this to the ripest degree of ornamental beauty in majestic variants. In the production of the magnificent Korans of the age of the Il-khans, with their large size and their few and incomparably imposing lines of script in black and gold, Persian masters were primarily concerned; and they carried to Tabriz and Samarkand the new principles for the decoration of the holy book, especially the rich arabesque illumination.

The Timurid Schools.—When Timur altered the whole political complexion of western Asia, a highly productive centre arose at his capital of Samarkand. His chief secretary, Amir Mohammed Badr ud-din, gained a reputation as a master of all forms of writing, and two of the great emperor's grandsons, Ibrahim Mirza and Baisonqur Mirza, were famous calligraphers. At Timur's court there came into favour, through the stimulus of far eastern models, the separate sheet bearing a light ink sketch, sometimes with some touches in gold and colour, to be pasted on cardboard and collected in albums. The traditional miniature illustration in body colour found in this period a new and prosperous evolution in the schools of Herat and Shiraz.

Baisonqur Mirza, who unfortunately met with an early death in 1434, earned much honour by founding at Herat an academy in connection with his library; for years it employed 40 calligraphers, besides numerous illuminators and painters. In this academy the Persian texts were no longer written in *naskhi*, but in *nastaliq*, an offshoot of the old cursive character, invented by the celebrated Mir Ali of Tabriz. All the 40 masters of Herat were directly or indirectly his pupils, and toward the end of the century the style of calligraphy invented by him found its most splendid representative in Sultan Ali of Meshed (d. 1513), the protégé of the famous poet and minister Mir Ali Shir Newai and friend of the great poet, Jami.

The preference that painters displayed for subjects drawn from the national literature, and the enthusiasm with which they steeped themselves in the magic of their native countryside, give to Persian painting of this period a romantic note which often chimes with the atmospheres found in contemporary western Gothic. In the east, however, the purely decorative and impersonal character of the pictures continued, and Shiraz rivaled with Herat in the same line, but using a colour scheme of its own.

It was at this time that the harmony between picture and text reached the highest imaginable degree of perfection, and the leaves of the extant manuscripts are astonishing in the skill with which the painters fitted their subjects into spaces allotted to them quite arbitrarily by the calligraphers. Meanwhile at the beginning of the 14th century the backgrounds were still carefully coloured red or yellow; subsequently a rich blue became general, and it was not until the end of the period that a gold background came into favour. The incidental landscape is generally of a steppelike character; jagged rocks, isolated trees, and little brooks rippling among stones and bordered by growing flowers, are the essential features of almost all open-air scenes, and only occasionally is the mysterious atmosphere of the forest or the luxuriance of a flower garden depicted. The highly effective motif of a tree in blossom, which is often used in smaller pictures, is obviously taken from Chinese models of the Ming period. Under the Timurids direct contact with the far east became increasingly frequent.

Behzad of Herat.—An undeniable weakness of Timurid painting lies in the diagrammatical conventionalizing of the figures, the spiritless treatment of the heads, and the absence of expression in the movements. In this respect no progress can be seen throughout the whole development of the art, which in other directions is so astonishing; and the appearance of a completely revolutionary personality was needed before a change could be brought about and new paths indicated. This personality was found in the genius Behzad of Herat, who is rightly honoured as the greatest master of Persian painting. Behzad understood how, even in his most populous compositions, to differentiate every single figure in countenance and bearing; his palette was extraordinarily rich, especially in warm, full tones, and this enabled him to individualize his portraits by the employment of numerous colour nuances for costumes and even for flesh. He was also a reformer in the treatment of landscape, which appears more naturalistic in his pages than in those of his forerunners, and in the choice of subject a markedly realistic note is likewise seen. Moreover, it was he who revolted against the dictation of the calligraphers, and admitted no text at all, or only a few lines of verse in one corner, in the pages he illustrated; even a number of double-page miniatures by his masterly hand can be seen.

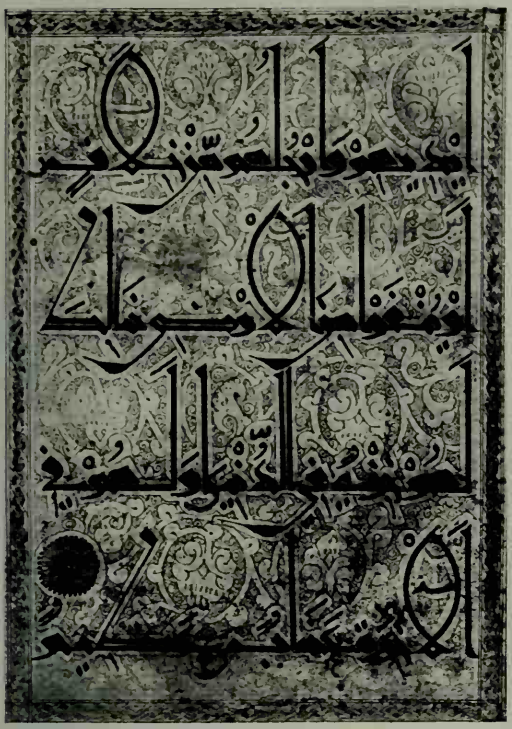
Behzad, who was born before 1450 and died after 1520, represents the zenith of the Timurid and the opening of the Safavid period in Persian painting. He was head of the Herat academy until 1506, when Shah Ismail took him to Tabriz, made him his chief librarian, and covered him with honours. Only a few extant works are indisputably by his hand. Both in Herat and in Tabriz he had many pupils, who carried his style far and wide in Persia, western Turkestan and India; and even in the 16th century his name was already so famous that his art was imitated on every side, while later on pages of the most various origins were furnished with his signature to enhance their value.

The Tabriz School.—The next generation of painters in Tabriz is dominated by the highly gifted Sultan Mohammed, who exercised a commanding influence in the whole field of art at the court of Shah Tahmasp. In collaboration with other masters he illustrated de luxe editions of the Persian epics, several of which have come down to posterity; but for the most part he preferred genre subjects and portraits, which were produced as single sheets and were designed to be bound in volumes together with specimens of the handwriting of famous calligraphers. He opened new fields of activity to the painters by bringing lacquer bindings into fashion, and also by inducing them to design patterns for textiles and knotted carpets to be made at the royal factories. Some of the studies for the celebrated hunting and animal rugs of the 16th century were made in his studio, as were also a few velvets and silk brocades with figure subjects.

From the end of the 15th century an immense impetus had been given to Koran decoration at Tabriz. It was here that the picturesque division of the title pages into star- or medallion-shaped fields and borders with a reciprocal pattern or a cartouche design was devised, and this again brought about a revolution in the style of Persian carpetmaking. The ornament grew richer and more complicated; to the arabesque were added slender floral twines in a profusion of lines, palmettes, rosettes and cloud patterns.

In Behzad's time Shah Mahmud of Nishapur came to eminence as a master of the *taliq* script and later Mir Ali of Tabriz, "the royal scribe" (d. 1559). Many other calligraphers and illuminators heard the call of the Ottoman rulers and founded a school of book decoration at Constantinople, which adhered closely to the tradition of Tabriz; they were accompanied by painters like Shah Quli and Wali Jan.

The Isfahan School.—Late in the 16th century, when all the artistic forces of Persia were once more being concentrated at the new capital, Isfahan, under the powerful impulse communicated by Shah Abbas the Great, there arose also in Isfahan a new and important centre for the art of book production in all its various forms. Mir Imad al-Husni (d. 1618) and Riza 'Abbasi competed in calligraphy for the royal favour, while others sought to attract attention by animal figures ingeniously constructed out of pious mottoes and similar jests, or by a perfect mastery of the *shikasta*, a complicated script so full of flourishes as to verge on illegibility. In painting there is a link with the schools of Herat and Tabriz in the person of Ustad Mohammedi, who was undoubtedly the first to put his observations of nature on to paper in the purest ink-wash technique without any reference to a text. His successor as head of the painters' guild at Isfahan was Riza 'Abbasi, whose signature, genuine or doubtful, is frequently met with; it is still not



Leaf of a Koran in ornamental Kufic; 11th century

Painting showing the building of a mosque. By Behzād of Herat; end of the 15th century. Walters Art gallery, Baltimore, Md.

Painting of rural life. By Mir Seyid Ali; 16th century. Fogg museum, Cambridge, Mass.

Humay and Humeyan in the imperial garden at Peking. Herat school; about 1450

EXAMPLES OF PERSIAN ART, 11TH TO 16TH CENTURIES

BY COURTESY OF (TOP LEFT) EHEMALS STAATLICHE MUSEEN BERLIN, ISLAMISCHE ABTEILUNG, (BOTTOM LEFT) FOGG ART MUSEUM, HARVARD UNIVERSITY, (FORMER LOUIS CARTIER COLLECTION) PHOTOGRAPHS, (TOP RIGHT, BOTTOM RIGHT) F. BRUCKMANN

PERSIAN ART

Portrait of a young man. By Rizā Abbāsi, Isfahan; late 16th century

Gazelles, from a bestiary dated 1298

Scene from a Shahnameh manuscript, Tabriz; c. 1330–40

Bahram Gur hunting. From a Persian anthology made for the Library of Baisonqur; dated 1420

Calligraphy in nastaliq. By Imad al-Husni; 16th century

EXAMPLES OF PERSIAN ART, 13TH TO 16TH CENTURIES

BY COURTESY OF (TOP LEFT, BOTTOM LEFT) THE ISLAMISCHES MUSEUM, BERLIN, (TOP RIGHT) PIERPONT MORGAN LIBRARY, N.Y.; PHOTOGRAPH, (CENTRE) A. C. COOPER LTD.

established beyond dispute whether this artist is identical with Aga Riza, who is thought to be of an older generation. Be that as it may, it was he who filled the albums of Persian and Indian collectors with his gay, sure-handed colour sketches and drawings in red chalk on the most everyday subjects, and with carefully executed pages in rich colour; and he ultimately became so much admired as almost to overshadow, for a time, the fame of Behzad. He likewise gave a new impulse to the illustration of manuscripts, and his elegant, fashionable style gained him a great influence in the other decorative arts also; wall paintings, figural tiles and lacquered doors in the garden palaces of Isfahan clearly show the mark of his atelier. Riza's best pupil, and his bosom friend, was Mu'in, one of whose extant works is a portrait of his master. The style created by the latter was still a living force at the end of the 17th century, when Shah Abbas II's effort for an assimilation to European painting had already failed, as is shown by the fact that of the young artists he sent to Rome only Mohammed Zaman gained some reputation.

In the 18th century European paintings and engravings were slavishly copied, and Nadir Shah's expeditions to India introduced transitory influences of the Mogul school. At the beginning of the 19th century an enormous impetus was given to lacquer painting, though only as an ordinary bazaar industry, and decoration also took the form of large canvases. Since the end of the 19th century the growing interest for Persian miniatures has called into existence a considerable number of workshops for the production of fakes, where single pages and even complete manuscripts are concocted in the style of any old master or period. This somewhat questionable development has at least the advantage of maintaining some contact with the masterpieces of the past. (E. K.)

ARCHITECTURE, CERAMICS, TEXTILES, METALWORK

As with painting and calligraphy, a certain strain of decorative skill dating from the Islamic conquest permeates all other forms of Islamic art generally known as Persian, but pre-Islamic influences are not absent, and such Sasanian motives as twinned animals facing each other appear constantly.

Architecture.—In architecture, the love of barrel-vaulted porches can be traced directly to Sasanian palaces and were the chief motives of the great mosques where they were flanked by twin minarets in the design of which appears that emphasis on height which is universally Persian. A second characteristic was the use of a dome with two shells, the outer onion-shaped and supported on a high drum, and the swelling slight in early examples but more pronounced later. Daring ingenuity of construction marks all these vaults and domes. The stalactite (*see* STALACTITE WORK) corbels, elaborate intersections of curved surfaces, delicate groined lines and scalloped forms display great skill and differ widely from similar Islamic buildings elsewhere.

The progress of architecture from the Seljuk domination continues to a rich climax in the 16th and 17th centuries.

During the 18th century there developed rich and delicate wooden construction including slim columns, intricate cornices treated with lavish carving and inlays used frequently in the exquisite formal gardens so important to Persian life. The Muslim love of surface ornament led to dominance of plane surfaces covered with tiles so that walls, vaults, domes and minarets glowed with blue-greens and turquoise, rose and yellow. In no other style has applied colour become such an integral part of architectural design. (*See* ISLAMIC ARCHITECTURE; TILE.)

Ceramics.—Springing from the most ancient Mesopotamian development of pottery Persian ceramics developed in about the 13th century into one of the most exquisite of all arts. The pottery body was coarse because of the available clay but the glazes were developed to a high degree of perfection and the coloration, especially the blues ranging from turquoise to cobalt, became world famous. Sasanian, Parthian and Byzantine influences lent vigour and charm. By the 14th century floral ornament became more important and the designs were freer and less formal. Vases were decorated in low relief and covered with monochrome blue glaze. During the 16th century the Chinese influence made itself felt and became strong in the 17th century not only in design but in methods of manufacture and at the same time Persian influences were felt in China. Tiles were of course an important phase of the ceramic industry. (*See* POTTERY AND PORCELAIN: *Islamic Pottery;* MOSAIC.)

Textiles.—Church treasuries throughout Europe reserve textiles that are obviously of Asiatic origin showing the same Sasanian and Byzantine influences felt in Persian ceramics. Lions, eagles and imaginary beasts enclosed in geometric patterns form the decoration on a material of woven silk and sometimes gold and silver. Prior to the 13th century these textiles came from different parts of the Islamic world but later from Turkey and Persia, the Turkish development appearing in conventionalized ornament and the Persian from the 18th century onward showing greater complexity in formality and realism, and influenced eventually by Chinese elements as a result of the Mongol domination.

Rugs are the most important of Persian textiles, the best of them, which date from the 16th and 17th centuries, displaying amazing delicacy in technique and great decorative skill in design with rich soft colours marvelously adapted to the texture. (*See* EMBROIDERY; TEXTILES; RUG AND CARPET; BROCADE.)

Metalwork.—The Persians were aesthetic craftsmen in metal and their delicate inlaying of silver and gold into copper and steel of intricate geometric and naturalistic ornament shows decorative genius and the greatest of technical facility. The motives in this work were similar to those used in ceramics and textiles.

A rinceau or branching scroll ornamented with sharp pointed spearlike leaves was widely used. Much of this artistry was employed, of course, in the decoration of arms and armour and although there is a definite resemblance between the work of Turkey and Persia, the Persian far surpasses with its richness and delicacy. *See* IRAN: *Archaeology;* METALWORK, DECORATIVE; SILVER AND GOLD WORK; *see* also references under "Persian Art" in the Index. (T. F. H.; X.)

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PERSIAN GULF extends southeastward for about 500 mi. (805 km.) from the mouth of the Shatt al Arab to the Musandam peninsula and varies in width from 140 mi. (225 km.) at the head to 220 mi. (354 km.) at its widest part. However, "the Gulf" is a term frequently used to refer not only to the Persian Gulf proper but also to its outlets, the 50-mi. (80 km.) wide Strait of Hormuz and the Gulf of Oman, which opens into the Arabian Sea. In the Persian Gulf the depth of water rarely exceeds 50 fathoms and increases more rapidly from the Iranian than from the Arabian shore. Off the Arabian coast there are large areas of water less than 20 fathoms deep where valuable pearl banks occur.

There are nine political units with shorelines on the gulf. Iran occupies the entire northeastern shore and the head east of the Shatt al Arab. Iraq has a 40-mi. (64 km.) wide frontage west of that river. The Arabian side is divided among Kuwait (Al Kuwayt), the Neutral Zone, the kingdom of Saudi Arabia, the sheikhdom of Bahrain, the sheikhdom of Qatar, the seven sheikhdoms of Trucial Oman, and the Sultanate of Muscat and Oman.

PHYSICAL GEOGRAPHY

Coasts.—The coasts of the Persian Gulf have a total length of nearly 2,000 mi. (3,219 km.) and there are important contrasts between the Iranian and Arabian sides. On the Iranian side, moun-

TOPOGRAPHY OF THE COUNTRIES SURROUNDING THE PERSIAN GULF. DERRICKS INDICATE MAJOR OIL-PRODUCING AREAS

tain ranges which make up the edge of the Iranian plateau run parallel to and at no great distance from the shore so that the land rises abruptly from a narrow coastal plain. On the Arabian side, the rise is much more gentle and there are broad lowlands between the Gulf and the interior plateau.

The Iranian coast extends southwestward from the Strait of Hormuz to Lengeh, cutting across the southeastern ends of a number of parallel mountain chains. The large island of Qeshm (Qishm), 67 mi. (108 km.) long, is separated from the mainland by the Clarence Strait (Khuran). The mainland coast is an alternation of cliffs and alluvial lowlands. The latter represent the deltas of small rivers descending from the mountains and contain mangrove swamps. Beyond Lengeh the coast turns northwestward parallel to the mountain ranges. The coastal plain is narrow except where valleys open out into areas of swamp, marsh, and mud flat. North of Bushire (Bushehr) the plain is much wider and the coasts low and sandy.

The head of the Gulf is a deltaic area fed by the only major rivers which flow into it. The Shatt al Arab (the lower course of the combined Tigris and Euphrates), together with the much smaller Karun and Jarrahi rivers, bring down large quantities of silt and extend the land steadily seaward. Thus a zone of swamps, up to 40 mi. (64 km.) wide, characterizes this stretch of coast.

The whole of the Arabian shore is desert, the only water being provided by springs. The desert is stony in the northwest but predominantly sandy in the southeast. Numerous small shifting creeks occur and there are stretches of mangrove swamp and salt marsh, the latter most widespread along the Trucial Coast. Coral reefs lie offshore and there are many small islands. The northern part of the Musandam Peninsula is precipitous and rocky.

Geology.—Structurally the Persian Gulf is a continuation of the Tigris-Euphrates trough, the whole forming a median zone between the fold mountains of southern Iran (the Zagros Mountains) and the stable continental block of the Arabian foreland. Minor folds within this median zone have little effect on surface relief with the exception of the Musandam Peninsula and the southern side of the Gulf of Oman. There, an upfold of Jurassic and Cretaceous rocks, with an igneous core, forms the Jabal al Akhdar, a much-dissected plateau with peaks rising to nearly 10,000 ft. (3,048 m.). This area is a product of mid-Cretaceous earth movement and formed a northward-projecting buttress against the Pliocene folding of the Zagros system. This arrangement accounts for the bowlike, curved form of the Iranian folds on either side of Bandar Abbas and for the narrowness of the Strait of Hormuz. The remainder of the median zone, from the strait to northern Iraq, is deeply infilled with sedimentary materials. Miocene, Pliocene, and Quaternary rocks, for the most part little disturbed, outcrop over wide areas in Mesopotamia and are continuous along most of the Gulf coast. The surface outcrops along the shores are a variety of sandstones, marls, limestones, and gypsum, with occasional exposures of Eocene and Upper Cretaceous limestones. The latter occur in elongated dome structures which form the Qatar Peninsula and the island of Bahrain. The numerous islands of the eastern half of the gulf are developed on intrusive salt plugs. On the Iranian mainland there are many of these features, which in some cases form great salt mountains rising to nearly 4,000 ft. (1,219 m.) above the surrounding plain; *e.g.*, near Borazjan. The salt masses are 4–6 mi. (6.4–9.7 km.) wide and appear as intrusions.

The oil resources of the area occur in the sedimentary rocks of the median zone. Those of southwestern Iran are found in Tertiary rocks which have been strongly folded. The oil fields of southern Iraq and of Arabia, in contrast, are a good deal older geologically, occurring in rocks of Jurassic and Cretaceous age. These lie at considerable depth beneath Tertiary deposits. Folding has been very restricted because of the protective presence of the rigid Arabian foreland so that the structures are broad, gentle anticlines. As a result, surface relief offers no guide to the distribution of oil pockets, a fact which has added to the difficulties of prospecting in the area. Other minerals of less importance are associated with the sedimentary rocks. Gypsum and salt are the most widespread and large quantities of the latter are now exported from the islands. In Oman some poor coal has been found and there is copper in the interior, but neither of these can be considered a major resource.

Climate.—The climate is characterized by high temperatures and low precipitation. In the winter months mean temperatures increase from west to east; in the summer the reverse is the case so that the annual temperature range is somewhat greater at the head of the Gulf than at its outlet. Temperatures below freezing have been recorded on a few occasions at the head of the Gulf in January, and readings above 38° C (100° F) are common throughout the area in summer.

Rainfall is appreciably higher on the Iranian coast than on the Arabian side, mean annual amounts being: Khorramshahr 8.4 in. (213 mm.), Kuwait 4.9 in. (124 mm.), Bushire 10.8 in. (274 mm.), Bahrain 3.2 in. (81 mm.), Jask 4.7 in. (119 mm.). In the Jabal al Akhdar the annual total rises above 20 in. (508 mm.). Throughout the area, most of the rain comes in the winter months in the form of heavy showers. The average number of days of rain varies from 27 at Khorramshahr to 7 along the Arabian shore. Relative humidity is high; values over 80% are common. The prevailing wind is the northwesterly shamal. This occurs as squalls of short duration in the winter but blows regularly in summer and may rise to gale force for several days. The southeasterly *qaus* and the southwesterly *suhaili* are less common but more dangerous, since they blow directly into otherwise sheltered anchorages. In the Gulf of Oman easterly winds are more frequent than in the Persian Gulf and predominate in the summer months. Land and sea breezes are important along these coasts, particularly in spring and autumn when there is a large diurnal temperature range.

Vegetation and Land Use.—Throughout the islands and coastal fringes of the Gulf natural vegetation is sparse. True desert is confined to the Arabian side: the Iranian shores may be classified as semidesert steppe, but over the whole region cultivation is limited to areas where irrigation water is available. Because of its higher rainfall and the rivers descending from the Zagros, the Iranian side is slightly more favoured and numerous agricultural districts exist there; one of the largest is around Bandar Abbas. Along the Arabian coast there are places at which freshwater springs, probably fed from the western highlands of Arabia, emerge and support oases of cultivation. The most productive of these occurs around the periphery of Bahrain Island, much of which is covered with date groves and smaller patches of citrus fruits, cereals, and fodder crops. Similar cultivation on a smaller scale occurs from the coast opposite Bahrain inland to Al Hufuf, around the fringes of the Qatar peninsula and around Sharjah on the Trucial coast. In Kuwait dates, vegetables, and cereals are produced, but the water supply is very limited. A special case is provided by the northern coast of Muscat, where streams and springs from the Jabal al Akhdar provide irrigation water for

a considerable area on the lower slopes. The crops include millet, wheat, barley, fruit, and coffee. Over most of the Arabian coastlands, however, cultivation is impossible and the area is one of pastoral nomadism. Camels are bred extensively, particularly in Oman, and flocks of sheep and goats are kept.

Fish.—About 200 varieties of fish are known, including the seer, mullet, sea bass, members of the horse mackerel family, the Indian shad, several species of sea perch and sea bream, and varieties of the sardine. Sharks, rays, porpoises, and swordfish are common and the narwhal is sometimes seen. The edible fish are mostly caught by trap or stake net and dried fish is an important element in the diet of some areas.

THE ECONOMY

Pearling.—The Great Pearl bank is in the waters of the bight between Sharjah and the north of the Qatar peninsula and south of a line from this point to the island of Abu 'Ali off the Saudi Arabian coast. Small quantities of pearls are also found off the Iranian coast. Although the industry has declined greatly since the introduction of the cultured pearl, it is still of some importance, the pearling fleet being based mainly on the Trucial Coast.

Oil.—The economy of the area has been completely transformed by the discovery and exploitation of oil. This applies particularly to the states on the Arabian side of the Gulf, where oil is the major source of revenue. The Khuzistan fields of southwest Iran, together with those of southern Iraq, may be considered as part of the Persian Gulf oil area. The former occupy a belt along the southwestern flank of the Zagros mountain ranges and are six in number: Lali, Masjed Soleyman, Naft-e Safid, Haft Gel, Agha Jari (Aqa Jari), and Gach Saran. There is also a gas field at Pazanan. The Masjed Soleyman field was opened in 1908 and the remainder at various dates between 1928 and 1938. The six fields together account for about 95% of the total Iranian production. The fields of southern Iraq, in contrast to those in the interior of the country, were discovered later, that at Az Zubayr having been opened in 1949 and that at Rumaylah (Rumaila) in 1953. These two fields, to the southwest of Basra, rapidly increased their production, and in 1960 accounted for about half the Iraqi production. The Iranian and southern Iraqi oil fields were connected by pipeline to the Abadan refinery and to the new oil terminal at Al Faw respectively. Iranian oil is also shipped from Bandar-e Ma'shur and from the new refinery on Khark Island.

Although oil was discovered at a number of points along the Arabian coast in the 1930s, the only field developed on any scale before World War II was that on Bahrain Island. In the postwar period, however, many important discoveries were made and production increased very rapidly. Exploration, including that of submarine resources, continues and output is likely to rise still further. Within the present zone of oil production, stretching about 700 mi. from Kuwait to Trucial Oman, there are about 12 main producing districts.

In Kuwait oil was first discovered in the Al Burqan district in the late 1930s but it was not until after 1945 that the vast potential of this small state was fully recognized. Al Burqan, together with the adjacent Ahmadi field and the Raudhatain field near the Iraq frontier, were connected by pipeline to the refinery and terminal at Mina' al Ahmadi. Kuwait's total output of crude oil in 1963 was 97,197,000 metric tons (709,538,000 bbl.), making that country the world's fourth producer after the United States, Venezuela, and the U.S.S.R. The Wafrah field, in the Neutral Zone, was opened in 1953 and in 1963 produced 16,441,000 metric tons (120,019,300 bbl.). Oil from this source was pumped to the refinery at Mina' Su'ud (Sa'ud), on the zonal coast, and to Mina' 'Abd Allah (-al-Abdullah) in Kuwait.

The Gulf coast of Saudi Arabia contains a number of fields, of which the Al Qarah field is the most important. Strikes made at 'Ayn Dar and Harad in 1948 and at Shadqam and 'Uthmaniyah in 1951 proved to be on a single field covering an area of about 2,000 sq.mi. (5,180 sq.km.). Earlier areas of production are Ad Dammam (opened in 1936), Buqayq (Abqaiq) (1941), and Al Qatif (1945), and later developments took place farther north at Saffaniyah (1951) and Abu Hadriyah-Fadili-Kharsaniya (1956–57). The various fields were linked to refineries and terminals at Ras Tanura (Ra's at Tannurah) and Bahrain. In order to obviate the long sea passage around the Arabian peninsula and through the Suez Canal, Tapline (Trans-Arabian pipeline) was completed in 1950; it linked the Saudi Arabian fields to Sidon on the Lebanese Mediterranean coast. Total production from the Saudi Arabian fields in 1963 was 81,142,000 metric tons (592,336,600 bbl.).

The Bahrain field began production in 1932 and output doubled after World War II. However, reserves there are limited, and production was not expected to rise much above the 1963 level of 2,236,000 metric tons (16,322,800 bbl.). The refinery and terminal on the island handle the entire output.

Qatar contains the large Dukhan field on the west coast, from which crude oil is piped across the peninsula to the Musay'id terminal. The field was opened in 1940 and produced 9,096,000 metric tons (66,440,800 bbl.) in 1963. Production from the Murban field on the Abu Dhabi (Trucial Oman) coast began in 1963, a year after the opening of the large offshore Umm Shaif field. Production from these two sources in 1963 totaled 2,342,000 metric tons (17,096,600 bbl.). The development at Umm Shaif illustrated both the rapidity with which new reserves were being discovered and exploited, and the increasing attention being paid to the underwater fields of the Gulf.

Total output from the Persian Gulf fields, excluding Iran and Iraq, rose from 1,100,000 metric tons (8,030,000 bbl.) in 1938 to 208,454,000 metric tons (1,521,714,200 bbl.) in 1963. The latter figure was somewhat above those of Venezuela (170,000,000 metric tons; 1,241,000,000 bbl.) and the U.S.S.R. (200,000,000 metric tons; 1,460,000,000 bbl.) for the same year and was exceeded only by that of the United States (410,000,000 metric tons; 2,993,000,000 bbl.). Iran as a whole (72,825,000 metric tons; 531,622,500 bbl.) is the world's sixth largest producer, and Iraq (56,669,000 metric tons; 413,683,700 bbl.) the seventh.

Until 1950 control of the oil fields was completely in the hands of European (predominantly British) and U.S. concerns, subject only to royalty agreements with the local authorities. The Iranian fields were run by the Anglo-Iranian Oil Co., and those of Iraq were controlled by the Iraq Petroleum Co. Ltd., a joint British-Dutch-U.S.-French concern. The Kuwait Oil Co. Ltd. was owned jointly by British Petroleum and the U.S. Gulf Oil Corp. In Saudi Arabia the concession was held by Aramco (Arabian American Oil Co.), a consortium of four major U.S. concerns. The American Independent Oil Co. and the Getty Oil Co. (U.S.) held jointly operated concessions in Kuwait, Saudi Arabia, and the Neutral Zone. The Bahrain Petroleum Co. Ltd. was a joint subsidiary of two U.S. concerns and the Qatar field was run by the Iraq Petroleum Co. This situation marked a considerable increase in U.S. interest in the area compared with prewar years.

After 1950 a number of important developments occurred. First, the concessionaires relinquished control of parts of their holdings to the local states. In 1951 the Anglo-Iranian Oil Co. was taken over by the Iranian government and in 1954 agreement was reached between the National Iranian Oil Co. (N.I.O.C.) and a consortium of British, Dutch, French, and U.S. operators whereby the concessions were the property of the N.I.O.C. and profits were divided equally between the national company and the foreign operators. In 1962 the Kuwait Oil Co. Ltd. relinquished to the state of Kuwait its rights over about three-fifths of the territory. Although the area given up contained no proven reserves, it might well eventually become productive.

A second development was the entry into the area of capital from new sources. This trend is represented by Japan's Arabian Oil Co. Ltd., which in the 1960s held the concession for the offshore area of the Neutral Zone. Production on a significant scale began in 1961, the crude oil being shipped to Japan.

The sudden influx of wealth into the area has had a tremendous effect on its economy, particularly in the case of the states of the Arabian peninsula, whose national incomes previously were negligible. That of Saudi Arabia in 1930, for example, was £150,000. In 1960 oil royalties alone amounted to £100,000,000. Much of this wealth, the actual proportion varying greatly from one country to another according to government policies, has gone into economic

development of many kinds. Large numbers of formerly semi-nomadic people have settled down to regular paid employment. The political implications have been numerous. Apart from the increased significance attached to the area by the great powers, increased wealth has enabled the states to adopt a more independent policy. At the same time dissension among them has been increased by their division into oil-rich and oil-poor groups. Since the Middle East as a whole is reputed to contain between 50% and 75% of world petroleum reserves, the significance of the Persian Gulf states is likely to increase still further.

Ports.—No part of the Gulf coast is particularly favourable for port development. Natural harbours are rather more common on the Iranian side, but even they have little shelter from the prevailing wind. Bandar Abbas, on the Strait of Hormuz, and Bushire are connected by road to the interior. Bandar-e Shahpur, however, is the chief port of Iran. Standing at the head of the Gulf, it is connected to the Iranian rail system. Abadan, 40 mi. up the Shatt al Arab, is of more recent origin and owes its existence to the oil traffic. Apart from the oil terminal at Al Faw on the coast, the only other Iraqi port is Basra, on the inland side of the marsh zone.

On the Arabian side ports are of two kinds: the older are small centres of trade, fishing, and pearling; the newer are large oil terminals constructed at points suitable for tanker access. In the first category are Al Manamah (Manama) in Bahrain, Ad Dawhah (Dohah) in Qatar, Dhahran (Az Zahran) and Ad Dammam in Saudi Arabia, and Ash Shariqah (Sharjah) and Dubai (Dubayy) on the Trucial Coast. The new oil terminals are at Mina' al Ahmadi and Mina' 'Abd Allah in Kuwait, Mina' Su'ud in the Neutral Zone, Ras Tanura in Saudi Arabia, Bahrain, and Musay'id in Qatar.

(J. C. De.)

HISTORY

The continuing theme of Persian Gulf history has been its evolution as an area linking East and West, starting from the time when the Sumerians pioneered navigation from Eridu (*q.v.*), then on the sea. About 700 B.C. the Babylonians were trading with India, but history is largely conjectural until the time of Alexander the Great (d. 323 B.C.). Most of it then derives from classical writers. Gerrha (modern Al 'Uqayr on the Gulf of Bahrain) early became an important trading centre.

The Arab conquests brought Islamic rule to all the Gulf countries in the 7th century. In the 9th, Siraf, visited by Chinese vessels, and Basra were the principal ports. During the 14th century Hormuz, with an immense Indian trade, was the chief entrepôt.

European Trading Rivalries.—Early in the 16th century the Portuguese captured world trade supremacy, and control of the Gulf became an important objective in securing the route to the Far East. By 1515 Affonso de Albuquerque had secured Hormuz and closed the Gulf to other shipping. Throughout the 16th century the Portuguese controlled all trade through Hormuz but toward its end Dutch and English adventurers began to compete for spices.

In 1600 the English East India Company was formed, and obtaining a licence from Shah Abbas I of Persia in 1616, started trading at Jask. The Portuguese opposed them, but with reluctant English help the shah took Hormuz in 1622: he had taken Gombrun as a countercheck upon Hormuz and renamed it Bandar Abbas. He allowed the English company to establish a factory there in 1623, but the Dutch, who had formed the Dutch East India Company in 1602, quickly followed and took the lead. In 1639, therefore, the English started trading at Basra under a Turkish licence. A factory was established in 1643. The French East India Company, formed in 1644, started a factory at Bandar Abbas but the Dutch remained predominant until toward the end of the century. With their withdrawal from Basra, Bushire, Bandar Abbas, and Khark (Kharg) Island between 1752 and 1766 Dutch influence ended and chaotic conditions in Persia left the British virtually supreme.

Soon after 1793, Saiyid Sultan bin Ahmed, brother of the ineffective imam of Oman, established himself on the Persian coast and became a new force in the Gulf area. In 1798 the East India Company made an agreement which secured his support and strengthened the English position.

British Influence in the Gulf.—During the 18th century the interests of the English in India ensured their continued concern with the Gulf. In 1698 the English, Dutch, and French had agreed to share responsibility for policing gulf waters, but the whole responsibility gradually passed to the English. The shah's decree in 1763 described the English agent as "Governor-General for the English nation in the Gulf of Persia," and gave the East India Company virtually exclusive liberty of trade. The residency established at Bushire in 1763 was entirely commercial at first but increasingly assumed political control.

In the early 19th century the "pirate coast" of Arabia became the main problem. After expeditions against the headquarters of the dominant seafaring tribe, the Qawasim, at Ras al Khaimah in 1809 and 1819, the sheikhs signed a general treaty of peace in 1820, agreeing to abstain "from plunder and piracy by land and sea" except by way of acknowledged war. Following the Maritime Truce in 1835 the coast was renamed the Trucial Coast. The Perpetual Maritime Truce of 1853 outlawed all sea warfare and gave Britain formal responsibility for enforcement. Great Britain avoided internal commitments though the Wahhabis of Arabia were expelled from the Al Buraymi (Buraimi) Oasis in 1869.

A British agreement with the Trucial sheikhs in 1869 restraining them from relations with other governments alarmed the Turks, who occupied Al Hasa and Dohah on the Qatar peninsula in 1871. Although Britain recognized Turkish influence over Kuwait, the Turks feared British use of the port would lessen Basra's trade, and so exercised some control.

In 1892 Britain signed agreements with the rulers of both the Trucial Coast and Bahrain which placed their territories under British protection. Russian attempts to secure a railway concession linking the Mediterranean with the Persian Gulf (with implications of Russian influence at Kuwait) also caused the British to meet the Sheikh of Kuwait's request for protection and in 1899 a comprehensive treaty was signed. In 1902 the Germans obtained a concession to extend the Anatolian Railway to Baghdad and Basra but an Anglo-Turkish agreement in 1913 gave Britain representation on the board and control of extensions south of Basra. It recognized Kuwait as an autonomous Turkish *kaza* (district), and the validity of Anglo-Kuwait agreements. Turkey abandoned pretensions to sovereignty over Bahrain, Qatar, Muscat, and the Trucial Coast and recognized the British right to police, light, and buoy the Gulf. Turkish limits were defined by a line roughly marking the southern boundary of Najd, including Al Hasa.

In 1913 Ibn Saud's capture of Al Hasa brought the Wahhabis back to the coast. He was warned against interference with Qatar or the Trucial sheikhdoms. Qatar became a British-protected state in 1916 and in the Treaty of Jidda (1927) Ibn Saud agreed "to maintain friendly and peaceful relations" with Great Britain, Kuwait, and Bahrain.

Effects of Oil Discoveries.—The discovery of oil meant a change in the British role, particularly on the Arabian coast. Protection of natural resources from hostile powers required direct concern with landward boundaries, and defense of the protected states became more important. In 1914 World War I forced Great Britain to occupy Basra to protect the oil fields and the Abadan refinery. The disappearance of the Turkish Empire meant the emergence of Iraq, under British mandate until 1932. The British resident at Bushire, responsible to the government of India, had much influence on the Persian coast until the Persian military leader Reza Khan consolidated his position. In 1935 the naval base was removed to Bahrain. After Reza Shah Pahlavi's (Reza Khan) abdication in 1941 British functions were merely consular.

By the 1930s oil developments had made the United States the principal western influence in Saudi Arabia, but later discoveries led to greatly increased British political activity. To prevent the exploitation of the Gulf rulers, Great Britain persuaded them not to grant oil concessions without approval but did not hinder reputable non-British companies from competing for concessions.

The oil industry led to air travel, making the Gulf as important a link between East and West as it had been in the 16th century. An Anglo-Persian agreement in 1928 resulted in Imperial Airways

establishing a service along the Persian coast in 1929 but the route was, in 1932, transferred to the Arabian coast via Basra, Bahrain, Ash Shariqah, and Gwadar to Karachi. By the outbreak of World War II, the British, Dutch, and French were operating regular services to the Far East via these ports.

After World War II.—World War II made little direct impact on the Persian Gulf. The British residency at Bushire was moved to Bahrain in 1946 and in 1947 full control of British interests was transferred to the foreign office.

Militant nationalism ended Britain's close relations with Persia (Iran after 1935). The Soviet-supported Tudeh Party organized a strike at the Abadan oil refinery and in the Khuzistan oil fields in 1946. In 1951, with Muhammad Mossadegh (*q.v.*) as prime minister, the government of Iran nationalized the oil industry. The Abadan refinery was closed and the British staff of the Anglo-Iranian Oil Co. was withdrawn. Diplomatic relations were broken off in 1952 and were not resumed until December 1953. A solution of the oil dispute was not reached until 1954 when a consortium was formed to operate the oil fields (see *Oil* above).

Britain's ties with Bahrain, Qatar, and the seven Trucial sheikhdoms (Abu Dhabi, Dubai, Sharjah, Ajman, Umm al Qaiwain, Ras al Khaimah, and Fujairah) continued on their former footing. A British political resident at Bahrain was in charge of relationships with these states: subordinate to him were British political agents at Bahrain, Qatar, Abu Dhabi, and Dubai. The treaty signed in 1899 with Kuwait was replaced in 1961 by an agreement under which Britain undertook to help the Kuwaiti government if so requested. Kuwait thus became fully independent. The Sultanate of Muscat and Oman remained an independent state, bound to Britain only by treaty relationship. Britain maintained a consul-general and a vice-consul at Muscat who were subordinate to the resident at Bahrain. Consuls at Dhahran (Az Zahran) and Kuwait looked after the important interests the United States had in the Gulf area through its oil companies.

By 1961 there were international airports at Basra, Abadan, Bahrain, Dhahran, and Kuwait. Regional airports included Ad Dawhah (Dohah), Abu Dhabi, and Muscat, and there were many additional landing strips.

Other developments of the postwar period were:

In 1949 Saudi Arabia claimed the Al Buraymi Oasis, an area potentially rich in oil. The claim was disputed by Muscat and Oman and by Abu Dhabi, supported by Great Britain. The course of the dispute is described in SAUDI ARABIA: *History*.

In 1955 the imam of Oman, Sheikh Ghalib bin Ali, attempted to establish Oman as an independent state. This led to a prolonged struggle between the imam and the sultan of Muscat, for an account of which *see* MUSCAT AND OMAN.

In 1961, following the termination of the 1899 agreement with Great Britain, Kuwait was claimed by the Iraqi prime minister, Abdul Karim Kassem, as an integral part of Iraq. Threatened with invasion Sheikh (Sir) Abdullah as-Salim as-Sabah appealed to Great Britain for help. The danger was averted by the dispatch of British troops, which were later replaced by Arab units after Kuwait had joined the Arab League.

Political Trends.—After the seizure of the Abadan refinery in 1951 British influence in Iran declined and when diplomatic relations between the two countries were resumed in 1953 they were on a different footing.

In the political calculations of the Arab states Arab nationalism became a factor of increasing importance. At the same time the influence of the United States in the Middle East generally and in Saudi Arabia in particular made itself felt throughout the area of the Persian Gulf. *See* also IRAQ; IRAN; BAHRAIN; KUWAIT; QATAR; TRUCIAL OMAN.

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PERSIAN HISTORY. The name "Persia" in its strict significance denotes the area inhabited by the people known as Persians; *i.e.*, the district known in antiquity as Persis (*q.v.*), the modern Fars. In western countries, following classical usage, custom extended the designation to the whole Iranian plateau and then to the empire and political state occupying most of that region of southwest Asia.

The archaeology of this area is dealt with in the article on the modern country, IRAN. This article discusses the history of Persia from the earliest period to contemporary times and is divided into the following sections:

I. Pre-Achaemenid History
II. Achaemenid Empire
III. Hellenistic Period
IV. Parthian Empire, 2nd Century B.C.—3rd Century A.D.
V. Sasanian Empire, *c.* A.D. 224–651
VI. From the Fall of the Sassanids to the Rise of the Safavids, 651–1501
VII. Safavids, 1501–1736
VIII. Afsharids, 1736–49
IX. Zand Dynasty, 1757–94
X. Qajar Dynasty, 1794–1925
XI. Pahlavi Dynasty

I. PRE-ACHAEMENID HISTORY

Ancient Ethnography.—In the 3rd and 2nd millenniums B.C. the Zagros mountain chain was inhabited by the Guti, whose territory lay north of the Sulaymaniyah; the Lullubi in the Shehrizor district; the Elamites who occupied the plain of Susiana and the surrounding hill country; and the Kassites to the northeast of Elam. Elamite was an agglutinative (noninflective) language, related to no other known tongue. Kassite appears to be connected with a linguistic group found in the Caucasus.

Among the Kassites, however, there was a second linguistic element. The names of Kassite kings of Babylonia are compounded with the names of Indo-European gods, for example, the pest-god Maruttash and the sun-god Shuriash, which may be compared respectively with Sanskrit Marut and Surya. It is, therefore, to be presumed that prior to the Kassite invasion of Babylonia in the late 18th century B.C. an Indo-European people had entered Iran and imposed itself as a ruling aristocracy on the native Kassite tribes. This migration formed part of an extensive movement of Indo-Europeans into Asia. About the beginning of the 2nd millennium the Hittites and related peoples appeared in Asia Minor; by the 16th century B.C. another group, who worshiped the Aryan gods Mithra, Varuna, Indra and the Nasatyas, had seized the leadership of the native Hurrian population of north Mesopotamia; and about the 15th century the Vedic Aryans reached northwest India. Some authorities, for example G. G. Cameron and A. T. Olmstead, maintain that the Indo-Iranian Medes and Persians also occupied the highlands of northern Iran early in the 2nd millennium. These tribes, however, do not appear in the records until the 9th century, and the view of E. E. Herzfeld and R. Ghirshman that they, together with other Indo-Iranian peoples, entered Iran from south Russia at the beginning of the 1st millennium seems more probable.

In the Achaemenid period the principal tribes were the Persians, Medes, Parthians, Arians, Drangians, Arachosians, Bactrians, Sogdians and Chorasmians (for the location of their territories *see* the list of provinces in *Achaemenid Empire: Provincial Administration*, below). They were divided into minor tribes or clans and included both settled and nomadic people. Different dialects of the Old Iranian language were spoken among them. For Old Persian and Avestan, the language of the Avesta or sacred writings of the Zoroastrians which was probably current in northeast Iran, there are contemporary sources. For Median the evidence is indirect. Parthian, Sogdian, Chorasmian (Khwarazmian or Khorezmian) and Bactrian are known from post-Achaemenid sources. The various tribes to the north and northeast of Iran, called Scythians (Saka) by the Persians, also spoke an Old Iranian language or languages. In his inscriptions Darius I of Persia calls himself an Aryan (Ariya) of Aryan lineage. From the term Ariya is derived Middle Persian Eran and modern Iran. (*See* also IRANIAN LANGUAGES.)

Early History to 553 B.C.—Information on the political history of Iran prior to the Achaemenid period is limited to the west-

ern part of the country. Native records are relatively few and intermittent and almost entirely confined to Elam (*q.v.*), where a literate, urban civilization developed early in the 2nd millennium. A native pictographic script, known as proto-Elamite, first appears on clay tablets at Susa and at Sialk, near Kashan, in levels contemporary with the Jamdat Nasr period of Sumer (*c.* 2900 B.C.). The archaeological evidence indicates that Sialk had been forcibly occupied by Elamites, probably as a trading outpost. The proto-Elamite script was derived from that of Sumer, where the first inscribed tablets were earlier in date (*c.* 3100 B.C.). By about 2500 B.C. it had developed into a linear script, which has been deciphered. This died out toward the end of the 23rd century, being replaced by the Akkadian cuneiform script, which, as the result of the political and cultural influence of Sumer, had also been used for writing Elamite since the 25th or 24th century. Very few texts have been found outside Elam and on present evidence it would appear that much of the country remained illiterate until the 1st millennium. The records of Babylonia and Assyria (*q.v.*) are far more informative than the native sources. For political and commercial reasons both countries sought to control western Iran.

The turbulent hill peoples of the Zagros were a perpetual menace to their internal security and to their trade with Iran, which provided essential raw materials in which they were deficient, in particular metal, stone and building timber. Between Babylonia and Elam, which forms part of the south Mesopotamian plain, relations were often intimate but seldom amicable.

In the 3rd millennium the chief districts or cities of Elam were: the commercial centre of Susa; Awan, possibly near Shushtar; Barahshi in the northwest; Anshan in the Bakhtiari mountains of western Persis; and Simash, north of Susiana. Wars between their rulers and the city-states of Early Dynastic Sumer are recorded from about the middle of the millennium, and for a brief period Awan was recognized as suzerain by the whole of Sumer. In the 24th–23rd century Sargon of Agade (*c.* 2370–15, or, according to some authorities, *c.* 2350–2300) and his successors incorporated Elam into their empire and campaigned against the hill tribes of Lullubium and Gutium. Their inscriptions gave the names of Elamite rulers and officials, among them Luhhi-ishan of Awan, the chief opponent of Sargon, who is known from Elamite sources to have been the eighth ruler of his dynasty. At Susa Akkadian influence on the local culture was strong. The Akkadian language largely replaced Elamite and many of the personal names were Semitic. Other parts of Elam may have been less affected since a treaty between Hita, a ruler of Awan, and Naramsin of Agade (*c.* 2290–54, or, according to some authorities, 2267–30) is in Elamite. The rock inscriptions of two kings of Lullubium, near Hulwan, are in Akkadian, however, and the accompanying victory reliefs are modeled on those of Naramsin.

On the breakup of the Akkadian empire about the time of Sharkali-sharri (*c.* 2253–29), western Iran regained its independence. Kutik (Puzur)-Inshushinak of Awan, who as governor of Elam under Naramsin had campaigned as far north as the Kirkuk area, not only rose in revolt but invaded Sumer and Akkad, penetrating to Opis. He expressed the revival of national feeling by reverting to the Elamite script and language and by erecting a temple to Inshushinak, chief deity of Susa. His reign was followed by an obscure period in Elamite history which may be connected with the invasion and domination of Sumer by the Gutians of the northern Zagros, who controlled the country for over a century. After their expulsion the 3rd dynasty of Ur revived the expansionist policy of Sumer. Shulgi (*c.* 2095–48, or, according to some authorities, *c.* 2112–2064) conquered much of Elam and made numerous expeditions into the Zagros. Close commercial relations were developed with Susa, where the Ur kings erected temples and dedicated votive objects to the local gods. During the reign of Ibbi-Sin of Ur (*c.* 2029–06, or *c.* 2046–21) Amorite pressure in the west and internal dissensions so weakened the empire that the Elamites, under the leadership of Simash, were able to regain their independence. About 2006 they sacked Ur, which they held for several years, and carried Ibbi-Sin captive to Anshan, so ending the Ur dynasty. Toward the end of the 20th century Elam for a time fell under the domination of Gungunum of Larsa (1932–06). In 1834 Larsa was itself seized by Kudur-Mabug, probably not, as has been supposed, an Elamite king but an Amorite, whose tribe had settled on the western borders of Elam. In 1764 Elam and Gutium joined with Assyria, Eshnunna and Malgium in an unsuccessful attack on Hammurabi of Babylon.

In 1742 there occurs the first reference to an attack on Babylonia by the Kassites, whose Indo-European leaders must have reached the Zagros prior to that date. In the course of the next 150 years they occupied much of the country and after the Hittite raid of *c.* 1595 entered Babylon. A Kassite dynasty ruled Babylonia until the 12th century. There is no evidence of a Kassite occupation of Elam, but the absence of native records between the 16th and 14th centuries suggests a political collapse which may have been due in part to Kassite pressure on the frontiers.

Elamite recovery began at the end of the 14th century with the establishment of a new dynasty, the members of which bore the title "king of Anzan (Anshan) and Susa." Hubanumena, the third king, inaugurated a policy of foreign conquest, extending his rule as far as the island of Liyan in the Persian gulf. Toward the end of the 13th century Kidin-Hutran twice invaded Babylonia, and 60 years later Shutruk-Nahhunte I attempted to establish permanent control over that country. In 1160 he overthrew Zababa-shum-iddina, appointed a governor and exacted tribute. In 1157 Kutir-Nahhunte removed the last Kassite king, Enlil-nadin-ahhe, who had continued to resist, and carried off the statue of the god Marduk as symbol that Babylonian independence was at an end. Still wider conquests were made by his brother, Shilhak-Inshushinak, the greatest of Elamite rulers. The whole Zagros area as far as the lower Zab river and the borders of Assyria fell into his hands, while in the southeast his rule extended to the Persepolis district. He was, however, unable to hold Babylonia, where power passed to the 2nd dynasty of Isin. Under Nebuchadrezzar I (1124–06) the Babylonians avenged their earlier defeats, invading and plundering Elam and killing Huteludush-Inshushinak, Shilhak-Inshushinak's successor. This victory smashed the power of Elam and for over 300 years its sources are silent.

From the 9th century the political history and geography of the Zagros area are known in some detail from the records of Assyria and Urartu. The principal districts were then Ellipi,

OLIVE KITSON

LOOKING NORTH FROM THE RESIDENTIAL PALACE OF CYRUS THE GREAT TOWARD THE TALL-I-TAKHT OR CITADEL HILL AT PASARGADAE

which extended from the northern border of Elam as far as Kermanshah and Nahavand; Zamua in the Sulaymaniyah district; Manna, south and east of Lake Urmia; and to the southwest of the lake Parsua or Parsuash, probably the first halting place of the Persians in western Iran. Southeast of Manna lay Mada (Media), the territory of the Median tribes, which included Hamadan (ancient Echatana) and extended as far as Mt. Demavend. Parsua and the Medes are first mentioned by Shalmaneser III in 835 and thereafter occur with increasing frequency in the Assyrian records. The settlement pattern in these districts of western Iran was one of scattered villages and occasional fortified citadels, such as those excavated at Hasanlu in Manna and at Sialk. The economy was based on agriculture, but metalworking was highly developed, particularly in Manna, and horse breeding was important, western Iran being the main supplier of horses to the Assyrian army.

During the 9th century the Assyrians won control of all the Zagros from Manna to the borders of Elam. Local rulers and tribal chiefs were laid under tribute and, where possible, Assyrian garrisons were established at strategic points. Nevertheless constant and arduous campaigning was necessary to maintain Assyrian authority. When at the end of the century the power of Assyria declined, Urartu (*q.v.*) under Menuas I and Argistis I expanded south into Manna and Parsua. Tiglath-pileser III (745–727) drove the Urartians back, but in the time of Sargon II (722–705) their anti-Assyrian intrigues led to serious revolts in Manna in which Indo-Iranian chiefs were implicated. Sargon re-established Assyrian authority and also conducted punitive expeditions against Parsua and Mada, in 713 receiving tribute from 45 Median chiefs.

In the south the re-emergence of Elam as a strong military power presented a serious threat to Assyrian interests in the central Zagros and in Babylonia, now an Assyrian vassal state. For over 30 years its kings actively supported anti-Assyrian elements in these territories. Humbanigash of Elam formed an alliance with the Chaldean Merodach-baladan, who in 721 had revolted against Sargon and seized the Babylonian throne, and in a battle fought at Der in 720 compelled the Assyrian to abandon his campaign against the rebel. Although his successor, Shutruk-Nahhunte II, failed to support Merodach-baladan when Sargon renewed his attack in 710, he assisted his revolt against Sennacherib in 703. In 707 he was also involved in an anti-Assyrian intrigue in Ellipi. The failure of both these undertakings was probably the cause of his overthrow by his brother, Hallushu-Inshushinak, in 699. In 694, while Sennacherib was campaigning against Chaldean rebels in the marshlands at the head of the Persian gulf, Hallushu-Inshushinak raided Babylonia, captured its governor, Sennacherib's son, and set Nergal-Ushezib on the Babylonian throne. He was unable to prevent the removal of his nominee by Sennacherib, however, and in 693 was deposed by his disappointed subjects. Within ten months his successor, Kudur-Nahhunte, was assassinated, following an Assyrian attack on Elamite territory, and was succeeded by Huban-immena. In co-operation with the Chaldean Mushezib-Marduk, Aramaeans of the east Tigris districts, Ellipi and other peoples of western Iran, Huban-immena mounted a major offensive against the Assyrian forces in Babylonia (691). In 689, however, he was smitten with a fatal paralysis and the Elamite forces withdrew. Weakened by the long struggle with Assyria and by the pressure of the Persian tribes on its frontier, Elam was torn by rival factions and ceased to be a major force in international politics. Henceforth no single ruler exercised effective authority over the whole country, which was split up among a number of independent princes.

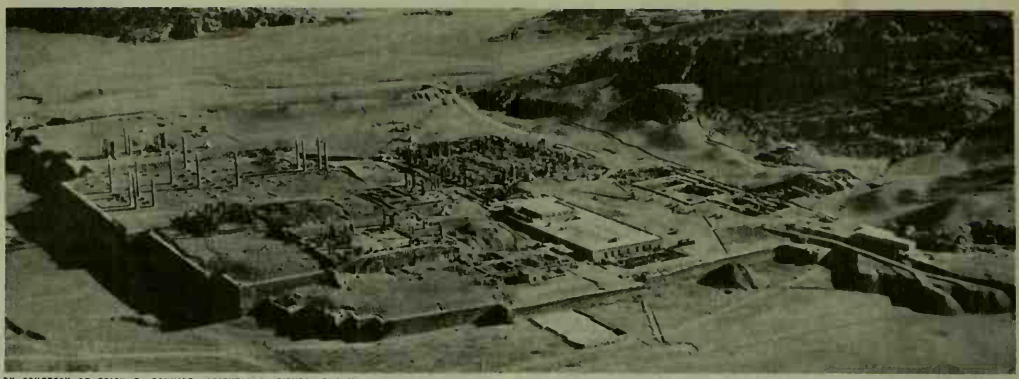
Early in the 7th century Scythian and Cimmerian hordes swept into Iran from the north. In Manna they allied themselves with the local ruler against Assyria and despite the claim of Esarhaddon (681–669) that he suppressed the revolt it is evident that by about 674 his control of the district was seriously weakened. In 676 he made a successful raid through Mada as far as Patusharri, a district on the edge of the Salt desert bordering Mt. Demavend, and the most easterly point in Iran ever reached by an Assyrian army. It may have been in connection with this campaign that he reinstated three Median chieftains who had appealed to him for help against their rebellious subjects. The location of their territories is uncertain. One of them, Ramataia of Urukazabarna, together with seven other rulers of western Iran, in 672 signed treaties with Esarhaddon, the purpose of which was to secure the succession of Ashurbanipal to the Assyrian throne. Relations between Elam and Esarhaddon were cordial, but the intrigues of Tepti-Huban-Inshushinak (*c.* 663–653) provoked an attack by Ashurbanipal in which the Elamite was slain. In an attempt to secure a pro-Assyrian policy in Elam Ashurbanipal placed two Elamite princes, to whom he had given asylum, on the thrones of Hidalu and Madaktu. Enmity toward Assyria, however, was too deep rooted for this maneuver to have any chance of success. When in 652 Shamash-shum-ukin of Babylon revolted from Ashurbanipal, Huban-nugash of Madaktu sent a strong force to his assistance. Although military defeats led to rapid changes of rulers, the Elamites continued to support Shamash-shum-ukin and, following his defeat and death, the rebel Chaldean Nabu-bel-shumati. After a further unsuccessful attempt in 646 to install an Assyrian nominee in Elam, Ashurbanipal invaded the country, sacked Susa with great ferocity and ended Elamite independence (*c.* 639).

Thereafter Assyrian sources fail. In 615, as recorded in the Babylonian chronicle, the Median tribes, united under Cyaxares (*q.v.*; Uvakhshatra), had begun the attack on Assyria which was to lead in 612 to its overthrow. According to Herodotus the Medes were united into a strong, independent confederation by Deioces (*q.v.*) at the beginning of the 7th century. This account cannot be reconciled with the Assyrian evidence. Although some authorities identify Deioces with a certain Daiukku (Dayukku), who in 715 participated in an unsuccessful revolt of Manna against Sargon, it is evident that in the time of Esarhaddon there was no unity among the Medes, many of whose chieftains recognized Assyrian suzerainty. The movement toward unification, the driving force of which was resistance to Assyria, may, however, have started in 674 when Medes, Cimmerians and Mannaeans united against Esarhaddon under the Mede Kashtaritu (Iranian Khshathrita), generally identified with the Phraortes (*q.v.*), son of Deioces, of Herodotus. According to Herodotus, Phraortes was killed in battle against the Assyrians, but before his death he had made the Persians subject to the Medes.

By this date the Persians had migrated to Parsa (Persis; modern Fars), and were led by Teispes (*c.* 675–640), perhaps the son of Achaemenes (*c.* 700–675), the eponymous ancestor of the Achaemenid dynasty. Their territory included the Elamite district of Anshan. The sons of Teispes, Cyrus I and Ariaramnes, were both kings, and each was followed by kings in his own line. In the opinion of some authorities this implies that the kingdom of Teispes was divided between them; an alternative view is that there was alternation in succession between the senior and junior line. Following the final campaign of Ashurbanipal against Elam, Cyrus I acknowledged Assyrian overlordship, sending his eldest son, Arukku, to Nineveh as hostage (*c.* 640). On a gold tablet, Ariaramnes calls himself "great king, king of kings," a title that should imply that he was an independent ruler and leader of a considerable federation. This inscription, however, is considered by some scholars to be a forgery of late Achaemenid date.

Herodotus states that Cyaxares, the son of Phraortes, was for 28 years subject to the Scythians. On regaining his independence, he reorganized the Median army, hitherto a loose mass of tribal contingents, dividing it on the Assyrian model into bodies of spearmen, archers and cavalry. With this united and formidable fighting force the Medes were at last a match for the Assyrians and took the leading part in the destruction of their empire. The Babylonian chronicle records that in 615 Cyaxares invaded the Assyrian province of Arrapkha (Kirkuk). In 614 he took Tarbisu, near Nineveh, and then sacked Ashur. There is archaeological evidence that he also attacked Kalakh (Nimrud). After the sack of Ashur he concluded a treaty with Nabopolassar of Babylon, who since his revolt in 626 had been engaged in attacks on Assyrian territory. In 612 the Medes and Babylonians, probably reinforced by Scythians, sacked Nineveh.

In 610 their capture of Harran ended the last Assyrian resistance in Mesopotamia. While Babylonia won control of the western provinces of the Assyrian empire, Cyaxares extended his power in



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AERIAL VIEW OF THE RUINS OF PERSEPOLIS, ONE OF THE CAPITALS OF PERSIA DURING THE ACHAEMENID PERIOD

Iran and Asia Minor. By 590 the conquest of eastern Anatolia had brought him to the borders of Lydia and for five years he was involved in inconclusive fighting with its ruler, Alyattes. The war ended in 585 when a battle was interrupted by a solar eclipse. By a treaty, for which Nebuchadrezzar of Babylon and the ruler of Cilicia acted as mediators, the two powers recognized the river Halys as their common boundary. Cyaxares was succeeded by his son Astyages (Arshtivaiga) *c.* 585.

In Persian territories, once again subject to Media, Ariaramnes was followed by his son Arsames, called "king of Parsa" in an inscription which, like that of his father's, is of uncertain authorship. In the other branch of the family Cyrus I was followed by Cambyses I, called by the Babylonians "king of Anshan," and in 559 by Cyrus II the Great.

II. ACHAEMENID EMPIRE

Political History.—The history of the Achaemenid empire is treated under individual kings (*see* also *History* sections of BABYLONIA AND ASSYRIA; EGYPT; GREECE). This article gives only a brief conspectus of the main events. The order of kings is as follows:

Cyrus II (559–530)
Cambyses II (530–522)
Smerdis (Gaumata) (522)
Darius I (522–486)
Xerxes I (486–465)
Artaxerxes I (465–424)
Xerxes II and Secydianus or Sogdianus (424–423)
Darius II (423–404)
Artaxerxes II (404–359/358)
Artaxerxes III (359/358–338/337)
Arses (338/337–336/335)
Darius III (336/335–330)

The chronology is established by the Ptolemaic canon, by numerous Babylonian and a few Egyptian documents and by the evidence of the Greeks.

In 553 Cyrus II rebelled against Astyages, having previously formed an alliance with Nabonidus of Babylonia, who wished to evict the Medes from Harran. In 550 Cyrus captured Astyages and made himself master of the Median confederation. Nabonidus took Harran but soon realized that Cyrus constituted a greater danger to his empire than Astyages, in whose overthrow he had assisted. When war broke out between Cyrus and Croesus of Lydia, possibly in 547, Nabonidus entered into an alliance with Croesus, as did Egypt and Sparta. Before help could be sent, however, Cyrus defeated Croesus and seized Sardis. During the next few years he and his generals secured the submission of the rest of Asia Minor and probably detached part of Syria and Palestine from the Babylonian empire. The attack on Babylonia itself opened in 540 and Babylon fell the following year. Cyrus also subdued northern and eastern Iran, but details of these campaigns are unknown. He died in 530 in battle against the nomads of eastern Iran. In the brief span of 20 years he had raised an obscure and secluded tribe to the mastery of an empire that stretched from the Mediterranean to the Indus. Able generalship and the fighting qualities of the Persian army contributed to this remarkable achievement, but a major factor was the liberal and lenient treatment accorded by Cyrus to conquered states, a policy without parallel in the previous history of the near east. In consequence many peoples welcomed him as a liberator from existing tyranny, whether foreign or native. Thus it is probable that the provinces of the Babylonian empire offered him little, if any, resistance, while in Babylonia he had the support of a large part of the population and, in particular, of the priesthood, which had been antagonized by the religious policy of Nabonidus.

The conquest of Egypt, which had shown its hostility to Persian expansion by allying itself with Croesus, was carried out by Cambyses II in 525. The usurpation of the Persian throne by Smerdis (Gaumata) in 522 and his assassination by Darius I led to serious revolts in Iran and Babylonia and the defection of the Persian governors of Egypt and Sardis. Lack of co-ordination among the rebels, however, enabled Darius to deal with them individually, and by 518, when he visited Egypt, he had established his authority and restored order throughout the empire. The revolts had nevertheless demonstrated the strength of separatist tendencies and, while not departing from the system devised by Cyrus, Darius took steps to strengthen the imperial administration. He completed the division of the empire into provinces, introduced checks on the power of their governors and fixed the annual taxation of each province. In foreign policy his main concern was to counter external threats to the security of the empire. To protect his northern borders from incursions by the Scythian nomads he attacked the tribes east of the Caspian in 519 and those of European Scythia in 513. Although the latter expedition had to be abandoned because of failure of supplies, it resulted in the submission of Macedonia, Thrace and the islands of Lemnos and Imbros. He thus held the approaches to Greece, conflict with which was inevitable, for Persian control in western Asia Minor was threatened by the support given by the Greeks to their Asian kinsmen. Nevertheless it was not until Athens and Eretria assisted the Ionian revolt of 499 that Darius attacked European Greece. The expeditions led by Mardonius (492) and Datis (490) were unsuccessful, and the carefully prepared campaigns of Xerxes ended in the defeats of Salamis (480), Plataea and Mycale (479). The victory of Cimon on the Eurymedon followed *c.* 466. The invasion of Greece had failed completely, largely through the military and diplomatic blunders of the Persian king and his commanders. The European territories were lost and large numbers of Asian Greeks, Carians and Lycians joined the Delian league.

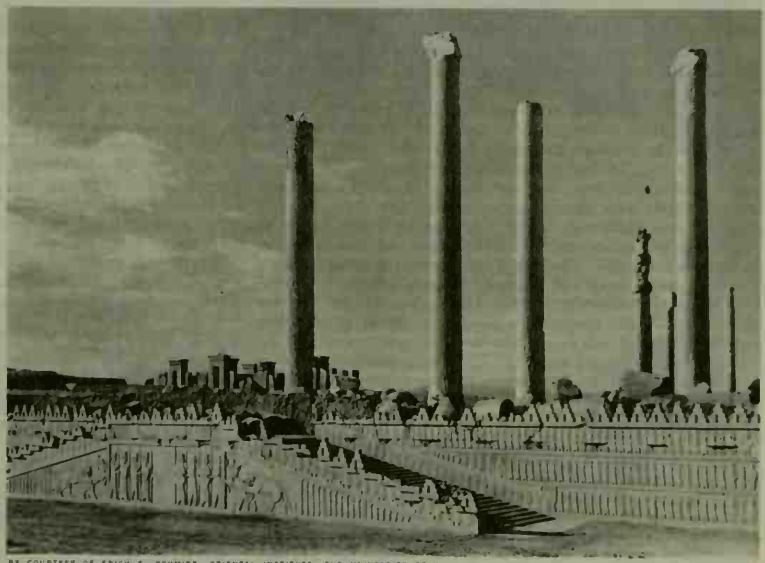
The failure of Xerxes' expeditions proved a turning point in the history of the empire. Although the territorial losses were of no great significance, its prestige and military strength had suffered a severe blow and thereafter it declined into a condition of immobility and stagnation, a process which was assisted by the deteriorating influences of civilization and imperial power

on the character of the ruling race. The royal line degenerated and the successors of Darius were weak, capricious, pleasure-loving potentates, easily accessible to personal influence. Only the brutal Artaxerxes III possessed the will and energy to prosecute a vigorous and positive policy. At court the influence of the royal harem and the eunuchs made disastrous progress, dynastic disputes became frequent and intrigue and corruption were rife. Men of energy and ambition began to find the temptations of power stronger than their patriotism and loyalty to the crown. High court officials such as Artabanus, who murdered Xerxes, and Bagoas, the assassin of Artaxerxes III and Arses, attempted to seize the reins of power in fact if not in name. In the provinces, satraps aspired to independence and as the central authority weakened and the checks on their power diminished their revolts became more frequent and dangerous. In considering the subsequent wars and disorders, however, it must be borne in mind that they usually affected restricted parts of the empire; only on isolated occasions were extensive areas involved in prolonged strife. For most of the provinces the Achaemenid domination was synonymous with two centuries of peace, order and improved economic conditions.

Under Artaxerxes I and Darius II the situation in the empire remained stable. Isolated satrapal revolts and a rising in Egypt were suppressed and Persian diplomacy, backed by gold, was able to exploit the dissensions of the Greeks to Persian advantage. Athens had not the strength to undertake a serious offensive against the empire. It failed in its attempts to detach Egypt and Cyprus from Persia, and *c.* 448 its difficulties with the other Hellenic states constrained it to conclude the peace of Callias whereby it renounced the Persian war while Artaxerxes acknowledged the loss of the cities in Asia Minor under Athenian rule. The collapse of Athenian power before Syracuse (413), however, gave Darius the opportunity to regain the lost territories. An alliance was formed with Sparta, part of Ionia was recovered and Persian subsidies enabled Lysander to complete the overthrow of Athens in 405. When war subsequently broke out with Sparta, Artaxerxes II supported its Greek adversaries. The annihilation of the Lacedaemonian fleet at Cnidus in 394 crippled Spartan power and gave Persia the mastery of the Aegean. Exhausted by their struggles, the Greeks in 386 accepted the peace of Antalcidas and recognized Persian rule over the Greek cities of Asia Minor and Cyprus. Persia became the arbiter of Greece, and the feuds that followed centred on the efforts of the combatants—Sparta, Thebes, Athens and Argos—to secure Persian support. The goal for which Darius and Xerxes had striven had at last been achieved, but the Persian success was due to the internecine strife of the Greeks rather than to Persian military efforts. The weakness of the empire was revealed by the revolt of Cyrus the Younger, the failure of the two expeditions sent against Egypt, which had rebelled in 404, the loss of Paphlagonia, Bithynia and other districts in Asia Minor and the widespread satrapal revolts in Asia Minor and Syria. That the weakness of Artaxerxes II was in large measure responsible for these calamities, which threatened to disrupt the empire, is shown by the swift recovery of Persia under his able and energetic successor, Artaxerxes III. He curbed the power of the satraps, compelling them to dismiss their Greek mercenaries, forced Athens, which had supported some of them, to conclude peace (355) and, after an initial reverse, reconquered Egypt (343). As a result of these measures the empire appeared to be more powerful and more firmly established than at any time since Darius.

In the Greek world, however, the rise of Philip II of Macedonia had fundamentally changed the situation. Philip's immediate purpose was Macedonian expansion at the expense of Thrace and Thessaly and the subjugation of the Balkan peninsula, but in his efforts to extend his power over the Greek states he was bound to assume the leadership of the movement which, inspired by writers such as Isocrates, aimed at the unification of Greece for the struggle against Persia. Artaxerxes, pursuing the traditional Persian policy, supported Perinthus, Byzantium and Athens against Macedonia, but in 338 Philip defeated Athens and in 337 formed the League of Corinth, embracing the whole of Greece except Sparta, for the purpose of liberating the Greeks of Asia Minor from Persian rule. The invasion of Asia Minor, begun by Philip in 336, was resumed by Alexander (334; *see* ALEXANDER III the Great) after Philip's assassination. By the autumn of 333 Alexander had won most of Asia Minor and defeated Darius III at Issus. It was probably after Issus that he first thought of conquering the whole Persian empire. To hold Asia Minor meant a defensive war, since Persia would certainly seek to regain it; Phoenicia and Egypt were known to be disaffected; and the superiority of the Greek army over that of Persia had been decisively demonstrated. The overtures of Darius were therefore rejected. Except at Tyre and Gaza Alexander met no serious resistance and the occupation of the western provinces, including Egypt, was completed by 332. In 331 Darius was defeated at Gaugamela (*see* GAUGAMELA, BATTLE OF) and fled to Bactria, where in 330 he was murdered by Bessus. Although it took Alexander several years to complete his conquest of Iran, the victory at Gaugamela gave him the mastery of Asia and brought the Achaemenid empire to an end.

The Monarchy.—The Achaemenid king ruled by divine right. "By the grace of Ahura Mazda I am king; Ahura Mazda gave me the kingdom," says Darius I, and on the monuments Ahura Mazda, in the winged disk, regularly hovers over the king, symbolizing the divine favour and protection so much insisted on in the royal inscriptions. The succession was hereditary, but the rule of primogeniture does not appear to have been strictly observed. The king



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STAIRWAY LEADING TO THE APADANA AT PERSEPOLIS. IN THE BACKGROUND IS THE TACHARA, PRIVATE APARTMENTS OF DARIUS I

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DETAIL OF A RELIEF ON THE EASTERN WALL OF THE APADANA AT PERSEPOLIS SHOWING PERSIANS (FLUTED HAT) AND MEDES CELEBRATING THE NEW YEAR FESTIVAL OF THE VERNAL EQUINOX

apparently had the right to choose his successor from among his sons and was expected to do so before risking his life in foreign war. Thus 12 years before his death Darius named as heir apparent not his eldest son but Xerxes, the first son born to him after his accession. Notwithstanding the nomination of a crown prince the succession, after the time of Xerxes, was frequently disputed, harem intrigues being a main cause. The succession of a new king was generally followed by the assassination of close relatives; in consequence the royal house was so decimated that on the death of Arses the throne passed to a collateral branch.

While the power of the king was, at least in theory, absolute, he acted in consultation with his high officers of state. There are references in Ezra to seven counselors, but there is no exact information on their titles and functions. It is probable that the *hazarapat* (Greek *chiliarchos*), the commander of the royal bodyguard, was the foremost among them; his office corresponded to that of vizier. The head of the chancellery must also have occupied a leading position in the government. The chief Persian and Median nobles were closely connected with the court. Among them the descendants of the six men associated with Darius in the murder of Gaumata held the highest rank and were influential in the king's counsels. They alone had the right to enter the royal presence unannounced and possessed princely estates.

Provincial Administration.—The Persian empire was far more extensive and comprised a greater variety of peoples than any that preceded it. In relation to the subject population the Persians were in a small minority. They were, moreover, inferior in civilization to the ancient nations that lay to the west of Iran. To hold the empire by force alone was therefore an impossibility. Recognizing this, Cyrus and Darius sought to govern by persuasion and consent. Propaganda was effectively used as an instrument of policy, especially by Cyrus. Vanquished peoples were treated with clemency and permitted as much freedom in the conduct of their affairs as was consonant with the efficiency of the imperial administration. This policy, however, was only partially successful in reconciling the subject populations to foreign domination, and national revolts led to departures from the liberal principles laid down by Cyrus.

Among the peoples of the empire the Persians occupied a leading and privileged position, for it was on their loyalty that the Achaemenid dynasty ultimately depended. They alone were exempt from taxation. They were liable for military service, however, and, together with the Medes, provided the standing army. Persian military colonists were settled in the provinces and endowed with lands; they formed the nucleus of the provincial levies and were the mainstay of the satrapal governments. The leading Persian families supplied the majority of the army commanders and the chief officers of the central and provincial administration. To train them in their duties, sons of the nobility were brought up at the royal and satrapal courts, where they were instructed in the handling of arms, riding and hunting, and in history, religion, law and judicial procedure.

Although for geographical reasons the administrative capital of the empire was Susa, the associations of the monarchy were with the ancestral homeland of the dynasty. The kings were buried in Persis and were consecrated at Pasargadae, the city of Cyrus II. In the interior of the country Darius founded the city of Parsa, the Persepolis of the Greeks, the most magnificent of the royal capitals. Pride of race and country was strong in king and people. Darius calls himself "a Persian, the son of a Persian, an Aryan of Aryan stock."

The Achaemenid monarch was no less conscious of his unique position as supreme ruler of a great diversity of nations. Darius was "one king of many, one lord of many, . . . the great king, king of kings, king of the countries possessing all kinds of peoples, king of the great earth, far and wide." In the subject territories Persian rule was direct, native dynasties being suppressed and replaced by Persian governors. Only in a few states which had submitted voluntarily were native kings permitted to remain in vassalage to Persia.

This was the case in Cilicia, where the governor belonged to the native royal house, and in Byblos, Sidon and Citium (in Cyprus), the rulers of which, although subordinate to a Persian governor, called themselves kings. In Babylonia Cyrus retained the monarchy but assumed the kingship himself, adopting the title "king of Babylon," a measure designed to flatter national pride and reconcile the Babylonians to foreign rule. In his official pronouncements he represents himself as the king chosen by Marduk, the national god, and therefore the legitimate successor to the Babylonian throne.

A similar policy was followed by Cambyses and Darius in Egypt. The revolts of Babylonia and Egypt against Xerxes led, however, to a change of policy. The Babylonian monarchy was abolished, the statue of Marduk, without which no king could legitimize his rule, being destroyed. In Egypt Xerxes refused to adopt the native royal titulary, thus abandoning the fiction that he was the legitimate successor to the Pharaohs.

The empire was divided into provinces, the number and limits of which varied with changes in the imperial frontiers or in the administration. Different lists are incorporated in the inscriptions of Darius I. The earliest, in the Bisitun text (completed by 518 B.C.), gives 23 lands, and the latest, in the tomb inscription, 30, as follows:

The Iranian provinces of:

1. Persis (*q.v.*; Parsa) in modern Fars, which probably included Carmania (Karmana) to the east;
2. Media (*q.v.*; Mada) in the northwest;
3. Elam (*q.v.*; Huvja) in Khuzistan;
4. Parthia (*q.v.*; Parthava) in Khurasan, which at this date included Hyrcania (Varkana) southeast of the Caspian sea in the Asterabad (Gorgan) district;
5. Aria (Haraiva) along the Arius (Harirud) river;
6. Bactria (*q.v.*; Bakhtrish) on the northern slopes of the Hindu Kush as far as the Oxus (Amu-Darya) river, to which was joined Margiana (Margu), centred on the oasis of Merv, which preserves the ancient name;
7. Sogdiana (Suguda), the mountainous region between the Oxus and Jaxartes (Syr-Darya) rivers;
8. Chorasmia (Uvarazmish), the Khiva oasis along the lower Oxus which still bears the name Khwarizm;
9. Drangiana (Zranka; Sarangia in Herodotus) along the Helmand river in Seistan;
10. Arachosia (Harahuvatish), the district of the Helmand river and its tributaries round Kandahar;
11. Maka, probably Makran.

The three provinces lying east of Iran:

12. Sattagydia (Thatagush), of uncertain location;
13. Gandhara (Gandara), also called Paruparaesanna (Paropamisidae, "the land beyond the mountains"; *i.e.*, the Hindu Kush) in the Kabul valley;
14. India or Sind (Hindush) in the Indus valley.
15. The *hauma*-preparing (?) Scythians (Saka haumavarga; the Amyrgian Scythians of Herodotus) in the Pamirs.
16. The pointed-cap Scythians (Saka tigrakhauda) east of the Caspian sea.
17. Babylonia (Bahairush).
18. Assyria (Athura; Aramaic Ebir-nari, "across the river" [Euphrates]), which included Syria, Phoenicia and Palestine and prior to Xerxes was administered jointly with Babylonia; the later list of Herodotus includes Cyprus in the province.
19. Arabia (Arabaya).
20. Egypt (Mudraya).
21. The Libyans (Putaya).
22. The Ethiopians (Kushaya).
23. Armenia (Armina), which according to Herodotus stretched to the Black sea.
24. Cappadocia (Katpatuka).
25. Lydia (called Sparda after Sardis the capital).
26. Ionia (Yauna).
27. Scythians across the sea (Saka paradraya) on the steppe north of the Black sea.
28. Thrace and Macedonia (Skudra).
29. Ionians wearing the petasos cap (Yauna takabara), elsewhere called (Ionians) "by the sea" (Tyaiy drayahya), possibly to be identified with Hellespontine Phrygia.
30. Carians (Karka).

To these provinces a list of Xerxes adds Dahae (Daha), east of the Caspian, and "men of the mountain land" (Akaufaciya), of uncertain location.

The list of tributary provinces given by Herodotus, which must have been derived ultimately from an official Persian source, perhaps of Artaxerxes I, differs considerably from those of Darius and Xerxes. The reduction in the number to 20 reflects the loss of territory in Europe and administrative changes. A number of lands previously listed separately are combined, notably Parthia, Chorasmia, Sogdiana and Aria (province xvi), Drangiana and the

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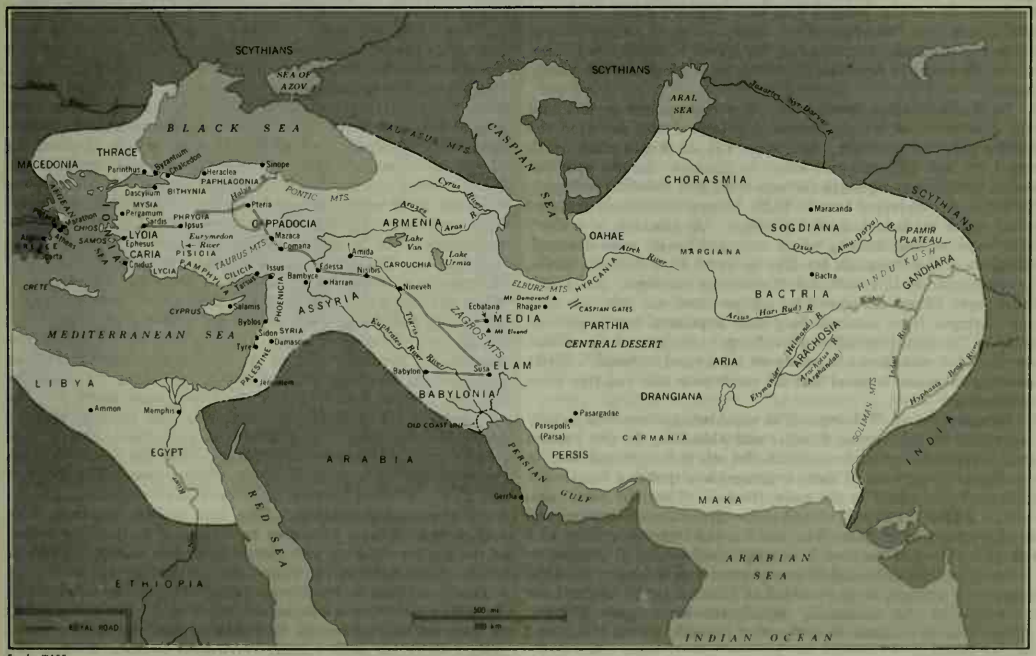
AERIAL VIEW OF THE RUINS OF SUSA, CAPITAL CITY OF THE PERSIAN EMPIRE AT THE TIME OF DARIUS I

Mycians (Maka) with other tribal districts and islands in the Persian gulf (xiv), Sattagydia and Gandhara (vii) and Egypt and Libya with Cyrene and Barca (vi). Caria is joined to Ionia, which also includes Magnesia on the Maeander (Menderes) river, the Aeolians, Lycians, Milyans and Pamphylians (i). Cappadocia includes the Hellespontines or Greeks of northwest Asia Minor, Phrygia, Asiatic Thrace or Bithynia, Paphlagonia and the Mariandynians (iii). This province was sometimes called Dascylitis by the Greeks after the capital Dascylium. Herodotus gives a number of provinces which do not appear in the Achaemenid lists, for example Cilicia (iv), and omits Persis because it was exempt from taxation and Arabia and Ethiopia because they did not pay a fixed annual tribute.

The central government retained rights over foreign policy and the assessment of tribute, but the provinces were as far as possible



E. J. WASS

THE PERSIAN EMPIRE IN THE TIME OF DARIUS I AND XERXES I (ACHAEMENID PERIOD)

left to govern themselves. Each was under a governor or satrap (*q.v.*), normally a Persian of high rank, who was head of the civil administration, supreme judicial authority and commander of the provincial troops. Assisting him was a council of Persians and native representatives. It became evident in the time of Darius that such wide powers could encourage the satraps to aim at independence and a system of controls was therefore devised. Garrison commanders in the province were made independent of the satrap; a royal secretary was attached to him to deal with his correspondence with the king; and inspections of the provinces by royal officials were instituted. By the time of Artaxerxes III, however, these controls had weakened and the satraps had greatly increased their military strength by recruiting large numbers of Greek mercenaries.

The subject peoples occupied a tolerably independent position. Their forms of local government were generally retained, their laws and customs were respected and they provided subordinate officers of the provincial administration and army. National revolts led in certain instances, however, to a curtailment of these privileges. Thus in Babylonia Darius replaced many of the native officials by Persians, a process which was accelerated under his successors. The system of local government within the provinces varied according to local conditions. In large cities, such as Babylon, Jerusalem and the Egyptian towns, internal affairs were controlled by the elders or the officials of the community. The great temple dominions, such as Bambyce in Syria and the two Comanas in Asia Minor, were administered by the priests. City-states might have a monarchy, as at Byblos, Sidon and Citium; an aristocracy, as in Bithynia, Caria and Lycia; or tyrants, as in the Greek towns. In tribal districts authority was in the hands of the chieftains. Complete subjection of many of the wild and warlike tribes in inaccessible mountain and desert areas was impossible or not worth the effort. When in 401/400 Xenophon marched from the Tigris to the Black sea, the tribes of the Pontic mountains were completely independent. Outside the authority of the satraps were the royal domains, with great parks and hunting grounds (the paradises), and the estates bestowed by the king on Persians or members of subject peoples who had rendered signal service to the crown (the "benefactors"). Many of these estates formed large principalities; *e.g.*, those of the house of Otanes in Cappadocia, Hydarnes in Armenia, Themistocles in Magnesia and Lampsacus.

To maintain close liaison with the provinces and to facilitate the movement of troops, Darius I improved and extended the earlier network of routes. Best known is the Royal road, which ran from Susa to Sardis and thence to Ephesus. Linked with this was a branch running south through Syria and Palestine to Egypt. Other routes traversed Iran to India. Royal messengers traveled along these roads in a system of relays. At intervals of a day's ride were posting stations where men and horses were changed. Whereas it took caravans 90 days to travel from Susa to Sardis, couriers could by this method do the journey in a week. As Herodotus says: "They are stayed by neither snow nor rain, nor heat nor darkness from accomplishing their appointed course with all speed. The first rider delivers his charge to the second, the second to the third, and thence it passes on from hand to hand." Strict security measures ensured that the roads were safe and free from brigandage.

Language and Writing.—The royal inscriptions were usually trilingual, in Old Persian, Elamite and Akkadian, the Old Persian text being the original from which the others were translated; in provinces where none of these languages was spoken a fourth legend might be added in the native tongue. Thus the Suez canal stelae of Darius I were inscribed in the three official languages and in Egyptian hieroglyphs. The Old Persian text was written in a simplified form of the cuneiform script consisting of 41 characters. In the time of Darius and Xerxes payments to workmen from the Persepolis treasury were recorded in Elamite cuneiform and the personnel of the accounting department was largely Elamite. There is some evidence, however, that the orders were first issued in Old Persian.

Aramaic, with its alphabetic script which could be written in ink on papyrus, parchment or clay, was employed throughout the empire for imperial administration and also for diplomatic correspondence. Royal pronouncements and decrees and enactments of the imperial chancellery were provided with an Aramaic translation, as is shown by an Aramaic copy of the Bisitun inscription preserved among the papyri of the Jewish garrison at Elephantine. In Egypt correspondence between Persian and Egyptian officials and even between Persians was conducted in Aramaic, and in Asia Minor coins minted by Persian satraps and generals usually bore an Aramaic legend. Aramaic characters were adapted for the writing of Iranian languages, the earliest-known example being an inscription in Persian on the tomb of Darius at Naksh-e Rostam dateable to the first half of the 3rd century B.C.

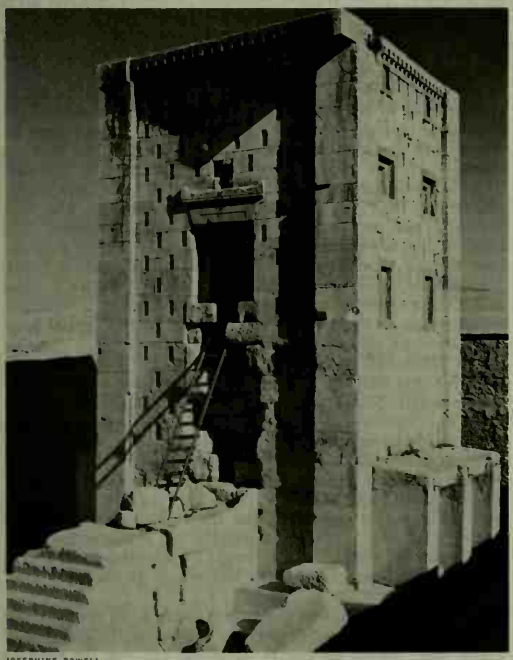
Law.—No collections of Persian laws have survived and information on the legal system is scant. The traditional, tribal law was unalterable, but the king could issue decrees. In matters of law and custom he was advised by the royal judges. They held their office, which was usually hereditary, for life and could be removed only for professional misconduct. Herodotus mentions the case of a judge who was executed by Cambyses II for accepting bribes and giving an unjust judgment. The punishment for treason was death, usually by beheading or crucifixion, but for other crimes the death penalty was not imposed for a first offense. It was customary to weigh the good deeds of an offender against his crime, as for example in the case of another corrupt judge who was reprieved by Darius because of his previous services to the crown. In the provinces the satrap was the chief judicial authority and there were Persian judges. Civil matters in the lower courts were usually decided by native officials in accordance with the native law. In Egypt Darius I caused the native law to be written down by the wise men, priests and scribes. There is evidence, however, that the administration of justice was often corrupt.

Armed Forces.—All the peoples of the empire were liable for military service. The standing army was composed mainly of Persians and Medes. The core troops were the Immortals, so called because their number was never allowed to fall below 10,000, a replacement being always available if a man fell sick or died. The first 1,000 formed the royal bodyguard, which was under the command of the chiliarch. In time of war contingents were drawn from the provinces, each being under the command of the satrap. There were permanent garrisons in the chief cities and border forts, many of the troops being mercenaries, as for example the Jews at Elephantine. In the higher ranks the command was predominantly Iranian. The army was organized in divisions of 10,000, battalions of 1,000, companies of 100 and squads of 10. It was divided into cavalry, infantry and archers. In all branches the usual arms were the bow, spear and dagger, but the equipment could vary according to nationality. Although the spear and dagger might be used in a charge, the bow was the chief Persian weapon. The aim was to overwhelm the enemy with a hail of arrows and never to allow him to come to close quarters. While the infantry knelt to shoot, the cavalry swarmed round the hostile squadrons, threw their lines into confusion and completed their discomfiture by a vigorous pursuit. Since it was essential for the archers to be mobile and their use of the bow to be unhampered, armour and shields were light. The empire was won by such tactics, but in the Greek wars, when once the generalship of a Miltiades or Pausanias had brought about a hand-to-hand conflict, the Persians, despite their bravery, succumbed to the heavily armed hoplites. After the time of Xerxes, therefore, the bow became a subordinate arm. The Persians had plenty of good cavalry, since each landowner maintained a troop of mounted retainers. The foot soldiers, however, were mainly undisciplined tribesmen or serfs, and in the later period of the empire the king and satraps came increasingly to depend on Greek mercenaries for their trained infantry.

The naval forces were supplied by Phoenicians, Egyptians, Cypriots and seafaring peoples of Asia Minor. The commanders of the fleet were, however, high-ranking Persians, and to guard against defection each trireme carried 30 Persian, Median and Scythian marines.

Economic Policy.—The financial basis of the empire was the payment of tax, in cash or kind, by all the subject peoples. Under the fiscal system introduced by Darius I, each province was liable for a fixed annual amount, which was assessed according to its productivity. The largest contributor was Babylonia, which, according to Herodotus, provided 1,000 silver talents, 500 eunuchs and four months' supply of food for the army. Egypt, the granary of the empire, supplied 700 talents, 120,000 measures of grain and profits from the fisheries. From India was exacted gold dust to the value of 4,680 talents. Herodotus assessed the annual cash payments, including the Indian gold dust, at 14,560 Euboic talents. Tax collection was the responsibility of the satrap, who, after deducting the cost of his administration, forwarded the balance to the king. Surplus revenues accumulated as a reserve fund which was stored in the royal treasuries, mostly as bullion, the gold and silver being melted down and poured into clay jars. Estimates of the amount of treasure seized by Alexander the Great vary, but according to Quintus Curtius he found 50,000 talents of uncoined silver at Susa, 120,000 talents at Persepolis and 6,000 talents at Pasargadae. Taxes in kind, which included horses and cattle, foodstuffs, clothing materials and all kinds of manufactured goods, provided for the support of the army and the households of the king and the satraps.

It is difficult to assess the burden of this taxation. It was probably not as onerous as is sometimes suggested, but corruption in the fiscal administration was undoubtedly a major cause of discontent. Against the taxation must be set the economic and social advantages conferred by peace, security and the development of trade among all parts of the empire.



JOSEPHINE POWELL

ZOROASTRIAN FIRE TEMPLE AT NAKSH-E ROSTAM

To facilitate the exact calculation of tax, Darius standardized coinage and weights and measures. The gold coin of 129 gr. was known in Greek as *dareikos*, a word derived by some authorities from the king's name, by others from Old Persian *daraniya*, "gold." It contained about as much gold as an English guinea and was the equivalent of 20 silver shekels. The coinage of gold was the exclusive prerogative of the king, but silver and copper could be coined by the satraps, generals, dynasts and autonomous cities. In the commercial centres of the west, where various forms of metal currency, including coinage, had previously been in existence, this monetary reform was of great advantage to trade and banking, but it can have had little effect in the more backward parts of the empire where the method of exchange was still by barter. The introduction of a money economy to a community which had hitherto known only payments in kind is strikingly illustrated by the wage lists from Persepolis. Payment based on coined money was introduced there by Darius about 493. In the first part of Xerxes' reign two-thirds of the wages were paid in kind and the balance in cash. Later in the reign the payment in kind was reduced to a half and in one instance to a third of the total amount due.

Imperial trade was further assisted by the improvement of land and sea communications. The great road system, while primarily developed for political and military reasons, also served the interests of commerce, as did the completion by Darius of the canal between the Nile and the Red sea and the exploration by Scylax of the sea route between India, Persia and Egypt.

Persian Religion.—During the Achaemenid period the polytheistic nature worship of the Aryan tribes was reformed by Zoroaster (*q.v.*) into an ethical dualism centred on Ahura Mazda (*q.v.*) as the only true god. The prophet preached the new faith in eastern Iran, probably in Chorasmia, in the 7th–6th century. How widely it was spread in its pure form is difficult to determine, but by the 5th century a religion had developed combining certain of Zoroaster's tenets with the cult of the old Aryan gods. (*See* also ZOROASTRIANISM.)

The extent to which the Achaemenid kings were influenced by Zoroaster's teaching is the subject of keen controversy. Inscriptions of the early rulers throw no light on the exact nature of their religious beliefs. Those of Darius I and Xerxes give pre-eminence to Ahura Mazda; no other gods are named, though their existence is recognized. Darius constantly insists on the aid and protection accorded him by Ahura Mazda and also stresses the nefarious role of the lie, which, he says, caused the provinces to rebel against him. Since exclusive devotion to Ahura Mazda and the concept of the dualism of truth and falsehood are basic to Zoroaster's religion, it is considered by many authorities that the beliefs of Darius were ultimately derived from those of Zoroaster, who, however, is never mentioned by the king. It has further been argued that Zoroastrian ideas were introduced into western Iran by Darius and that at first they were adopted only by the royal family and court circle. That the old nature worship continued among the common people is evident from the statement of Herodotus in the 5th century that the Persians sacrificed to the sky, sun, moon, earth, water and winds. Under pressure from the old religion, Zoroastrianism eventually became fully polytheistic. Artaxerxes II and Artaxerxes III invoke not only Ahura Mazda but also Mithra, the ancient Aryan god of the contract, and Anahita, who appears in the Avesta as a goddess of water and later as a fertility deity.

The gods might be represented by their particular symbols. So on Achaemenid reliefs Ahura Mazda is depicted rising from the winged disk, a symbol derived from Assyria though ultimately Egyptian in origin. The worship of divine images, however, was first introduced by Artaxerxes II, who was presumably influenced by cult practices in the western part of the empire. Herodotus says that the Persians had neither temples nor altars, that they offered blood sacrifices but lit no fire and made no libations. Although there is no evidence for temples housing a divine statue, at any rate prior to Artaxerxes II, places of worship certainly existed, for Darius states that he restored those destroyed by Gaumata. The towers at Pasargadae and Naksh-e Rostam are identified by some authorities as fire temples, while a terraced structure at Pasargadae and a building of unusual plan at Susa may also be shrines. Libations by a Magian priest appear to be mentioned in an Elamite tablet from Persepolis. This may refer to the offering of *hauma* (*homa*), an intoxicating drink, well attested for eastern Iran in the Avesta. A

fire altar is depicted on the royal tomb reliefs and also on a tomb at Qez Qapan in the district of the Shehrizor, for which a date of 600–550 is suggested. Actual examples of fire altars standing in the open occur at Pasargadae. The blood sacrifices to the gods are described in detail by Herodotus and Achaemenid kings are frequently mentioned by the Greeks as sacrificing horses and cattle and even on occasion human beings.

Sacrifices could take place only in the presence of a Magus, a member of a separate clan or caste of the Medes. The Magi (*q.v.*) were distinguished by certain peculiar customs, notably exposure of the dead. During the sacrifices they chanted a hymn and held a bundle of reeds (the barsom). They wore felt caps and covered their mouths with a band (*paitidana*) so that their saliva might not defile the sacred fire which it was their duty to tend. In addition to officiating at sacrifices, they participated in the coronation ceremony, guarded the royal tombs, accompanied the army with the sacred fire, interpreted dreams and assisted in the education of the royal princes. They constituted the professional priesthood of western Iran, serving all cults, and it is to their influence that the fusion of Zoroastrian and pre-Zoroastrian doctrines must be attributed.

The Achaemenids adopted a tolerant attitude toward the diversity of religions within the empire. In part this was a matter of policy, for by conciliating the native priesthoods they hoped to win influential support for their rule. This is well illustrated in Babylonia, where Cyrus II presented himself as the defender of the faith against the heretic Nabonidus and as the king chosen by the national god, Marduk. He not only permitted the priests to maintain existing rituals but himself participated in them and also restored the temples. A similar policy was followed by Cambyses and Darius in Egypt, although the former suppressed certain abuses in the temples and thereby earned the enmity of the priests. Cyrus permitted the exiled Jews to return to Jerusalem and rebuild the Temple, a decision which was confirmed by Darius, and Artaxerxes I afforded protection to Ezra and Nehemiah. With all the Greek oracles, even those in Greece, the Persians maintained excellent relations. In Babylonia, however, national revolts caused Xerxes to abandon a conciliatory policy. To prevent any future pretender from legitimizing his rule he destroyed the statue and temple of Marduk.

Sources for the Period.—For the inscriptions of the Achaemenid kings *see* R. G. Kent, *Old Persian: Grammar, Texts, Lexicon* (1950). Important details on the rise of Cyrus to power and his capture of Babylon are contained in the Persian verse account of Nabonidus and the Nabonidus chronicle (*see* S. Smith, *Historical Texts Relating to the Capture and Downfall of Babylon*, pp. 27 ff.; 1924). In the Old Testament, only the contemporary books of Ezra and Nehemiah are of importance, but there are a few statements in the later Esther romance. Information on the struggle of Egypt for independence in the 4th century is given in the *Demotic Chronicle* (*see* W. Spiegelberg, *Die Sogenannte Demotische Chronik*, 1914). The tablets from the Persepolis treasury and fortifications provide important information on religion and economic affairs in the time of Darius and Xerxes (*see* G. G. Cameron, *Persepolis Treasury Tablets*, 1948). Large numbers of business contracts from Babylonia throw light on economic and social conditions in that country. In Egypt Aramaic documents of the 5th century give information on administration and judicial procedure (see *Aramaic Papyri of the Fifth Century B.C.*, edited by A. Cowley, 1923; and *Aramaic Documents of the Fifth Century B.C.*, edited by G. R. Driver, 1957).

Among Greek sources, the most ancient work preserved is that of Herodotus, which is very valuable for the period up to 479. His material was drawn partly from sound tradition, partly original knowledge, as in the account of the satrapies, the Royal road and the army of Xerxes, but there is also much that is fabulous. The physician Ctesias of Cnidus, who for 17 years (414–398) was in the service of Artaxerxes II, composed a great work on Persian history, known from an extract in Photius and numerous fragments. Ctesias possessed a more precise acquaintance with Persian views and institutions than Herodotus did, and where he deals with matters that come under his own cognizance he gives much useful information. For the early period, however, he proves how rapidly the tradition had degenerated since Herodotus, and his narrative must be used with caution. Also of value is the work of Dinon of Colophon (*c.* 340), known from fragments, and a few statements from Heraclides of Cyme, which afford evidence on Persian institutions. To these must be added the testimony of the other Greek historians (*e.g.*, Thucydides, Ephorus, Theopompus, with the histories of Alexander) and, before all, that of Xenophon in the *Anabasis* and *Hellenica*. The *Cyropaedia* is a didactic romance, written with a view to Greek institutions and rarely preserving genuine information on the Persian empire. (J. M. M.-R.)

III. HELLENISTIC PERIOD

Alexander's conquest of the whole of the Achaemenid empire cannot be related in detail here. (*See* ALEXANDER III the Great.) The essential fact, however, is that after the victory of Gaugamela and still more completely after the assassination of Darius—avenged, according to the Persian laws, on the perpetrators—Alexander regarded himself as the legitimate head of the Persian empire and therefore adopted the dress and ceremonial of the Persian kings. With the capture of the capitals the Persian war was complete: a truth symbolically expressed in the burning of the palace at Persepolis.

Then began the world conquest—not in the sense of the "world kingdom" concept that subsequent to Alexander grew to comprehend specifically a plan to conquer the Mediterranean shores to the Strait of Gibraltar (the Alexander Romance had the great Macedonian actually accomplishing this feat) but in the more general and accepted sense of the vast Persian empire, whose ruler had become the nearest approach of the orient to its ancient ideal of universal king and whose domain Alexander probably expected to secure and extend. The basis of this new world order was to be the union of Macedonia and Persia, which Alexander began even while campaigning in the east and carried forward upon his return from India. It was in support of this program that the ceremonial of the Persian court, including *proskynesis* (prostration), was adopted by Alexander. This development was readily accepted by the Persians but not by the Macedonians, who, with few exceptions, acquiesced in it only with great reluctance. The union of the two nations was consummated by a great marriage feast at Susa, at which all Alexander's officers, with about 10,000 Macedonians, were married to Persian wives (324 B.C.). The Macedonian veterans were released and the army reorganized, with Persians serving on an equal footing. At this critical juncture Alexander died in Babylon, in June 323 B.C.

The Diadochi.—Alexander left no heir. Consequently his death not only ended the scheme of universal conquest but led to an immediate Macedonian reaction. The Macedonian army, which was considered as representative of the Macedonian people, took over the government under the direction of its generals. The policy of partnership between Macedonians and Persians initiated by Alexander was entirely abandoned; the Persian wives were practically all discarded and the Persian satraps removed, at least from all important provinces. But the attempt to maintain the empire in its unity proved impracticable, and almost immediately there began the embittered war, waged for several decades by the "successors" (Diadochi) for the inheritance of the great king. (*See* HELLENISTIC AGE.)

It was soon obvious that the eastern rulers, at all events, could not dispense with the native element. Peucestas, the governor of Persis, there played the role of Alexander and won the Persians completely to his side, for which he was dismissed by Antigonus Monophthalmus in 316. A similar position was attained by Seleucus—the only one of the Diadochi who had not divorced his Persian wife, Apama—in Babylonia, which he governed from 321 to 316 and regained in the autumn of 312. While Antigonus, who since 316 had striven to win the kingdom of Alexander for himself, was detained by the war with his rivals in the west, Seleucus, with Babylon as his headquarters, conquered the whole of Iran as far as the Indus. In northern Media alone, which lay outside

the main scene of operations and had been only partially subject to the later Achaemenids, the Persian satrap Atropates, appointed by Alexander, maintained his independence and bequeathed his province to his successors. His name is borne by northern Media to the present day (Atropatene, modern Azerbaijan). So, too, in Armenia the Persian dynasty of the Hydarnids held its ground. To these must be added, in the east of Asia Minor, the kingdoms of Pontus and Cappadocia, founded about the end of the 4th century B.C. by the Persians Mithradates and Ariarathes. These states were fragments of the Achaemenid empire which had safely transferred themselves to the Hellenistic state system.

The Seleucids.—The annexation of Iran by Seleucus I Nicator led to a war for the countries on the Indian frontier, Seleucus' opponent being Sandrocottus or Chandragupta (*q.v.*) Maurya, the founder of the great Indian Maurya empire with its capital at Pataliputra (Gr. Palibothra, modern Patna). The result was that Seleucus abandoned to the Indian king not merely the Indian provinces conquered by Alexander but even the frontier districts west of the Indus. As compensation for this cession of imperial territory he received 500 elephants, with other presents (*c.* 303 B.C.). His next expedition was to the west to assist Lysimachus, Ptolemy and Cassander in the overthrow of Antigonus (*qq.v.*).

The battle of Ipsus (*q.v.*), in 301, gave Seleucus Syria and northern Mesopotamia, and from that time he made the Syrian city of Antioch on the Orontes river his residence. Shortly afterward he handed over the provinces east of the Euphrates to his son Antiochus I Soter, who in the following years exercised in the east a very energetic and beneficial activity, which continued the work of his father and gave the new empire and the oriental Hellenistic civilization their form. In his campaigns Alexander had founded several cities in Bactria, Sogdiana and India in which he settled his veterans, and before his death he had begun or planned the foundation of Greek cities in Media and other parts of Iran. These plans were now executed by the Seleucid kings on the largest scale.

Most of the new cities were probably military colonies in the first place and only later evolved to the class of city. They fulfilled strategic needs, serving as a screen against unruly hill tribes within the frontiers of the empire (*e.g.* in Media) or against external enemies. Some, however, were from their foundation truly self-governing Greek cities of the normal type. Of this class may be mentioned Antioch in Persis, founded by settlers from Magnesia in Asia Minor; Alexandria (also known as Charax) at the mouth of the Tigris; Seleucia (*q.v.*) on the Tigris; and Seleucia (Susa; *q.v.*) on the Eulaeus (Karun) river.

Though many of the inhabitants were Asians or people of mixed race, the new colonies preserved their distinctive character as islands of Greek life and influence. The Seleucids counted upon these widely distributed settlements for active support in maintaining their authority in the various regions of their empire. Except in Bactria, where after about 250 B.C. they supported their own dynasty, the Greek settlers did in fact usually identify their interests with those of the Seleucid kings and proved their loyalty. In return for this loyalty they were apparently allowed much freedom in their internal affairs. The degree of control exercised over them by the provincial governors, either satraps or strategi ("generals"), and the variation in this control between one place and another cannot in the absence of sufficient evidence be determined. The new foundations, as had no doubt been envisaged by their founders, greatly aided the growth of commerce throughout the empire and with foreign countries.

Shortly after his conquest of Babylonia, Seleucus Nicator had founded a new capital, Seleucia on the Tigris, his intention being at once to displace the ancient Babylon from its former central position and to replace it by a Greek city. This was followed by a series of other foundations in Mesopotamia, Babylonia and Susiana (Gr. Elymais). "Media," says Polybius (x, 27), "was encircled by a sequence of Greek towns, designed as a barrier against the barbarians." Among those mentioned are Europus (formerly Rhagae) near modern Teheran, Laodicea (? modern Nahavand), Apamea and Heraclea. To these must be added Achaea in Parthia and, farther to the east, Alexandria (Herat) in Aria, Antioch (later Merv) in Margiana (on the site of a destroyed Alexandria) and many others; farther still, Alexandropolis or Alexandria (usually identified with Kandahar) in Arachosia, Alexandria Prophthasia in Drangiana, and the towns founded by Alexander in Bactria, Sogdiana and the mountain country of the Hindu Kush (*see* ALEXANDRIA [cities]).

Thus an active Hellenic life soon arose in the east; Greek settlers must have come in numbers and founded new cities which afterward formed the basis of the Greco-Bactrian kingdom. Journeys of exploration, which were aimed at seeking out and developing new routes for commerce, were undertaken by Seleucid generals in central Asia beyond the Jaxartes (Syr-Darya) river, the northeastern frontier of the empire, and around the shores of the Caspian sea.

While Hellenism was thus gaining some footing throughout the east, the native population remained absolutely passive. Apart from the rude mountain tribes, no national resistance was dreamed of for a long time. The Iranians quietly accepted the foreign yoke, and the higher classes adopted the external forms of the alien civilization even though they actually retained their own characteristics. Eratosthenes, for instance, spoke in high terms of the Iranians, ranking them (as well as the Indians, Romans and Carthaginians) on a level with the Greeks in their capacity for adopting city civilization. The later Parsee tradition contends that Alexander burned the sacred books of Zoroaster, the Avesta, and that only a few fragments were saved and afterward reconstructed by the Arsacids and Sassanids. This however is absolutely unhistorical. The Persian religion was never attacked by the Macedonians and Greeks. Under their dominion, on the contrary, it expanded with great vigour, not only in the west (Armenia, north Syria and Asia Minor, where it was the official religion of the kings of Pontus and Cappadocia) but also in the east, in the countries of the Indian frontier. That the pre-Zoroastrian gods—Mithra, Anahita (Gr. Anaitis), etc.—had come to the forefront has been mentioned above. This movement, however, was void of all national character and ran on precisely the same lines as the movement in the Syrian, Jewish and Egyptian cults. Only in Persis itself did the national character of the religion survive side by side with the memory of the old Persian empire; there a local Persian dynasty continued to rule in the centre of the province at Istakhr (*see* PERSIS).

Decline of the Seleucids.—The gigantic empire conquered by Seleucus I, stretching from the Aegean sea to India, was not easy to control, and everywhere it offered points of attack to external enemies. The wars which the Seleucid kings of the 3rd century B.C. had to fight with their Ptolemaic rivals in Egypt and with lesser states such as Galatia and Pergamum inevitably had repercussions in the eastern regions of their empire, the more so since the vast empire with its many races held together only in a loose administrative framework was always threatening to break apart. The borders of Iran were severely affected. In Parthia two brothers, Arsaces and Tiridates, revolted against their Seleucid satrap and founded an independent kingdom and the Parthian era, beginning in 247 B.C. In vain did Seleucus II toward the end of his reign (228 B.C.) attempt to suppress the new state. The Bactrian Greeks had established an independent state at about the same time.

At the accession of Antiochus III (223 B.C.) the greater part of Iran was, however precariously, still in Seleucid hands. In 220 Antiochus suppressed an insurrection of the satraps of Media and Persis. Ten years later he led a great expedition into the eastern provinces with the purpose of restoring the imperial authority in its full extent. Media was reduced to order (210), and successful campaigns were waged against the Parthians (209) and against Euthydemus, king of Bactria (208–206). In spite of his successes Antiochus concluded peace with both kingdoms, rightly considering that it would be impossible to retain these remote frontier provinces permanently. He next made a pact of friendship with the Indian king Sophagasenus (Subhagasena; 206), then returned by way of the southern provinces—Arachosia, Drangiana, Carmania and Persis—to Babylonia, which he reached in 205 or 204. This great expedition had fully re-established the Seleucid do-

minion in Iran and its border lands. But Antiochus' defeat by the Romans in 190/189 B.C., with the resultant loss of territory in Asia Minor and the heavy war indemnity imposed, enfeebled the rest of his empire. In order to raise money he plundered a wealthy temple of Bel in Elymais but was killed by the inhabitants (187). His presence in Elymais suggests that he had decided to undertake new measures to strengthen his hold on the eastern provinces.

The governors of Armenia now asserted their independence. Artaxias founded the kingdom of Greater Armenia and Zariadres the kingdom of Sophene on the Euphrates and the source of the Tigris. In other districts rebellions also occurred; and in the east the Bactrian kings, Euthydemus and his successors, began to conquer the eastern Iranian provinces (Arachosia, Aria, etc.) which were still nominally Seleucid. (*See* BACTRIA; DEMETRIUS [king of Bactria]; EUCRATIDES; EUTHYDEMUS.)

Antiochus IV Epiphanes (175–163 B.C.) restored once more (at least in part) the eastern dominion. He defeated Artaxias of Armenia, restored several towns in Babylonia and subdued the Elymaeans. Persis, also, and Media were still subject to him. He tried to strengthen Hellenism throughout his empire by settling Greek colonists and mercenaries in the native towns and granting them the status of Greek cities. But his premature death at Gabae (Isfahan) in Persis prevented his achieving his next aim: the conquest of Parthia and the reincorporation within the Seleucid empire of the independent Bactrian state in east Iran. In 161/160 Demetrius I Soter (162–150 B.C.) suppressed the revolt in Media and Babylonia of Timarchus, the governor of the upper satrapies. During his reign the Seleucid empire still embraced those provinces and perhaps also Persis. *See* also ANTIOCHUS; SELEUCID DYNASTY. (R. H. Si.)

IV. PARTHIAN EMPIRE, 2ND CENTURY B.C.–3RD CENTURY A.D.

Arsacids.—Meanwhile, in the east, the Parthian Arsacids had begun their expansion (*see* ARSACES). Phraates I (*q.v.*; *c.* 176–171 B.C.) subdued the Mardians in the Elburz mountains. His brother Mithradates I (*q.v.*, *c.* 171–*c.* 138 B.C.) had to sustain a difficult war with Eucratides of Bactria, but eventually succeeded in wresting from him the districts of Tapuria and Traxiana which lay in the vicinity of Tus and Meshed. However the tradition that Mithradates advanced eastward beyond the Indus depends only on a doubtful interpretation of a passage in Orosius. In the west he conquered Media and invaded Babylonia. Though in 140 the Seleucid king Demetrius II Nicator took the field in order to save the east, the latter was defeated and captured. Mithradates next reduced the province of Elymais, according to Strabo and Justin, sacking an important temple of Artemis in the mountains, and capturing the Greek city of Seleucia on the Hedyphon (Surraq, near Behbehan in southwest Iran). His son Phraates II (*c.* 138–128) was attacked in 130 by Antiochus VII Sidetes, brother of Demetrius II, whom Phraates promptly released. Antiochus advanced and once more recovered Babylonia, but was defeated during 129 in Media, and fell in a desperate struggle. With this battle Seleucid dominion over the countries east of the Euphrates was finally lost. The Babylonian towns, especially Seleucia, were handed over by Phraates to the Hyrcanian Himerus, who punished them severely for their resistance.

TABLE I.—*Arsacid* (*Parthian*) *Kings*

Name	Reign years	Name	Reign years
Arsaces	*c.* 250/247 B.C.–?	Orodes III	A.D. 4–*c.* 6/7
Tiridates I	?–*c.* 211	Vonones I	7/8–12
Artabanus I	*c.* 211–191	Artabanus III	12–*c.* 38
Priapatius	*c.* 191–176	Tiridates III	*c.* 36
Phraates I	*c.* 176–171	Cinnamus	*c.* 37
Mithradates I	*c.* 171–138/137	Gotarzes II	39 or 44–51
Phraates II	*c.* 138–128	Vardanes	*c.* 39–47/48
Artabanus II	*c.* 128–124/123	Vonones II	*c.* 51
Mithradates II	*c.* 123–*c.* 87	Vologaeses I	51/52–79/80
Gotarzes I	91–81/80	Pacorus II	78–115/116?
Orodes I	80–77/76	Artabanus IV	80–81
Sanatruces	..77/76–70 or 69	Osroes	*c.* 109/110–128/129
Phraates III	70 or 69–58/57	Parthamaspates	*c.* 117
Mithradates III	56–55	Vologaeses II	105/106?–147
Orodes II	*c.* 57–37	Mithradates IV	128/129?–147?
Pacorus I	d. 38	Vologaeses III	148–192
Phraates IV	*c.* 38–*c.* 32	Vologaeses IV	191–208/209
Tiridates II	*c.* 30–25	Vologaeses V	208/209–228/229
Phraataces (Phraates V)	2 B.C.–A.D. 4	Artavasdes	212/213–224
			c. 228

In 140 the Seleucid king Demetrius II Nicator took the field in order to save the east, the latter was defeated and captured. Mithradates next reduced the province of Elymais, according to Strabo and Justin, sacking an important temple of Artemis in the mountains, and capturing the Greek city of Seleucia on the Hedyphon (Surraq, near Behbehan in southwest Iran). His son Phraates II (*c.* 138–128) was attacked in 130 by Antiochus VII Sidetes, brother of Demetrius II, whom Phraates promptly released. Antiochus advanced and once more recovered Babylonia, but was defeated during 129 in Media, and fell in a desperate struggle. With this battle Seleucid dominion over the countries east of the Euphrates

During these wars great changes had taken place in eastern Iran. Powerful nomadic tribes, the Sacae and the Tochari (or Tukharians, called Yue-chi [*q.v.*] by Chinese writers), forced their way into Sogdiana, and about 130 overran Bactria. From Bactria they began to advance farther into Iran and India. Phraates II marched to encounter them. He pressed into service Greek prisoners from the army of Antiochus, but these deserted him in the battle. Phraates was defeated and slain, while his country was extensively ravaged. His successor was Artabanus II (also numbered I; *c.* 128–124/123), the uncle of Phraates, who likewise fell in battle against the Tochari; but his son Mithradates II, called the Great (*c.* 123–*c.* 87), apparently defeating the Scythians, restored for a while the power of the Arsacids. He also defeated Artavasdes, king of Greater Armenia, whose son Tigranes (*q.v.*) became a hostage in Parthian hands, and was redeemed, as Strabo related, only for the cession of 70 valleys. Tigranes subsequently attempted to seize Cappadocia, and the Roman praetor L. Cornelius Sulla advanced against him. In 92 B.C. Mithradates, whose forces were also advancing into north Syria against the declining Seleucids, concluded the first treaty between Parthia and Rome.

Meanwhile a prominent Parthian, Gotarzes, named as satrap of satraps in the Greek inscription at Bisitun, was establishing himself as an independent monarch in Babylonia. Mithradates still controlled Iran and northern Mesopotamia until his death (not before 87 B.C.), after which, profiting from the division of the Parthian kingdom, Tigranes of Armenia extended his power and assumed the dignity of "great king." Soon, however, a son of Mithradates II, Orodes I, had risen in Iran to assert his hereditary right against Gotarzes. Cuneiform tablets show that by 80 B.C. Orodes had replaced Gotarzes in Babylonia. His reign was brief. It was followed by the period of the famous "campaign coins" which, exceptionally, bear mint names Rhagae (Ray), Traxiana, Margiana, Aria and an inscription in Greek meaning "on an expedition." They seem to attest a reconquest of territory from Orodes, though whether by a Gotarzes returned to power or by an "unknown king" is still disputed. This period of confusion came to an end when in 77 B.C. the octogenarian king Sanatruces was set on the Parthian throne by the central Asian tribe of the Sacaraucae. Yet it was not until Sanatruces' successor, Phraates III (*c.* 70–*c.* 57), that the kingdom was once again in a completely settled state.

Organization.—The Parthian empire as founded by the conquests of Mithradates I and restored first by Mithradates II, and again by Phraates III, was in many of its outward forms a revival of the Achaemenid empire. Thus the Arsacids began to assume the old title "king of kings," though previously their coins had, as a rule, borne only the legend "great king." As will be seen, their script was directly derived from the Aramaic of the Achaemenid chancery.

Meanwhile, as successors to a Greek administration in one province after another, the Parthians assimilated Greek government practice, and, in addition to their own ideographically written language (described below), for many purposes made use of Greek (*e.g.*, on their coinage), while there are several reports of Parthian rulers who understood spoken Greek. In reality, however, the Parthian empire was radically different in structure from its predecessors. Instead of aiming at direct, centralized government of its territories, it was an early example of a feudal type of organization, in which the greater part of the empire was governed on behalf of the "king of kings" by vassal princes belonging to hereditary local dynasties. Thus the direct possessions of the kings —provinces governed by their satraps—consisted of a rather narrow strip of land, stretching from the Euphrates and north Babylonia through southern Media and Parthia as far as Arachosia (in southeastern Afghanistan). In addition to the vassal states, there were also a number of Greek cities of Seleucid foundation which retained some degree of local autonomy within the royal provinces and the states of the vassal kings. Nicephorium, Anthemusia,

Ichnae, Artemita and Chala are all mentioned as Greek cities in Mesopotamia, but by far the most important of the autonomous cities was Seleucia on the Tigris. The documents of the royal administration were often dated according to the Arsacid era, which commenced in 247 B.C. In contrast the Greek cities continued to date by the Seleucid era, which in the Babylonian reckoning commenced in 311 B.C. (used for instance on the Parthian tetradrachma coinage minted at Seleucia), or with a double dating referring to both eras.

Topography of the Parthian Empire.—The main axis of the empire lay along the principal trade route running from west to east, but in the 1st century B.C. there was a shift in the centre of gravity of the Parthian kingdom from the northeast to the plains of Mesopotamia. This was no doubt the result of pressure in the east from the nomadic central Asian tribes. Thereafter the capital of the empire was generally at Ctesiphon (*q.v.*), the Parthian suburb opposite Seleucia on the east bank of the Tigris, the two forming a twin city. It is noteworthy that the mint for the Parthian royal tetradrachma coinage seems always to have remained at Seleucia.

To the west, on the Euphrates, excavations at the Parthian frontier post of Doura-Europus (*q.v.*) have revealed many notable finds. Between Doura and the Tigris lay Hatra (Arabic Al Hadr), a frontier fortress held by Arab allies of Parthia, and also the site of important excavations by the Iraq government. Eastward of the capital lay Artemita, and farther along the eastward route lay Kangavar, a town which still exists and was in Parthian times the site of a temple of Artemis (Anahita) of which traces survive. Ecbatana (Hamadan) seems to have retained its importance under the Parthians.

An important centre farther east was Rhagae (Ray), of which the ruins are situated a few miles southeast of the modern capital of Iran at Teheran. Eastward again from Rhagae were the districts of Choarene and Comisene. In the latter district Polybius describes an important city and early Parthian capital at Hecatompylos, thought to be in the neighbourhood of modern Damghan, though the site has not been identified on the ground. Near Hecatompylos was a mighty castle, Tagae, sometimes identified with the medieval stronghold of Girdkuh, rather than the site northeast of Damghan known as Taq.

Not far from this point the main route crossed to the north of the Elburz range into Hyrcania (Gorgan province). Here the provincial capital was Zadracarta; this site may be marked by the findspot of the Hellenistic inscription near Asterabad (Gorgan). In the same province are mentioned the towns of Tambrax and Syrinx, of uncertain location.

The next district was Astavene (Ustawa), with its chief city Asaak (apparently in the vicinity of modern Quchan) where Arsaces, the first Parthian king, was proclaimed. There a perpetual fire was reverenced. Farther to the northeast was the district of Parthyene, with its capital city Mithradatkert (Nisa), near to the modern Ashkhabad, the scene of important Soviet excavations. Then followed Apavarcticene (Abivard) and Margiana (the district of Merv).

Southward of Merv, following the Royal road, lay the province of Aria (Herat), with its two cities of Artacavana and Alexandria of the Arians. Beyond these to the southwest came the territory of Anauon, in which lay the cities of Farah, Bust and Neh, all of which still retain their names in virtually the same forms as in Parthian times. There followed the districts of Drangiana, Sakastan (Sanskrit Sakasthana, known also as Paraetacena) and Arachosia, the latter comprising the modern province of Kandahar. These eastern provinces were only for limited periods subject to the central government of the Parthian king. During the 1st century A.D. they appear to have formed part of the independent Indo-Parthian kingdom, with its best-known centre at Taxila in West Pakistan.

Vassal States.—The royal provinces were surrounded to the south by a ring of minor states, which as a rule were dependent on the Arsacids, though occasionally transferring their allegiance on the rise of a new power, such as that of Tigranes of Armenia, or a Roman invasion. Of the vassal kingdoms, only Characene, Elymais and Persis together with some of the city-states, such as Hatra and Seleucia, were permitted to issue coinage while under Parthian control. The most important of the Parthian vassal states were the following:

1. The kingdom of Osroene (*q.v.*) in the northwest of Mesopotamia, with Edessa as capital.

2. The desert of Mesopotamia, which came to be known in Parthian as Arabistan, after its population of Arab tribes under the rule of chiefs. One of these, Alchaudonius, became prominent in the period of Tigranes and Crassus. According to Plutarch and Pliny the former encouraged the Arabs to settle in Mesopotamia. In the 2nd and 3rd centuries A.D. the Arab city of Hatra in this region became an important Parthian frontier fortress, governed by its own dynasty, of Aramaic origin.

3 and 4. To the east of the Tigris two kingdoms, Gordyene (Cordyene), the country of the Carduchians, a mountainous district south of Armenia; and Adiabene (Hadyab), the ancient Assyria, with its metropolis at Arbela (Irbil; *q.v.*), situated on either side of the Zab river.

5. On the farther side of the Zagros mountains, adjoining Adiabene to the east, the kingdom of Atropatene in north Media,

THE PARTHIAN EMPIRE

the name of which is preserved in the modern Azerbaijan. By the ancient writers this kingdom was often referred to simply as Media (*q.v.*).

While the power of Armenia was at its height under Tigranes in the 1st century B.C., all these states acknowledged his rule. After the victories of Pompey, however, the Romans claimed the suzerainty, and during the expeditions of Crassus and Mark Antony they oscillated between Rome and Parthia, though their inclination was generally to the latter.

6. In the south of Babylonia, in the district of Mesene (Persian Meshan), on the fall of Antiochus VII Sidetes in 129 B.C. a local prince, Hyspaosines or Spasines, son of Sagdodonacus, founded a kingdom which survived until the rise of the Sasanian empire. In a cuneiform inscription of 127, on a clay tablet dated after that year, he is called Aspasine. A town originally founded by Alexander near the junction of the Eulaeus (Karun) with the Tigris was refortified with dikes by Spasines and became known as Spasinu Charax ("the fort of Spasines"), or, in Pliny, simply Charax. In the following centuries it was the main mercantile centre on the Tigris estuary, but the site has not been precisely located in modern times.

This kingdom of Mesene, also called Characene, is known from occasional references in various authors, especially Lucian. The chief source of information, however, is to be found in the numerous coins of the dynasty, to which a large find of coins from Basra brought important accessions. The coins are dated according to the Seleucid era and make it possible to compile the following fairly complete list of the local kings:

Hyspaosines (127–*c.* 121 B.C.)	Abinerglus (*c.* A.D. 10–*c.* 13)
Apodacus (*c.* 109–*c.* 105)	Adinerglus (*c.* 22)
Tiraeus I (*c.* 90–*c.* 89)	Attambelus III (*c.* 38–*c.* 44)
Tiraeus II (*c.* 78–*c.* 48)	Thionesius II (*c.* 46)
Artabazus (48–47)	Thionesius III (*c.* 52)
Attambelus I (*c.* 46–*c.* 28)	Attambelus IV (*c.* 54–64)
Thionesius I (*c.* 20)	Attambelus V (*c.* 73)
Attambelus II (*c.* 17 B.C.–*c.* A.D. 8)	Attambelus VI (*c.* 104–*c.* 105)
	Thionesius IV (*c.* 111–*c.* 112)

7. East of the Tigris lay the kingdom of Elymais (Elam), to which belonged Susa and its modern representative Ahvaz, farther down on the Karun. The heart of the kingdom lay not at Susa, however, which seems to have fallen into Parthian hands and to have been administered by a Parthian satrap, but close under the mountains of Luristan near Behbehan and Izeh (formerly called Malamir), where the local dynasty has left rock reliefs and inscriptions in a form of Aramaic. The monuments of Tang-e Sarvak, north of Behbehan, which relate to a King Orodes of this dynasty, were studied in detail by W. B. Henning. The dynasty seems to have been founded by a ruler named Kamnaskires, known from coins dated 81 B.C. The coinage of another Orodes, who reigned shortly after A.D. 59, displays Aramaic script. The kingdom, though seldom mentioned, survived until its extinction by Ardashir I.

8. In the district of Persis (*q.v.*), the local dynasts became independent in the time of Antiochus IV, and on their coins appear as zealous adherents of Zoroastrianism and the fire cult. These coins bear inscriptions in the Persian language but written ideographically with Aramaic characters. They were forced, however, to acknowledge the suzerainty of Parthia, to which they stood in the same position as the Persians under the forefathers of Cyrus had stood to the Medes. Later, before the foundation of the Sassanid power, Persis disintegrated into a number of small local states. Even in Carmania (Kerman) there were independent kings.

9. The east of Iran was never subject to the Arsacids. In Arachosia and the Punjab, however, there appears in the 1st century A.D. an independent dynasty with Iranian and indeed peculiarly Parthian names. This was the Indo-Parthian dynasty. Its best-known representative, Gondophares (*q.v.*), reigned over Arachosia and the Indus district from *c.* A.D. 19 to 45. According to a legend which may contain a substantial core of historical truth, it was under Gondophares that the apostle Thomas visited northern India to preach there. A vivid picture of life in Taxila under the Indo-Parthians is also given by Philostratus in his *Life of Apollonius of Tyana*, which describes in somewhat legendary terms a visit to that city of the sage Apollonius. Apollonius reached Taxila after visiting the Parthian capital in the third year of Vardanes I (A.D. 42/43), and having resided there for at least one year and four months; other indications suggest that Apollonius was in Taxila in A.D. 49. There is a description of the Indo-Parthian "satrap of the Indus," presumably one of the satraps of Chukhsha known from inscriptions, who was corresponding cordially with the Parthian king in the tone not of a vassal but of the representative of a fully independent power, an impression that is likely to be historical. It was the Kushan invasion of the Indo-Parthian empire in the second half of the 1st century A.D. which brought about its downfall. This event may have occurred around A.D. 78, and approximately contemporary is the reference in the anonymous *Periplus of the Erythraean Sea* to Parthian princes at Minnagar in the Indus delta (an unlocated site) "continually expelling one another."

Remains of the Parthian Language.—Knowledge of the history and culture of the Parthian empire is largely based on descriptions given by Greek and Latin authors. Research in the 20th century, however, has made available an increasing body of material relating to the language employed by the Parthians themselves. The speech of the nomadic founders of the Parthian state, the Parni and Dahae, was described by Justin as "halfway between Scythian and Median, and a mixture of both." They seem, however, to have adopted the speech of the original Iranian inhabitants of Parthia (Parthava), and the language subsequently attested as Parthian is a standard north Iranian dialect. Until the middle of the 1st century B.C. it retained unvoiced consonants between vowels, together with the other characteristics of an Old Iranian dialect. Later came the transition into the Middle Iranian phase. To this Middle Iranian dialect, however, a peculiar writing system was applied, that which in later times was called Pahlavi, meaning "Parthian." In modern usage, however, the term Pahlavi is specifically applied to the form of writing used by the Sasanians (*see* PAHLAVI LANGUAGE), the term Parthian being reserved for the earlier form. The script was a derivative of Achaemenid chancery Aramaic, and in the writing of many common Iranian words the Aramaic equivalent was written to represent the root but with the addition of the terminations proper not to the Aramaic but to the Iranian dialect itself. The resulting hybrid forms were simply pronounced as Iranian. With the passage of time the proportion of Aramaic ideograms diminished and that of Iranian phonetic spellings increased, this process evidencing the gradual falling out of use of the Aramaic language in Iran.

Among the earliest monuments of this ideographically written Parthian language are the ostraca discovered in Soviet excavations at Nisa, a site named Mithradatkert after its Parthian founder in ancient times. It is situated not far from Ashkhabad in the Turkmen S.S.R. Also in ideographically written Parthian is one of the three parchments found at Avroman (Owraman) in Kurdistan and dated to A.D. 53, the other two being in Greek and dating from the 1st century B.C. Apart from these the extant texts in ideographic Parthian are limited to a small number of minor inscriptions and to the Parthian texts of the bilingual and trilingual Sasanian inscriptions, discussed below.

There exist, however, a considerable number of texts in Parthian dialect, written phonetically in a form of the Syriac script, among the Manichaean documents recovered by expeditions from central Asia. The work of piecing together these fragmentary manuscripts was carried on over many years by F. Andreas, F. Müller, C. Salemann, W. B. Henning, M. Boyce and others. From this material a considerable body of linguistic evidence was brought together, which greatly extended knowledge of the spoken forms of Parthian and contributed to the interpretation of the more difficult texts in ideographic writing.

Besides these written texts, there is substantial evidence of the existence among the Parthians of an extensive literature of oral poetry, recited by minstrels, notably at the courts of kings and nobles. This poetry, mainly devoted to heroic subjects, seems to have been composed, unlike the later Islamic Persian verse, in stressed rather than syllabic metre and without the use of rhyme,

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PERSIAN COINS: (TOP) SIGLOS OF DARIUS; (SECOND) TETRADRACHMA OF THE SATRAP TISSAPHERNES; (THIRD) TETRADRACHMA OF MITHRADATES II OF PARTHIA; (BOTTOM) DRACHMA OF SHAPUR I [ENLARGED]

an Arabic innovation. It is reflected, though in reworked form, in Gurgani's poem *Vis u Ramin*, and in the episode of Godarz in the *Shah-nama* of Firdausi; also more directly in the *Yadgar i Zareran*, a Middle Persian poem in the Pahlavi script. Though apparently of great richness and extent, this Parthian minstrel poetry was rarely set down in the cumbrous ideographic script and has otherwise almost entirely perished.

Cultural Elements in the Parthian Empire.—Three national elements of widely differing kinds contributed to the origin of the Parthian empire. On the one hand the state sprang from a predatory nomad tribe, the Scythian Dahae, which had established itself in Khurasan, on the borders of civilization, and gradually annexed further districts as the political situation or the weakness of its neighbours allowed. Consequently these nomads were the main pillar of the empire, and from them appear to have derived the great magnates, with their huge estates and hosts of serfs, who composed the imperial council, led the armies, governed the provinces and made and unmade the kings.

The military organization was nomadic in character and was made up of two arms. First the heavy cavalry (cataphracti), in which the rider and often even the horse were fully protected in armour of steel scales. These were armed with the great lance (contus) and employed shock tactics to break an enemy line. The heavy cavalry with their elaborate equipment were recruited mainly from the wealthier retainers of the nobles and composed the bodyguard of the generals—for example that of Surenas (the Suren, a Parthian hereditary title) on the occasion of the Roman defeat at Carrhae (53 B.C.). The mass of the Parthian cavalry, however, was composed of horse archers, less heavily armoured but of legendary equestrian skill and mobility. From these is derived the familiar picture of the Parthian horseman shooting over his shoulder as he retires.

The importance of the nomadic element in the Parthian empire is obvious from the fact that in the civil wars the deposed kings consistently took refuge among the Scythian Dahae and were restored by them. Yet in Parthia these nomads became assimilated to the local peasantry and came to adopt their dress and manners as well as their religion. Even the kings, after the first two or three, wore their hair and beards long after the Iranian fashion, whereas their predecessors were beardless.

Unlike the Achaemenians and the Sassanids, the Arsacids seem to have lacked any strong religious conviction; yet they appear to have acknowledged at the same time the old Iranian gods and the leading tenets of the Zoroastrian fire cult. They erected fire altars and, according to Justin, obeyed the commandment to abandon all corpses to the dogs and fowls. At the same time archaeological excavation both at Susa and in Soviet territory suggests that inhumation burial in sarcophagi of terra cotta continued to be practised in Iran under Parthian rule, at least among the subject populations. The union recommended by the Zoroastrian creed between brother and sister—and even son and mother—occurred among the Parthians. And besides the council of the nobility there was, according to Strabo, a second council of "Magians and wise men."

At the same time, the dominant world culture of Hellenism had also penetrated Parthia and Media. Parthia was indeed the successor state of the Seleucid empire, and some acquaintance with Hellenic culture was indispensable to every state which hoped to play a part in world affairs and was not so utterly secluded as Persis and Atropatene. Moreover the Arsacids lacked any strong cultural tradition of their own. Many of their institutions were borrowed from the Seleucid empire—their coinage with its Greek inscriptions, its nomenclature and Attic weight standard, and in all probability much of their administrative practice also. In the towns many Greek merchants were settled. The first Mithradates himself assumed, after his great conquests, the title Philbellene, "friend of the Greeks," which was retained by many of his successors. There follow the surnames Epiphanes, "(God) Manifest"; Dikaios, "the Just"; and Euergetes, "the Benefactor." All these were essentially Greek in their reference and were regularly borne by the Parthian kings. Orodes I spoke good Greek, and Greek tragedies were staged at his court, as Plutarch relates.

It was not until the 1st century A.D. that Greek influence began to weaken. The Greek script of the chanceries in Media and Babylonia was replaced by Parthian, as can be seen from the third of the Avroman parchments. The Hellenistic character of the coinage succumbed to a process of conventionalization, and as the Greek coin inscriptions become increasingly illegible the name of the king is in several cases indicated by Parthian inscriptions, usually in the form of abbreviations. This decline of Parthian Hellenism can naturally be associated with the seven-year revolt of Seleucia from the royal authority between A.D. 35 and 42. The city was finally brought to terms by Vardanes. Subsequently Vologaeses I (*q.v.*; A.D. 51/52–79/80) founded nearby in the district of Nahr Malka (*i.e.*, of the royal canal, which joined the Euphrates to the Tigris near Seleucia) the city of Vologesias or Balashabad. The new city took over much of the commercial prosperity of the old, and from this moment the influence of Babylonian Hellenism was greatly reduced.

Wars With Rome.—The feudal and decentralized structure of the Parthian empire may help to explain why, though founded on annexation and perpetually menaced by hostile armies both in the east and the west, it never took a strong offensive after the days of Mithradates II. It was bound to protect itself against

attack both from the Scythians in the east and from the Romans in the west. To maintain or regain suzerainty over Mesopotamia and the vassal states of that region, as also over Atropatene and Armenia, was the imperative task. Parthia thus tended to remain on the defensive and even in this role was often lacking in energy. Whenever it made an effort to enforce its claims, it retreated as soon as confronted by a resolute foe.

The wars between Parthia and Rome therefore were initiated not by the Parthians—deeply injured though they were by the encroachments of Pompey—but by Rome itself. Rome felt itself obliged, reluctantly enough, to enter upon the inheritance of Alexander the Great, and since the time of Pompey had been subjecting the Hellenistic countries as far as the Euphrates. The task now faced the Romans of annexing the remainder of the Seleucid empire, which had covered the whole east from the Euphrates to the Indus, and thus of saving Greek civilization (as is argued by Plutarch in his comparison of Nicias and Crassus). The aristocratic republic quailed before such an enterprise, though Lucullus at the height of his success entertained the thought. However the ambitious men whose goal was to erect their own sovereignty on the ruins of the republic took up the project. With this objective M. Licinius Crassus, the triumvir, in 54 B.C. took the offensive against Parthia, the occasion being favourable because of dynastic troubles between Orodes II, the son of Phraates III, and his brother Mithradates III. The Roman infantry proved incapable of countering in open country the cavalry tactics of the Parthians; Crassus' forces were reduced to the last extremity, and he met his death at a parley, allegedly by treachery (June 9, 53 B.C.), after his army was routed at Carrhae. After this battle Mesopotamia was regained by the Parthians, and King Artavasdes of Armenia entered their alliance. But apart from the ravaging of Syria (51 B.C.) by Pacorus, the son of Orodes, the threatened attack on the Roman empire materialized neither then nor during the civil war of Caesar and Pompey.

At the time of his assassination Caesar was intent on resuming the expedition of Crassus. The Parthians formed a league with Brutus and Cassius, as previously with Pompey, but gave them no support until in 40 B.C. a Parthian army led by Pacorus and the republican general Q. Labienus harried Syria and Asia Minor. It was repulsed by Publius Ventidius, Mark Antony's lieutenant, and Pacorus himself fell on June 9, 38 B.C., at Gindarus in northern Syria. Antony then attacked the Parthians in 36 B.C. and penetrated through Armenia into Atropatene, but was defeated by Phraates IV—who in 37 B.C. had murdered his father, Orodes II—and compelled to retreat with heavy losses. The continuation of the war was frustrated by the conflict with Octavian. Armenia alone was subdued in 34 B.C. by Antony, who treacherously captured and executed King Artavasdes.

Roman Settlement.—That the Romans expected Augustus to take up the work of his predecessors, annihilate the Parthian dominion and subdue the east as far as the Indians, Bactrians and Seres is clear from Virgil, Horace and the other Augustan poets. Augustus, however, disappointed these expectations, since his whole policy and the needs of the newly organized Roman empire demanded peace. His efforts were devoted to reaching a *modus vivendi* by which the authority of Rome and its most vital claims might be peacefully vindicated. This the weakness of Parthia enabled him to do without much difficulty. His endeavours were assisted by the revolt of Tiridates II (*q.v.*), before whom Phraates IV was compelled to flee (32 B.C.) until he was restored by the Scythians. Augustus lent no support to Tiridates in his second march on Ctesiphon in 26 B.C., and Phraates was all the more inclined on that account to stand on good terms with him. Consequently in 20 B.C. he restored the standards captured in the victories over Crassus and Antony and recognized Roman suzerainty over Osroene and Armenia. In return the Parthian dominion in Babylonia and the other vassal states was left undisputed.

Shortly after the restoration of the standards in 20 B.C. Augustus sent as a present to Phraates IV an Italian slave girl named Musa, by whom Phraates had a son, Phraataces, known later as Phraates V. Subsequently Musa persuaded her husband to send his older children to Rome, where they remained as hostages to Augustus. In 2 B.C. Musa secured the throne for her son by poisoning Phraates IV, and in A.D. 2 she and Phraataces were married, an event which horrified the Greeks and Romans but which is no doubt an example of the kin marriages advocated by the Magi and apparently adopted in this period, as later under the Sasanians, by the Iranian people in general. The portrait of Musa appears with that of Phraataces on the coinage at this time. In A.D. 4, however, Phraataces was driven into exile and died soon afterward. The Parthians then obtained the release of the eldest of the princes interned at Rome, Vonones I (*q.v.*), but his foreign manners and dependence on Rome soon caused them to call in another Arsacid, Artabanus III (*see* ARTABANUS), known chiefly for his letter of Dec. A.D. 21 to the magistrates and city of Susa, the only Arsacid royal document which has been preserved. His reign was interrupted *c.* A.D. 36 by another Roman nominee, Tiridates III, whose rule was of short duration.

Decline of Parthia.—The close of the reign of Artabanus III (*c.* A.D. 38) was followed by the rebellion of Seleucia, which lasted for seven years, and by a period of civil war between Gotarzes II, whose power was centred in Hyrcania, and Vardanes, who seems to have controlled Babylonia. These ended only with the assassination of Vardanes in A.D. 47/48. Another pretender to the throne, the Roman nominee Meherdates, was defeated and captured by Gotarzes, whose own death followed in A.D. 51. Further conflict with Rome broke out under Vologaeses (Volagases) I (reigned 51/52–79/80), who made his brother Tiridates king of Armenia. After a long war, described by Tacitus, in which the Roman army was commanded by G. Domitius Corbulo, peace was concluded in 63, confirming Roman suzerainty over Armenia but recognizing Tiridates as king (*see* CORBULO, GNAEUS DOMITIUS). Tiridates himself visited Rome and was invested with the diadem by Nero (66). After that Armenia continued under the rule of an Arsacid dynasty. During this fighting Vologaeses was diverted by attacks on his eastern frontier in Hyrcania. "Hyrcanian" emissaries even visited Corbulo, and if Tacitus is correct in saying that they returned home by way of the Indian ocean, they must have been representatives of the Kushan power, which in this period was expanding to the detriment of the eastern frontiers of Parthia. Later the Alans (Alani), a great Iranian tribe of south Russia, broke for the first time through the Caucasus passes and ravaged Media and Armenia.

After the reign of Vologaeses I came a period of great disturbances in the history of Parthia. A continuous narrative is lacking, but the evidence of coins, added to that of isolated literary references, shows that at certain periods there were two or more kings reigning concurrently. One of the best-known episodes was the invasion of Parthia by the Roman emperor Trajan. With the Parthian kingdom divided between Osroes, Vologaeses II and perhaps also Pacorus II, the Romans were able to march down the Euphrates, haul their fleet across to the Tigris and occupy Ctesiphon unopposed (115). Trajan then sailed down the Tigris to the Persian gulf, receiving on the way the submission of the king of Characene, and is even said to have contemplated an expedition to India. However he returned to Babylon in 116 to learn that the greater part of the conquered territory was in revolt. Though he encompassed the death of the Parthian prince Sanatruces by embroiling him with his cousin Parthamaspates, Trajan's position was untenable, and in 117 he retreated up the Tigris, evacuating Parthian territory after a fruitless siege of the desert fortress of Hatra. Hadrian, who succeeded him in the same year, favoured a peaceful settlement of the Parthian problem.

In 161 Vologaeses III invaded Cappadocia and Syria; as a consequence a powerful Roman expedition was sent to the east under Lucius Verus, the colleague of Marcus Aurelius, and the general Avidius Cassius. In 165 the latter led the legions into Parthian territory, capturing Doura-Europus and reaching and storming Ctesiphon, but was forced to evacuate the Parthian capital by an outbreak of smallpox. Subsequently sporadic fighting in Mesopotamia and Armenia led to further reductions of Parthian influence. Septimius Severus also campaigned on the Parthian frontier, but it was not until 198 that he penetrated deep into Parthian territory, occupying Seleucia and Babylon, while Ctesiphon was

taken by storm and sacked. On his return march Septimius Severus, like Trajan, failed to capture Hatra.

These repeated invasions appear to have crippled the Parthian kingdom. Vologaeses IV was succeeded in 208/209 by his son of the same name; yet from 212/213 the latter was obliged to share his kingdom with a rival, Artabanus (Ardavan) V, whose control of Susa in 215 is attested by an inscription discovered at that site. Meanwhile the dated coinage of Seleucia continued until 228/229 with the types of Vologaeses V. The Roman emperor Caracalla was not the only one to exploit the weakness of the Arsacids by an invasion of Media. In southern Iran the new dynasty of the Sasanians was gathering strength, and by 226/227 Ardashir had overthrown both the Arsacid princes, leaving only Artavasdes (Ardavazd), the son of Artabanus, to carry on a hopeless struggle for a few years in the mountains of Azerbaijan.

V. SASANIAN EMPIRE, *c.* A.D. 224–651

Rise of Ardashir I.—At the beginning of the 3rd century A.D. the Arsacid empire had been in existence for 400 years. It had been undermined, however, by repeated Roman invasions, and the kingdom was once more divided, this time between Vologaeses V, who seems to have ruled at Ctesiphon, and Artabanus V, who controlled Iran, and whose authority at Susa is attested by an inscription of A.D. 215. The moment was thus ripe for the overthrow of the Arsacids, and it was against Artabanus V that the blow eventually fell.

On his borders there arose in Persis (Fars)—just as Cyrus had arisen against Astyages the Mede—a great personality. Ardashir I (*q.v.*), son of Babek (Papag or Papak) and descendant of Sasan, was the sovereign of one of the small states into which Persis had gradually been divided. His father had taken possession of the city and district of Istakhr (Estakhr), which had replaced the old Persepolis, long a mass of ruins. Babek was succeeded by his eldest son, Shapur, who was soon killed in an accident, so that in A.D. 208 Ardashir came to the throne. He first built for himself an impregnable stronghold at Gor (Gur), also called after its founder Ardashir-Khurre, the modern Firuzabad in the recesses of Fars southeast of Shiraz. Then he subdued the neighbouring potentates, disposing also of his own remaining brothers. Ardashir's seizure of Carmania (Kerman), Isfahan, Elymais and Characene (Mesene) quickly led to war with his suzerain, Artabanus V. The conflict lasted for several years, and the Parthians were worsted in three battles. The last of these was the battle of Hormizdagan (224), which resulted in the death of Artabanus.

Yet though Ardashir appears subsequently to have occupied the capital, Ctesiphon, his progress to suzerain power could not have been without setbacks. Thus Vologaeses V struck coins at Seleucia as late as the Seleucid year 539 (A.D. 228/229). Another Parthian prince, Artavasdes, a son of Artabanus, is known also from coins on which his distinguishing feature is his forked beard. This personage retained a portion of the empire to an even later date.

TABLE II.—*Sasanian Dates Established on Direct Ancient Evidence*

Event	Regnal years	Seleucid era	Christian era
Accession of Artabanus (Ardavan) V	1		212/213
Inscription of Khwasak at Susa names Artabanus "king of kings"			215
Birth of Mani	5	527	216/217
Artabanus V overthrown and killed by Ardashir			224
Official first regnal year of Ardashir		538*	226/227
Last coin of Vologaeses V minted at Seleucia		539	228/229
Mani, in 13th year, receives divine revelation	3	539	228/229
Official first regnal year of Shapur I		553	241/242

*Syrian reckoning.

Moreover Ardashir on his coins is distinguished by no fewer than four different crowns: (1) as king of Fars; (2) before the battle of Hormizdagan as claimant to the empire; and (3) and (4) with two quite separate crowns as emperor. This situation suggests that Ardashir had more than one coronation ceremony as suzerain ruler, the second perhaps following on some short-term setback by which he temporarily lost the throne. A rock sculpture near Firuzabad depicts the overthrow of Artabanus by Ardashir. In another at Naksh-e Rostam near Persepolis, Ardashir tramples underfoot the vanquished Artavasdes. The members of the Arsacid line who fell into the hands of the victor were put to death. Yet a number of the princes found refuge in Armenia, where the Arsacid dynasty maintained itself until 428.

Ardashir then subdued Seistan (Sakastan), Gorgan (Hyrcania), Abarshahr (modern Khurasan), Merv (Margiana), Balkh (Bactria) and Khwarizm (Chorasmia). Since most of these territories had formed part of the Kushan empire, the implication is that he overcame the Kushans. This deduction is confirmed by the statement of al-Tabari that after these campaigns the kings of the Kushans, of Turan (Quzdar, south of Quetta) and of Makran made their submission to Ardashir. The victorious Ardashir also took possession of the palace at Ctesiphon, assuming the title "king of kings of the Iranians." The city of Seleucia he refounded after the fighting under the name of Veh Ardashir, "the good deed of Ardashir."

The chronology of events in the early Sasanian period was calculated by T. Nöldeke in 1879, and many authorities still adhere to his system of dating. The discovery, however, of evidence from later manuscript finds concerning the date of events in the life of Mani (*q.v.*), a religious leader active in the early Sasanian period, led W. B. Henning to call for a reassessment of this system of dating in favour of a revised system in which the chief events are dated about two years earlier. This view was disputed by S. H. Taqizadeh, who prefers another alternative in which the chief events are placed about six months later than the dates established by Nöldeke. Since the dating systems employed by the Sasanians themselves were based on the regnal years of the kings, whose exact coronation dates are often subject to dispute, a final solution of the problem is not yet possible. Errors in the various computations may have arisen from such circumstances as the possible second coronation of Ardashir, and the unknown lapse of time between the demise of one ruler and the coronation of his successor, a common source of discrepancy. Where the ancient authorities quote dates in terms of the Seleucid era—either according to the reckoning which prevailed in Babylonia, which commenced from 311 B.C., or the Syrian reckoning, counted from 312 B.C.—a firmer basis of calculation is obtained. In Tables II and III are set out dates established on the direct testimony of ancient coins or literary evidence, and the differing chronological systems of Nöldeke, Henning and Taqizadeh.

TABLE III.—*Chronological Systems of Nöldeke, Henning and Taqizadeh*

Event	Nöldeke	Henning	Taqizadeh
Ardashir's "first year" begins		Sept. 27, 223	Sept. 26, 226
Ardashir's actual accession	Sept. 26, 226	April 28, 224	April 6, 227
Shapur's first year begins		Sept. 23, 239	Sept. 22, 241
Shapur's actual accession	Sept. 22, 241		
Shapur's coronation		April 12, 240	April 9, 243
Shapur's death		May 270	April 273
Accession of Ormizd (Hormizd) I	Sept. 14, 272		
Ormizd's death		June 271	April 274
Accession of Bahram I	Sept. 14, 273		
Death of Mani (about age 60)		March 2, 274	Feb. 26, 277
Death of Bahram I		Sept. 274	July 277
Accession of Bahram II	Sept. 13, 276		

Source: T. Nöldeke, *Geschichte der Perser und Araber zur Zeit der Sasaniden* (E. J. Brill Ltd., Leiden, 1879); S. H. Taqizadeh and W. B. Henning, "The Dates of Mani's Life," *Asia Major*, vi, part 1, pp. 106–121 (London, 1957).

Wars of Shapur I.—Shortly before his death, no doubt as a consequence of failing health, Ardashir abdicated the throne in favour of his chosen heir, Shapur I. The latter, however, though assuming the responsibilities of government, delayed his coronation until after his father's death. Thus coins exist portraying Ardashir together with his son as heir apparent, and Shapur alone wearing the eagle cap as prince regnant before his coronation, besides the normal series of Shapur crowned as king. Immediately after his accession, Shapur was faced with an invasion of Persian territory by the Roman emperor Gordian III. He confronted the Roman forces at Massice on the Euphrates, defeating them in a major battle in which Gordian was killed. From this event the town of Massice received the name of Firuz-Shapur, though in

later history it is usually known as Al Anbar (*see* ANBAR). The survivors of the Roman force raised Philip the Arab to the purple, and he was able to negotiate a peace with the Persians, ransoming the Roman prisoners for a large sum of gold. In A.D. 256 (A.D. 252 according to other authorities) a dispute over Armenia led Shapur to invade the Roman provinces of Syria and Cappadocia, destroying a Roman army of 60,000 men at Barbalissus and capturing 37 cities, including the capital city of Syria, Antioch itself. When the emperor Valerian marched with a large force to the defense of Edessa, he was utterly routed by Shapur, who performed the unparalleled feat of personally taking prisoner the Roman emperor. The destruction of the Roman force laid Syria and Cappadocia open once more to devastation and plunder by the Persian armies, while the hapless Valerian was held prisoner in Persia for the remainder of his life.

Knowledge of the reign of Shapur I was greatly extended in 1938 through the discovery by the expeditions of the Oriental institute, Chicago, of a long inscription containing Shapur's own account of these events. This was found near Persepolis on the walls of an Achaemenian monument known as the Ka'aba-e Zardusht. The text is in three languages, Sasanian Pahlavi, Parthian and Greek, and, besides its narrative of the military operations, contains a description of the Persian empire of the time and an account of Zoroastrian religious foundations established by Shapur to commemorate his wars. These were fire temples dedicated to the memory of members of the Sasanian royal family and of the prominent officials who had served under Shapur and his predecessors; the officials are individually specified by name in a list which throws considerable light on the administrative arrangements of the kingdom at that time.

Organization of the Empire.—In contrast to his father, Shapur I assumed the title "king of kings of Iran and non-Iran" (*shahan shah Eran ut Aneran*), thus emphasizing his claim to world dominion. This formula was retained by his successors and became the regular designation of the Sasanian emperors. The supremacy of the ruler was powerfully emphasized under the dynasty of Ardashir. The hereditary local dynasties which under the Arsacids had ruled many of the most important provinces were to a large extent abolished. Instead, such fiefs as Maishan (Mesene) and Sakastan (Seistan) were ruled by members of the Sasanian family appointed by the sovereign with the title of shah (king). Among such viceroys precedence was often held by the heir to the throne, who was placed in control of great territories such as the conquered lands of the Kushan empire (Kushanshahr), or of Armenia, and entitled *vuzurg shah* ("great king"). Next in the hierarchy to royalty came a few remaining hereditary vassals, including the kings of Iberia (Georgia) in the Caucasus, and the chief nobles of the kingdom, of whom the Varaz, Suren and Karen retained their prominence from Parthian times. These were followed by the satraps, whose importance had considerably diminished since the Achaemenids and who were now no more than the administrators of substantial cities, and by the various officials of the court.

The extent of the Sasanian empire under Shapur I is defined by the list of provinces given in the inscription of the Ka'aba-e Zardusht. No fewer than 27 provinces are enumerated: (1) Persis; (2) Parthia; (3) Khuzistan; (4) Maishan; (5) Asuristan (*i.e.*, Iraq, the province of Ctesiphon); (6) Adiabene; (7) Arabistan (*i.e.*, northern Mesopotamia); (8) Azerbaijan; (9) Armenia; (10) Iberia; (11) Machelonia; (12) Albania; (13) Balasakan, extending to the Caucasus mountains and the Alans' Gates; (14) Patishkhwagar (*i.e.*, the Elburz mountains); (15) Media; (16) Hyrcania (*i.e.*, Gorgan); (17) Merv; (18) Aria; (19) Abarshahr; (20) Carmania; (21) Seistan; (22) Turan; (23) Makran; (24) Paratan; (25) India (the exact extent of the Sasanian province is undefined, but it may have been restricted to the Indus delta); (26) Kushanshahr, extending from before Peshawar to Tashkent, Sogdiana and the borders of Kashgaria; and (27) on the further side of the sea, Mazun (*i.e.*, Oman). This empire, considerably more extensive than that controlled by the Arsacid dynasty, was governed on behalf of the Sasanian dynasty not by feudal chiefs but by members of the dynasty and by appointed officials directly responsible to the throne. The greater degree of centralization attained by the Sasanian government no doubt partly explains its increased military effectiveness in comparison with the preceding administration of the Arsacids.

Another tendency which developed in the Sasanian period (and which indeed had already made itself felt under the Arsacids) was a strict principle of dynastic legitimacy. For a usurper not of the royal blood to achieve the throne was an extremely rare occurrence, though it was in fact accomplished by Bahram Chobin (*q.v.*). Allegiance attached, however, to the whole royal house, rather as it did in the later Ottoman empire. The person of the individual ruler was a matter of less importance, and one member of the dynasty could readily be removed and replaced by another. In accordance with this principle of legitimacy, Persian tradition carried the Sasanian line back to the Achaemenids and, still further, to the kings of the legendary period.

TABLE IV.—*Sasanian Kings**

Name	Reign years	Name	Reign years
Defeat of Artabanus (Ardavan)	224	Firuz	457 or 459–484
Ardashir I	226–241	Balash	484–488
Shapur I	241–272	Kavadh I (first reign)	488–496
Ormizd I	272–273	Jamasp	496–498 or 499
Bahram I	273–276	Kavadh I (second reign)	498 or 499–531
Bahram II	276–293	Khosrau I	531–579
Bahram III	293	Ormizd IV	579–590
Narses (Narseh)	293–302	Khosrau II Parvez (first reign)	590
Ormizd II	302–309	Bahram VI Chobin	590–591
Shapur II	309–379	Khosrau II Parvez (second reign)	591–628
Ardashir II	379–383	*Bistam* (rebel in Media)	591–596
Shapur III	383–388	Kavadh II Shiruya (Siroes)	628
Bahram IV	388–399	Ardashir III	628–630
Yazdegerd I	399–420	*Shahrvaraz*	630
Bahram V Gor	420–438	*Borandukht*	630–631
Yazdegerd II	438–457	*Ormizd V*	631–632
Ormizd III	457–459?	Yazdegerd III	632–651

*Based mainly on T. Nöldeke's chronology.

Religious Developments.—The forebears of Ardashir had played a leading role in the rites of the fire temple at Istakhr, known as Atur-Anahid, "The Anahit fire." With a dynasty having such priestly antecedents, it is natural to expect that important developments would have taken place in the Zoroastrian religion during the Sasanian period. Indeed the evolution of Zoroastrianism as an organized religion in something resembling its modern form can be regarded as having commenced in the period of this dynasty. Prior to the Sasanian period, there is little evidence of any centralized religious organization in Iran. Under the Parthians local Magi (*q.v.*) had no doubt continued to perform the traditional ceremonies associated with the old Iranian deities, the fire cult, the creed preached by Zoroaster, with its emphasis on the worship of Ahura Mazda, and even the cults of cosmopolitan deities introduced in the Hellenistic period and later.

It is probable that the Parthians enforced no sharp distinctions between these diverse forms of religious activity. Under the Sasanians, however, stress came to be increasingly placed on the fire cult and the worship of Ahura Mazda. Strong links were developed between religion and the state, and an ecclesiastical organization was evolved in which every considerable district had its mobed (*magupat*, "chief priest"). At the head of these stood the *mobedan mobed* (supreme priest), who in addition to his religious jurisdiction appears in later times to have exercised considerable influence in connection with the choice of a successor to the throne. There is some evidence that besides their religious function the Magi, by virtue of their proficiency in the complicated Pahlavi writing system necessary for the understanding of the Iranian scriptures, performed the offices of registrars and scribes, after the fashion of the Christian clergy in medieval Europe. The *magukhana* (Magus house) will thus have replaced the office of the Hellenistic bibliophylax (archivist) as the repository of the local archives, title deeds and other similar legal documents.

In the matter of religious practice, the rites of the Sasanians appear to have developed from those previously current in their home province of Persis. There extraneous religious influences were slight. The opposition between the good spirit of light and the demons of evil—between Ahura Mazda (*q.v.*; Ormazd) and

Ahriman—still remained the principal dogma of the creed. All the other gods and angels, however estimable their aid, were but subordinate servants of Ahura Mazda, whose highest manifestation on earth was less the sun-god Mithra than the holy fire guarded by his priests. At the same time the names of such deities as Verethragna (Bahram), Mithra and Anahit were still associated with the names of fire temples or classes of fire. All the prescriptions of purity—partly connected with national customs and impossible of execution abroad—were diligently observed. The elaborate ritual still maintained by the modern Parsees (*q.v.*) for the purification and custody of the sacred fire were no doubt observed under the Sasanians. The responsible priest was girt with his sword and carried in his hand the barsom, or bundle of sacred twigs. His mouth was covered to prevent the sacred flame sustaining pollution from his breath. Yet the practice of animal sacrifice, abhorred by the modern followers of Zoroaster, is attested in the history of the Sasanian period at least as late as the reign of Yazdegerd I (399–420). On the great festivals, such as the day of Nauruz (the Iranian new year) and the day of Mihrajan, the sacred fire was displayed to the faithful populace at nightfall from some point of vantage, a platform on rock or hill. Moreover under the Sasanians the injunction not to pollute the earth with corpses but to expose the dead on the mountain tops to vulture and dog was observed in its full force. At the same time Ahura Mazda preserved his character as a national god, who bestowed on his worshipers victory and world dominion. In the sculptures of the Sassanids, as also in Armenian traditions, he appears on horseback as a war god.

Under the Sasanians theology was further developed and an attempt made to modify the old dualism by envisaging both Ahura Mazda and Ahriman as emanations of an original principle of infinite time (Zurvan). This doctrine enjoyed a degree of official recognition under the earlier Sasanian reigns. Indeed the innovation had even been known earlier to the Mithra cult of the west, where Zurvan appears as Aion. However, in the reign of Khosrau I the "sect of the Zurvanites" was pronounced heretical. The chief development of Sasanian religion, apart from the process of institutionalization to which reference will be made later, was the elaboration of ritual and of the doctrine of purity. There was evolved a complete and detailed system of casuistry dealing with all things allowed and forbidden, the forms of pollution and the expiation of each, which recalls the similar prescriptions in the Pentateuch. The consequences of this development were that orthodoxy and literal obedience to priestly injunctions assumed an increasing importance. Heathenish cults and forbidden manners and customs came to be regarded as a pollution to the land and a deep insult to the true God. It became the duty of the believer to combat and destroy the unbeliever and the heretic. In short, the tolerance of the Achaemenids and the indifference of the Arsacids came to be replaced by increasing intolerance and religious persecution.

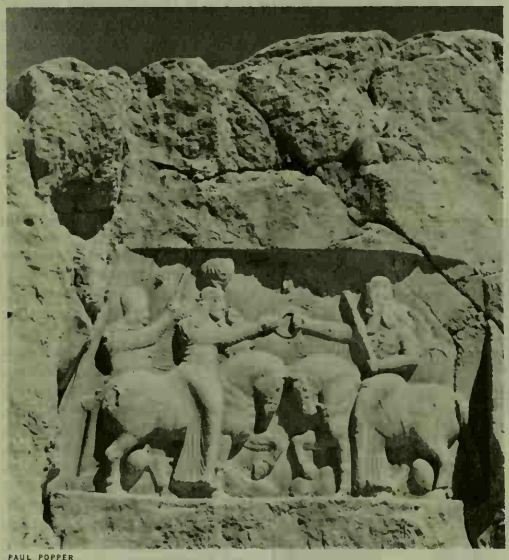
Such was the religious background to the inauguration of the Sasanian dynasty. Yet despite his priestly origins, Ardashir himself seems not to have been the person responsible for giving religious affairs this new direction. It was once believed that the institutionalization of the Zoroastrian church and the codification of its scriptures and beliefs was the work of a high priest named Tansar, contemporary of Ardashir I, of whose doings an account is preserved in the *Letter of Tansar* contained in the *History of Tabaristan* of Ibn Isfandiyar. The later interpretation of the Sasanian inscriptions of Fars, however, suggests that if Tansar was in fact a historical personage his role in these matters may have been less significant than that of Kartir, a Magus, or rather a *herbed*, prominent under Shapur I, who in the subsequent reign of Bahram II (A.D. 276–293, by Nöldeke's chronology) appears as the dominant figure in the Zoroastrian church. He claims credit for the suppression of non-Zoroastrian religious communities in Iran, for the imposition of orthodoxy and discipline in the Magus estate, and for the establishment of royal foundations making provision for the maintenance of Magi and of sacred fires.

The reference in the Pahlavi inscriptions of Kartir to two sects of Christians, besides Buddhists, Brahmans and other foreign religious communities, confirms the indications from Syriac sources that Christianity had by this time gained a firm footing in the countries of the Tigris and Euphrates, where it was naturally strongest among the Aramaic-speaking communities. Yet ultimately Christian missionary enterprise came to stretch over the whole of Iran and even farther afield. As long as the Roman empire remained pagan, the Christian communities of Iran lived undisturbed by persecution. At the same time the Christians themselves evidenced the strongest hostility toward the heterodox sects, such as the Manichaeans and the Gnostic followers of Marcion and Bardesanes, who existed side by side with them (*see* BARDESANES; GNOSTICISM; MANICHAEISM; MARCIONITES). However, when the emperor Constantine made Christianity the official religion of the Roman world, the Iranian Christians were, on the one hand, drawn to feel a certain sympathy for their foreign coreligionists, while, on the other, political significance came to be attached by the Sasanian rulers to these religious connections with an often hostile power. After A.D. 339, therefore, the Christians of Iran were subjected to severe persecutions at the hands of Shapur II and his

THE SASANIAN EMPIRE IN THE TIME OF SHAPUR I

successors. Nonetheless, substantial Christian communities survived in parts of Iran long after the close of the Sasanian dynasty.

At the same time, the old idea that every religion contained a portion of the truth and that it was possible to borrow something from one and amalgamate it with another had not lost all its power. From such a conception arose the teaching of Mani. Knowledge of Manichaeism was greatly increased by the discovery of many fragments of its literature in eastern Turkistan; these include portions of the *Shapuraghan*, a work in Middle Persian dedicated to the Sasanian emperor Shapur, and the *Evangel*. Subsequently a large part of the *Kephalaia*, a book of the religious injunctions of Mani, was recovered in a Coptic text from Egypt. These texts can be collated with the versions of Manichaean doctrines reported by the Church Fathers, among others St. Augustine. It is clearly seen that Manichaeism originated from a Gnostic sect. Mani was the offspring of a Parthian family resident in Babylonia but himself a speaker of Aramaic. He proclaimed himself as the last and greatest apostle of Jesus and as the paraclete announced in the Gospel of St. John. With the Gnostic interpretation of the Gospel he tried to combine the doctrines of Zoroaster and of Jesus to create a new universal religion. There is a tradition that he made his first appearance as a teacher on the coronation day of Shapur I, but other evidence suggests that Mani was not necessarily in Iran at that time but may have been occupied with his journey by sea to India when he commenced to preach. He subsequently returned and found many adherents, among whom are



PAUL POPPER

SASANIAN ROCK RELIEF AT NAKSH-E ROSTAM SHOWING THE INVESTITURE IN A.D. 226 OF ARDASHIR, THE FOUNDER OF THE DYNASTY, WHICH ENDURED TILL THE MID-7TH CENTURY

numbered Firuz (Peroz), a brother of Shapur, and Mihrshah, governor of Maishan, the province at the head of the Persian gulf. Even the king is said to have been impressed and to have granted the prophet no fewer than three interviews. The prophet's decision to dedicate to him the *Shapuraghan* is further evidence of a degree of royal favour. During the reign of Shapur the religion of Mani was thus propagated in Iran and beyond. Even the heir to the throne, Ormizd (Hormizd) I, was favourably disposed toward him; but Shapur's younger son, Bahram I, yielded to pressure from the priests, and Mani was executed. After that Manichaeism was persecuted and extirpated in Iran. Yet it maintained itself not merely in the west, penetrating far into the Roman empire, but also in the east, in Khurasan and beyond the bounds of the Sasanian dominion. There the seat of its pontiff was at Samarkand, whence Manichaeism penetrated into central Asia. There, buried in the desert sands which entomb the cities of eastern Turkistan, have been discovered numerous fragments of the works of Mani and his disciples. They are written in a form of the Syrian script adapted by the Manichaeans for their scriptures, and in the Middle Persian and Parthian languages; others are in the east Iranian Sogdian dialect.

Art and Literature.—Perhaps the most characteristic and certainly among the most striking relics of Sasanian art are the great rock sculptures carved on the abrupt limestone cliffs which are found in many parts of the country. The best-known groups are at Naksh-e Rostam and Naksh-e Rajab, near Persepolis, and at Shahpur (Bishapur), the ancient city a few miles north of Kazerun in Fars. At Firuzabad, the ancient Gor, in the same province, are two reliefs of Ardashir, one depicting his overthrow of Artabanus V, the other an investiture scene. Not far away in the lonely valley at Sar Mashad, a representation of Bahram II slaying two lions was discovered by E. Herzfeld in 1932. At Darabgird a ruler of uncertain identity, perhaps Ardashir, is shown triumphing over a Roman emperor, while at Naksh-e Bahram, north of Kazerun, Bahram II is depicted enthroned; the same ruler appears in small reliefs at Qasr-e Abu Nasr, near Shiraz, and at Guyom, not far away. Sasanian sculptures are less numerous outside the province of Fars, where such work may have been put in hand by the Magus Kartir, but an equestrian figure which once existed at Ray was replaced in the 19th century by a representation of the Qajar king Fath Ali Shah. At Shahpur (formerly Salmas) on Lake Urmia (Reza'iyeh) Ardashir is shown on horseback receiving the surrender of Parthian personages. There are later Sasanian sculptures at Taq-e Bostan, near Kermanshah, showing Ardashir II, Shapur III and Khosrau II. In many of these sculptures the Sasanian kings can be recognized by their individual crowns, but a poorly preserved relief at Finik, near Jazirat Ibn Umar in Iraq, reported by Sir A. H. Layard and G. Bell, may be of pre-Sasanian date. At Sar-e Pul in Afghanistan a rock carving seen by J. P. Ferrier before 1856 has never been relocated. It may, however, be Sasanian.

The most celebrated architectural achievement of the dynasty is no doubt the vast palace at Ctesiphon (*q.v.*), built by Khosrau II, of which a part is still standing. It is known as the Taq-e Kisra, and is notable for its great barrel vault in baked brick, a typically Sasanian device. Many Sasanian buildings can also be seen in Fars, where the characteristic construction is of limestone blocks embedded in strong mortar. The most important of these is the palace of Ardashir at Firuzabad (*q.v.*), and a small, well-preserved palace at Sarvestan, in which the rooms are roofed with domes and squinches, features often found under the Sasanians. French excavations at Shahpur near Kazerun have revealed some mosaic floors, among other features of the considerable Sasanian town. Numerous fire temples of the period survive, especially in Fars; these are square buildings roofed by a dome over four arches. Moreover Sasanian remains of considerable extent exist at Qasr-e Shirin, on the Baghdad-Teheran road, and at Jundai Shapur (modern Shahabad, south of Dezful).

The Sasanian epoch was indeed one of a general renascence in Iranian art, which if not on the same level as the Achaemenian achievement was of no small importance. Metalwork of the period enjoyed a high reputation, its most characteristic decorative theme being hunting scenes portraying the Sasanian kings. The position of Iran on the silk route between China and the west encouraged the establishment of an important silk industry, which often supplied the Roman world and of which the influence can be traced in the west. The art of gem engraving produced many intaglio stamp seals, especially of the characteristic domed shape, and a few fine cameos. The coins invariably bear a Pahlavi legend—on the obverse the head of the king, wearing his characteristic crown, and accompanied by his name and title; on the reverse the fire altar with its guardians and the inscription "fire of Ardashir, Shapur, etc." or, in the later period, an abbreviated mint name and the regnal date.

The acquaintance with the Greek language and literature maintained by the Arsacid court was already in decline during the last

century of that dynasty. Nonetheless Greek translations accompany the inscriptions of Ardashir I and Shapur I, notably the long Greek version of the latter's great inscription at the Ka'aba-e Zardusht, which may show traces of Parthian official terminology. Later inscriptions, however, are only in Parthian and Pahlavi (in the cases of the inscription of Narses at Paikuli) or in Pahlavi alone. Little of the surviving literature in book Pahlavi is as old as the Sasanian period. A few works, however, contain material which goes back to the period of Khosrau I (531–579). The *Dadhastan i Menoghkhrad* ("Doctrine of Celestial Wisdom") and the *Ardagh Viraz-Namagh* ("Vision of Ardagh Viraz") contain material on Zoroastrian theology. The *Madhighan i Hazar Dadhastan* ("Account of a Thousand Decisions") is a compendium of Sasanian law, which names many Sasanian jurists and quotes their opinions. The *Karnamak-i Ardashir-i Papakan* contains a version of the life of Ardashir I which, though legendary, is shown by Agathias to have been current in the late Sasanian period. The *Letter of Tansar*, mentioned above, though perhaps also legendary, is taken from a Pahlavi work of the time of Khosrau. The later compilations, especially the *Denkard*, though mainly concerned with cosmology and religious legend, contain some important historical references relating to the Sasanian period. According to one of these, Shapur I ordered the collection and translation of religious, astronomical, medical and philosophical texts from the Byzantine empire and from India. Other translations from Indian literature are known under the Sasanians; *e.g.*, the book of tales called *Kalilah and Dimna*, the legends of Barlaam and Josaphat and the Indian legends in the *Letter of Tansar*. The books of moral precepts (*andarz*) constitute another important genre in Sasanian literature, which, with the orally transmitted popular romances in verse, are often reflected in the writings of the Islamic period.

Foreign Policy.—In foreign policy the problems under the Sasanian kings remained, as of old, the defense and, when possible, the expansion of the eastern and western frontiers. In the east Ardashir I had quickly defeated the Kushans, annexing the western part of their empire. There are indications that Shapur I before his accession had played a leading part in these operations, and was probably the first Sasanian prince to bear the afterward well-established title of *Kushanshah*, "Viceroy of the Kushans." His inscription defines the Kushan province under Sasanian rule as extending from the Indus to Sogdiana and the boundaries of Kashgar. Successors of the Kushans seem to have retained some independence only in the Punjab, where they were still subject to Sasanian inroads until they finally succumbed to the expanding Gupta empire of India in the mid-4th century. Farther south, the Sasanian governorate of Sakastan included "India [? Sind] and Turan (Quzdar) to the shores of the Indian ocean." Thus all the local principalities of Baluchistan had come under Sasanian control.

In the west, the old contest for Osroene and northern Mesopotamia with the fortresses of Carrhae, Nisibis (Nusaybin) and Edessa still smoldered. The Sassanids were all the more eager to regain Armenia because there the Arsacid dynasty still survived and turned for protection to Rome, with which, in consequence, new wars perpetually broke out. In the reign of Bahram II the emperor Carus, burning to avenge the disaster of Valerian, invaded Mesopotamia without meeting opposition and reduced Coche (near Seleucia) and Ctesiphon; but his mysterious death in Dec. 283 prevented further success, and the Roman army returned home. Bahram had been diverted from the scene by the dangerous rebellion of his brother, the Kushanshah Ormizd (Ormies), who had occupied Merv and Herat, claiming imperial status for his Kushan viceroyalty. He was however defeated by Bahram, who was able to appoint his younger son, the future Bahram III, as viceroy of Sakastan. After the father's death, Narses, the youngest son of Shapur I, then viceroy of Armenia, contested the succession of Bahram III and won the crown. In memory of his victory he erected a great tower at Paikuli, in the mountains west of the upper Diyala, discovered in 1843 by Sir Henry Rawlinson and investigated in three expeditions by E. Herzfeld. Decorated with busts of Narses, the monument bears a long inscription in Parthian and in Sasanian Pahlavi, recounting the history of these events. After his victory Narses occupied the independent portion of Armenia. In the following year he sustained a severe reverse in that province, losing his war chest and his harem. He then concluded a peace, by the terms of which Armenia remained under Roman suzerainty, and the steppes of northern Mesopotamia, with Singara and the hill country on the left bank of the Tigris as far as Gordyene, were ceded to the victors. In return Narses recovered his household. By this peace, concluded in 296, which lasted for 40 years, the Sasanians withdrew completely from the disputed districts.

After the death of Ormizd II, the son of Narses, the nobles imprisoned or put to death his adult sons, one of whom, Ormizdas (Hormisdas), later escaped to the Romans, who used him as a pretender in their wars. Shapur II (*q.v.*; 309–379), a posthumous child of the former king, was raised to the throne, proof that the great nobles held the sovereignty in their own hands and attempted to order matters at their own pleasure. Shapur, however, when he came to manhood proved himself an independent and energetic ruler.

Renewed Conflict With Rome.—Meanwhile, the Roman empire had become Christian, so that the Syro-Christian populations of Mesopotamia and Babylonia began to feel some sympathy with Roman policies. For similar reasons Christianity became predominant in Armenia; as early as 294 King Tiridates was converted by St. Gregory the Illuminator and adopted the Christian faith. The Sasanian empire was thus the more constrained to consolidate its Zoroastrianism. Under Shapur II the compilation of the Avesta was completed, and state orthodoxy perfected by the chief mobed, Adhurbad. All heresy was proscribed by the state, defection from the true faith was pronounced a capital crime and the persecution of the heterodox—particularly the Christians—began. Thus the duel between the two great empires became simultaneously a duel between two religions.

In this situation a fresh war with Rome was inevitable. It was begun by Shapur in 337, the year that saw the death of Constantine the Great. The conflict focused upon the Mesopotamian fortresses, Shapur thrice besieging Nisibis without success. The emperor Constantius conducted the war feebly, but Shapur was diverted by the appearance of a new enemy, the nomadic Chionites (Huns; *see* HEPHTHALITES), on his eastern frontier. He campaigned against them for five years (353–358) in Khurasan, giving its modern name to the great city of Nev-Shapur (Nishapur; *q.v.*), formerly known as Abarshahr. Finally, winning over the Chionites as his auxiliaries, he returned to Mesopotamia and stormed Amida (359), an episode vividly narrated by Ammianus Marcellinus; the next year he also reduced Singara.

Julian the Apostate (363) undertook an invasion of the Persian empire, also described in detail by Ammianus. He pressed forward to the neighbourhood of Ctesiphon but succumbed to a wound. His successor, Jovian, found himself in such straits that he could extricate himself and his army only by a disgraceful peace at the close of 363; this ceded the possessions on the Tigris and the great fortress of Nisibis, and pledged Rome to abandon Armenia and its Arsacid protégé, Arsaces III, to the Persians. After desperate Armenian resistance, the greater part of the kingdom was made a Persian province under a *marzpan*.

From Yazdegerd I to the Turks.—After several disturbed reigns Yazdegerd I (*q.v.*; 399–420) came to the throne. His reign is differently viewed by Christian and Magian sources. The Christian writers praise his clemency, but the sources dependent on the Magian tradition refer to him as "Yazdegerd the Sinner." Inclined to tolerance of the Christian and Jewish religions, Yazdegerd was concerned to limit the power of the nobles, whose obdurate resistance finally drove him to severity. Furthermore, the growing fanaticism of the Christians made repression at last unavoidable. In the end Yazdegerd was probably assassinated. The nobles refused to admit any of his sons to the throne, but one of them, Bahram V, was supported by al-Mundhir, Arab prince of Hira, and also apparently by Mihr-Narseh, chief minister of Yazdegerd's last years, whom Bahram retained in office subsequently. As king Bahram (*q.v.*), surnamed Gor, "the Wild Ass," became the favourite of Persian popular tradition, which is eloquent on his

adventures in the chase and in love. Unsuccessful in a war with Rome (421–422), Bahram made a peace granting freedom of worship to the Christians. On his eastern frontier he was successful in repelling an invasion by a new wave of nomadic Hephthalites. However, in the succeeding reigns continued Hephthalite attacks harassed and weakened the Sasanians. Firuz (*q.v.;* 457 or 459–484) fell in battle against them; his treasures and family were captured and the country devastated. His brother Balash (484–488), unable to repel them, was deposed and blinded, the crown being bestowed on Kavadh I (*q.v.;* 488–531), son of Firuz. As the empire continued to suffer distress, he was dethroned and imprisoned; but he escaped to the Hephthalites and was restored in 498 or 499 by their assistance. The Nestorian doctrine had now become dominant among the Christians of Iran. Already favoured by Firuz, in 483 it was adopted by a synod and definitively established as the regular form of Christianity in the Sasanian empire.

Kavadh proved himself a vigorous ruler. He restored order in the interior and in 502 attacked the Romans and destroyed Amida (modern Diyarbakir), but was compelled to ratify a peace because of an inroad of the Huns. Toward the close of his reign (527) he resumed the war, defeating Belisarius at Callinicum (531), with the zealous support of the Arab al-Mundhir II of Hira. Early in his reign he had inclined away from the Zoroastrian church and favoured Mazdak, the founder of a communist sect which had made headway among the people (*see* MAZDAKISM). The crown prince, Khosrau, however, was an orthodox Zoroastrian; toward the close of his father's reign, in conjunction with the chief mobed, he contrived the condemnation of the Mazdakites, who were butchered in a great massacre (528). On his father's death, acceding as Khosrau I (*q.v.;* 531–579), surnamed Anushirvan ("of the immortal spirit"), he concluded peace with Justinian (532). He re-established Zoroastrian orthodoxy, yet though some persecution of the Christian communities occurred during periods of hostilities against Byzantium, the restoration of peace saw a return of tolerance.

Khosrau I was one of the most illustrious sovereigns of the Sasanian empire. From his time dates a new and equitable adjustment of the imperial taxation. The levying of land revenue in kind was replaced by a fixed assessment in cash, and these assessments continued in force later under the Arabs. His reputation as an enlightened ruler stood so high that when Justinian in 529 closed the philosophy school at Athens, the last Neoplatonists bent their steps to him in hopes of finding in him the true philosopher-king. Though disillusioned with conditions at the court, their gratitude was great when Khosrau by the peace of 549 obtained for them the right to return. From 540 onward he had been conducting a great war against Justinian, which, interrupted by several armistices, lasted until the 50 years' peace of 561. The net result, indeed, was merely to restore the status quo; but during the campaign Khosrau sacked Antioch and transplanted the population to a new suburb of Ctesiphon (540). He also extended his power to the Black sea and the Caucasus. On the other hand, a siege of Edessa failed (544).

The Turks.—Meanwhile, about 560, a new nation, that of the Turks, had appeared in the east. By concluding an alliance with them Khosrau crushed the Hephthalites and conquered Bactria south of the Oxus. Inevitably this alliance soon turned to hostility, and in the second Roman war the Turkish khan was leagued with Rome.

Khosrau bequeathed this war to his son Ormizd IV (579–590), who in spite of repeated negotiations failed to re-establish peace. Ormizd had not the ability to keep his father's authority, and he further affronted the Magian priesthood by declining to take action against the Christians. Eventually he succumbed to a conspiracy of his nobles headed by the general Bahram Chobin (*q.v.*), who had defeated the Turks and was afterward beaten by the Romans. Ormizd's son, Khosrau II, was set up against his father and forced to acquiesce in Ormizd's execution. But immediately new risings broke out, in which Bahram Chobin—though not of the royal line—attempted to secure the crown, while simultaneously a Prince Bistam entered the lists. Khosrau fled to the Romans and the emperor Maurice undertook his restoration at the head of a great army. People flocked to his standard; Bahram Chobin was routed (591) and fled to the Turks, who slew him, and Khosrau again ascended the throne at Ctesiphon. In Media Bistam held out until 596.

Khosrau II (590–628), though distinguished by the surname Parvez ("the Victorious"), lived to witness unparalleled vicissitudes of fortune. He achieved a splendour and material wealth unprecedented in a lavish period. The assassination of Maurice in 602 impelled him to a war of revenge against Rome, in the course of which his armies penetrated as far as Chalcedon opposite Constantinople, ravaged Syria, reduced Antioch (611), Damascus (613) and Jerusalem (614), and carried off the true cross to Ctesiphon; in 619 Egypt was occupied. Meanwhile the Roman empire was at its lowest ebb.

The great emperor Heraclius, who assumed the crown in 610, took years to create the nucleus of a new military power. This done, however, he took the field in 622, and retaliated vigorously against the Persians. Their armies were everywhere defeated. In 624 he penetrated into Atropatene (Azerbaijan) and destroyed the great fire temple; in 627 he entered the Tigris provinces. Khosrau attempted no resistance, but fled from his residence at Dastagerd to Ctesiphon. A revolution followed in which Khosrau was deposed and slain by his son Kavadh II (628). When Kavadh died a few months later anarchy resulted. The true cross was meanwhile returned to Heraclius. After a succession of ephemeral rulers, the nobles united, and in 632 elevated to the throne Yazdegerd III (*q.v.*), grandson of Khosrau.

The Arabs.—Prolonged hostilities had drastically enfeebled both the great powers. Room was given to a new enemy that now arose against both states and religions—the Arabs. After several encounters the fate of the Sasanian empire was decided at the battle of Kadisiya (637) on one of the Euphrates canals. Ctesiphon with all its treasures was laid at the mercy of the victors. The king fled to Media, where his generals attempted to organize resistance; but the battle of Nahawand (641) decided matters there. Yazdegerd sought refuge in one province after another, until at last, in 651, he was assassinated near Merv (*see* CALIPHATE).

The fall of the empire sealed the fate of its religion. The Muslims officially tolerated the Zoroastrian faith, though persecutions were not unknown. But little by little it vanished from Iran, except for the few survivors who remain at Yazd. Other Zoroastrians found refuge in western India, where they are now chiefly concentrated at Bombay. These Parsees (*q.v.*) have preserved but a small part of their sacred writings; but they still number their years by the era of Yazdegerd III, the last king of their faith and the last Sasanian sovereign of Iran. (A. D. H. B.)

VI. FROM THE FALL OF THE SASSANIDS TO THE RISE OF THE SAFAVIDS, 651–1501

Arab Caliphates.—After the Arab conquest the greater part of Iran was divided into four provinces: Khuzistan and Fars, attached to Basra; Media or Iranian Iraq, attached to Kufa; Khurasan; and Seistan. Arab tribal forces were established in a number of garrison towns (such as Qom and Shiraz), the largest bodies of them being settled in Khurasan (Nishapur, Merv, Herat, and later on Balkh, Bukhara and Samarkand), to serve as effectives for further conquests in central Asia. The Arabs interfered little with the Iranian population or their religions. For the most part the feudal nobility (*dihkans*) and the small principalities in the east were left in possession of their lands and privileges, subject to good behaviour and the payment of a stipulated rate of taxation or tribute, for which the local *dihkans* acted as collectors. Relations between the Arab administration and the feudal classes seem to have been generally good, and a contingent of Iranian troops assisted the Arabs in the conquests in Transoxiana (notably under Kutaiba ibn Muslim, 705–715) and in repelling the later counterattacks of the central Asian Turks. There is evidence that the Arabs intermarried extensively with the Iranian population and that at an early date the mingling of the two speeches had begun to lay the foundations of the modern Persian language.

On the other hand, increasing fiscal pressure under the later Omayyads caused discontent among the cultivators and townsmen, as well as among a number of *dihkans*. The social strains result-

ing from the old feudal system also were intensified as large numbers of Iranians were converted to Islam, with its equalitarian ideals. These discontents were exploited by the missionaries of Arab revolutionary groups opposed to the Omayyad caliphate, and particularly, from 745, by an emissary of the Abbasid family named Abu Muslim (*see* CALIPHATE). By clever tactics he took advantage of the tribal feuds by which the Arabs in Khurasan were divided; and, adding his weight to a general rising of the Yemenite (or southern Arab) faction, he drove the Omayyad governor, Nasr ibn Sayyar, out of Khurasan and, on the occupation of Iraq by the Khurasanian forces, succeeded in supplanting the Omayyads by the Abbasid caliphate (750).

The Abbasid caliphs based their military power upon a standing army of Khurasanians, both Arabs and Iranians, stationed at Baghdad, and their administration, under the influence of Khurasanian nobles, notably the Barmecides (*q.v.*), was closely assimilated to the former Sasanian regime. When, however, the second Abbasid caliph, al-Mansur, suspicious of Abu Muslim's power and designs in Iran, murdered him in 754, a series of insurrections by his followers disturbed the peace in Khurasan for about 50 years. After the overthrow of the Barmecides a serious general rising broke out and Harun al-Rashid died at Tus on the way to suppress it (809).

The government of Khurasan passed to Harun's son al-Ma'mun, who restored order but quarreled with his brother, the caliph al-Amin. A new Khurasanian army was raised, commanded by the Iranian general Tahir ibn Husain, who besieged and captured Baghdad and killed al-Amin (813). After much fighting the Khurasanians re-established the caliph's control over the Arab provinces, but when a fresh insurrection threatened to break out in Iran under Mazdakite leadership al-Ma'mun found it necessary to appoint Tahir viceroy of Khurasan and the east (821). Tahir was succeeded by his sons, and until 872 the Tahirids constituted a practically independent dynasty and at the same time held the command of the caliphs' Khurasanian guard at Baghdad. During the half-century of Tahirid government a great part of northeastern Iran probably enjoyed a measure of security and prosperity greater than it had known for several centuries. Tahirid power, however, was really effective only in the region of Khurasan centred on their capital at Nishapur. But their influence extended farther because members of the family held posts at Baghdad and Samarra, which meant Tahirid influence on areas governed either directly from the metropolis or by its nominees. Conditions in Khurasan by about 870 and the capture of Nishapur by Yaqub ibn al-Layth indicate that prosperity did not long survive the decline of Tahirid power.

Minor Dynasties.—The Tahirids, though semiautonomous in Khurasan, represented a continuation in altered terms of the Arabs' compromise with the Iranian landowning aristocracy. The caliphate's increasing weakness; its distraction on account of the Zanj rebellion (869–883), which engaged al-Muwaffak, who might otherwise have restored Abbasid power; and the disappointment of the Iranian masses, who had rallied to Abu Muslim and helped to raise the Abbasids, in the Abbasid family—all were factors which encouraged movements claiming greater independence. The Abbasid-Tahirid regime in Iran could only with difficulty suppress the religio-political rebellion of the *khurramis* in Azerbaijan and made no headway against Iranian chiefs and Shi'ite refugee leaders on the Caspian littoral and in the adjacent mountains. From 865 more far-reaching movements than these local insurrections arose. These were helped by the prevailing insecurity consequent upon Kharijite activities. This sect carried to extremes the democratic ideas latent in Islam and practised excessive puritanism. To them neither the Omayyads nor the Abbasids were acceptable, while to another faction, the Shi'a, only descendants from the Prophet through his son-in-law, Ali, had the right to lead the Muslim community. Iran became the scene of Kharijite depredations and Shi'ite intrigues. The latter flourished for a time when al-Ma'mun attempted reconciliation with Shi'ite leaders, and, in the meantime, a Shi'ite dynasty had become established in the Caspian region, with influence in neighbouring Dailam. Kharijite outrages favoured the rise in Seistan of the Saffarid dynasty (*see* SAFFARIDS), whose founder, Yaqub ibn al-Layth, posed as a suppressor of their disorders while recruiting Kharijite warriors into his army. He was thus soon strong enough to control the whole of eastern Iran from Balkh to Shiraz, and from bases in Khuzistan eventually threatened the caliphate itself. He liquidated Tahirid power in Khurasan. Although his achievements have left Iranians the memory of a great hero, ousting the Tahirids from the north left a power vacuum in Khurasan to be filled by forces that had coalesced under another Iranian, Ismail the Samanid, who defeated Yaqub's brother Amr in 900.

The Saffarid ("coppersmith") dynasty's origins had been popular. The Samanids (*q.v.*) were aristocrats, but they also expressed Iranian reaction against Arab domination. Their main cities, Samarkand and Bukhara, enriched by extensive commerce with the far east, became centres of learning and the arts. Persian emerged as the language of great poetry; philosophy and history were encouraged and the foundations of Iranian Islamic culture laid. The Samanids were unable to conquer the Shi'ite leaders in the mountains of Dailam, whence issued the Buyids (*q.v.*). The three sons of Buya, a former Samanid officer, succeeded in gaining control of the caliphate and, as the Samanids did in the northeast, established an Iranian interlude in western Iran and Iraq. Both powers, their vassals and those who ruled where their power was not effective, were supplanted in the 11th century by the Seljuks. Arab power had either been infiltrated or repulsed altogether, but the way had been opened to another race of nomad tribes, this time from central Asia.

Ghaznavid and Seljuk Turks.—After the middle of the 9th century, the practice grew up in all Muslim kingdoms of purchasing Turkish prisoners and slaves from central Asia and forming them into regiments of guards (*see* MAMELUKE). As each dynasty weakened, its Turkish officers acquired an increasing measure of control and occupied the chief political offices at the capital and in the provinces. This led in due course to armed rivalries and revolts, by which the power and authority of the dynasty were undermined. The Samanids, after their conquest of Afghanistan, had established a Turkish officer as governor in Ghazni; this officer's son, Alptigin, ousted by a rival from his command in Khurasan, withdrew to Ghazni in 962 and defied the Samanid prince. He was succeeded by his son and several of his Mamelukes, the third of whom, Subuktigin (976–997), made his peace with the Samanids and obtained the government of Khurasan in addition to Ghazni. Subuktigin was succeeded after a year's interval by his son Mahmud (*see* MAHMUD OF GHAZNI), the first of the great military sultans, under whom the Muslim invasion of India began. When the Turkish Il-khans destroyed the Samanid kingdom, Mahmud kept them out of Khurasan and finally forced them to acknowledge his suzerainty. His government was a centralized military despotism in which the old feudal structure was gradually broken down; his administrative officers, however, were drawn from the landowning classes in Khurasan, where the old traditions of the Tahirids were still preserved; and their strong Sunni sympathies contributed to Mahmud's championship of the Abbasid caliphs against the Buyids and other Shi'ite sectaries.

At the end of the 10th century the converted Turkish tribes of central Asia, under the leadership of the Il-khans, had occupied Transoxiana. Among the nomadic Turkmen groups that had migrated into the country, one, the Ghuzz, was transported by Mahmud to Khurasan. During a struggle between Mahmud's sons, the Ghuzz, led by Togrul (*q.v.*) and Chakir of the Seljuk family, allied themselves with the nobles of Khurasan, defeated the Ghaznavid army at Dendenkan (1040) and set out on the conquest of western Iran (*see* SELJUKS). Togrul entered Baghdad in 1055, and he and his successors Alp Arslan and Malik Shah (*qq.v.*), aided by the great Khurasanian vizier Nizam al-Mulk, united the whole of Iran, with Iraq and Syria, under their rule. Each province was assigned to a Seljuk prince (*malik*), whose army was maintained by military fiefs (*ikta*). After Malik Shah's death the rivalries of these princes led to renewed disintegration, except in Khurasan where his son Sanjar maintained order until 1153. Most of the other principalities were taken over piecemeal by former officers of the Seljuk army, called atabegs, who founded new dynasties, the

most important of which in Iran were the atabegs of Azerbaijan and the Salghur Turkmens of Fars. Favoured by this disintegration, the Shi'ite sect of the Assassins (*q.v.*) firmly established themselves in the highlands of Dailam and by their terrorism contributed to the demoralization of the governing classes.

The massive immigration of Turkmen tribes accompanying the Seljuks also made heavy inroads on the economy of Iran. Much cultivated land was turned into pasture, and only the walled cities and fortresses provided a measure of security for their environs, from which the revenues of the military fiefs were drawn. The devastation was increased when fresh bands of Ghuzz swarmed into Khurasan, defeated and captured Sanjar and looted its cities before moving on to occupy Kerman and to extinguish the Seljuk principality there. Sanjar's territories were disputed between his former vassals, the shahs of Khwarizm (Khiva), and the chiefs of Ghor in Afghanistan; eventually the Khwarizm-shah Takash (1172–99) conquered Khurasan and Isfahan, and his son Ala ud-Din Mohammed (1199–1220) drove out the Ghorids, conquered the rest of Iran and occupied Transoxiana. Their armies, recruited mainly from the half-pagan Kipchaks of the steppes, added to the general rapine and disorder, and the Khwarizm-shah himself devastated the border lands of Transoxiana in his conflicts with the Turkish khans in central Asia.

Mongols.—It is thus historically false to represent the Mongol invasions as suddenly and ruthlessly tearing down a flourishing civilization and prosperous economy and reducing Iran to a desert. Their effect was rather to intensify the process of nomadization, by destroying most of the cities—especially those of Khurasan during the first invasion under Genghis Khan in 1220—and disrupting the organizations in which the old traditions of Persian-Islamic culture were still cultivated. It was as if, in medieval Europe, the cities and schools of Italy and France had been laid in ruins and their populations killed or dispersed. Except for a few individuals in the service of the Mongols, learning and culture survived only in the peripheral regions, of which Fars was the most important. There is therefore some symbolic truth in the popular view of the Mongols, insofar as they finally destroyed the social and economic foundations upon which the culture of Persia had rested, even if more and more precariously, for a thousand years.

Under the successors of Genghis Khan the Mongols extended their power over the whole of Iran and consolidated it by a fresh invasion led by his grandson Hulagu (*q.v.*), who destroyed the Assassin fortresses in 1256 and captured Baghdad in 1258, putting the last of the Abbasid caliphs to death. Hulagu thus became the first of the new "provincial dynasty" (Il-khans; *q.v.*) of Iran, which, though nominally subordinate to the Mongol Great Khan in China, governed their territories as autonomous princes until 1335.

The Il-khans.—Except for occasional conflicts with their Mongol kinsmen of the Golden Horde to the north and the Jagatai khanate to the east, the external policy of the Il-khans was directed for about 50 years toward the conquest of Syria. This brought them into conflict with the Mamelukes of Egypt (*see* EGYPT: *History*) and some ineffectual negotiations with the crusaders and the Christian powers, but their ephemeral seizures of Aleppo and Damascus in 1260 and 1303 were terminated by crushing defeats.

In internal affairs the most constructive policy of the Il-khans was their interest in trade, which was directed through Azerbaijan to the Black sea and made Tabriz a centre of international commerce. They introduced a new system of administration and taxation which continued into the Safavid period but was constantly impeded by tribal risings and military disturbances. Religious questions also created many difficulties. The early Mongols were Buddhists, but were generally tolerant toward Islam and all other religious communities. The third Il-khan, Ahmed Takudar, adopted Islam in 1282 but was dethroned by the Mongol nobles and replaced by his nephew Arghun, under whom there was a reaction against the Muslims. His employment of a Jewish doctor, Sa'd al-Dawla, as finance minister in 1288, and the latter's severe measures against the Muslims, led to such general disorder and discontent that Sa'd al-Dawla's downfall and execution was followed by violent pogroms in all the provinces. A still more disastrous attempt was made in 1294 to issue paper currency, in imitation of the Chinese *chau*, but without monetary backing. In the following year Arghun's son Ghazan was raised to the throne, although he was already converted to Islam, and set on foot an impressive series of measures of reform. Most of them aimed at reconstituting the pre-Mongol land system, including military fiefs, and restoring order and security, but Ghazan's early death (1304) prevented him from carrying them through.

Although the economic results of Ghazan's reign were quickly dissipated, the political and religious results were important. Islam again became the official religion of the state, and its religious and social institutions benefited from state support. Most of the Mongol nobles and tribesmen in Iran had by now been converted to Islam, and the faith was making rapid progress also in the neighbouring khanate in central Asia. The reign of Ghazan's brother Ulja'itu (1304–16) was a period of relative tranquillity and moderate prosperity. Under his nephew Abu Said (1316–35) the internal and external forces of disruption became too strong to hold down. Powerful officers contended for control of the Il-khanate, and after his death set up rival successions of puppet princes. The contest was won finally by the Mongol Jelairs, whose chief, Hasan Buzurg (1336–56), established them in power in Iraq and Azerbaijan.

Out of the confusion which attended the decay of the Il-khans, Fars and Herat (in both of which local dynasties had continued under Mongol rule for several decades) regained independence—Herat under its former Ghorid princes, known as the Kurts, Fars under the dynasty of Muzaffar. Besides the Jelairs, other nomadic chiefs governed parts of Iran, notably in Luristan. A more remarkable phenomenon was the success of an association of local bands in Khurasan who called themselves Serbadars and controlled most of the province, an instance of the new kind of associations which were growing up (mostly in relation to some Sufi leader or group) among the general population, in reaction to the political anarchy of the preceding centuries. The most notable political event of the period was the failure of an attempt by the Golden Horde to seize Azerbaijan (1357), while the economic decay of Iran was accentuated both by the disruption of trade routes and by disastrous plagues.

Whatever elements of urban culture survived these disasters were almost entirely destroyed by Timur (*q.v.*). The Mongol Il-khans had only with much difficulty protected the eastern frontier against the Jagatai khans of Transoxiana. This task, on passing to the Kurt kings of Herat, was eased for a time by internal dissensions in the Jagatai khanate. But when, between 1370 and 1380, Timur recreated a centralized power at Samarkand, they were powerless to resist, and after the fall of Herat in 1383 he swept over Iran without meeting effective opposition. Later risings were put down with ruthless cruelty; city after city was destroyed and their populations were massacred, except for the craftsmen who were transported to Samarkand to embellish the conqueror's capital. (H. A. R. G.; P. W. A.)

Timurids and Turkmens.—Timur died as he was setting out on an expedition to China (1405), and his conquests were divided between numerous descendants, of whom his sons Miranshah (d. 1407) and Shahrukh held western and eastern Iran respectively, and a grandson, Pir Mohammed, held Fars. The devastation and depopulation of Iran had left only three centres of power outside Transoxiana; these were Herat, Fars and Tabriz, and the conflicts of the next century developed into a struggle between Herat and Tabriz. Rivalries and warfare among the Timurids weakened them against the Turkmens of Azerbaijan and Armenia, themselves grouped in two rival confederacies, the Kara-Koyunlu (Black Sheep) and Ak-Koyunlu (White Sheep). The Black Sheep were at first the more powerful, and their chiefs Kara Yusuf (1388–1420) and Iskandar (1420–38) repeatedly occupied Azerbaijan and Mesopotamia. Nevertheless Shahrukh (1405–47) succeeded in time in reuniting most of Timur's empire under his rule. Unlike his father, he devoted himself to restoring some measure of prosperity and made his capital Herat the centre of a renewed and artistically brilliant Persian culture. He was succeeded by his only surviving son, Ulug-Beg (1447–49), formerly governor of

Samarkand; Ulug-Beg's name was made famous by the astronomical tables (*zij*) drawn up under his patronage, but in his time the Uzbek Turkmens began to challenge the Timurid government in Transoxiana. His murder was followed by further struggles among the Timurids, during which the Black Sheep under Jahanshah (d. 1467) extended their rule over Iraq, Fars and Isfahan (1453). Scarcely had Miranshah's grandson Abu Said established his power in the east than Jahanshah invaded Khurasan and seized Herat (1458), but the growing power of the White Sheep under Uzun Hasan brought about an agreement between Abu Said and Jahanshah to divide Iran between them. Defeated by the Ottoman Turks in 1461, Uzun Hasan turned against the Black Sheep and defeated and killed Jahanshah (1467), whose son appealed to Abu Said for assistance. Rejecting Uzun Hasan's overtures for peace, Abu Said marched into Azerbaijan and was defeated and killed (1469). The White Sheep were now supreme in the west, but were preoccupied with the growing Ottoman power, and the Timurids remained in possession of Herat, where the sultan Husain Bayqara (1468–1506) maintained a brilliant and luxurious court. After the deaths of Uzun Hasan (1478) and his son Yaqub (1490), the White Sheep confederacy began to break up, and western Iran and Iraq gradually became fragmented between petty governments, which opened the way to the conquests of the Safavids.

(X.)

VII. SAFAVIDS, 1501–1736

Shah Ismail I (*q.v.*), the founder of the Safavid (Safawid) dynasty, was sixth in descent from the saintly Sheikh Safi al-Din (1252–1334) of Ardabil, who had founded an order of Sufis there. Sheikh Safi claimed descent from the Prophet Mohammed through the imam Musa al-Kazim, the seventh of the imams or spiritual leaders of the Shi'a. Sheikh Safi and those of his descendants who succeeded him as the head (*pir* or *murshid*) of this order were greatly revered. They formed a theocratic form of government at Ardabil, ruling only as spiritual leaders. Their theocracy became so popular and influential that it excited the fears of Jahanshah, the Black Sheep chieftain who ruled over central and northwestern Iran from 1457 to 1467.

Sheikh Safi and his son and successor Sheikh Sadr al-Din were both Sunnis, but Sheikh Sadr al-Din's son Khwaja Ali, who succeeded to the headship of the order in 1399, adopted Shi'ism (*q.v.*) in a moderate form. His successor, Sheikh Ibrahim, became, however, imbued with extreme Shi'ite views, as was his son Sheikh Junaid who perished when fighting against the Sunnis of Dagestan (Daghistan) in 1455. Sheikh Haidar, who became head of the order on his father's death, gave to his followers, who were all Shi'ite Turkmens, the scarlet cap with 12 gores (one for each of the Shi'ite imams) which earned for them the nickname of Qizilbash ("Red Head"). Sheikh Haidar married Marta, the daughter of the White Sheep ruler Uzun Hasan and his Christian wife Despina Katerina, daughter of Kaolo Joannis, the penultimate emperor of Trebizond (Trabzon); by Marta Haidar had three sons and one daughter. Haidar, like his father, was a militant Shi'ite, and he was killed when fighting against the Sunnis in 1488, when his third son, Ismail, was only one year old. Ismail and his two elder brothers narrowly escaped capture by their enemies on a number of occasions. Eventually both the elder brothers were killed, leaving only Ismail, who thus succeeded to the headship of the Sufis of Ardabil. Ismail, by virtue of his position, won the support not only of the local Turkmens but also of many other tribes which had sought sanctuary in order to escape the persecution of the Ottoman Turks. With the aid of these tribes Ismail was able to capture Tabriz, where he was enthroned as shah of Azerbaijan in July 1501. In the course of the next few years Shah Ismail gained control over the greater part of Persia. He thereupon attacked the Sunni Uzbeks who had occupied part of northeast Persia and defeated them in a great battle near Merv in 1510. Despite the fact that many of his subjects had at the outset been Sunnis, Shah Ismail converted the majority to Shi'ism, which he made the state religion. He had even wider religious aspirations, a fact which brought him into conflict with Sultan Selim I (*q.v.*) of Turkey, a fanatical champion of Sunnism. The clash came at Chaldiran in northwest Persia in Aug. 1514. Though they fought with great bravery, Shah Ismail's tribal levies proved in the end no match for Selim's well-trained Janizaries and his corps of artillery. Selim followed up his victory by taking Tabriz, but a mutiny of his troops soon after forced him not only to relinquish it but to withdraw to Turkey.

The defeat at Chaldiran was a severe blow to Persian morale, but, on the other hand, Ismail was able thereafter to keep both the Ottoman Turks and the Uzbeks at bay and to retain the provinces of Baghdad and Mosul, which he had wrested from the former in an earlier campaign.

One of the consequences of Vasco da Gama's discovery of the sea route from Europe to the east by the Cape of Good Hope was the appearance of the Portuguese in the Persian gulf under the able leadership of Affonso d'Albuquerque early in the 16th century, when they captured the island of Hormuz and also made themselves masters of part of the adjoining mainland. Owing to his life and death struggle with the Ottoman Turks, Shah Ismail could do no more than make a protest to Portugal, but this aggressive action rankled not only in his mind but also in the minds of his successors.

Shah Ismail died, deeply regretted by his subjects, in 1524. During his reign he had welded his peoples into a nation; in this connection, the fact that he had made Shi'ism the dominant faith in Persia was of importance since the threat of attack by the Sunni powers on both the northwestern and northeastern frontiers served to knit the various racial elements together in defense of their common creed.

Tahmasp I and His Successors.—Shah Tahmasp (reigned 1524–76), Ismail's eldest son, was only 11 years old when he succeeded to the throne; he was thus for a number of years no more than a puppet in the hands of the powerful Turkmen chiefs. The early years of his reign were disturbed by repeated onslaughts of the Uzbeks and also by local revolts. Fortunately for Persia it was not until after these troubles had ceased that Sultan Suleiman I (*q.v.*) the Magnificent invaded Persia, capturing Tabriz and recovering the territory in Mesopotamia which Shah Ismail had conquered. The Turks soon relinquished their possession of Tabriz and withdrew to their own country, but in 1538 they renewed their onslaught, taking Tabriz again; once more, however, their possession of the Persian capital was brief. It was the proximity of Tabriz to the Turkish frontier which induced Shah Tahmasp to make Kazvin his capital in 1548.

In the course of Tahmasp's reign the western European powers were often hard-pressed by the Turks. The fact that the latter had a relatively strong and often hostile power on their eastern border was a factor of importance; on one occasion Augier de Busbecq, the emperor Ferdinand's envoy at Constantinople, remarked, "It is only the Persian who stands between us and ruin."

In 1561 the English merchant and traveler Anthony Jenkinson arrived at Kazvin bearing a letter from Queen Elizabeth to the shah, his object being to establish trade between England and Persia across Russia. Tahmasp received Jenkinson courteously, but brusquely bade him depart on discovering that he was a Christian.

When Shah Tahmasp died in 1576, Persia had grown appreciably weaker than it had been at the outset of his reign, one reason being that he had allowed the Turkmen chiefs to increase their power and influence. On the other hand, he had managed to prevent the Ottoman Turks and the Uzbeks from permanently alienating any of his territory.

On Tahmasp's death the crown passed to his elder son, Ismail, a drunken and dissolute tyrant who was poisoned after reigning for only a few months. His brother Mohammed Khudabanda, who succeeded him, was purblind and of weak character. The Turkmen chiefs took advantage of the situation to make themselves practically independent; when the Turks and Uzbeks once again invaded the country, they paid little or no heed to the shah's appeals for help.

Abbas I.—So serious did the situation become that a patriotic chieftain belonging to the Ustajlu tribe deposed Mohammed Khudabanda in 1587 in favour of his son Abbas (*see* ABBAS I, shah of Persia), who was then a youth of 16. The outlook for the

young monarch was most discouraging. Not only was much of his realm in the hands of the Turks and Uzbeks, but in the territory which remained free of their control the Turkmen tribes enjoyed a monopoly of military power. It being essential to break this military monopoly, Shah Abbas made a beginning toward this end by creating a special force which was paid directly from the royal treasury. Realizing that with his still very limited military strength he could not hope to contend successfully with both the Turks and the Uzbeks simultaneously, Shah Abbas made peace with the former on unfavourable terms in 1599 in order to concentrate on the latter. Fortunately for him, the Uzbeks were at that time weakened by internal dissensions, so the Persians' first onslaught on them was successful. The Uzbeks thereupon composed their differences and forced the Persians to evacuate Balkh, which they had occupied; they were unable, however, to renew their incursions into Persia. Early in 1599 the English adventurer Sir Anthony Sherley, his brother Sir Robert and a number of other Europeans arrived at the Persian court on an unofficial mission from the earl of Essex, with the object of inducing the shah to ally himself with the Christian powers against Turkey and to improve commercial relations between England and Persia.

As the trial of strength with Turkey had yet to come, Shah Abbas was most anxious to reform his army. By a fortunate chance, Sir Robert Sherley was a well-trained and capable soldier, and with his aid the shah formed three bodies of troops, all of whom were properly trained and armed and, moreover, were paid out of the royal treasury. One of these bodies of troops was a cavalry corps called the Qullar or "Slaves"; they were not in fact slaves, but were so called because they were recruited for the most part from Caucasia whence the Persians had for long been wont to take slaves. Like the Turkish Janizaries, the Qullar were mostly of Christian descent. The Tufangchis (musketeers) formed the second corps; they were at first infantry but were later converted into cavalry. The Topchis (artillerymen) formed the third corps. With his new army in being, Shah Abbas greatly reduced the strength of the Qizilbash levies and then, in 1603, he attacked the Turks. In this war his troops acquitted themselves brilliantly, proving more than a match for their formidable foes, with the result that Turkey had to relinquish the territory it had seized. Moreover, in a later campaign, Shah Abbas carried the war into Mesopotamia, capturing Baghdad. By his wise leadership and the valour and efficiency of his army, Persia's prestige was greatly enhanced. Although endeavours were made on more than one occasion to form a definite alliance between Persia and the western powers, these met with no success; but, as had previously been the case, the fact that Turkey had a strong military power on its eastern frontier curbed to some extent its activities in Europe.

Shah Abbas' reign was remarkable not only for his striking military successes but also for the efficiency of his administrative system, the magnificence of his court and his genius and zeal as a builder. Having made Isfahan his capital in 1598, he replanned and largely rebuilt it, endowing it with many splendid buildings such as the Masjid-i-Shah (*masjid*, "mosque"), the smaller but exquisite Masjid-i-Shaikh Lutfullah, the Ali Qapu and the Chihil Sutun; all these, with the exception of the Chihil Sutun, front onto the splendid Maidan-i-Shah or royal square. In consequence of Shah Abbas' endeavours, Isfahan became a worthy capital of his realm, rivaling even London in size (*see* ISFAHAN).

Shah Abbas fostered trade and industry in his new capital by settling many Armenians from the north of Persia in a new suburb called Julfa (Jolfa). He encouraged the English and Dutch East India companies to establish branches in Persia, giving them special trading facilities. He ruthlessly put down brigandage, making the routes once more safe for caravans and travelers; he also improved communications by constructing many bridges and caravansaries.

As Shah Abbas was an ardent nationalist, the Portuguese foothold in southern Persia was extremely irksome to him. In 1602 he expelled them from the mainland to the north of their trading centre on the island of Hormuz. Twenty years later, with the aid of the fleet of the English East India company, he ousted the Portuguese from Hormuz itself; to show his gratitude to the company he gave it valuable privileges at the port of Bandar Abbas (which was named after him).

In religion Shah Abbas was a zealous Shi'ite. As most of the holy cities of Islam were in the hands of the Sunni Turks, he urged his subjects to confine their pilgrimages to shrines of the imam Riza at Meshed and of his sister Fatima at Qom; he set them an example by performing the pilgrimage from Isfahan to Meshed on foot. Notwithstanding his religious zeal, Shah Abbas was most tolerant toward Christians, allowing the Carmelites and other orders to set up missions and build churches at Isfahan and elsewhere.

Although he had so many admirable qualities, Shah Abbas' character was marred by a cruel streak which manifested itself mostly against members of his own family. He not only blinded and imprisoned his father and his two brothers, but he also had his own son Mohammed Baqir Mirza executed and another son, Imam Quli, blinded.

Shah Abbas, unquestionably raised Persia from the depths of degradation to the status of a great power, yet he was nevertheless partly responsible for its subsequent decline by introducing the practice of immuring, for purposes of security, the heir apparent (as well as the other royal princes) in the harem, with the result that when the moment came for him to mount the throne he was totally inexperienced in the art of government. Shah Abbas died in Jan. 1629 at the age of 58, having reigned 42 years.

Decline of the Safavid Dynasty.—After the death of Shah Abbas the Safavid dynasty lasted for nearly a century, but, except for an interlude during the reign of Shah Abbas II (1642–66), it was a period of decline. One of the main reasons for this decline was the deterioration in the character of the sovereigns, which was due largely to the above-mentioned pernicious practice of incarcerating the heir apparent in the harem until the moment came when he had to succeed his father. In the circumstances, the court eunuchs obtained an undue measure of influence and power. As had been the case in Achaemenian times, this undoubtedly contributed to the decline of the dynasty. Shah Safi (1629–42) showed himself indifferent to affairs of state or the good of his country. He was cruel and bloodthirsty and he put to death many of his own relations as well as a number of the generals and statesmen who had greatly contributed to the glory of Shah Abbas' reign. Sultan Murad IV, the last of the Turkish warrior sultans, invaded Persia repeatedly, massacring the inhabitants of Hamadan and Tabriz and recovering Baghdad. Under Shah Abbas II Persia recovered some of its glory, and the pomp and pageantry of the court dazzled European envoys and travelers. Shah Abbas II's successor, Shah Suleiman, was a debauched tyrant, indifferent to the welfare of his people or to governmental affairs, and decline set in once more; it became accentuated under the pious but weak Shah Sultan Husain who ascended the throne in 1694. During his inglorious reign the control of affairs came more and more into the hands of the court eunuchs and the mullahs.

The first outward sign of impending disaster was the successful revolt of the Ghilzai Afghans of Kandahar in 1709 under the able leadership of their chief Mir Vais. He defeated the forces sent against him and ruled as an independent monarch until his death in 1715. In 1720 his son Mahmud raided Persia, penetrating as far as Kerman; he was then forced to return to Kandahar to quell a revolt there. In 1722 he again invaded Persia, once more taking Kerman. He then continued his advance. Although he was repulsed at Yazd, he marched boldly on Isfahan. Near the village of Gulnabad, 12½ mi. E. of the capital, the Afghans encountered the vastly superior Persian forces. Due mainly to bad leadership, the Persian troops were routed and fled in confusion back to the capital. Mahmud thereupon resumed his advance and invested the city, gradually cutting off all sources of supply from outside. In due course, famine set in and was followed by pestilence which took a terrible toll of the inhabitants. Tahmasp Mirza, the heir apparent, escaped from Isfahan with the object of raising a relieving force, but he failed to take any active steps to do so. Eventually, on Oct. 23, 1722, Isfahan surrendered and Shah Sultan Husain had to surrender his crown to his uncouth Afghan conqueror. As the Ghilzais were never in control over more than a portion of the

country, however, and as the Safavids were restored in 1729, the dynasty may be regarded as continuing until its complete suppression seven years later.

Peter the Great of Russia had for long been contemplating the establishment of a trade route to India across the Caspian sea and the countries beyond. The losses sustained by some Russian merchants in northern Persia in the course of a tribal uprising there in 1721 gave him the pretext for invading that country in the following year. Peter's action alarmed the Turks, who likewise invaded Persia in order to prevent Russia from gaining control over the territories contiguous to their country. For a time war between Turkey and Russia seemed imminent, but a settlement was reached in 1724 when the two powers agreed to partition much of Persia between them, Russia taking part of the northern provinces while Turkey occupied the northwest and west portions. Mahmud, the Ghilzai usurper, was left in possession of central and part of southwestern Persia, while the remainder of the country was in loyalist hands.

Mahmud died or was put to death in 1725 and was succeeded by his more capable cousin Ashraf. Although he held the capital and its district, Shiraz and other parts of southern and southwestern Persia, his position was most insecure, as his Afghan troops were greatly outnumbered by those who remained loyal to the Safavids. The Afghans were detested by the Persians on racial grounds and also because they were stanch Sunnis. Tahmasp Mirza, who had proclaimed himself shah on hearing of his father's deposition, was gathering troops in the northeast, and Russia and Turkey were determined to retain the Persian territories they had seized. As Peter the Great had alleged that he would endeavour to restore the Safavid dynasty, Ashraf remonstrated with Turkey for allying itself with Russia, a Christian power, in order to deprive him, a Sunni ruler, of his throne in favour of a Shi'ite claimant. Ashraf's arguments met with some favour in Turkey, but the latter nevertheless declared war on him. Ashraf, by skilful propaganda, undermined the morale of the Turkish troops and won a victory over them. By his studied moderation after his military success and by his appeal for unity among Sunnis, he made peace with Turkey on relatively favourable terms, being recognized as shah of Persia. Turkey, however, refused to cede to him any of the provinces it had occupied.

Nadr Quli Beg.—Ashraf was no sooner freed from the Turkish menace than he was confronted with another danger the serious nature of which he failed at first to realize. Tahmasp Mirza was at this juncture joined by Nadr Quli Beg, a member of the Afshar tribe and former leader of a band of robbers. Nadr Quli Beg brought with him 5,000 Afshars and other tribesmen to whom he had already given some military training. In gratitude for his adhesion, Tahmasp Mirza gave Nadr Quli Beg the title of Tahmasp Quli Khan. Tahmasp Mirza had already obtained the support of 3,000 Qajar tribesmen under their chief Fath Ali Khan. Both Tahmasp Quli Khan and Fath Ali Khan were intensely ambitious men, and a keen struggle for supremacy immediately ensued. This struggle ended in Tahmasp Quli Khan's favour when Tahmasp had his rival executed on a charge of treason.

Tahmasp Quli Khan soon showed that he was a soldier of genius. He took great pains to train the prince's forces, inspiring them with confidence not only in him but also in themselves. Deeming the Ghilzai Afghans too formidable to be attacked by his still only partially disciplined men, he first led them against rebels who had set themselves up as independent rulers in Meshed and Herat, in both cases achieving complete success.

Meanwhile, Ashraf, having at last become aware of his danger, marched eastward to attack Tahmasp Mirza and his formidable general. In a series of brilliant victories, Tahmasp Quli Khan defeated and almost annihilated the Afghans; on the recovery of Isfahan in 1729, Tahmasp was able at last to ascend the throne. Tahmasp Quli Khan then attacked the Turks and drove them out of most of the territory they had occupied; a revolt in Khurasan prevented him, however, from completing their expulsion. In his absence in Khurasan, Shah Tahmasp rashly attacked the Turks; having sustained a heavy defeat, he had to make peace on humiliating terms. Tahmasp Quli Khan hastened back from Khurasan, deposed Tahmasp and placed the latter's infant son Abbas on the throne. He thereupon resumed the war with Turkey, retrieving the provinces lost by Tahmasp and completing the expulsion of the Turks from Persia. By threatening war, Tahmasp Quli Khan made Russia relinquish its conquests in Persia.

In the spring of 1736 Tahmasp Quli Khan felt himself strong enough to cast all pretense aside, deposing Abbas III and mounting the throne himself; on so doing, he took the title of Nadir Shah (*q.v.*).

VIII. AFSHARIDS, 1736–49

Nadir Shah had successfully dealt with both the Turks and the Russians, having previously shattered the Ghilzai Afghans. Nevertheless, the Ghilzais, under Husain, Mahmud's brother, still maintained themselves in the province of Kandahar, a fact which made Nadir determined to attack them. Husain had ample warning of Nadir's intentions and had accumulated large stocks of provisions and military stores. The fortress of Kandahar, moreover, was very strong. As Nadir had no siege artillery, a long blockade followed the investment of the fortress. For many months the siege went on, great damage being done to the defenses; at length, after nearly a year had elapsed, Kandahar fell. Nadir treated the survivors of the garrison with moderation and enlisted many of them in his army. With the capture of Kandahar and the subjugation of the surrounding district, the recovery of the lost provinces of Persia was complete.

Indian Campaign.—Nadir, who was an intensely ambitious man, was not satisfied with this achievement, great though it was. For some years past, the lure of India and its incalculable wealth had had him in thrall. It so happened that the Mogul dynasty, like that of the Safavids, had for some time been on the decline, and Mohammed Shah, the degenerate descendant of Babur and Akbar, and his imbecile ministers were not the men to be in control of a vast empire at a time of serious crisis. As soon as Nadir could complete his preparations after the fall of Kandahar, he and his well-trained veterans set out on their eastward march. After capturing Kabul, Nadir pressed onward, but found the Khyber pass held in force by the Indian troops. Nothing daunted, Nadir traversed the mountains by the parallel Tsatsobi pass and attacked and routed the Indians from the rear. The Persian forces then resumed their advance, capturing Peshawar and crossing the Indus without meeting serious resistance.

Meanwhile, Mohammed Shah had at last realized the danger confronting him. He and his main forces marched from Delhi to Karnal, 70 mi. to the north, where they formed a strongly entrenched camp in which to await the oncoming enemy. Nadir, when his army drew near, realized the strength of the Indian position, and decided to give battle only if the emperor's forces emerged; if they failed to do so, he would march directly on Delhi. At this juncture, Sa'adat Khan, the subahdar of Oudh, joined Mohammed Shah with 30,000 men. Hearing a report that the Persians were plundering his baggage, Sa'adat Khan impetuously attacked them, but was lured into a trap, defeated and taken prisoner. Part of the emperor's forces who had gone to Sa'adat Khan's assistance then became involved with the Persians. In the battle which ensued Nadir's forces obtained a complete victory. He thereupon surrounded the Indian camp and cut off all supplies.

Mohammed Shah, knowing that his troops would not fight again and that supplies would soon be exhausted, surrendered. Nadir treated him outwardly with respect but in reality made him and his nobles prisoners. In company with the luckless emperor, Nadir thereupon marched in triumph to Delhi, which he entered in March 1739. He then proceeded to strip the emperor and his people of their treasures, obtaining, it is said, booty to the value of Rs. 700,000,000. As the Indian historian Anand Ram Mukhlis remarked, "the accumulated wealth of 348 years changed owners in a moment."

Nadir remained for two months in Delhi. He put down with such terrible severity a rising of the citizens against his troops that a *nadir-shahi* is still synonymous there with a massacre. After this tragic event, Nadir demanded and obtained the hand of a granddaughter of Aurangzeb for his second son, Nasrullah Mirza.

When, in accordance with Mogul etiquette, inquiries were made as to Nasrullah's descent to the seventh generation, Nadir said: "Tell them that he is the son of Nadir Shah, the son of the sword, the grandson of the sword, and so on until they have a descent of 70 instead of seven generations."

Realizing that he could not hold Delhi, Nadir restored it and the bulk of the empire to Mohammed Shah, but he annexed the provinces on the right bank of the Indus, which during the reign of Darius had been incorporated in the Achaemenian empire. Then, after a stay of less than a year, he returned to Persia with greater power, wealth and glory than any other Asian conqueror since Timur.

Campaign Against Bukhara and Khiva, 1740.—During the siege of Kandahar, Nadir had dispatched Reza Quli Mirza, his eldest son and heir, against Balkh, whose ruler had promised help to Husain, the Ghilzai ruler. The prince had proved himself worthy of the command and succeeded in taking the city. He then crossed the Amu-Darya river and defeated a strong force of Uzbeks. Nadir, who was unwilling to attack Bukhara at that juncture, then recalled Reza Quli. After the Indian campaign the situation, however, was completely changed. Nadir had not forgotten the raids made on Khurasan by the Turkmens of Khiva, and he realized that a campaign against the two Uzbek states would form a natural corollary to the conquest of India, besides protecting Khurasan against Turkmen raids for some time to come. Large quantities of grain had been collected at Balkh and loaded into boats, and the expedition then began its march down the Amu-Darya to Charjui (Chardzhou) where a crossing was made by means of a bridge of boats. The amir of Bukhara, realizing that he could not hope to resist Nadir's veterans, promptly submitted and went to the Persian camp. There he was at first treated with disdain, but Nadir finally restored him to the throne on condition that the Amu-Darya should again form the boundary of Persia and that the amir should supply a contingent of troops for the Persian army.

After Bukhara it was the turn of Khiva. On learning of Nadir's approach, Ilbars, the khan of Khiva, set out to destroy the bridge of boats at Charjui, but Nadir forestalled him and routed his forces. Taking his supplies by boat down the Amu-Darya, Nadir pursued Ilbars along the river bank and decisively defeated him near Khiva. Soon afterward Ilbars surrendered. As he had put to death the envoys whom Nadir had sent to him before the campaign, the conqueror executed him together with 30 of his councilors. At Khiva Nadir found two Englishmen who were members of the staff of Jonas Hanway, the intrepid merchant who endeavoured to establish trade between Persia and central Asia across Russia and who has left a most valuable account of the state of Persia at this time. Nadir treated the Englishmen kindly, giving them passports and promising them compensation for their losses. One result of this campaign was the release of thousands of Persian and Russian slaves; furthermore, the crushing of the Khivans stopped for some time their incursions into Persian territory.

Nadir was now at the zenith of his fame. Not only had he driven all Persia's foes from its soil, but he had made its territories more extensive than those of the Safavids. Through him Persia was once again a great military power. Had he possessed any foresight and any real concern for his people, he would have abandoned all further idea of war and conquest and so would have enabled Persia to become prosperous and settled. Nadir, however, had no administrative capacity or thought for the well-being of his people; he lived only for war.

While Nadir was besieging Kandahar, Ibrahim Khan, his only brother, who was in command of the forces in northwestern Persia, having heard of the successes of his nephew Reza Quli Mirza in Turkistan, wished to emulate them. He rashly attacked the formidable Lezgian tribe, but lost his life in so doing. Nadir, on learning of this disaster, felt bound to avenge his brother. He accordingly set out for Dagestan; on his way, he was shot at and slightly wounded. Like Shah Abbas, Nadir was jealous of his eldest son, whom he unjustly suspected of having instigated this attempt on his life. He subsequently had the unfortunate prince blinded. The prince reproached his father, saying, "It is not my eyes but those of Persia which you have put out."

At the outset of Nadir's campaign against the Lezgians all went well, but the main bodies of these hardy and warlike tribesmen retreated to the densely wooded higher country where conditions were ideal for ambushes and surprise attacks. The result was that the Persian troops were repeatedly defeated, suffering heavy loss. These reverses infuriated Nadir, but despite the utmost efforts of his troops, the stubborn Dagestanis more than held their own and eventually forced him to retreat baffled and sullen. At the close of the campaign Nadir found himself with an exhausted and depleted army and with his prestige much impaired.

The success of the Lezgians caused revolts to break out in various parts of the country, but Nadir suppressed them with merciless severity. He had unwisely endeavoured to reunite Islam by making his people abjure Shi'ism and join the Ja'fari sect, which he intended to be a fifth sect of the Sunnis. At the time his subjects did not openly object to the change, but it was nevertheless most unpopular. Moreover, in Turkey it met with a hostile reception, the religious leaders there giving the following decision: "The new sect is contrary to the true belief, and it is permissible to kill the people of Persia." This decision was followed by the invasion of Persia by an enormous army, which was determined to avenge former defeats. Nadir, however, as great a general as ever, inflicted a crushing defeat on the Turks, capturing the whole of their artillery and stores. Negotiations for peace followed in the course of which Nadir agreed to abandon his claim to found a new sect and to release his prisoners. This was his last victory.

Death of Nadir Shah, 1747.—During the last few years of his life Nadir became increasingly savage and cruel, being subject to sudden outbursts of rage. In these paroxysms he put to death so many of his officers and advisers that no one felt safe. The consequence was that he was assassinated in his tent one night when endeavouring to suppress a revolt in Khurasan. Thus ended the career of Nadir Shah, who, endowed with superb physique, a voice of thunder, dauntless courage and a real genius for war, had hewn his way to the throne. As in the case of Napoleon, with whom he may be compared, success had caused moral deterioration, and when he died the nation which he had saved from the Afghans, Turks and Russians received the news with intense relief. Had the attempt on his life in 1741 been successful, he would have been the national hero for all time.

Nadir's assassination was the signal for the breakup of his composite army. Ahmad Khan Abdali and his Afghans, who had remained loyal to Nadir to the last, marched off to Kandahar. On the way Ahmad had the good fortune to intercept a Persian treasure convoy. He thereupon marched on and founded the kingdom of Afghanistan, taking the title of Ahmad Shah Durrani. The Persian throne was seized by Nadir's nephew Ali Quli Khan, who took the title of Adil Shah. His reign was very brief, as he was soon deposed and blinded by his brother Ibrahim. The new shah attempted to seize Shahrukh, the son of the ill-fated Reza Quli Mirza, but failed to do so. Not long afterward Ibrahim was killed by his own troops, and Adil Shah also lost his life at this juncture. Shahrukh was then made shah, but in Dec. 1749 he was supplanted and blinded by a Safavid claimant, who styled himself Suleiman II.

At this juncture the Afsharid dynasty may be said to end; although Shahrukh was reinstated by Ahmad Shah Durrani after the brief rule of the Safavid usurper (who was himself deposed and deprived of his sight after ruling for only 40 days), his authority, such as it was, was limited to Khurasan which was for many years merely an appanage of Afghanistan.

Meanwhile, a stern triangular contest for control over the rest of Persia had developed, the aspirants for power being Karim Khan, of the Zand tribe of Fars; an Afghan general named Azad Khan; and Mohammed Hasan Khan, a son of Fath Ali Khan Qajar whom Tahmasp had put to death in 1726. Victory went first to one and then to another of the three claimants until, after Mohammed Hasan Khan had been killed and Azad Khan had surrendered, Karim Khan was left supreme.

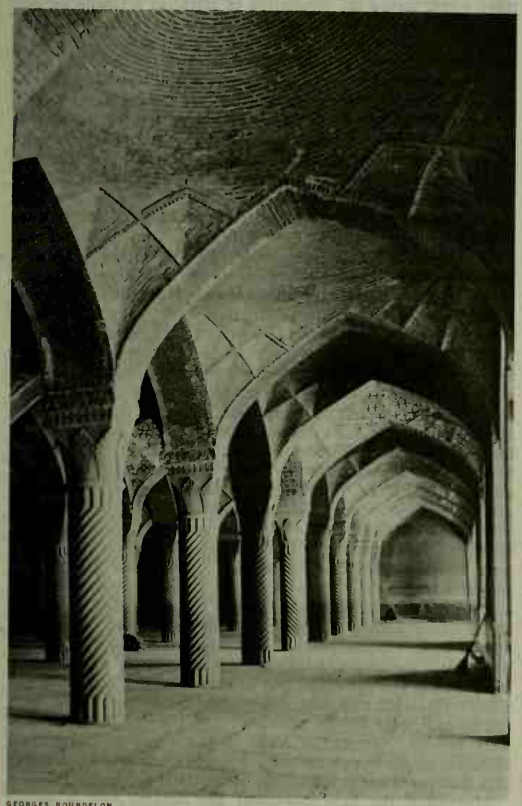
IX. ZAND DYNASTY, 1757–94

Karim Khan, a man of humble birth, had served in Nadir's army, without, however, achieving any distinction as a leader. He owed his popularity to his probity, his tolerant views and his kindliness. Under his rule Persia enjoyed a much-needed period of peace and justice, with the result that there was some return to prosperity. He never styled himself shah, being content with the title of *vakil* (regent). Being a man of the south, he made Shiraz his capital and adorned it with many noble buildings and beautiful gardens.

Persia's period of peace and prosperity was ended on Karim Khan's death in 1779, when various members of the Zand family strove for the succession. For a number of years one of the hostages at Karim Khan's court was Agha Mohammed Khan Qajar, a son of Mohammed Hasan Khan. When very young he had fallen into the hands of Adil Shah, who had made him a eunuch, a cruel act which permanently warped his character. When Agha Mohammed learned that Karim Khan was *in extremis*, he escaped from Shiraz and hastened to the Qajar tribal country in the northeast where he gathered together a strong force. Subsequently, he gained over to his side Hajji Ibrahim, the redoubtable vizier of the Zand family, with whose help he was able to defeat and capture the gallant Lutf Ali Khan, the last of the Zand dynasty, whom he most cruelly tortured and put to death.

X. QAJAR DYNASTY, 1794–1925

Agha Mohammed Shah.—Agha Mohammed owed his success not so much to his generalship as to his statesmanship and guile.



GEORGES BOURDELON

PRAYER ROOM IN THE HAKIL MOSQUE, SHIRAZ; THE CITY WAS EMBELLISHED BY KARIM KHAN IN THE 18TH CENTURY

As Hajji Ibrahim remarked after his death, "That monarch's head never left work for his hand." As pointed out, his mutilation when a mere youth had left a permanent mark on his character, making him vindictive and inordinately cruel.

After Agha Mohammed's final defeat of his rival, he attacked King Erekle (Heraclius) II of Georgia who, after Nadir Shah's death, had declared the independence of his country and had annexed territories extending southward to the Aras river. He had subsequently placed Georgia under the protection of Russia. Agha Mohammed acted so swiftly that he was able to defeat Erekle in the field and capture and sack Tbilisi (Tiflis) before Russia could respond to the Georgian ruler's appeal for aid. Agha Mohammed then evacuated Tbilisi and returned to Teheran which he had made his capital city.

In the spring of 1796 Agha Mohammed, yielding with feigned reluctance to the pleadings of his courtiers, had himself enthroned in Teheran. Almost immediately after the ceremony the shah set out for Khurasan, where Shahrukh still held his pathetic court. Being unable to offer resistance, Shahrukh submitted, but Agha Mohammed had a further motive; he knew that the prince had in his possession many of the priceless jewels which his grandfather had looted in Delhi in 1739. He thereupon subjected the prince to torture, forcing him gradually to give up his treasures. Finally, after Aurangzeb's famous ruby had been extorted in this way, Shahrukh, worn out by his sufferings, fell ill and died, cursing the Qajar monarch.

Agha Mohammed had intended to attack Bukhara after attaining his object in Khurasan, but, on learning that the Russians had invaded northern Persia, he hastened westward with his forces to oppose them. The Russians succeeded in taking Derbent and Baku but failed to capture Enzeli. Later they entered Shamakhi, in Shirvan, and were thus in a position to threaten Azerbaijan when the news of the death of the empress Catherine caused them to withdraw.

In the spring of 1797 Agha Mohammed Shah set out for Georgia to attack Erekle again. Before he came to grips with the Georgians, he was murdered in his tent by two of his servants whom he had sentenced to death for some trivial offenses but had nevertheless allowed to continue in attendance on him. Thus died the founder of the Qajar dynasty (*q.v.*), who had made himself detested and feared by all his subjects.

Fath Ali Shah.—The assassination of Agha Mohammed Shah was followed by a struggle for the throne which ended with the triumph of his nephew Fath Ali (reigned 1797–1834), a man of very different stamp. He was in general kindly and humane, though he could on occasion be capricious and cruel. It was during his reign that Persia, due to its position on the overland route to India, became involved in the rivalries of European powers. In 1798 Zaman Shah, the amir of Kabul, invaded India, advancing as far as Lahore. Lord Wellesley, the governor general, sent an envoy to Teheran to request the shah to take any steps short of war to curb the ambitious amir. Zaman Shah at this juncture demanded the cession of Khurasan by Persia, which led Fath Ali Shah to co-operate with the British by sending military aid to two Afghan pretenders; the amir thereupon withdrew his forces from Indian soil. Hardly had this danger to India been averted when what appeared to be a far more ominous menace developed. Napoleon and his Russian ally, the emperor Paul, planned to invade India jointly, by way of Persia. Although in the light of modern knowledge of the territories concerned it is clear that the scheme would have been impracticable, it was taken seriously at the time. Lord Wellesley sent Captain (later Sir John) Malcolm to Teheran, at the head of an imposing mission, to take all possible steps to persuade the shah to put pressure on the amir of Kabul to counteract the French designs and to negotiate a political and commercial treaty. Malcolm, who conducted the negotiations in an able manner, obtained the desired assurances from the shah and concluded a political and commercial treaty with him. Unfortunately, when Malcolm returned to India, no one was sent to replace him at the Persian court.

The murder of the emperor Paul in 1801 removed the danger of a joint Franco-Russian attack on India, but the threat from France

remained. In Dec. 1801 Russia formally annexed two provinces of Georgia and four years later declared war on Persia, taking Derbent and Baku. As the government of India failed to respond to the shah's appeals for help, he turned, but with some reluctance, to France (he had for long been unwilling to become the ally of a nation which had put its own monarch to death). By the treaty of Finkenstein, signed in May 1807, France undertook to help Persia to recover the provinces of Georgia and the other territories which Russia had seized. Almost immediately afterward, Napoleon made peace with Russia, with the result that the treaty of Finkenstein became a dead letter. Persia therefore received no help in its struggle with Russia, which ended disastrously in 1813 with the conclusion of the treaty of Gulistan (Golestan). By this treaty Persia had to renounce all claim to Georgia and to cede Qareh Dagh, Ganja (Kirovabad), Shirvan, Derbent and Baku. In 1814 the British government concluded a treaty with Persia whereby the latter agreed not to sign treaties or to cooperate militarily with countries hostile to Great Britain; in return Persia was to receive a subsidy of £150,000 a year, which would cease if Persia engaged in a war of aggression. What the British government failed to realize was that, while the French peril was a thing of the past, Persia's enforced cession of territory to Russia under the terms of the Gulistan treaty had created an entirely new situation.

Owing to ambiguous wording, the treaty of Gulistan led in 1825 to a dispute between Persia and Russia concerning three districts. While negotiations were in progress, Russia arbitrarily occupied these districts, an act which so stirred Persian public opinion that the shah had to declare war (1827). At the outset the Persian forces carried all before them, recovering much of the lost territories. Due to the parsimony of Fath Ali Shah, most of his troops had to be disbanded when the shah refused to pay them during the winter. Russia then gained the upper hand and forced Persia to conclude peace on ignominious terms by the treaty of Turkmanchai (Torkaman) in 1828. By this treaty, Persia had to cede Erevan (Yerevan) and Nakhichevan, besides giving up all claim to Georgia and the other areas lost in the earlier war. Persia was forced to pay a heavy indemnity and to grant extraterritorial rights to Russian nationals on Persian soil. By a commercial treaty concluded at the same time, Persians in Russia and Russians in Persia were to be allowed to export and import goods on payment of an ad valorem duty of 5%. These treaties inaugurated a new era and became the basis on which other European nations conducted their intercourse with Persia. Great Britain recognized the changed position; moreover, as Persia had been the aggressor in the war, Britain refused to continue the subsidy.

Fath Ali Shah realized that his country's defeat by Russia was final. He thereupon turned his attention eastward in order to endeavour to regain the territories which had been lost there. The prospects did not seem unpromising, as the Durrani dynasty had greatly declined since the death of its founder, Ahmad Shah. The shah sent Abbas Mirza, the heir apparent and commander in chief of the royal forces, to Khurasan to restore the situation there before attacking the Afghans. Abbas Mirza successfully attacked the Turkmens, who, although aided by the khan of Khiva, were effectively subdued. Abbas Mirza thereupon summoned Kamran, the nominal Sadozai ruler of Herat, to submit, but Abbas Mirza died before he could lead his main forces against Kamran. Mohammed Mirza, Abbas Mirza's eldest son, had meanwhile laid siege to Herat, but withdrew his army and hastened to Teheran when the news of his father's death reached him. Not long afterward Fath Ali Shah died, aged 63, having reigned for 37 years. It was his misfortune that his reign coincided with the rivalry of France, Great Britain and Russia over eastern affairs and with the revival of Russia's *Drang nach Osten*, which Peter the Great had inaugurated a century earlier.

Mohammed Shah.—Fath Ali Shah's successor was his grandson Mohammed Mirza, but his accession was disputed by several rival claimants to the throne. His bid for the throne succeeded because of the skilful handling of his troops by their commander, Sir Henry Lindesay-Bethune.

Mohammed Shah (reigned 1834–48) was obsessed with the desire to win military renown, but he was sensible enough to realize that he could not hope to do so if he resumed hostilities with Russia. With the active encouragement of the Russian minister, the shah determined to resume operations against Herat. Great Britain, anxious as ever to protect India, endeavoured, but without success, to dissuade Mohammed Shah. Great Britain feared that if Persia conquered the province of Herat and possibly additional territory to the east, Russia would be able, in virtue of the treaty of Turkmanchai, to appoint consuls in those regions and so extend its influence both commercially and politically almost to the Indian frontier. At this juncture a British military mission reached Teheran, but the shah received it with coldness and pressed on with his plans. In 1837 the Persian forces began the siege of Herat. Yar Mohammed, Kamran's able vizier, had had ample warning of the shah's intentions and had not only repaired the fortifications but had also laid in large stocks of food and munitions; moreover, Eldred Pottinger, a British artillery officer, opportunely arrived on the scene and gave valuable help to the besieged forces. In the spring of 1838 Sir John McNeill, the British minister, reached the Persian camp and endeavoured to persuade the shah to raise the siege. The shah, however, preferred to follow the advice of Count Simonich, the Russian minister, whose aide-de-camp proceeded to direct the siege operations. McNeill, being thus flouted, left the Persian camp. Soon after the envoy's departure, the shah's forces made their final assault, but it was repulsed with heavy loss. The shah was very dejected at this costly failure; consequently, when he received a communication from the British minister that the British government would regard the occupation of Herat as a hostile act and that British troops had already occupied the island of Khark (Kharg) in the Persian gulf, the shah broke off the siege. The last few years of Mohammed Shah's reign were troubled by the revolt of the Aga Khan, the spiritual leader of the Isma'ilis, a dispute with Turkey and disturbances caused by the Babi movement. The Aga Khan's revolt was crushed and he was forced to take refuge in India. The dispute with Turkey was settled by the joint intervention of Great Britain and Russia, but the Babi movement remained unsuppressed. The founder of this movement was Mirza 'Ali Mohammed, the son of a merchant of Shiraz, who, after long meditation and having performed the pilgrimage to Mecca, proclaimed himself to be the Bab (gateway) to the Divine Truth. The Babi movement rapidly gained strength in the years that followed, despite the imprisonment of the Bab himself in 1847 (*see* BAB; BABISM). In the following year Mohammed Shah, who had for long been in failing health, died.

Nasir ad-Din Shah.—Nasir ad-Din (*q.v.*; reigned 1848–96) was only 17 when he succeeded his father. Though so young, he had for several years been governor general of Azerbaijan (it was customary in the Qajar period for the heir apparent to hold that position), and he brought with him from Tabriz his remarkably able and scrupulously honest minister Mirza Taqi Khan, whom he made his vizier. With this minister's aid some serious disturbances which had broken out on the death of Mohammed Shah were quelled. Taqi Khan, who had been impressed by the liberal movement in Turkey, induced the shah to introduce some much-needed reforms. For the first time for many years the army was regularly paid and the sale of offices, titles and justice was stopped, as were also a number of other abuses. Taqi Khan was also responsible for the founding of the École Polytechnique in Teheran and for the publication of the first Persian newspaper. Unfortunately, Taqi Khan's reforms made him a number of enemies, among whom was the queen mother, whose influence over her son was great. She alleged to the shah that his minister was becoming too powerful and persuaded him to have him put to death. Taqi Khan's execution had most unfortunate results for Persia, as it put an end to the reform movement and many of the old abuses were revived. Thereafter Nasir ad-Din ruled as an absolute monarch, but he was on the whole a more enlightened and humane man than his father or indeed any of his Qajar successors.

Meanwhile, the Babi movement had become such a serious menace that the Bab himself was executed in 1850. Two years later an unsuccessful Babi attempt to assassinate the shah led to

such a fierce persecution of the sect that most of the survivors fled the country. The Baha'i faith (*q.v.*), an offshoot of the sect founded by the Bab, still exists and has many followers not only in Persia, but also in the Levant and the United States.

Nasir ad-Din was, like his father, desirous of obtaining compensation for the territorial losses to Russia in northern Persia earlier in the century by conquest in the east, Herat being as before the primary objective. These aspirations were encouraged by the Russian minister at Teheran. Yar Mohammed, Kamran's capable vizier, had died, leaving the government of the province of Herat to his imbecile son, whose first action was to open up negotiations with Persia. Great Britain thereupon protested and imposed a treaty on Persia whereby the Persian government undertook not to send troops to Herat unless that province were attacked from outside. Notwithstanding this undertaking, Persia subsequently gained possession of Herat (1856) through an Afghan nominee. Great Britain thereupon seized the island of Khark again and landed an expeditionary force under Sir James Outram near Bushire. This force marched inland and defeated a strong body of Persian troops; it then withdrew to the coast, crossed the head of the Persian gulf, sailed up the Shatt al Arab and captured Mohammerah (Khorramshahr). Meanwhile, unknown to both the belligerent forces, Britain and Persia had concluded the treaty of Paris (1857) whereby the shah undertook to evacuate Herat and to recognize the kingdom of Afghanistan.

As already stated, Russia, earlier in the century, had enveloped Persia on the north. Moreover, in the reign of Mohammed Shah, it had established a naval base on the island of Ashurada in the southeast corner of the Caspian sea in order to keep the piratical Turkmens in check. An attempt to subdue the khanate of Khiva, however, failed. The serious revolt in the Caucasus, together with the Crimean War, prevented Russia from pursuing its expansionist policy in central Asia for a number of years. Once freed from these difficulties, however, Russia resumed its advance, subduing the khanates one by one. In 1881 Gen. Mikhail Skobelev stormed Geok-Tepe, the stronghold of the formidable Tekke Turkmens, and three years later Russia completed the conquest of central Asia by the occupation of the Merv oasis. Persia thus found itself enveloped by Russia on the northeast as well as on the north.

Meanwhile, trouble had arisen between Persia and Afghanistan over Seistan. This question was settled in 1872 by the Seistan Arbitration commission, the province being divided between the two countries. Subsequently, the frontier between Persia and British Baluchistan was satisfactorily settled.

Through the influence of the enlightened Mirza Taqi Khan, Nasir ad-Din had become imbued to some extent with liberal ideas, but the failure of the constitutional movement in Turkey and Sultan Abdul-Hamid II's reversion to autocratic rule in 1878 discouraged the Persian liberals and caused the shah to modify his views, with the result that he became strongly opposed to reforms in his later years. Nevertheless, some progress was made during his reign toward the modernization of Persia in a number of ways, such as the introduction of the electric telegraph and a postal system, the establishment of a college in Teheran where science and other subjects could be studied on modern lines, the growth of the press and the construction of roads for wheeled traffic. It was greatly to Nasir ad-Din's credit that he established security throughout his realm. He was able to leave his country and visit Europe in 1873, 1878 and 1889. Although he was in general kindly, he could be stern and cruel at times; he was for most of his reign liked and respected by his subjects and he was, without question, the best of the Qajar sovereigns. In his later years, however, he lost his popularity partly because of his action in granting concessions to foreigners more with the object of pecuniary gain for himself than for the development of his country and partly because of his refusal to accede to the growing demand for reforms. He was assassinated in May 1896 four days before the 50th lunar anniversary of his accession.

Muzaffar ad-Din.—Nasir ad-Din was succeeded by his son Muzaffar ad-Din (reigned 1896–1907). Though not unkindly by nature, the new shah was of weak character and lacking in initiative. He suffered much from ill health and made this the excuse for costly journeys to Europe; his extravagance and that of his court brought the country to the verge of bankruptcy. After his accession the agitation for reforms grew rapidly in intensity. One of the chief leaders of the popular movement was Jamal al-Din al-Afghani (*q.v.*), an extremely able man who had gained considerable influence in the closing years of the previous reign. He was a pan-Islamist rather than a constitutionalist (*see* PAN-ISLAMISM). Another prominent leader was Malkom Khan, who was for many years Persian minister in London. Like Jamal al-Din, he was a great enemy of Amin as-Sultan, the shah's chief minister. He published in London a paper entitled *Qanun* in which he advocated the promulgation of a code of laws and other reforms; this paper, though officially banned in Persia, nevertheless had a wide circulation there.

In 1905 a number of merchants, in protest at the extravagance of the shah, the misgovernment and corruption of his ministers and the introduction of an onerous customs tariff, following an ancient custom, took *bast* (sanctuary) in one of the mosques in Teheran, where they were joined by some mullahs. On being expelled from this mosque, they went to the shrine of Shah Abdul-Azim, a few miles to the south of the city. When efforts to disperse them failed, the shah promised to dismiss the chief minister and to convene an *adalat-khaneh* ("house of justice"). The *bastis* thereupon dispersed, but the shah failed to implement his promises, whereupon many of the ulema went to Qom and threatened to go from there to Mesopotamia.

In consequence of further acts of oppression by the government, a large number of persons, including merchants, bankers and members of the ulema, took *bast* in the grounds of the British legation whence they renewed their demands for the dismissal of the obnoxious minister, the promulgation of a legal code and the recall of the ulema from Qom. Though the shah yielded to the extent of dismissing the unpopular minister, the people persisted in their demands, which included for the first time a request for a constitution. With great reluctance the shah complied with this last demand, with the result that in Oct. 1906 the first *majlis* (national consultative assembly) was convened. A committee of members was then formed which drafted the Fundamental Law of the constitution. This law was signed by the shah, who was by then moribund, on Dec. 30, 1906. Five days later he died.

The achievement of the constitutionalists was a truly remarkable one; except for the few reactionaries who continued to support the shah, practically the whole nation took part in the struggle. Although it ended in failure, the attempt by the Russian constitutionalists to end the autocratic rule of the tsar had a considerable effect on Persian public opinion, particularly in Azerbaijan.

Mohammed Ali.—Mohammed Ali (reigned 1907–09), Muzaffar ad-Din's eldest son, succeeded his father; he was aged 34. While governor general of Azerbaijan, he had shown himself bitterly opposed to the movement for reform. Although on his accession he took a solemn oath to preserve the independence of the country and the rights of the people and to observe the Fundamental Law of the constitution, he speedily showed that he had no intention of abiding by it. He was forced, however, by popular clamour to agree to the drafting of a supplementary Fundamental Law, to reaffirm that Persia had a constitution and to dismiss the Belgian head of the customs administration who had made himself most unpopular.

The able but reactionary Amin as-Sultan, who had been exiled, was recalled at this stage and reinstated as vizier, with the object of undermining and finally destroying the constitution. He endeavoured to persuade the moderate party in the *majlis* to agree to the raising of a loan to replenish the empty treasury, and might have achieved this object had he not been assassinated at the end of Aug. 1907. Pressure of public opinion forced the shah to appoint the liberal-minded Nasir al-Mulk as his successor, but, apart from inducing the shah to sign the supplementary Fundamental Law of the constitution in Oct. 1907, he could achieve little or nothing in the way of reforms.

Meanwhile, on Aug. 31, 1907, the Anglo-Russian agreement had

been signed which was designed to settle all differences between Great Britain and Russia insofar as Tibet, Afghanistan and Persia were concerned. As regards Persia, this agreement divided the country into three zones for commercial development; Russia was allocated the north and centre and Great Britain the southeast, which consisted almost entirely of deserts. The southwest of the country was declared neutral; from the British point of view the creation of this area as a neutral zone was a serious error, in view of the subsequent discovery of oil and its enormous development there by the Anglo-Persian Oil company. Russia had undoubtedly the better of the bargain. In this agreement the two powers, after affirming their respect for the independence and integrity of Persia, stipulated that neither should seek concessions of any kind in regions conterminous with the frontier of the other.

The Persian people were dismayed when the terms of this agreement became known to them; Great Britain, which had hitherto shown such sympathy with the constitutionalists, had, it seemed, betrayed them. What was not fully realized in Persia was that this agreement had been forced upon Great Britain and Russia because of their common fear of the growing might of Germany. A subsequent statement by the two powers that the object of the agreement was to prevent intervention and not to bring it about did little to allay Persian disquiet.

A serious crisis occurred in Dec. 1907 when it seemed that the shah was intending to dissolve the *majlis* by force and arrest the leading members. Such strong feeling was aroused that the shah, feigning submission, vowed on the Koran (the most solemn oath in Persia) to preserve the constitution and abide by its provisions. Oaths, however, meant nothing to the shah, who, six months later, ordered his artillery to bombard the *majlis* building, killing and wounding many deputies. Of the survivors a number were seized and executed, but some managed to escape and take sanctuary in the British legation. This outrageous action caused a serious rising in Tabriz which the shah's forces were powerless to quell; it was terminated only when Russian troops, with the ostensible object of protecting their nationals, entered the city in the spring of 1909.

Meanwhile, such was the feeling aroused throughout the country that strong nationalist forces were organized, chiefly at Rasht and Isfahan. In July 1909 these forces combined and marched on the capital, which they entered after meeting with only slight resistance. The shah, fearing for his life, took refuge in the Russian legation. The leading nationalists, the chief *mujtahids* and mullahs and a number of the survivors of the *majlis* then met and decreed the shah's deposition; they chose his eldest son, Ahmad Mirza, who was only 11 years of age, as his successor. Mohammed Ali, who was thereupon exiled, went to Russia. Thus the Persian revolution was accomplished with comparatively little loss of life.

Ahmad Mirza.—The nationalists had won a complete victory, but dissensions soon arose within their ranks and two main parties emerged, the Revolutionaries and the Moderates, between whom great hostility soon developed.

After the nationalist occupation of Teheran and the deposition and exile of Mohammed Ali, Ephraim Khan, the military leader of the Revolutionary party, organized an efficient police administration in Teheran which preserved order there. The Russians, however, on the ground that special measures were needed for the protection of their nationals, dispatched troops to Kazvin whence they refused to withdraw despite protests by Great Britain, which advocated a policy of nonintervention in accordance with the Anglo-Russian agreement of 1907. The lack of administrative experience on the part of the personnel of the new regime soon showed that the governmental departments could not be effectively reorganized without the help of foreign advisers. When this matter was discussed Great Britain and Russia stated that nationals of one or more of the minor powers should be engaged, otherwise they would have to insist on the appointment of their own nationals. These discussions ended early in 1911 when, despite Russian opposition, the Persian government engaged a U.S. citizen, William Morgan Shuster (*q.v.*), to serve as treasurer general of Persia with a staff of four assistants for a period of three years for the supervision, collection and disbursement of the revenues of the country. In June 1911 the *majlis*, by a large majority, passed an act conferring full powers on Shuster in regard to the handling of the national finances; for an assembly which was filled with nationalist sentiment, this was a striking act of statesmanship.

Hardly had Shuster and his staff begun their work when the deposed shah landed on the Caspian coast in order to attempt to recover his throne; his brother, Salar ad-Dauleh, raised the standard of revolt in western Persia, ostensibly on Mohammed Ali's behalf but really, it is believed, on his own. The former shah's forces, which consisted mainly of Turkmens, were defeated, and he was obliged to flee back to Russia; in the west, a force under the capable Ephraim Khan routed Salar ad-Dauleh's supporters.

Although Shuster was given every facility by the Persians, his activities were viewed with disfavour by Russia and in Nov. 1911, though legally in the right, he behaved with some tactlessness toward the Russian consul-general over a case respecting the property of one of the former shah's brothers who claimed to be under Russian protection. Russia thereupon used this matter as a pretext for demanding Shuster's immediate dismissal and threatened to order Russian troops to occupy Teheran in the event of Persia failing to comply. Despite protests by Great Britain, Russia persisted in its attitude, which occasioned strong feeling in Persia. However, faced with Russia's by no means empty threat of armed intervention, the regent, Nasir al-Mulk, by means of a *coup d'état*, dissolved the *majlis* on Dec. 24 and agreed to accede to Russia's demand for the dismissal of Shuster and his colleagues, who thus had to leave the country just when their labours were beginning to produce tangible results. Affairs in Teheran and throughout the country were in great confusion; the financial administration was carried on by Belgian customs officials so far as their limited powers permitted, but any real improvement was naturally impossible in the circumstances.

Russia's policy toward Persia and Great Britain's acquiescence therein, Shuster's dismissal and the consequent failure to organize Persia's finances and to found a new era for the country aroused strong resentment and criticism in the United States and in liberal circles in Great Britain and elsewhere. On the other hand, Sir Edward Grey, the British foreign secretary, and the other members of the cabinet, being deeply concerned at the growing threat of Germany to world peace, were convinced that there was little hope of successful resistance without a *rapprochement* with Russia and that such a vast stake excused a policy of compromise and resulting injustice to Persia.

When World War I broke out in 1914 Persia declared its neutrality, but Turkey's violation of Persian territory in order to attack Russia, and the Turkish threat to the oil field and refinery of the Anglo-Persian Oil company in the south, led to the occupation by British and Russian troops of parts of the country as a countermeasure.

On the conclusion of the war Persia was admitted as an original member of the League of Nations. The defeat of Russia in the war and the subsequent Bolshevik revolution freed Persia for a time from traditional Russian pressure. Great Britain was tempted to take advantage of this changed situation to include Persia in the protective zone that had been established adjacent to India. At the instance of Lord Curzon, then British foreign secretary, an agreement was signed with Persia on Aug. 9, 1919, which, had it been ratified, would have assured British ascendancy in that country. This agreement, while reaffirming the independence and integrity of Persia, provided for the appointment of British military and civil advisers, close co-operation with Great Britain for the construction of railways and other forms of transport and the revision of the customs tariffs. By a second agreement signed on the same day, Great Britain undertook to make Persia a loan of £2,000,000.

On the strength of this agreement, British military and financial advisers were sent to Persia, but their activities were cut short when the *majlis*, in consequence of the strong feeling which the agreement had aroused in the country, refused to ratify it.

The Soviet government, which had already been recognized by Persia, took advantage of this situation to negotiate a treaty in

Feb. 1921 whereby, in order to gain Persia's friendship, it abandoned the imperialistic policy of the tsarist regime by renouncing the use of force and guaranteeing nonintervention in Persian affairs. All the treaties which had been concluded between tsarist Russia and other powers in regard to Persia were denounced, a provision aimed especially at the Anglo-Russian agreement of 1907. Moreover, all concessions which had been granted to the Russian government and Russian nationals were canceled, as were also all loans and debts. All Russian concessionary rights relating to railways, roads, ports and docks reverted to Persia; it was expressly stipulated that none of the property thus returned to Persia could be alienated to any other power. Under article 6, the Soviet government reserved the right to send troops into Persian territory should it become a base for military action against Russia.

In the meantime the weakness and corruption of the cabinet and the incompetence of the young shah had stirred patriotic elements in the country to bring about a drastic change. This change was effected in Feb. 1921 when Sayyid Zia ad-Din Tabatabai, a leading reformer and editor of an influential newspaper, having made contact at Kazvin with Reza Khan, the able and forceful commander of the Persian Cossack brigade, persuaded him to march with his men on Teheran. They entered the capital on Feb. 21, whereupon the cabinet fell. Sayyid Zia ad-Din and Reza Khan then formed a new government, the former becoming prime minister and the latter minister of war and commander in chief. Five days later the treaty with the Soviet government was signed and the Anglo-Persian agreement was denounced.

Three months later, Reza Khan, although still officially only minister of war, gained control of the government, having forced Sayyid Zia ad-Din to resign. He appointed a statesman named Qavam as-Saltaneh prime minister. Almost his first task was the building up of a strong and efficient army; as this object could not be achieved without the funds for providing the troops with regular pay, Reza Khan insisted on certain branches of the ministry of finance being placed under his control as minister of war. By degrees he built up an efficient and disciplined force some 40,000 strong with which he proceeded to establish the authority of the central government throughout the country, particularly in the tribal areas in the southwest which had for long been quasi-independent. The sheikh of Mohammerah (now renamed Khorramshahr) was unwise enough to revolt in 1924, but his forces were defeated and he was compelled to submit; subsequently, he was removed to Teheran where he was detained as a political prisoner until his death in 1934; he had always been on good terms with the British, particularly with the Anglo-Persian Oil company, whose refinery at Abadan was built on property leased from him.

In the meantime, as the finances of the country were in confusion, Reza Khan invited a U.S. financial expert, A. C. Millspaugh, to reorganize them. Millspaugh, who was assisted by a number of other Americans, performed his difficult task successfully. Due to his efforts and to the increasing royalties paid by the Anglo-Persian Oil company, the financial stability of the country was restored.

XI. PAHLAVI DYNASTY

Reza Khan, commander of the Persian Cossack brigade and a leader of the revolt, thereupon made himself prime minister and summoned the *majlis*. He subsequently obtained from that body the grant of comprehensive military powers which could be withdrawn only by it; he thus became completely independent of the shah's authority. For some time past the people had become disillusioned respecting the monarchical form of government, due to the character and behaviour of the last three Qajar sovereigns, and there was some support in the country for the creation of a republic, with Reza Khan as president. The religious leaders, however, having noted the action of the Turks in abolishing the caliphate and divesting Islam of some of its traditional character, strongly opposed the idea of a republic. Reza Khan thereupon decided to retain the monarchy, to depose the shah and mount the throne himself. Accordingly, on Oct. 31, 1925, the *majlis*, by a large majority, declared that the rule of the Qajar dynasty was ended and arranged for the convening of a constituent assembly to make the necessary changes in the constitutional laws. This assembly was duly convened and on Dec. 12 it formally vested the crown in Reza Khan, with right of succession to his heirs. On Dec. 15 the new shah took the oath to defend the constitution and on the following day he was publicly proclaimed amid great popular enthusiasm as Reza Shah Pahlavi (*q.v.*). On April 25, 1926, the coronation took place.

The contracts of the members of Millspaugh's financial mission expired in Aug. 1927 and were not renewed. After a short interval, during which the Belgian customs staff carried on the financial administration, a German financial expert, Kurt Lindenblatt, was appointed in April 1928 to succeed Millspaugh, but with greatly reduced powers.

Following the example of Turkey and Afghanistan, in 1927 Reza Shah gave notice to the powers concerned of his intention to denounce all treaties in which extraterritorial rights (capitulations) were conferred on their subjects. The abolition of these rights was formally put into effect on May 28, 1928. In the previous year, by introducing the French judicial system, Reza Shah had challenged the competence of the religious courts in civil matters. He looked upon the majority of the ulema as backward and regarded their influence as detrimental to his policy of westernizing the country.

During 1927–32 the German firm of Junkers provided passenger and mail air services between Teheran and a number of provincial towns, and in Nov. 1928, after lengthy and difficult negotiations, agreement was reached with Imperial Airways for the establishment of bases in Persia for that firm's services to India.

Relations between Persia and the U.S.S.R. during the earlier years of Reza Shah's reign were marred by frequent disputes over commercial matters. In 1926 the Soviet government, in order to enforce compliance with its demands, placed an embargo on all imports of Persian goods, thus causing great hardship to Persian merchants. The Caspian fisheries were also a bone of contention, but this question was settled by the granting of a new concession to the Soviet government which provided, *inter alia*, for the formation of a joint Perso-Russian company to operate the fisheries. With Great Britain, too, Persia's relations were often far from happy. The most serious crisis occurred in consequence of the Persian government's unilateral cancellation of the D'Arcy oil concession which was held by the Anglo-Persian Oil company. The dispute was referred to the League of Nations, but was ultimately settled by direct negotiations which resulted, in May 1933, in the conclusion of a new agreement on satisfactory terms for both parties. Persia's periodic claims to sovereignty over the Bahrain Islands was another cause of friction, as were also the British coaling stations at Basa'idu (Basidu) and Hanjam (Hangam) (these stations were removed in 1935).

In Persia itself Reza Shah, using his well-trained army with much ability and courage, effectively subdued and disarmed the tribesmen of the southwest, a feat which had been far beyond the power of the previous dynasty. More than this, the Bakhtiari and the Kashgais were placed under the rule of military officers while their chiefs were either put in prison or forced to accept subordinate positions. The same policy was pursued with the smaller tribes. As the tribesmen were made to abstain from robbery, security of the roads in their areas was assured. An attempt to suppress nomadism failed, however, because inadequate provision had been made for the tribesmen to maintain their flocks in the areas chosen for their settlement. The power of the ulema, like that of the nomad chiefs, was also curtailed. Persia was really under military rule.

The shah fully realized the importance of communications, and steady progress in road building was made under engineers from the United States. The postal services were greatly improved, and the Junkers company in 1927 inaugurated a regular air service between Teheran, Shiraz, Meshed, Baghdad and Baku. Radio stations were also established and made available for public use. The construction of a railway line from the Caspian sea to the Persian gulf was eagerly desired by the shah, whose enthusiasm infected the whole nation. U.S. engineers surveyed the various routes, and in the autumn of 1927 the shah inaugurated this great

undertaking. The construction work was undertaken by U.S., European and Persian contractors, with Italian and Persian labour, under the supervision of the Consortium Kampsax, a Danish-Swedish consortium which took over the work in 1933.

Reza Shah's industrialization policy was likewise of great importance for the country; textile, cement, sugar beet and other factories were established in various parts of the country. Many of these enterprises soon showed a profit and contributed to economic stability and to a rising standard of living. Education was substantially reformed and improved, and the proportion of literacy steadily rose. The University of Teheran was established in 1935 and its staff included a number of European experts of good standing. Medicine and hygiene showed a marked advance. The judiciary was remodeled on French lines, and civil offices were opened for marriages. The veiling of women was abolished by a sudden and effective decree in 1935. In these reforms the policy of Turkey was very influential; in fact, Reza Shah modeled himself to a large extent on Mustafa Kemal Atatürk.

In 1935 Iran became the official name of the country.

Foreign Relations, 1938–41.—Naturally enough, Iran viewed the onset of World War II with deep anxiety. Having suffered from the invasion of the Turkish, Russian and British armies in World War I, the country was unanimously resolved to keep clear of all entanglements and preserve its neutrality.

At the outset of the struggle, the sympathies of the Iranian people were largely with the Allies, but the shah himself, some of the ruling classes and a number of army officers tended to favour Germany and Italy, partly because of the long-standing distrust of the U.S.S.R. and Great Britain and partly because they were contemptuous of the timidity and confusion in Allied councils which culminated in the Munich agreement. The shah, resolute and forthright in all things and believing in swift, implacable decisions, was impressed by these same qualities in Mussolini and Hitler. German propaganda, moreover, was well organized and well financed, besides being skilful and unscrupulous.

The Soviet government's accommodation with Germany, the indecision and ambiguity of Allied plans and the disastrous defeat of France convinced the shah, his officers and gradually the bulk of his people that the Allies were doomed. Germany meanwhile had laid its plans well for its new *Drang nach Osten*, aiming at penetrating to the Persian gulf and India.

Since 1935 Germany had held third place in Iranian foreign trade, and by 1938 it had begun to make strenuous efforts not only to enlarge this trade but also to play a dominant role in Iran's internal economic development. Despite the memory of unethical procedures in the German part of the construction of the Trans-Iranian railway and even more of the corruption and mismanagement of some of the German officials of the National bank, the Germans were able by propaganda and infiltration to secure a commanding position in Iran. Moreover, many German technicians were employed in the building up of Iranian industry. Within one year Germany tripled its exports of iron, urgently needed in Iran, radio equipment, military supplies, agricultural machinery and other heavy industrial products. German technicians built chemical, glass and hardware factories and provided highly trained specialists at uneconomic rates to maintain technical services. Propaganda films were supplied free of charge and generous contributions were made to charities. After the Allied occupation of Syria and Iraq, Teheran became a centre for German intrigue for the whole of the middle east, and the German embassy, in accordance with Nazi custom, was heavily overstaffed.

The presence in Iran of a large number of German technicians caused apprehension in Great Britain lest they might attempt to damage or destroy the highly important installations of the Anglo-Iranian Oil company (as the Anglo-Persian Oil company had been renamed in 1935) in southwest Iran. In June 1941, following upon the German attack on the U.S.S.R., the Soviet government likewise viewed the presence of these Germans with alarm. It then made representations to the Iranian government, stating that some of these Germans were organizing bands of terrorists in Azerbaijan and were instigating acts of sabotage elsewhere. As the U.S.S.R. was in urgent need of munitions from the western Allies and as Iran was the only practicable land route, the Soviet and British governments jointly requested the Iranian government to allow military supplies to be sent in transit across Iran to the U.S.S.R. The Iranian government refused to accede to this request or to take action regarding the Germans in the country. The Soviet and British governments then sent an ultimatum to the Iranian government demanding compliance with their demands, but this was rejected. Thereupon, on Aug. 25, 1941, British and Soviet troops simultaneously entered the country from the north and south respectively. British forces also entered Iran from the west, occupying Kermanshah and later making contact with the Soviet forces south of Kazvin. Although the Iranian troops in the south offered some resistance, this was soon brushed aside and the safety of the Abadan refinery and the oil fields was assured. The British and Soviet governments carefully defined their respective zones, the former assuming responsibility for the south, centre and west while the latter occupied the northern provinces of Azerbaijan, Gilan and Mazanderan. The U.S.S.R. could plead justification for its action by citing the Soviet-Persian treaty of 1921 which gave it the right to send troops to Persia should that country become a base for aggression against the Soviet Union.

The immediate consequence of this joint action by Great Britain and the U.S.S.R. was the abdication of Reza Shah on Sept. 16, 1941, in favour of his eldest son, Mohammed Reza Pahlavi (*q.v.*), who was then aged 22. The former shah was exiled first to Mauritius and later to South Africa, where he died in July 1944.

There can be no doubt that Reza Shah, in the earlier years of his reign, had conferred great benefits on his country. He had re-established security and the authority of the central government throughout Persia, he had galvanized the governmental machinery into action, he had done much to promote industry and to improve communications (his greatest achievement was the construction of the Trans-Iranian railway without recourse to a foreign loan) and he had provided facilities for the education and welfare of his people. On the other hand, in his later years he had become increasingly autocratic and arbitrary, with the result that his popularity had waned.

Mohammed Reza Pahlavi.—The new shah, who had been educated in Europe, at once announced his intention of ruling the country on constitutional lines. However, the transition from the arbitrary rule of his predecessor to that of a democracy inevitably proved to be difficult, and there was a great deal of political rivalry and maneuvering in Teheran.

On Jan. 29, 1942, Great Britain, the U.S.S.R. and Iran concluded a treaty of alliance, whereby the first two powers undertook to respect Iran's territorial integrity and sovereignty and to evacuate their forces within six months of the conclusion of hostilities with Germany and its allies. In Sept. 1943 Iran declared war on Germany.

The Trans-Iranian railway proved to be a very great benefit to the Allies, who greatly increased its usefulness, efficiency and capacity by constructing docks and supply centres in the south, connecting the port of Khorramshahr with the Trans-Iranian railway by means of a branch line from Ahvaz and importing many locomotives and additional rolling stock. Great improvements were also made in the road system. The result was a great increase in the quantities of urgently needed war material which the western Allies were sending to the U.S.S.R. across Iran. Also of great value to the Allied cause were the operations of the Anglo-Iranian Oil company in southwest Iran, as they made available large supplies of gasoline, fuel oil and other products.

Although it was not technically an occupation, the presence of British and Soviet troops in Iran was most distressing to the inhabitants, who saw in it a physical renewal of the ancient threat of Russia and Great Britain to partition the country between them. The combination of a bad harvest with the diversion of transport facilities for Allied military purposes led to a serious food shortage in many parts of the country in the winter of 1942–43. Moreover, the situation was aggravated by the refusal of the Soviet authorities in Azerbaijan to allow grain and rice to be sent from that productive province to relieve shortages in other parts of the country. The heavy expenditure by the Allied powers in Iran led

to greatly increased incomes especially in the middle and working classes, while the cessation of importation resulted in a scarcity of consumer goods. The combination of these factors occasioned very severe inflation which threatened the stability of the currency. The cost of living in Teheran and elsewhere soared to ten times the prewar level.

At this juncture the shah and Husain 'Ala, his minister of court, as well as veteran liberals such as Furughi and Taqizadeh who had done so much to create the modern Iran, appealed to the United States for aid; the Iranian people, fearing both Great Britain and the U.S.S.R., felt that the United States had no political ax to grind and recalled that it had in the past rendered friendly and disinterested services. On the recommendation of the state department, A. C. Millspaugh, who had done so much to reorganize the Persian finances during 1923–28, was appointed treasurer general with wide powers, while Col. Norman Schwartzkopf was placed in command of the gendarmery. A U.S. military mission was sent to advise on the administration of the army. U.S. experts were also appointed to serve in the departments of agriculture, health, municipal police, etc.

On Dec. 1, 1943, during the conference of Allied war leaders in Teheran, Franklin D. Roosevelt, Winston Churchill and Joseph Stalin issued a communiqué, at Roosevelt's suggestion, acknowledging Iran's services in the transportation of supplies to the U.S.S.R., promising economic aid during and after the war and reiterating the desire of the three powers for "the maintenance of the independence, sovereignty and territorial integrity of Iran."

Notwithstanding this declaration, the U.S.S.R. continued to extend its influence in the north, supporting the then newly formed Tudeh party and fostering the separatist tendencies of a small minority element in Azerbaijan. In Sept. 1944 the Soviet government suddenly demanded an exclusive oil concession covering the northern provinces and exerted such pressure that the prime minister, Mohammed Sa'id Maraghei, was forced to resign. This brusque behaviour produced a very strong reaction in Iran, and the *majlis* passed a bill which had been tabled by Mohammed Mossadegh (*q.v.*), at that time a comparatively unknown deputy, forbidding the granting of oil concessions to any foreign interests during the war.

Postwar Developments.—When the war was over Great Britain and the United States withdrew their forces from Iran within the period stipulated in the 1942 treaty although the United States had not been a party to it. The U.S.S.R., on the other hand, disregarded its obligations and refused to evacuate the northern provinces. When the Soviet army finally withdrew, it left a number of agents behind who, late in 1945, started a movement designed to make Azerbaijan secede from Iran and join the U.S.S.R. A puppet "democratic" regime was set up in the province, and carefully manipulated elections were held. In Dec. 1946, despite Soviet protests and threats, Qavam as-Saltaneh, the Iranian prime minister, sent a force into Azerbaijan which easily overthrew this regime and re-established Iranian authority. Earlier in that year Qavam as-Saltaneh, during a visit to Moscow, had been forced to sign an agreement with the Soviet government for the establishment of a joint Iranian-Soviet oil company to exploit oil in northern Iran. This agreement proved so unpopular in Iran that in Oct. 1947 the *majlis* declared it null and void.

In 1948 the Anglo-Iranian Oil company offered the Iranian government an increased payment to compensate it for the reduced royalties resulting from the dividend limitation policy of the British government. The Iranian government replied that, while it appreciated this offer, it would prefer to make it form part of a settlement of a more general nature. Negotiations between the government and the company resulted in the signature of a supplemental agreement in July 1949. This agreement, which was to come into force on its ratification by the *majlis*, increased the basic royalty rate and included other substantial financial advantages for Iran.

Later in 1949 the *majlis* passed an act implementing a seven-year plan, an ambitious project for the economic development of the country, to be financed largely by means of the royalties of the oil company. Unfortunately, the plan soon became moribund through the diversion into other channels of much of the money allocated to it, mismanagement and, finally, the cessation of royalty payments in 1951 because of the Anglo-Iranian oil dispute.

Because of the opposition by Mossadegh and his followers, the bill for the ratification of the supplemental oil agreement was withdrawn from the *majlis* in Dec. 1950. When in Feb. 1951 the oil company offered to conclude a 50–50 profit-sharing agreement, the campaign for the nationalization of the Iranian oil industry was already in full swing; this campaign coincided with a wave of intense nationalism. Gen. Ali Razmara, the prime minister, on being asked whether nationalization of the oil industry was practicable, consulted his experts, who reported against it. On March 7, four days after he had submitted their reports to the *majlis*, he was assassinated by a member of an extremist organization.

Mossadegh became prime minister on April 30. On May 1 the act for the nationalization of the oil industry, having passed through parliament, received the shah's assent. Protests by the company and the British government were unheeded and no compromise could be reached. The company, after stopping all oil exports and closing the oil fields and Abadan refinery, was forced to withdraw its British staff from Iran in Oct. 1951. A subsequent offer by the U.S. president, Harry S. Truman, and the British prime minister, Winston Churchill, to resolve the deadlock was rejected in Aug. 1952, and in the following October the Iranian government broke off diplomatic relations with Great Britain.

By the spring of 1953 Mossadegh had lost the support of practically all those groups and individuals who had originally formed his National Front. The explanation of this development is to be found in Mossadegh's complete inability to compromise, his ever-increasing megalomania and consequent clashes with the shah, his insistence on retaining absolute power in defiance of the constitution and his acceptance of support from the Communist-led Tudeh party. He had failed to reap for his country any benefit from his victory over the British, and he had taken no steps to provide Iran with a constructive policy which would enable it to recover from the economic and financial morass into which his actions had precipitated it.

From April 1953 onward there was an open and often violent struggle for power between Mossadegh and Gen. Fazlollah Zahedi, who had been minister of the interior in previous cabinets; as time went on Zahedi's strength increased while that of his opponent waned. After some hesitation, the shah issued a decree appointing Zahedi prime minister in place of Mossadegh, but an attempt to arrest the latter on Aug. 15 failed. So grave did the situation seem that the shah fled by air to Rome, while Zahedi went into hiding. Four days later, however, mob action supported by the army resulted in Mossadegh's overthrow and arrest and his replacement by Zahedi as prime minister. On Aug. 22 the shah returned to Teheran where he received a frenzied welcome. The coup was plainly welcomed by the western powers and was sharply criticized by the U.S.S.R. The United States answered Zahedi's appeal for funds by a first installment of $45,000,000.

On Dec. 5, 1953, Iran resumed diplomatic relations with Great Britain. On Dec. 2, charges of high treason having been brought against Mossadegh, he was sentenced to three years' solitary confinement.

Internally, conditions remained unsettled. In April 1955 Husain 'Ala replaced Zahedi as prime minister. In April 1957 Husain 'Ala was succeeded by Manuchehr Eghbal, the chancellor of the University of Teheran and a personal friend of the shah. Eghbal issued a decree ending martial law, which had been in force for 16 years; he declared his intention of encouraging a free press and free speech, of setting up a democratic two-party system and of allowing the formation of new political parties (except by the Communists).

Meanwhile, with the fall of Mossadegh, the main obstacle to a solution of the oil dispute was removed. Late in 1953 a group of U.S., Dutch and British oil companies formed an international consortium in which the Anglo-Iranian Oil company had a 40% share. In April 1954 the consortium opened negotiations with the Iranian government and the National Iranian Oil company (which had been formed to take over the assets and installations of the Anglo-

Iranian Oil company in Iran). The negotiations resulted in the conclusion of an agreement on Sept. 19. Despite Communist attempts to prevent it, the agreement was ratified by the *majlis* and received the shah's assent. The principal terms of the agreement were that the consortium was to resume operations through two operating companies and that Iran should receive 50% of all the profits on all Iranian oil exported; the Anglo-Iranian Oil company (later renamed the British Petroleum company) was to receive £25,000,000 in compensation over a period of ten years from 1957 and the agreement was to remain in force for 25 years; at the option of the consortium it could be renewed under certain conditions for three periods of five years each.

This important development initiated a policy of increasing economic and political co-operation between Iran and the countries outside the Soviet bloc. In Dec. 1954 Iran signed a commercial treaty with India and also made contracts with British, French, West German, U.S., Dutch and Belgian firms. In Aug. 1955 the Iranian government signed a treaty with the United States and in the following October, despite Soviet protests, joined the Baghdad pact (*q.v.*). Nevertheless, Iran's relations with the U.S.S.R. remained cordial; after lengthy negotiations the two countries concluded a satisfactory agreement whereby the U.S.S.R. agreed to pay its war debt to Iran and to allow the Iranian-Soviet frontier to be mapped.

In the meantime, in March 1956, the shah ordered the implementation of the new seven-year plan, which had already been approved by the *majlis* and senate. In the following year the Iranian government authorized a private U.S. company to undertake in conjunction with the plan organization an ambitious development program in southwest Iran which would include the construction of an immense dam for irrigation purposes and also for the generation of hydroelectric power. Moreover, by the early 1960s good progress had been made with the development of the Iranian oil fields by the consortium, with production exceeding 50,000,000 tons annually. (*See* IRAN: *Economy.*)

In April 1958 the marriage between the shah and Queen Soraya was dissolved, and in Dec. 1959 he married Farah Diba, by whom he had a son, the crown prince Reza, on Oct. 31, 1960, thus assuring the succession in the Pahlavi line.

During 1961–63, under the leadership of the shah, progress was made in the implementation of an important program of political, social, economic and agrarian reform. The most important item in the program was the break-up of the great agricultural estates and the redistribution of the land among the peasantry.

On the night of Sept. 1/2, 1962, in a severe earthquake in northwestern Iran, about 10,000 persons lost their lives.

See also references under "Persian History" in the Index.

(L. Lo.)

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PERSIAN LANGUAGE. This is one of the modern Iranian languages (*q.v.*). It derives from a southwestern dialect of the Iranian branch of the Indo-European family and is most closely related to Middle and Old Persian, former languages of the province of Fars ("Persia") in southwestern Iran. Modern, or New, Persian is thus called *Farsi* by native speakers.

Persian is the official spoken language of Iran and the only one used for writing; it is the mother tongue of about 10,000,000 people (no exact figures are available) and a means of communication between speakers of mutually unintelligible dialects and languages. It exists in a number of socially, geographically and stylistically definable varieties.

A slightly divergent form of Persian is official in Afghanistan, besides Pashto (*q.v.*). More divergent is Tadzhik, spoken by about 1,000,000 people in the Tadzhik Soviet Socialist Republic and in parts of the Uzbek, Kazakh and Kirgiz Soviet Socialist Republics; Soviet officials classify Tadzhik as a separate language. Persian is written in Arabic characters, Tadzhik in Cyrillic, modified letters being added for special phonological needs.

The segmental phonemes of standard Persian are: i, e, a; *a*, o, u; ey, ow; b, d, g; p, t, k; v, z, q; f, s, x; ž, š; j, č; h, r, l, ?. Syllables never begin with more than one consonant. Word stress is most often on the last syllable.

The vocabulary contains many loanwords, especially from Arabic; in formal style they are sometimes very frequent.

The structure of utterances consists of a combination of word order, intonation, stress and the use of prepositions and affixes. A series of suffixes (*-am, -i, -ast, -im, -id, -and*, corresponding to

the English "(I) am," "(you) are," etc.) marks the predicative construction. To the English verb correspond constructions consisting of some or all of four elements: (1) the prefixes *mi-* or *bi-*; (2) a certain class of morphemes; (3) one or two special suffixes (*-id, -e*); (4) the members of the above series of suffixes. A small group of verbs of general meaning have special forms that function much as do such English nouns as "class" or "concept." Nouns and verbs may be modified (*e.g.*, made more concrete in meaning) by speech situation, context and affixes. Nouns, being uninflected and otherwise lacking in morphological indicators, have to be construed by context. At best, subject and object differ in not being equally tightly bound into the sentence structure.

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PERSIAN LITERATURE, the term used to describe literature written in Modern Persian, the form of the Persian language which had emerged by the 9th century A.D. (*see* IRANIAN LANGUAGES). After the Arab conquest of Iran in the 7th century, Islam replaced orthodox Zoroastrianism, and its related heterodoxies, as the dominant religion, and also eclipsed the minority religions, Buddhism, Nestorian Christianity and Manichaeism (all of which had some discernible influence on later literary subject matter and imagery); and Arabic became the language of law and culture. In the 9th century, however, the Persian political revival was accompanied by the emergence of a Persian literary medium, especially in northeast Iran, where the dialect known as "New" or "Modern Persian" began to be used for literary expression and so became established as the literary form of the Persian language in Iran and in northern India (*see* INDIAN LITERATURE: *Muslim Influence*). It also had some influence on Ottoman Turkish literary culture (*see* TURKISH LITERATURE: *Anatolian or Ottoman*). Mid-20th century research, by study of an indigenous spoken dialect preserved among the Iranian people, and of the learned language of Arabic, with its greater vocabulary, has revealed examples of the early form of this language. The first writings in modern Persian were in verse—the medium of praise and pleasure—and Arabic elements were small. As prose translations from Arabic began to be made, rhetorical refinements based on Arab literary conventions and more Arabic words and literary devices were introduced. An example is *saj'* ("rhymed prose"), an Arabic form for which vocabulary resources in two languages were useful (*see* ARABIC LITERATURE: *Belles-Lettres*).

POETRY

First Period.—According to a history of Seistan (Sistan) the first Persian verses were made by Abū Wasīf who was asked by Ya'qub the Saffarid (868–878) to translate some complimentary Arabic lines; this incident is typical in that it shows the new Persian rulers asking for literature in a tongue they knew. According to another legend the first Persian poet was 'Abbas of Merv, said to have composed a poem in Persian in honour of Harun al-Rashid's son, al-Ma'mun, in A.D. 809. The Arab geographer Ibn Khurdadhbih (*c.* A.D. 846) cites a Persian verse by Abu Taqi al-'Abbas ibn Tarkhan, and other fragments from *c.* A.D. 800–850 are coming to light.

The Tahirid rulers (820–873) were more concerned with Arabic than Persian but under the Saffarids (868–900) and especially under the Samanids (873–999) the old dialects of the country reasserted themselves in a much modified form. The Samanids, who ruled in the northeast, established a court giving poets a patronage soon imitated by other dynasties—the Buyids (945–1055), the Ziyarids (928–1042) and particularly the Ghaznavids (962–1186). The Buyids reigned in western and southern Iran and Mesopotamia; the Ziyarids in northern and central Iran; and the Ghaznavids in the east and, later, in large tracts of northern India; hence Samanid literary innovations were widely spread. Yet the force of regionalism remained: although Persian poets spoke for all whose language they used, they also displayed regional characteristics in expression, theme and social preoccupations.

The earliest major genres were the panegyric and elegy, both written in the form of the *qasida* (a formal ode), and their first great exponent was Rudaki (*q.v.*) who flourished under the Samanid Nasr II (913–943). Another form soon to develop was the shorter lyric or *ghazal,* used for bacchic odes and later for love poetry. Both the *qasida* and the *ghazal* were monorhymed. The introduction of the rhyming couplet, *mathnavi,* effected the release from the limitations of monorhyme, and led to the composition of epic and long didactic poems. Like the *ruba'i,* or quatrain, the *mathnavi* was a purely Persian development; and the *ruba'i,* unlike most other poetic forms which were borrowed from the Arabs, was unknown in Arabic.

The Epic.—Under the local Persian dynasties, which had practically freed themselves from the yoke of the Arab caliphate, much attention was paid to the Pahlavi writings recounting the ancient glory of pre-Islamic Iran (*see* PAHLAVI LANGUAGE). Nuh II (976–997) ordered his laureate Daqiqi to put into Persian verse the *Khvatay-namak* ("Book of Kings"), and the poet set to work upon this congenial task but had not progressed very far when he died in the prime of life. The great undertaking was carried forward by Firdausi (*q.v.*), who brought it to a triumphant conclusion by 1010. His *Shah-nama,* though spurned at first by the Ghaznavid Mahmud (998–1030), who had overthrown the Samanids, soon won wide popularity as the national epic of Iran; repeatedly copied in fine and exquisitely illustrated manuscripts, it continued to be recited by professional rhapsodes down to modern times. Other poets soon sought to emulate the success of Firdausi; none came anywhere near to equaling his achievement, though numerous epics on heroic and romantic themes have been preserved. His closest rival is Nizami (*q.v.*) who died about 1202; he composed five epic poems on a variety of topics, including the legendary exploits of Alexander the Great (*see* ALEXANDER ROMANCES: *Eastern Versions*), the life of the Sasanian emperor Bahram Gor and the Bedouin romance of Laila and Majnun. Asadi completed in 1066 a heroic epic on the loves and wars of Rustam's ancestor Garshasp. A little earlier Fakhr al-Din As'ad Gurgani wrote his charming *Vis u Ramin,* later put into Georgian, a poem probably based on Parthian legend which strongly resembles the story of Tristan (*q.v.*) and Iseult. In due course the epic was pressed into service as a handmaid of historiography. Thus, Hamd Allah Mustaufi, otherwise famous as a historian and a geographer, having produced a revised edition of the *Shah-nama,* proceeded to compose the *Zafar-nama,* a gigantic poem reviewing the course of events from the birth of Mohammed down to the year 1331. The exploits of Timur (Tamerlane), and later of the Safavids, were duly made into epics, while it is interesting to mention one of the last ambitious projects of this genre—the *Jarj-nama* composed in honour of George III by a Persian living in India, telling the political history of that country from its discovery by the Portuguese down to the British conquest of Poona in 1817. The Koranic story of Joseph and Potiphar's wife inspired a succession of poets: the first of the series is even attributed to Firdausi's old age, but the ascription has been contested by modern scholars, while the finest treatment was that of Jami (*q.v.*), who gave a mystical interpretation to the tale.

Panegyric.—Panegyric, which forms an important branch of all eastern literatures, is less interesting to the average western reader, but Persian *qasidas* merit the attention of all students of Persian for the mastery of language and expression displayed by the best-known practitioners. This important genre, already perfected in Arabic, especially by al-Mutanabbi (*q.v.*), could be as lucrative to the poet as it was pleasing to his patron; the richer and more powerful the prince, the more numerous his train of encomiasts. Sultan Mahmud of Ghazni created the congenial atmosphere for Farrukhi, Minuchihri, Asadi and 'Unsuri to display their virtuosity; their skilful productions paved the way for the court poets of the Seljuk Sultan Sanjar (1118–57)—Mu'izzi, the "prince of poets"; Adib Sabir; and, most highly esteemed of all

qasida writers. Anvari (*q.v.*), whose elegy describing the sufferings of his countrymen while Sanjar was held captive by invading Ghuzz tribesmen has been brilliantly translated into English as "The Tears of Khorassan," first by William Kirkpatrick (in *Asiatic Miscellany*, vol. 1, 1785), and later by E. H. Palmer (in *The Song of the Reed*, 1877). Contemporary with Anvari was his greatest rival Khaqani (*q.v.*), court poet to the Shirvanshah of northwestern Persia. Khaqani, being erudite in most branches of Islamic learning and a supreme master of Persian lexicography, composed in a forbiddingly obscure style and thus endeared himself to the later crop of commentators. Indeed it was held to be far from a fault in the panegyrist to write obscurely; rather it highly flattered his patron to be supposed capable of understanding the learned references of his poet. Every succeeding dynasty attracted and rewarded its circle of panegyrists, and all the Mogul emperors of India liked to have their exploits celebrated in Persian verse. Nor has the panegyric by any means vanished, though its themes tend to be national and party-political rather than personal. In general, though the lengthy passages of servile flattery make tedious reading in the countless products of the classical age, many *qasidas* contain vivid and beautiful descriptions of natural scenery and great occasions which more than atone for the stretches of boring bombast.

Didactic and Mystical Poetry.—The origins of didactic poetry, ever popular in a country abounding in proverbs, saws and maxims, may be traced back to Firdausi and his times. Abu Shakur of Balkh, favourite of the Samanid Nuh I (943–954), wrote a didactic poem called *Afarin-nama* of which only fragments have survived, but these are sufficient to establish it as the parent of such famous works as the *Bustan* of Sa'di; while Firdausi's *Shah-nama* abounds in sententious wisdom pithily expressed. Religious and mystical poetry was a natural outgrowth of moralizing didactic; the Isma'ili Nasir-i Khusrau (*q.v.*) composed an abundance of ethical and religious poems, while the mystics Abu Sa'id ibn Abi 'l-Khair (d. 1049) and 'Abd Allah Ansari (d. 1089) employed the quatrain to express mystical ideas. The first great mystical epic, the *Hadiqat al-haqiqa*, was composed in 1130 by Sana'i (*q.v.*), of Ghazni, who thus set a fashion which many later poets followed; he wrote a number of shorter epics as well, all of a religious character, and many odes and lyrics containing passages of great mystical insight and beauty. His immediate successor Farid ud-din 'Attar (*q.v.*) wrote numerous epics on religious and mystical themes, the most famous being the *Mantiq ut-tair* which Edward Fitzgerald (*q.v.*) abridged as the *Bird-Parliament*. It was later translated in full in French by J. H. Garcin de Tassy (*Mantic Uttair: le langage des oiseaux*, 1863), and this edition was rendered into an abridged English version by G. C. Nott (*Conference of Birds*, 1955). Mention may also be made of 'Attar's *Ilahi-nama* and *Asrar-nama*, in which mystical teaching is illustrated by lively and well-told anecdotes. He also composed many odes and quatrains, and in prose an extensive and valuable book of memories of the saints. After Sana'i and 'Attar came Jalal-ud-din Rumi (*q.v.*), who died in 1273 having passed most of his life in Konya (Iconium), Asia Minor; his *Mathnawi i ma'nawi*, which draws upon his predecessors, is by far the greatest work of its kind, while in his lyrics and quatrains he reached astonishing heights of pure poetry entitling him to be ranked with the world's great mystical poets. His contemporary Sa'di (*q.v.*), who has always been the most popular moralizing poet of Persia (though in his lyrics he displays a higher poetic gift), lives by his *Bustan* and *Gulistan*—the latter a graceful miscellany of rhymed prose interspersed with passages in verse. Jami's *Baharistan* and Qa'ani's *Parishan* are among the books written in emulation of the *Gulistan*, which has been translated into many languages.

Lyric Poetry.—While the *ghazal* played a minor part in Arabic literature because of the greater popularity of the *qasida*, Persian poets from Rudaki onward showed increasing fondness for the shorter poem. By Sana'i's time the convention of the *takhallus* (the poet's pen name signed in the poem) had been established and remained thereafter the distinguishing mark of the lyric. Whereas the *qasida* sometimes ran to as many as 100 or more couplets in monorhyme, the *ghazal* seldom exceeded twelve and settled down to an average of seven. The *takhallus* generally occurs in the last or penultimate couplet, a convention perhaps encouraged by copyists to distinguish one poet's work from another. The *ghazal* was perfected by Hafiz (*q.v.*) in the 14th century; it has been practised thereafter by almost all the Persian poets including those of India and continues to be popular in modern times.

End of the Classical Period.—Contemporary with Hafiz were 'Ubaid i Zakani (d. 1370), the most talented satirist of Persia; Ibn Yamin (d. 1368), admired for his occasional verse; Khvaju of Kerman (d. 1352), who composed romantic *mathnavis* in emulation of Nizami; and Salman i Savaji (d. 1378), panegyrist to the Jala'irid rulers of Baghdad. The golden age of Persian poetry came to an end with the Timurids, and Jami (*q.v.*; 1414–92) is generally regarded as the last of the classics; he distinguished himself in all branches and was also a notable prose writer. The Safavids, who gave a powerful impulse to painting and architecture, found poetry in a slow decline, though every generation brought its crop of imitators; the outstanding authors are Sa'ib of Tabriz (d. 1677), laureate to 'Abbas II, and, in the 18th century, Hatif of Isfahan (d. *c.* 1784). Under the Qajar dynasty (19th century) lived Qa'ani of Shiraz (d. 1853), considered by some the most brilliant and melodious of all the poets of Persia, though rather indifferent in his choice of subjects.

Persian Poetry in India.—The extension of Muslim rule in India gave rise to an Indian school of Persian poetry, founded by Amir Khusrau (*q.v.*; d. 1325) who lived at the court of the Khilji kings of Delhi and composed brilliantly and extensively in all genres. Thereafter all the Mogul emperors had their laureates, such as Faidi (d. 1590), 'Urfi (d. 1590), Nau'i (d. 1610) and many others. These poets refined and complicated the familiar conceits to such a point that "Indian poetry" became synonymous with obscurity and artificiality.

PROSE

The foundations of Persian prose, as of poetry, were laid in the time of the Samanid dynasty. In 963 Bal'ami, vizier of al-Mansur I, published an abridged translation of the famous annals of al-Tabari (*q.v.*). About the same time a band of theologians from Transoxiana made a Persian version of al-Tabari's other great work, his commentary on the Koran, thus proving that Persian was a fit medium for sacred as well as profane writing. Mansur I also commissioned the first Persian book on medicine, the pharmacopoeia of Abu Mansur Muvaffaq of Herat. The application of Persian to philosophy and science, which involved the coining of an extensive and subtle technical vocabulary, ranks among the outstanding achievements of Abu 'Ali ibn Sina or Avicenna (*q.v.*) whose formative years were passed at the Samanid court.

The Two Styles.—The two translations of al-Tabari mentioned above set a norm of simple and pure Persian style which has seldom been surpassed. The more artificial type of prose, under the influence of the *saj'* of the Arabs, was introduced by Hamid al-Din of Balkh whose *Maqamat*, composed in 1156 in imitation of the *Maqamat* of al-Hariri, proved that Persian was fully equal to all the complications of scholastic Arabic. The "battle of the styles" continued to be fought down the succeeding centuries; the taste of the Mongol conquerors encouraged involved and bombastic prose, satiation with which caused a reaction toward archaic simplicity. This polarity has continued to characterize prose writing ever since.

History.—Of all branches of prose writing, history has always been the most popular and every dynasty of kings and princes has had its circle of professional chroniclers. The anonymous history of Seistan, composed in the middle of the 11th century, was quickly followed by the history of the Ghaznavids by Baihaqi (d. 1077) in 30 volumes (only a sixth has survived). The Seljuk dynasty found a notable historiographer in Ravandi whose *Rahat al-sudur* was written *c.* 1203. The famous vizier Nizam al-Mulk (d. 1092) left a political testament called *Siyasat-nama*, important as a historical source and translated by H. Darke as *The Book of Government* (1960). As advice to rulers it belongs to the same tradition, going back to Sasanian days, as the *Qabus-nama* ("Mirror

of Princes") composed in 1082 by Prince Kai-Ka'us of the Ziyarid house. The advent of the Mongols ushered in an age of historiography. The *Tarikh i Jahan-gusha*, by 'Ala ud-Din 'Ata Malik Juvaini (*q.v.*), was completed in 1260, and is a masterpiece of great historical value. It was translated by J. A. Boyle as *History of the World Conquerer* (1958). Juzjani was another witness of the Mongol invasion, and his *Tabaqat i Nasiri* is especially interesting for its account of the events which occurred in Afghanistan and India. The history of Vassaf, completed in 1312, continues the authentic record of this critical period, but its usefulness is somewhat marred by its inflated style. Along with regional and dynastic histories, Persia has produced a number of universal histories on the grand scale, and the most valuable of these was written during the Mongol period: the *Jami' al-tawarikh* of Rashid al-Din Fadlullah (*q.v.*), who drew upon Chinese and European as well as Islamic sources. The output of histories large and small continued undiminished through the ensuing centuries, and mention may be made here only of a few outstanding works. The career of Timur i Lang and the exploits of his successors in the 15th century are told by Sharaf al-Din 'Ali Yazdi and 'Abd al-Razzaq Samarqandi. Mirkhwand (Mirkhond; *q.v.*), who died in 1498, laboured for many years upon his elephantine history of the world, the *Raudat al-safa'*, much used by early European historians of Islam. Khwandamir (Khondamir), his grandson, abridged this massive work and also compiled the *Habib al-siyar* tracing the emergence of the Safavid dynasty. The life and times of 'Abbas (*q.v.*) the Great were described by Iskandar Munshi, and later Nadir Shah, Karim Khan Zand and the Qajars had their own chroniclers. Many local and provincial histories of great value also exist; while Muslim India yielded a rich crop of general and special works, most of which were described and partly translated in Sir H. M. Elliot's *History of India*, eight volumes (1867–78).

This extensive historical literature is supplemented by many biographical works, particularly of poets, such as the *Lubab al-albab* of Muhammad 'Aufi (d. 1232) who also compiled a valuable encyclopaedia of stories; the *Tadhkirat al-shu'ara'* of Daulatshah, completed in 1487; and the *Atash-kada* of Lutf 'Ali Beg (d. 1781). Nur Allah Shushtari (executed in 1610) composed an important biographical dictionary of mystics and Shi'ite martyrs, and Jami's *Nafahat al-uns* contains valuable notices of the leading Sufis down to his times.

Geography.—Many of the Arabic-writing geographers of the 9th and 10th centuries were Persian, and the oldest geography in the Persian language is the anonymous *Hudud al-'alam*, written toward the close of the 10th century. Nasir-i Khusrau (*q.v.*), famous also as a poet and theologian, left a curious travelogue (*Safar-nama*) of his journey (1046–52) from Merv across Persia, Mesopotamia and Palestine to Egypt and back to Balkh. Of special importance is the geography of the Mongol period which forms a part of the *Nuzhat al-qulub*, a cosmographical work completed in 1430 by Hamd Allah Mustaufi who also compiled an important history, the *Tarikh i guzida*. Toward 1420 Hafiz i Abru finished and dedicated to Shahrukh his untitled geography in which certain Persian provinces are described along with an epitome of their histories. Many valuable additions to Mustaufi are found in Amin Ahmad Razi's *Haft iqlim* (completed in 1594), an encyclopaedia of geography and biography. In the 19th century the impact of western knowledge stimulated the writing of new geographies, and the diaries of the shah Nasir ad-Din (*q.v.*) recording his visits abroad are both entertaining and informative.

Theology and Mysticism.—Arabic was in general preferred by Persians writing on theology, but many important books were also composed in Persian. Nasir-i Khusrau wrote extensively on Isma'ili ideas, as did Nasir al-Din Tusi (1201–1274) during his Isma'ili period; he is best known in Persia for his ethical manual *Akhlaq i Nasiri*. The first Persian handbook of Sufism was composed toward 1050 by Hujviri of Ghazni; 'Abd Allah Ansari of Herat wrote down his *Munajat* or private litanies in charming rhymed prose interspersed with poetry. Mohammed al-Ghazzali (*see* GHAZZALI, AL-; ARABIC PHILOSOPHY) whose main output in the fields of jurisprudence, theology and mysticism was in Arabic, enriched Persian literature with his *Kimiya i sa'adat* on the mystical life and doctrine. His brother Ahmad Ghazzali (d. 1126) wrote a beautiful essay on the theme of the Lover and the Beloved, and Suhravardi Maqtul (executed in 1191) composed a series of mystical allegories in Persian in addition to his many Arabic books. These are but a few titles out of a very extensive literature, including in the 19th century, the writings of the Babis and Baha'is (*see* BABISM; BAHA'I FAITH).

THE MODERN PERIOD

In the 19th and the first half of the 20th century western thought and the demand for social and constitutional reform had their effect on Persian literature. The first signs of a new spirit may be traced back as far as Qa'im-Maqam Farahani (d. 1835), a vigorous stylist in prose and verse, and Amir Kabir (d. 1852). The idea of the novel as an instrument of social criticism sprang from *Hajji Baba* (1824) by James Justinian Morier (*q.v.*), which when first translated into Persian (probably by Mirza Habib of Ispahan, 1905) passed muster for some time as an original composition. It was under the influence of this work that Zain al-'Abidin (d. 1910) wrote his searing *Siyahat-namah i Ibrahim Beg*. Translations of foreign romances, such as the works of Alexandre Dumas, Jules Verne and the Arab Syro-Egyptian historical novelist Jurji Zaidan, stimulated the growth of the historical novel celebrating the splendour of ancient and medieval Iran; mention may be made of the *Dastan i Shams u Tughra* of Mohammed Baqir Khusravi (1909), the *Ishq u sultanat* of Musa Nathri (1919) and the *Damgustaran* of San 'ati-zada (1920–25). The first successful experiment with the short story was made by Jamalzada in his *Yaki bud yaki nabud* (published in Berlin, 1922); his lead was followed by many writers, of whom the most noted are Mohammed Hijazi (b. 1900, who also composed plays, essays and novels), Buzurg 'Alavi (b. 1908), Sadiq Chubak, Jalal Al i Ahmad and above all Sadiq Hidayat (d. 1951). The last-named author, who was a learned antiquarian and folklorist, came into great prominence as the inventor of the "new style" which brought into literature many words and idioms previously current only in colloquial speech. His most famous novel *Buf i kur* attracted wide interest and was translated into English and French (*The Blind Owl*, trans. by D. P. Costello, 1958; *La Chouette aveugle*, trans. by R. Lescot, 1953). The followers of this fashion were generally liberal in politics, and controversial.

The work of the first modernist poets, such as Adib i Pishavari (d. 1930), Adib al-Mamalik (d. 1917) and Iraj-Mirza (d. 1926), although important, was overshadowed by that of later writers. The earliest revolutionary poet was 'Ishqi, murdered in 1924; another was Lahuti (d. 1957), who spent the latter half of his life in the U.S.S.R. The most eminent of the "conservative" poets were Malik al-Shu'ara, mentioned above, and the remarkable woman writer Parvin i I'tisami (d. 1941). Though Sir Mohammed Iqbal (*q.v.*; d. 1938) was an Indian, his Persian poetry has been accepted into the canon of the national literature. Many poets rose to prominence after World War II, among them Parviz Natel Khanlari (1914–), editor of the literary magazine *Sukhan*, Mohammed Hussein Shahriyar (1904–), Gulchin, Fereydun Tavallali and Yasimi. Their work exhibited the increasing influence of western contemporary styles.

The extent of the modern renaissance of Persian letters is strikingly shown by the remarkable advance in book production. Not only were the Persian classics being edited in a scholarly manner—and much credit for this belongs to Mirza Mohammed of Qazvin—but a constant flow of original writings came from the presses in elegant and attractive print. The output was all the more astonishing since the reading public was still severely restricted by the low literacy figures, which, however, progressively rose as new schools and colleges were built.

The Press.—An important part in the modern literary movement has been played by the press, which has provided a forum for political and sociological discussion, for new literary criticism and for poetry on political and other new themes. The first Persian newspaper in Teheran appeared in the reign of Fath 'Ali Shah (1797–1835). Certain organs founded abroad by exiles or expatriates exercised real political influence during the long years of

struggle for a modern constitution; Istanbul, Calcutta, Cairo, Paris, London and Berlin all contributed at various times and in various ways. After the revolution of 1905–08 newspapers proliferated in Persia itself, and the number of titles runs into hundreds; the competition of wireless did not sensibly diminish the flow.

From the purely literary standpoint, the press rendered the language more pliant, simple and popular. Daily papers revealed the talents of 'Ali Akbar Dahkhuda (d. 1956), good poet and excellent reporter imitating in his satires the humorous speech of the bazaars; the poet laureate Malik al-Shu'ara' Bahar (d. 1951); and many others. Magazines, especially those devoted to literature and social comment, were also produced in great numbers, some fugitive and some more firmly established; through this medium many essayists and writers of short stories first appeared before the public. The Persian press had by the mid-20th century become as competent and influential as that of any comparable country.

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(V. F. M.; A. J. Ay.; P. W. A.)

PERSIMMON, the globular fruit of trees of the genus *Diospyros*, which belongs to the ebony family (Ebenaceae). The oriental persimmon (*D. kaki*) is an important and extensively grown fruit in China and Japan where it is known as *kaki*. It was introduced into France and other Mediterranean countries in the 19th century and grown to a limited extent there. Introduced into the United States a little later, it is grown commercially on a small scale in California. It is grown throughout the Gulf states of the U.S., mainly in home gardens. The fruit is two to three inches or more in diameter, yellow to red in colour, somewhat resembling a tomato in appearance. Except for varieties such as Fuyu, the fruit tends to be highly astringent until soft-ripe or, as is done in Japan, until treatment with certain gases. The trees will tolerate winter temperatures only to about 0° F.

The native American persimmon (*D. virginiana*) is a small tree, occasionally up to 40 ft. in height, and is native from the Gulf states north to central Pennsylvania and central Illinois. The fruit is one to two inches in diameter, usually rather flattened, and dark red to maroon in colour. Most fruits contain several rather large, flattened seeds. As in the Oriental species, the flesh loses its astringency and develops a rich flavour when it becomes soft. Considerable quantities are gathered from the wild and utilized. A number of superior kinds have been named and propagated to a limited extent, but are not grown commercially.

See W. H. Chandler, *Deciduous Orchards*, 3rd ed., pp. 409–415 (1957).

(J. R. Mag.; X.)

J. HORACE MCFARLAND CO.

PERSIMMON (DIOSPYROS VIRGINIANA), SHOWING (LEFT) STAMINATE FLOWERS ON LEFT AND PISTILLATE ON RIGHT; (RIGHT) MATURE FRUIT

PERSIS, the Greek form of Old Persian *Parsa*, modern Fars (*q.v.*), the southwestern part of Iran. It derived its name from the Iranian tribe of the Parsa (Persians) who settled there in the 7th century B.C. As was observed by Nearchus, the admiral of Alexander the Great (preserved by Arrian, *Indica*, 40 and Strabo, *Geography*, xv, 727), the country is divided into three parts of different character and climate. The seaboard is hot and sandy with little vegetation apart from date palms, the population is sparse, and there are no good harbours. About 50 mi. (80 km.) from the coast rise mountain chains through which steep passes lead to interior valleys, which lie about 5,000 ft. (1,524 m.) above sea level. There the climate is temperate, the country watered by rivers and lakes, the soil fertile and excellent for cattle rearing. It was in this area that there arose the brilliant civilizations of the Achaemenids and Sassanids. The third, northern part belongs to the central plateau and is still higher and colder in winter. Persis was bordered on the east by Carmania (Kerman), on the west by the Persian Gulf and Elam, on the northwest by Media, and on the north and northeast by the great desert.

The exact date and the circumstances of the occupation of Persis by the Persians are uncertain. It is possible that they derived their name from residence in the land Parsuash, south of Lake Urmia (Rezaiyeh), which is mentioned in Assyrian records between the 9th and 7th centuries B.C. By the 7th century, however, they had migrated southward to a district on the eastern frontier of Elam known to the Assyrians as Parsumash. Its Persian ruler, Cyrus I, acknowledged Assyrian overlordship following the campaign of Ashurbanipal against Elam (*c.* 640). In the Babylonian records Cyrus II is described as king of Anshan, a district on the Elamite border known since Sumerian times, and as king of Parsu (Parsa). Some scholars maintain that Parsumash, Anshan, and Parsa were separate districts conquered successively by the Persians, perhaps under the leadership of Teispes (*c.* 675–640). Others believe that they were alternative terms for the same area.

The Persians were a vigorous race, living in a healthful climate, accustomed to hardship, brave, and warlike. Herodotus lists their leading tribes as the Pasargadae, to which belonged the clan of the Achaemenidae, the royal family of Persia; the Maraphii; and the Maspii. It was these three that Cyrus II assembled to approve his plans for his revolt against Astyages, his Median overlord, in 553. Lesser tribes were the agricultural Panthialaei, Derusiaei, and Germanii (the Carmanians, living round Kerman, which takes its name from them) and the nomad Dahae, Mardi, Dropici, and Sagartii (Old Persian, Asagarta). Strabo also lists among the Persian tribes the Pateiskhoreis (Old Persian, Patishuvari), to which belonged Gobryas, the lance bearer of Darius I mentioned in the king's tomb inscription.

The inhabitants of Persis were considered to be the rulers of the empire and were exempt from taxation. This privilege was not, however, extended to Persian tribes living outside Persis, for example the Sagartians. As the homeland of the Achaemenid dynasty, Persis was closely associated with the monarchy. Cyrus II built his capital at Pasargadae (*q.v.*) in the territory of his tribe, and about 30 mi. (48 km.) to the southwest Darius I founded his new capital of Parsa, "the Persians," known to the Greeks as Persepolis (*q.v.*), "the Persian city." Although Persepolis was too remote to function as the administrative centre of the empire, which was fixed at Susa in Elam, it served as the spring capital. It was there that the king received homage and tribute of the subject

nations at the New Year festival, a ceremony which forms the subject of the magnificent reliefs of the apadana platform. Large amounts of the gold and silver received as tribute were stored in the treasuries at Pasargadae and Persepolis. Achaemenid kings were crowned at Pasargadae and buried on their native soil, Cyrus II at Pasargadae, Darius I and his immediate successors at Naksh-e Rostam, and later rulers at Persepolis. (J. M. M.-R.)

Post-Achaemenid Period.—When Alexander had won the victory of Gaugamela (Arbela) and occupied Babylon and Susa, he met (in the spring of 330) with strong resistance in Persis, where the satrap Ariobarzanes tried to stop his progress at the "Persian gates," the pass leading up to Persepolis. There Alexander set fire to the cedar roof of the palace of Xerxes as a symbol that the Greek war of revenge against the Persians had come to an end. It is said that he soon had the fire extinguished (Plutarch, *Alexander*, 38); the story of the feast at which Thaïs incited him to the burning is pure fiction, and it may well be that he repented the damage he had done (Arrian, *Anabasis*, vi, 30, 1).

Alexander had planned to amalgamate the former rulers of the world with his Macedonians. Peucestas, the new satrap of Persis, followed the example of Alexander and thus gained a strong hold on his subjects (Diodorus Siculus, xix, 48). About 311 the Iranian satrapies passed to Seleucus I Nicator. The subsequent history of Persis is obscure. There is little literary or archaeological evidence for the foundation of new cities, which was a conspicuous mark of Seleucid policy elsewhere. Laodicea in eastern Persis and Stasis, possibly a garrison town under Antiochus I Soter, are mentioned by Pliny the Elder and Stephanus Byzantinus; on the Persian gulf, Antiochia (Bushire) was founded by Antiochus I to replace an Elamite town and peopled with Greeks including a large contingent from Magnesia on the Maeander (Kuçukmenderes Nehri).

Lying apart from the main strategic and economic highways of Iran, Persis preserved its ancient culture, language, and religion; new sanctuaries at Persepolis and at Nurabad were built on traditional Iranian lines, by contrast with the temples, Greek in plan and style, erected in the same period at Kangavar, Khurha, and Nahavand in Media. Four series of coins, inscribed in Pahlavi, attest the effective independence of local princes in the district of Istakhr (Estakr, the town which succeeded Persepolis), probably as early as the reign of Antiochus I. Their names are Iranian and they are depicted in Iranian dress; the reverse types include the symbol of Ahura Mazda, the traditional Iranian "standard of Kaveh," and fire altars or temples. The four rulers of the first series, assigned to the 3rd century B.C., bear the title *Frataraka* ("governor"). One of them, Vahuberz (Oborzos), is said to have massacred 3,000 Greeks, and the destruction of 3,000 Persian rebels by a general of Seleucus II Callinicus may have been retaliation for this act (Polyaenus, *Strategica*, vii, 39 and 40).

In 220 a rebellion by Molon, satrap of Media, and Alexander, satrap of Persis, was suppressed by Antiochus III, but Persis was probably among the first of the Iranian satrapies to proclaim their independence after Antiochus' final defeat by Rome at Magnesia (winter 190–189). An attempt by Antiochus IV Epiphanes to restore Seleucid authority in Iran met with only transitory success, and soon after his death (163) Persis was forced to acknowledge the supremacy of the Parthian Mithradates I, although some of the inhabitants supported Demetrius II Nicator in his unsuccessful attack on Mithradates in 141.

The three later series of coins, dating between the 2nd century B.C. and the 3rd century A.D., give the rulers of Persis, who are shown in Parthian dress, the title of king. Strabo says that they were vassals of the Parthians and it is stated in the *Periplus of the Erythraean Sea* that their authority extended over the shores of Carmania and the opposite coasts of Arabia. Among them are found the traditional names of the Achaemenid dynasty and of Iranian mythology, Daryav (Darius), Artakhshatr (Artaxerxes), Narses, Manucihr, and others. In the early 3rd century there were different petty kingdoms and usurpers in Persis; the principal dynasty is called Bazrangi by the Arab historian al-Tabari. Sasan, the grandfather of Ardashir I (*q.v.*) and high priest of the temple of Anahita at Istakhr, was connected by marriage with the Bazrangi house, and this connection obtained for Ardashir a military command at Darabgird, which he used to subdue the rest of Persis. Meanwhile his father, Papak (Pabhagh, Babek), son of Sasan, supplanted the Bazrangi king Gochihr. In 208 the crown passed to Ardashir, who then conquered the neighbouring provinces of Carmania and Susiana and in 224 defeated and killed the Parthian monarch Artabanus V. He was crowned "king of kings" at Ctesiphon in 226. The Sassanid dynasty which he founded was thus heir to the Achaemenid cultural tradition and closely connected with the traditional Zoroastrian religion, which was henceforward maintained as the state religion of the empire (*see* ZOROASTRIANISM).

Istakhr, the new capital of Persis, lay about 9 mi. (14 km.) above Persepolis on the Pulvar River (Rudhkhaneh-ye Sivan). It was a great city under the Sassanids and was important in early Islamic times, when it was noted for its fanatical adherence to the old religion. It was destroyed in the mid-11th century. *See* also PERSIAN HISTORY. (E. E. D. M. O.)

PERSIUS (in full, AULES PERSIUS FLACCUS) (A.D. 34–62), Latin poet whose satires, written under the influence of Stoic philosophy, reach a higher moral tone than any other work of their kind in classical Latin literature and are also remarkable for the author's individual use of language. According to the *Life* attached to his poems in the manuscripts, Persius was born at Volaterrae in Etruria (hence his Etruscan name Aules, often latinized as Aulus), of a family of equestrian rank. Having lost his father when he was about six years old and his stepfather a few years later, he went to Rome at the age of 12 to study under Remmius Palaemon and the rhetorician Verginius Flavus. At the age of 16 he began a close friendship with the Stoic philosopher L. Annaeus Cornutus, whose pupil Lucan was also to show himself to be a generous admirer of all that Persius wrote. Another friend from his early youth was the lyric poet Caesius Bassus, and his friendship with Thrasea Paetus (whose wife Arria was a relative of his) lasted for some ten years. Later he met the younger Seneca, but was not attracted by his mind.

His reading of the tenth book of Lucilius revealed to Persius his vocation, and he began to write his own book of satires. He wrote slowly, however, and left his book unfinished at his premature death. Cornutus then suppressed all that Persius had written except the book of satires, in which he made some slight alterations before handing it over to Bassus for editing. On publication, it had an immediate success. Persius is said to have been gentle in disposition, girlishly modest, good-looking and affectionately devoted to his mother, sister and aunt. To his mother and sister he left a considerable fortune.

The six satires, which amount only to 650 lines, are composed in hexameters; but what appears as a prologue, in which the poet ironically asserts that he writes to earn his bread, not because he is inspired, is in choliambics. The first satire, which censures the literary tastes of the day as reflecting the decadence of national morals (this theme is not unlike that of Seneca in *Epistulae morales*, 114), contains a vivid description of a poet reciting his own work, a scathing account of literary conversation at a dinner party and an interesting passage deriding specimens of bland mythological writing and languishing style. Here Persius writes real satire, treating what he himself has seen with understanding, whereas the remaining five satires in his book are in fact philosophical discussions on themes often handled by Seneca. Satire ii discusses what we may justly ask from the gods; satire iii, those who live wrongly though they know the right and those who have not been enlightened by philosophy; satire iv, the necessity of self-knowledge for public men (*cf.* Plato, *Alcibiades I*); satire v, the Stoic doctrine of freedom (introduced by friendly allusions to the teaching of Cornutus); and satire vi, the proper use of money.

In earnestness and moral purpose Persius rises far above the political rancour or good-natured persiflage of the earlier Roman satirists on the one hand and the rhetorical indignation that Juvenal was later to display on the other. He seems, as it were, a forerunner of the great Christian apologists. His thought, however, is often very difficult to follow, and the meaning of his powerful expressions is sometimes far from clear. He seeks

brevity at all costs, and he is clumsy in his management of dialogue, so that it is often hard to know where one speaker is supposed to leave off and another to begin. Frequently his metaphors are strained and his colloquialisms jarring. He takes not only characters but also whole phrases, thoughts and situations from Horace, despite his great difference from Horace in ideals, temperament and technique.

Yet Persius can write with natural simplicity and genuine eloquence (as in ii, 61–75; iii, 23–43; and v, 26–29) and occasionally has passages memorable for their realism or for their metaphor: for instance, *nescit quid perdat et alto Demersus summa rursus non bullit in unda* (iii, 33–34: "he does not know what he is losing and, drowned in the depths, sends not a bubble back to the surface") or *dum veteres avias tibi de pulmone revello* (v, 92: ". . . while I pluck your old grandmother's notions from your breast").

The *Life* states that before the publication of the book of satires some lines were removed from the end so that it should appear to have been completed; this may mean that an unfinished sentence or paragraph had to be omitted. Cornutus is also said to have suppressed an offensive allusion to the emperor Nero's literary taste, changing the original *auriculas asini Mida rex habet* ("King Midas has ass's ears") to *auriculas asini quis non habet?* ("Who has not ass's ears?"; i, 121).

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(G. B. A. F.)

PERSONALITY. In defining personality the psychologist employs the two indispensable ideas of integration and uniqueness. While the various other concepts and principles of psychology refer to one or another segment of behaviour, personality invariably signifies, for one thing, the functioning of the whole person, and, for another, the unique organization of the individual that distinguishes him from his fellows. In accounting for a personality it therefore becomes essential to know how the person, in expressing his needs and his social relationships, functions as a recognizable unity with distinctive traits, drives, attitudes and habits which enable or prevent his attaining an adequate adjustment to his environment and to himself.

In the early 19th century James Ward in England stressed the individualistic orientation of the psychology of personality; in Germany, Wilhelm Stern adopted a similar standpoint in his personalistic approach. In conventional psychology textbooks personality is placed at the top of the conceptual hierarchy: the lower-order concepts lead systematically to personality as the most complex and inclusive.

There is a point of view, dating from about 1950, according to which personal experience is only one aspect of psychology; other aspects refer to other levels of behaviour. From this standpoint "psychology" would have to be replaced by the collective phrase "behavioural sciences" or, more simply, by the single term "humanics." Thus a reflex action, such as the blink of the eyelid in response to a sudden visual stimulus, would be regarded as behaviour at the physiological or neurological level, whereas a marked like or dislike of some other person, say a brother or sister, would fall directly within the domain of "personality" (more strictly, psychodynamics or idiodynamics; *see* below).

There is no unanimity of thought regarding personality in subhuman organisms, though, on the whole, psychologists tend to reserve the term, with or without sufficient justification, for the human species. Character (*q.v.*), as distinguished from personality, usually involves moral and other normative judgments. It is therefore used only sparingly in U.S. psychology, although in European writing the term often is equated with personality. Values, like any other data, are for the scientist a part of nature. Good and bad (as qualifiers of character, etc.) are always to be designated as belonging to a specific ethical frame of reference, not necessarily that of the observer or his social group.

To find one's way in this area of scientific research one must keep constantly in mind the difference between observation and explanation. In this account the methods of observing personality will first be described, followed by a survey of personality theory.

METHODS OF OBSERVATION

Subjective Methods.—In the subjective methods the subject himself discloses what he knows about himself. He makes himself an object of observation and reports his finding to the psychologist. Among the techniques used here are: the autobiography, elements of the life or case history, some types of interview and the so-called inventory method in which the subject reports about himself on a standardized questionnaire or check list. That these self-reports have the advantage of direct relevance and broad scope—who should know better than the person himself or have access to more facts about him than he does?—is readily appreciated; but these advantages are obviously counterbalanced by conscious or unconscious deception of self and others. It is therefore essential to include in such subjective methods control or stabilizing devices that help to identify at least the more obvious deceptive reports.

Objective Methods.—The objective methods of observation depend not upon the subject's own statements about himself but upon his overt behaviour as revealed to others who serve as examiners, observers or judges. Here are included not only verbal behaviour but physiological responses (blood pressure, heart rate, etc.), which may be recorded by special instruments, and adaptive or expressive physical or social responses (*e.g.,* intelligence tests). Objective observations may be made in the natural state (*e.g.,* the interview) by attending less to what the subject says about himself and more to his nonverbal, adaptive responses such as his stance, the amount rather than the content of his verbalization, nervous manifestations such as fidgeting, etc. Again, miniature life situations may be created in the laboratory for the single individual or for small groups that interact with each other under conditions defined by the investigator. Sometimes such observations are made through one-way observation screens or mirrors, and cinematic records of these observations may be obtained. Microphones may also be used to record verbal responses.

As will be noted, even in such objective methods of observation as those just described the verbal response of the subject may still play an important part. The difference between these records and the self-reports mentioned among the subjective methods lies in the treatment of the obtained data. In the objective approaches the verbal behaviour of the person is not necessarily construed at its face value. Instead it is treated much like any other behaviour; *e.g.,* movements of the limbs or of the internal organs. In such a frame of reference the verbal output of the subject is analyzed quite apart from his own conscious intent to communicate information about himself. The subject has merely behaved in a certain way under the given stimulating conditions. The quantity, form and content of his utterances may then be submitted to measurement and analysis. In the second quarter of the 20th century new techniques for the systematic analysis of verbal behaviour were contributed by a group of specialists devoted to the fields of semantics and information theory. (*See* also SEMANTICS, GENERAL; INFORMATION THEORY.)

Projective Methods.—The projective methods of appraising personality differ from both the subjective and the objective by approaching personality indirectly. Neither the person himself

nor the examiner takes the subject as an object of direct observation; instead the subject is requested to behave in an offhand manner—merely to exercise his imagination, to let himself go without self-criticisms or adaptive intent. In other words, he is encouraged to "project" himself and thus to reveal the implicit or unconscious content of his personality. The earliest of the projective methods employed on a systematic basis was that of word association, introduced by Francis Galton in 1879. Stimulus material is provided by individual words to which the subject responds with the very first word that comes to his mind as he hears the stimulus (*see* also ASSOCIATION, MENTAL). Sigmund Freud modified Galton's word association method into the free association technique for analyzing dreams, etc., as an aid to psychotherapy and personality research. Here the person responds to his own previous responses, *e.g.*, images from his own reported fantasies or dreams. In the inkblot method of Hermann Rorschach the subject is asked to tell what the blots look like to him. Responses provide clues to the subject's usual perceptual approach to real objects in terms of his habits, interests, needs and abilities. Another projective method is the Thematic Apperception Test, in which the subject is invited to tell stories in response to pictures that he is shown. Finally may be mentioned the Rosenzweig Picture-Frustration study. Cartoonlike drawings that portray a series of everyday frustrating social situations serve as the stimuli for the subject, who is asked to supply (in the blank caption box above the head of the frustrated person) the first verbal response that comes to mind. As will readily be seen, all these projective techniques encourage the person to respond in terms of his own bias, with a minimum of external stimulation, since their common aim is to assay that bias. The methods of assessing personality are discussed in detail in PSYCHOLOGICAL TESTS AND MEASUREMENTS: *Tests of Personality and Temperament.*

STRUCTURE OF PERSONALITY

A large class of concepts used for explanation or prediction refers to the structural organization of personality. Concepts of structure help to account for observed consistencies in behaviour at any given time (congruence) or from one time to another (homogeneity).

PERSONALITY TYPES

The concept of personality type makes two assumptions: (1) that personalities are divisible into two or more groups each of which excludes the other and (2) that in each type are to be found certain mutually dependent and interrelated traits or patterns of response that can be inferred from each other. This theory has an obvious appeal because of its simplicity. As a result of experience and experiment, however, the view, while still having its adherents, is rarely entertained in its simple form. Even as abstractions personality types have a very limited usefulness and often contribute more to prejudice and to hasty generalization than to sober judgment or real knowledge.

Humoral Types, Temperament and the Endocrines.—Historically, type theories go back to Galen with his four humors —blood, phlegm, choler (yellow bile) and melancholy (black bile) —from which the four temperaments—sanguine, phlegmatic, choleric and melancholic—were derived. While this humoral psychology was long ago abandoned, the words denoting the four types have been absorbed into occidental language. Moreover, the essential idea that bodily disposition, or perhaps even predisposition, determines difference in temperament still has its exponents. The humours themselves have been replaced by the secretions of the endocrine glands.

Personality is an organismic unity, embracing both physiological and psychological manifestations. Biological maladjustments can lead to serious disturbances in the cognitive and emotional life of the person, and, also, psychological upsets can disturb physiological functioning. Both the autonomic nervous system and the endocrine glands participate in such control. For example, overactivity of the thyroid gland results in nervousness, irritability and insomnia, in addition to the usual physical symptoms. Underactivity of the thyroid will bring about sluggishness, apparent mental deficiency, indifference to emotional stimuli, and so on. Again, the endocrine secretions of the sex glands have much to do with typical masculinity and feminity of personality as well as physique. Boys showing emotional and recreational interests below those typical of their chronological age have increased markedly in maturity upon receiving injections of male hormone. The pituitary, parathyroids and adrenals also affect personality traits (*see* also ENDOCRINE GLANDS). Various studies have attempted to relate phases of blood chemistry, such as acid-base balance, calcium-potassium ratio and sugar tolerance, to personality variables. While some of the experiments have returned encouraging results, none can be said conclusively to have proved a correlation between the physical and the psychological measurements. It must be emphasized that the positive findings with respect to endocrine glands relate mainly to instances in which glandular function was distinctly above or below normal. Interpretations of normal personality trends in terms of endocrine function must in the 1960s be regarded as largely speculative. A similar restriction applies to the data with respect to autonomic nervous system function (*see* also TEMPERAMENT; PSYCHOLOGY, PHYSIOLOGICAL; NEUROPHARMACOLOGY AND PSYCHOPHARMACOLOGY; TRANQUILIZING DRUGS).

Morphological or Physical Types.—A second chief theory of types depends upon the conformation of the human body—of its component parts or tissues. These morphological or physical types are then regarded as giving rise to, or being correlated with, types of personality. This theory is found in general terms in early Greek medical concepts. In the 19th century a notable contribution was made in France by L. Rostan, who distinguished digestive, muscular and cerebral types. About 1885 A. de Giovanni founded his school of clinical anthropology in Padua. His pupil G. Viola, utilizing the earlier work of the German Friedrich W. Beneke, and Viola's pupil S. Naccarati conducted detailed anthropometric studies with specified indexes for measuring the dimensions of physique and relating them to each other. The German psychiatrist, Ernst Kretschmer (*q.v.*) at about the same time was led by his work with mental patients to develop a threefold physical classification: pyknic, asthenic and athletic. The pyknic is characterized by a broad trunk and relatively short limbs, round face, usually with a tendency to gain weight in middle age; the asthenic has a narrow trunk, shoulders and hips, long limbs, long narrow face and is generally lean; the athletic has broad shoulders and trunk, narrower hips, well-proportioned limbs and good muscular development. Kretschmer found a marked predominance of the cyclothymic temperament among pyknics; *i.e.*, they tended toward extremes of gaiety and depression. By contrast the asthenics were introverted, shy, serious and ranging in temperament from hypersensitive to phlegmatic and dull. This latter pattern he called schizothymic. The athletic physique was found to be intermediate in temperament. Kretschmer's views were attacked on the grounds, first, that it is impossible to classify most persons in any of his three physical groupings with any degree of accuracy and, second, that there are too many exceptions to the expected temperamental relationships when physical classification seems fairly definite (*see* also PHYSIOGNOMY).

A considerable improvement on Kretschmer's work appeared in the research of W. H. Sheldon. In his approach the arbitrary classification of individuals into physical types was replaced by three ratings (on a seven-step scale) on three extreme physical patterns: the ectomorphic (resembling Kretschmer's asthenic), the mesomorphic (athletic) and the endomorphic (pyknic). Sheldon next reported three patterns of temperament (cerebrotonic, somatotonic and viscerotonic) and found that the physical and temperamental types agreed in a rather large proportion of cases. While this quantitative development might be expected to appeal to psychologists, Sheldon's conclusions have not been fully confirmed and have been looked upon with some doubt.

Psychological Types.—It was in psychiatry and philosophy that the third chief doctrine of types first emerged. As representative in the 20th century, the views of C. G. Jung and E. Spranger may be cited. Jung coined the terms introversion and extraversion to describe what he considered to be contrasting types.

Introversion was characterized as directing attention and interest inward, with a tendency to excessive daydreaming and introspection and to careful balancing of considerations before reaching a decision. Extraversion was characterized by outgoingness in attention and interest, responsiveness to external stimuli, especially other persons, and impulsiveness. Recognizing that the postulation of only two types failed to do justice to the rich variety of observable patterns, Jung subdivided introverts and extraverts according to the relative dominance of four psychological functions—sensation, thinking, feeling and intuition. But subsequent research has placed most persons somewhere between the type extremes. The theory is useful mostly in calling attention to certain poles of personality and in providing a framework for noting certain trends.

Another widely influential type theory was that of E. Spranger. He began by emphasizing the "dominant value direction" of the individual and held that for purposes of analysis it was convenient to assume the existence of pure or ideal types, one corresponding to each of six major values: theoretical, economic, aesthetic, social, political and religious. This classification was developed into a scale of values by Gordon W. Allport, P. E. Vernon and Gardner Lindzey whereby, as in Sheldon's advance over Kretschmer, the subject is assigned a rating for each of the values.

Types, Traits and Factors

As is now apparent, the concept of types has a limited validity. Its two basic assumptions do not gain strong confirmation from empirical studies. These indicate that a continuous distribution, ranging from one extreme to the other, is likely to be found for any one trait associated with a supposed type, whereas the type concept assumes a piling up of subjects at the two extremes (bimodally). Again, while certain traits are found clustered together interdependently as the type concept implies, the organization is not always of one sort. The peculiar way in which each person has organized the traits of the so-called types has not been taken into account.

For these reasons there has been a gradual shift from interest in types to interest in traits, singly and in their interrelationships. One of the most influential trait theories in the second quarter of the 20th century was that of G. W. Allport, who defined the trait as a psychophysical disposition acquired in the course of experience on the basis of a biological *Anlage*. Allport described traits as arranged in a hierarchy in the individual, some having a cardinal importance in relation to other subordinate ones. He strongly insisted on the existence of individual and even unique traits that might be found in only one person but still demanded to be included in any system of personality. He likewise stressed the individualized organization (congruence) of traits in every person —a view that contrasts with the universalized organization of traits in the type concept. This emphasis on individuality, adapted by Allport from Stern's personalistic psychology, was opposed by him to the exclusive interest of academic, experimental psychology in the generalized or average man. Following Wilhelm Windelband, Allport therefore wished to add the idiographic orientation to the nomothetic (universalized) orientation of general psychology. An almost simultaneous approach to traits developed in England, where K. Pearson's and C. E. Spearman's statistical methods for analyzing such human abilities as intelligence were adapted to the field of personality. Important contributions were made there by Cyril Burt and later by Hans Eysenck, and by L. L. Thurstone, R. B. Cattell and J. P. Guilford in the United States through factor analysis.

Factor analysis is essentially a statistical technique, one aim of which is to reduce a large number of correlated test scores or other assessments to a minimum number of uncorrelated dimensions (or orthogonal factors) by much the same procedure used for resolving physical forces (*see* Vector Analysis). In one common method factors are determined by an automatic analysis of a rectangular table or matrix (*q.v.*) of correlation coefficients into its principal components (or eigenvectors, as they are called). In dealing with personality such researches begin by collecting measures of traits in representative samples of subjects; the correlations between each pair of traits are then calculated, arranged in a matrix, and the analysis proceeds by determining first the factor (vector) that contributes the most matrix variance, then the next factor, and so on, till all the statistically significant variations are taken into account. The most important theoretical conclusion is that factors of personality appear to form a hierarchical structure, in keeping with the neurological views of the structure of the central nervous system. From a practical standpoint, when a factor analysis has been carried to completion, the next step is to invent so-called pure factor tests for measuring the factors directly, or else (since that approach is rarely successful) to devise a method of estimating the pure factors by some mode of weighting the initial assessments.

Some authorities have been led to say that factor analysis does not deliver what it claims: the factors derived by the method are held to depend too heavily on the original selection of tests, which are, of course, only a selection from a limitless number of possibilities; and, again, the factors themselves, once derived, have an uncertain psychological significance which is dubiously aided by the use of letters to designate them or by the arbitrary assignment of trait names that it is hard to justify on psychological grounds. Moreover, the various exponents of factor analysis employ somewhat different mathematical procedures, especially in the critical last phases and, accordingly, bring forth different sets of factors among which it is no easier to choose than among more a priori personality theories. Finally, it has been argued, by Allport and others, that factor analysis does not allow for individuality; the technique radically assumes that all persons reflect a common mold.

To supplement the conventional method of factor analysis, in which scores on a group of subjects are correlated with each other test by test, an inverse method of factor analysis was introduced by Burt and developed by William Stephenson. In it persons, each of whom has achieved a variety of test scores, are correlated with each other. Such person-to-person correlation is, in a sense, a new expression of the earlier typologies, here reapproached on a more empirical—a sophisticated statistical—basis. Moreover, inverse factor analysis has been used not only for relating the several test scores of an individual subject obtained at any given stage, but, taking into account the variability of personality in time, it has been used to compare the assemblage of scores received at one time with those acquired at another. These novel efforts in the use of factor analysis to study individuality are, however, still controversial as to method and meaning.

BIOLOGICAL AND CULTURAL DYNAMICS

The concepts or inferred variables thus far considered refer primarily to the structure of personality—the patterns or other modes of organization that account for the several forms of behaviour that are recognizably personal. In contrast to this approach is one that stresses dynamics; *i.e.*, the forces or drives that direct the personality toward various ends and that secondarily may become attached to certain structures or patterns of function.

Psychoanalytic Theory

This dynamic orientation is, again, a very ancient one; classical writers, like Plutarch, who devoted themselves to biography or morals implicitly used some sort of dynamic theory of personality, and the same is even more obviously true of the great poets, dramatists and novelists of nearly every age. But the 20th-century understanding of personality dynamics received fresh vigour and acquired a theoretical formulation from the writings of the psychologist Sigmund Freud, the founder of psychoanalysis. His interest in the raw, often fantastic data of experience in the individual case led Freud to explore not only dreams but other wayward and seemingly haphazard behaviour, such as slips of the tongue. Thus he developed the theory that both dreams and these other "lawless" or accidental acts were, like neurotic symptoms, the product of psychic determinism at an unconscious level. The concept of the unconscious became for him the basic one.

Just as during sleep, when the ego is not on the alert, the nonconscious forces of personality come into obvious play, so, he asserted, they are present also in the waking state and at every weak point—in fatigue, emotional states and conflict—break through the conventional mask worn by the conscious ego. Much energy is expended by the ego to keep these untamed and unwanted elements of personality from gaining access to consciousness. It was, in fact, in the study of these mechanisms of ego defense in the neuroses, particularly hysteria, that Freud first came to grips with the unconscious forces of personality (*see* also Ego; Defense Mechanisms). A few years later these initial studies were followed by his masterpiece *The Interpretation of Dreams* (1900). In psychoanalytic therapy the aim is to circumvent the ego defenses by the method of free association in the presence of an analyst who permits and, in fact, encourages the patient to disregard in that setting the conventional social amenities. This therapy is a kind of re-education of the personality in which the repressed becomes expressed, the unconscious conscious and the disintegrated integrated. While beginning with the neuroses and with dreams, Freud soon went on to apply the same methods of study and the same concepts to the history of civilization, to the various products of culture—religion, art, literature, etc.—and to the social practices of modern life. The influence of this theory of personality has been considerable, partly, no doubt, because it is itself a reflection of the period of social conflict and tension that contributed to its birth.

Freud based his study of personality on his medical background and hence tended to present his views as biological generalizations with universal application for Homo sapiens wherever found. The unconscious drives of which he wrote and which he discovered in his patients were to him universal instincts modified, to be sure, by family upbringing and social education, but nonetheless rooted in the biology of man. The paradox is that, as compared with other psychiatrists of his time, Freud made much more of environmental factors than they and tended to oppose, by his insistence on psychotherapy, their fatalism. But subsequent criticism has tended to emphasize Freud's implicit belief in the fatalism of the unconscious itself and of its inevitable repetition—as in the classical *Oedipus Rex* of Sophocles, which Freud invoked in naming the oedipus complex. True, the environment has power, it has an effectiveness in Freud's theories; infants can be fixated, adolescents are subjected to intolerable conflicts, etc., and neurosis results. But these influences of the culture are largely negative: they can misshape the personality by deflecting it from the biological goals to which it naturally strives. The positive shaping forces of the culture were scarcely considered in Freud's theories. He was alert to the negative features of religion, which he considered a group neurosis; of art, which he analyzed as a compromise expression of conflict in the artist's personality, etc. The more positive aspects of these cultural phenomena were neglected or ignored by him.

It became the major emphasis in the so-called neo-Freudian schools of Karen Horney, Harry Stack Sullivan (*qq.v.*) and Erich Fromm to compensate for Freud's overemphasis on universal biological forces in personality. In fact, many of Freud's concepts, particularly those concerned with sexuality, were repudiated or radically revised by them. The formative influences of culture have been studied and the findings of social anthropology (*q.v.*) have been invoked to support this newer orientation by showing that different cultures produce different effects on the personalities that develop within them. A healthful ferment has been added to the orthodox Freudian view. (*See* also Psychoanalysis.)

Social Influences on Personality

At this point it is in order to interrupt the exposition of the various concepts offered to explain personality by introducing a summary of general conclusions concerning the role of social influence in the formation and functioning of personality. One such conclusion concerns the importance of infancy in determining basic adult reactions. The child's first experience with any class of stimuli must inevitably have disproportionate significance for his future development. Foremost among such patterns are those concerned with attitudes of security and insecurity. If the child feels wanted, loved and understood, he will tend to be secure in social situations outside the home. Rejection in the family situation engenders insecurity and either withdrawal or hostility subsequently. If, again, the child learns to bow to firm authority in the home, his attitude toward firm governmental authority may become submissive. If, on the other hand, he is subjected to excessive or to inconsistent discipline and so rebels, he is likely to carry over similar rebellious attitudes into his relations with school teachers, employers and government (*see* Family: *Influence of the Family on Individual Personality*).

The family is important in molding personality not only because so many parent-child relationships are prototypes of adult situations, but also because the child there unconsciously assimilates many attitudes and social expectations. Children are extraordinarily sensitive to vocal inflection, facial expression and other manifestations of which adults may be quite unaware. Sarcastic remarks about labour unions, Negroes, people who are too aggressive and those who are not ambitious enough have their effects on the child listener. The division of society into men *v.* women, bosses *v.* workers, leaders *v.* followers becomes sacrosanct to him and he develops a rigid concept of how people ought to act when they assume a certain role. Moreover, parents impose standards of behaviour by reward or punishment. Much of this learning goes on before the acquisition of language; *i.e.*, it is unconscious and deeply implanted. Sexual experimentation, for example, is normal to young children, but severe punishment may cause the child not only to abandon habits of sexual play but also to forget (repress) that he ever thought of such acts.

The school system has a strong influence on the growing child's personality. Occasional arbitrary discipline, overrigid work assignments and the necessity for treating diverse individuals alike in crowded classes are examples of undesirable practices. Good teachers, on the other hand, may become models whom the child will imitate. The content of education is also significant. Narrow, nationalistic, prejudiced teaching in history and social studies not only misleads the child but gives him an outlet for repressed hostility that tends to fixate his manner of thinking on a low level. Finally, the competitive system of grading, with its emphasis on invidious personal comparisons, is open to criticism.

Economic conditions have been shown to have a significant effect on the personalities of both children and adults. Poverty, for example, tends on the whole to distort personality development. The alleged beneficial effects of hardship have, for moralistic reasons, been largely overrated. To note this point is not to suggest that maladjusted (neurotic or delinquent) personalities are never found in the upper economic classes. But on a percentage basis the child in a better-class home has a better *chance* of reaching maturity with a well-balanced personality.

Values, ethics and character standards are all functions of social influence. With respect to these complex variables the child at birth appears to be a blank slate. Potentially he may be molded to satisfy his biological need for security by selfishly protecting his interests in the face of competition, or he may learn to gain the very same end by altruistically sharing with and receiving from others. His later view of human nature and ethics will follow as a rationalization fitted, as verbalization becomes possible, to justify the unconsciously learned patterns of social behaviour. One thus sees that ideas of right and wrong, beliefs as to the proper ways of behaving socially, or gaining one's ends, etc., come basically from behaviour patterns that have been inculcated or have been acquired from observation and imitation of those in closest contact with the growing child. The improvement of the intimate environment and the education of children is therefore held to be one of the chief avenues for developing more mature personalities. (*See* also Child Psychology and Development; Psychology, Social.)

Experimental Psychodynamics

The cultural critique of Freud within psychoanalysis itself was supplemented by a critique on grounds of scientific method

from the ranks of academic psychology. Since Freud's findings were largely based on his clinical work with neurotic patients, it was reasonable to ask whether his concepts would stand up under experimental scrutiny. At the same time opportunity might be taken to probe the general applicability of Freud's theories to normal persons. (Freud himself regarded his theory as a psychology of the normal and the abnormal indiscriminately.) What resulted was not, however, merely a critique of Freud: it reflected the particular conceptual orientation of the research centres that performed the experimental work and led to a development that may be conveniently called experimental psychodynamics. In most of these investigations the aim was to study personality with a dynamic theoretical basis borrowed from or based on the insights of Freud but intended to offer new and more rigorous concepts for handling the same psychological data.

Carl Jung (*q.v.*), who was for a time a close associate of Freud, conducted what may be regarded as the earliest studies in experimental psychoanalysis, presented in his book on the word association method (1906). But the first concerted program of this sort was conceived and conducted at the Harvard Psychological clinic about 25 years later. In that laboratory, beginning around 1930, Rosenzweig instituted an experimental program devoted to the clarification of psychoanalytic principles such as repression. This work led to a set of concepts under the heading of frustration theory that took frustration as a key concept for analyzing personality dynamics. The program of research resulted in the construction of the Picture-Frustration study, mentioned above. By combining detailed investigations of biography and projective methodology with frustration theory, this view was later broadened to include growth and creativity in its theory of personality. Henry A. Murray, in another departure, formulated a theory of personality in which the concept of need was made pivotal. In collaboration with Christiana D. Morgan he developed the Thematic Apperception Test, cited above. Through the use of a wide variety of experiments, tests and interviews, supplemented by a diagnostic council of the principal investigators who all worked with the same subjects, the effort was made both to fathom personality dynamics in the momentary cross section and to reconstruct in selected instances the longitudinal life history. The result appeared in *Explorations in Personality* (1938).

At the Yale Institute of Human Relations a research program was pursued with a different ground of conceptualization. Behaviourism (*q.v.*) was the point of view there prevalent, and concepts of learning (*q.v.*) theory played the crucial role in the work of this group (Clark Hull, John Dollard, Neal Miller, Robert Sears and O. H. Mowrer). An interpretation of aggression as instigated by frustration was formulated and published (1939); the process of psychotherapy, including psychoanalysis, was reconceptualized with the principles of learning as a basis (1950). More fundamental even were the numerous studies of animal behaviour (*q.v.*), especially of the white rat, in controlled situations with dynamic significance (*e.g.*, fear, anxiety, conflict), some of which were planned as analogues of human psychodynamic principles (*e.g.*, regression). In soviet psychology, which historically initiated the behaviouristic approach, this emphasis is carried to an exclusive consideration of social conditioning, on the one hand, and organic, physiological function, on the other, the dynamic theories of psychoanalysis and of existentialism (*see* below) being completely rejected. One here sees how personality theory is, in part, an expression of cultural forces. From the soviet standpoint, psychoanalysis, and even more so existentialism, rationalizes the unhealthy individualism of capitalistic culture.

Self-Realization and the Self-Concept

A fruitful source of concepts for understanding personality has been psychotherapy (*q.v.*). While other psychologists, as above noted, worked with psychodiagnostic devices (*e.g.*, projective methods) or attempted to unravel motivation through experiments in the animal laboratory, a third group utilized the interaction of therapist and patient with actual human problems posed for solution. Freud was, of course, the pioneer in this field of work in his special domain of psychoanalysis, but in psychology proper Carl Rogers led the way. Beginning with a minimum of theory, Rogers recorded and studied therapeutic interviews of neurotic or merely troubled clients in an effort to discover objectively what changes occurred and how they were effected. By systematic exploration of this kind he was eventually led to a view of personality in which the so-called self-concept was pivotal and in which self-realization in the process of normal and abnormal development came under close scrutiny. Rogers was led to the theory that the individual normally has a drive toward self-development which when impeded by conflict leads to symptoms of disorder. The opportunity to review these blocks to growth in a permissive therapeutic situation proved an important means toward overcoming them, quite apart from any theoretical interpretation of the behaviour such as that given in Freudian psychoanalysis. The relationship between therapist and client was in itself salutary.

This conceptualization of the therapy of the neurotic in terms of autonomous growth was reinforced from other directions. For example, the neurologist Kurt Goldstein, first in Germany and later in the United States, studied cases of brain injury by inquiring in each instance how the individual adapted to his defect and managed somehow to cope or come to terms with it. Even in such grave situations, the capacity of the human organism for self-adjustment was shown to be remarkable, according to Goldstein's findings.

Abraham Maslow, working at the other extreme with normal and gifted persons, tried to throw light on the process of self-actualization. What, he asked, contributes in fortunate cases to successful self-expression and what, on the other hand, defeats such an outcome? From these diverse directions contributions have been made to a better understanding of the dynamics of frustration, growth and creativity.

In the theory of personality that Rogers gradually built up from his investigations of psychotherapy, the concept of the self played a leading part. Moreover, he was concerned less with his own concept of the subject's self than with the subject's self-concept. Changes in psychotherapy were interpreted as changes in this self-concept—in the way the client (or patient) modified his view of himself. The so-called real environment—if we leave aside that part of it which, as a minimum requirement for life, supplies the biological necessities—is important from the psychological standpoint only in the measure that and in the way that it is filtered through the subject's perception of it and of himself in relation to it. For this reason, the therapist in seeking to change personality works very largely with the client's own concept of himself, which, of course, in turn involves his feelings of relationship with others.

It is thus appropriate to consider, at least briefly, this concept of self. It is inferred by the psychologist that the newborn infant has no conception of himself. It is only in the course of the first year or two of life that the sense of personal identity is acquired. The baby's earliest interest in his own mirror image, for example, is often regarded as pointing to the dawn of this awareness. But there are, of course, many ramifications and dimensions of the subject's self-identity, and attempts have been made to trace the changes in the self-concept (or sense of identity) from infancy through childhood and adolescence to maturity and after. Closely connected with the achievement of a stable self-concept is the degree of security that the person has achieved by virtue of earlier experience. If in the earliest months of life the child has been made to feel secure, he more readily develops a stable sense of his own identity which stands him in good stead in bringing to fruition the potentialities of his personality and in utilizing the opportunities of his environment. It has been often stated, for example, that the image which the person has of his own body—the body image—is an important nucleus of his conception of self. If the body image is defective by virtue of a "real" or imagined crippling, an element of permanent instability may enter the self-concept. But, of course, the current secure or insecure situation in which the person has to exist is likewise important in reinforcing or impairing the sense of identity. One dimension of this influence is the feeling of hope or hopelessness

that may affect the self-concept in profound ways.

This approach to personality via the self-concept seems to many psychologists to refer back to older philosophical speculations; *e.g.*, those of German idealism. To some extent this criticism is doubtless valid, and it has led many investigators to avoid this form of personality theory and to prefer a more behaviouristic variety.

Phenomenology and Idiodynamics

The point of view of Rogers has been sometimes designated phenomenological—a term that gained currency beginning with E. Husserl (*see* Phenomenology). Starting as a branch of epistemology, European phenomenology strongly influenced developments in experimental psychology, particularly the studies of perception that gave birth to the German school of Gestalt psychology. While various theoreticians have given different interpretations to phenomenology, all have agreed in using the term to denote a discipline devoted to the analysis of immediate experience. As such, this discipline challenges the commonsense concept of the real world, the external environment as conceived by the biologist, and attempts to examine systematically the subject's knowledge of his world as an interdependent aspect of his self-knowledge. Rogers in his psychotherapeutic studies was little influenced by the more technical aspects of philosophical phenomenology. These are more clearly discernible in the approach of existential psychiatry. This orientation, dating from the second quarter of the 20th century, concerned itself initially with experiences of the schizophrenic and other mental patients, but its avowed implications extend to all the data of personality.

Among the Gestalt psychologists, Kurt Lewin made important experimental and theoretical contributions which belong in the framework of phenomenology. He generally ignored the remote history of the individual and subordinated it to the analysis of the momentary psychological situation. This cross section was analyzed with the aid of field theory in concepts adapted from the physical sciences and mathematics (vector analysis and topology). Lewin's aim was the prediction of specific behaviour that went beyond the statistical or actuarial objective. He maintained that psychology must posit and work within a different space from that employed by the physicist—a psychological or hodological space with properties of its own. Though purporting to bear directly on problems of personality dynamics, Lewin's work had more immediate influence on social psychology (group dynamics) than on the psychology of the individual.

A last conceptual approach that belongs under the general heading of phenomenology is idiodynamics. In this view the personality is conceived as an idioverse or idiocosm—an individual universe of psychological events (experiences)—which can be categorized and analyzed to show temporal and motivational consistencies. The universal norms of general psychology and the group norms of cultural anthropology here give way to individual norms in terms of which the personality operates and is to be understood. But this view has been advanced as but one approach to a composite science of psychology; as a complement to the several other dimensions of a complete analysis of personality.

RECONCILIATION OF CONCEPTS

The foregoing survey of concepts, ranging from the organic to the strictly psychological (subjective, phenomenological), may be interpreted in one of two ways: (1) as indicating, if taken at face value, the broad diversity of competing views in the field of personality theory; (2) as portraying the multidimensional nature of personality (and of psychology) which, of necessity, approaches the person—the human organism—at diverse but complementary levels or axes. On this latter view a composite set of levels must be plotted in a complete chart of personality; each level provides working concepts for specific problems related to it. *See* also references under "Personality" in the Index.

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PERSONALITY DISORDERS, which are manifestations of defects in personality structure, are characterized by lifelong behavioural patterns that are inadequate or inacceptable. These disorders may be categorized as personality pattern, personality trait or sociopathic personality disturbances.

See Alcoholism; Behaviour Disorders; Drug Addiction; Psychiatry: *Personality Disorders;* Sexual Deviations.

PERSONAL PROPERTY, one of the two main divisions of the English common law of property, the other being "real property" (*see* Real Property and Conveyancing, Laws of). This differs substantially from the Roman law division of property into immovables (land) and movables (goods, animals, etc.) which was adopted in most civil-law countries. The difference is that personal property embraces a body of interests in land, known as "chattels real." The explanation is historical.

In medieval England there existed certain forms of lawsuits known as "real actions," in which possession of land could be recovered by one having a freehold estate (*i.e.*, a life estate or an inheritable estate). Land interests of less than freehold were known as chattels real and comprised what became the various kinds of leasehold interests (*see* Landlord and Tenant).

The English term personal property is thus synonymous with chattels, the latter being divided into chattels personal (the equivalent of movables) and chattels real (leaseholds in land). Chattels personal are divided into choses in possession (tangible movables, including animals, merchandise, goods) and choses in action (intangibles, including promissory notes and rights of action). Tangibles in this context means physical things capable of being seen, felt, eaten, worn or driven.

The word "goods" is occasionally used synonymously with personal property, more frequently as a synonym for chattels personal, and sometimes in a still more limited sense as meaning tangible inanimate things as distinct from animals, money or intangibles. Important differences between real and personal property at common law included differences in their transmission at death. Until the time of Henry VIII, English law permitted only personal property, not real property, to be left by will. If he died intestate, the owner's real property descended to his heir (under primogeniture, his eldest son) whereas his personal property was distributed by his administrator among his next of kin (*i.e.*, his surviving spouse and children or, lacking children, the brothers and sisters, etc.). (*See* Intestate Succession.)

Categories of Property.—Distinguishing between different categories of property is sometimes difficult. Gold is a tangible; circulating gold coins are both tangibles and intangibles but have a greater value as intangibles. Ancient coins are now tangibles only; circulating paper money is an intangible almost exclusively. Promissory notes are considered intangibles. An autograph is, however, tangible. Therefore a promissory note of a famous historical personage might be valuable solely as a tangible; the promissory note of a solvent living "nobody" would have value solely as a chose in action, a claim for the money it promises to pay.

Similarly, growing crops form part of the real property, but upon being actually (or, sometimes, constructively) severed, they become personal property. An undoubted movable may, after being permanently affixed to or appropriated for use with the land, become part of the real property. Thus, permanent buildings become part of the real property. On the other hand, the soil itself, upon being taken from the surrounding land, becomes a chattel personal. Similarly, corporate stock shares are intangible chattels personal, even though the corporation assets consist entirely of real property.

A few anomalous chattels, not strictly fixtures but so closely identified with land that they are treated as if they were real prop-

erty, are: (1) heirlooms (*q.v.*); (2) title deeds (particularly in England, because of the lack of universal recordation of deeds); and (3) keys to the door of a building.

In cases both of fixtures and crops, a thing may be personal property as between A and B, yet be treated as real property between A and C. Improvements installed in a building by a tenant may remain his personal chattels as against his landlord, although had a landowner sold a building containing his own improvements of the same kind, such improvements would have passed as real property to the buyer as against the seller.

By the judicial fiction known as equitable conversion, courts in England and the United States will for some purposes treat particular land as if it had been converted into personal property, or personal property as if it had been changed into land, where the terms of a valid will, contract or settlement had directed such change. Thus, an enforceable contract to sell land is said to work an equitable conversion, whereby the land is treated as if it already belonged to the vendee, with the price being regarded as belonging to the vendor.

If the landowner-vendor dies before the actual conveyance, his legatees are entitled to the price as personal property. The purchaser takes the land upon paying the price; if he dies before paying, his heirs get the land, his administrator paying the price from the purchaser's funds.

Personal property embraces almost anything in existence, other than real property, that is capable of being enjoyed or used. Electric current is tangible property although invisible and not safely felt, being capable of manufacture, measurement and use. It is often said that there is no property in air or water, yet compressed air or bottled water is certainly property.

Blackstone declared that in English law the heir had no property in the bones of his ancestors. The prevailing view in the United States, partly by statute and partly by decision, is that the surviving near relatives of a deceased person may not only enjoin wrongful interference with his ashes but may also recover in damages for such invasions of their rights (whether called property rights or personal rights). The English common law declared that wild animals ceased to be property whenever they made good their escape, but several U.S. decisions have rejected this rule as to nonindigenous menagerie animals or those kept on a commercial fur farm.

Buying or Selling.—Ownership of personal chattels may be acquired, lost, transferred or affected in various ways. One method is by buying or selling. If A wants to buy an automobile from B, A may either: (1) buy it outright for cash; (2) exchange other goods for it (barter); (3) buy it by absolute sale but on credit; (4) take it under a "lease" (bailment agreement) containing an option to purchase on the completion of a stated number of rental payments, aggregating its price, without A being obligated to become the buyer or complete the payments (an example being the hire-purchase transaction widely used in England); (5) buy it on conditional sale, in which case A gets immediate possession, but the seller, B, retains title as security until the full price is paid, B being obliged to transfer title when full payment is made and A being legally bound to make such payment (*see* INSTALLMENT CREDIT; in those United States jurisdictions adopting the Uniform Conditional Sales act, methods 4 and 5 are usually treated alike, and likewise under the Uniform Commercial code); (6) buy it "subject to return," this being a present sale with an added privilege in A to call off the transaction within a specified time if not satisfied; (7) buy it "on approval," this being a bailment with an option to buy and becoming a sale only upon the bailee either expressly accepting the goods, failing to reject or return them within the time specified, or having used them inconsistently with his not having taken title. Ownership may also pass by involuntary sales, including judicial sales, tax sales and foreclosure of liens.

If the seller was neither the owner nor one having authority from the owner to sell, or was selling stolen goods, the question arises whether the good-faith purchaser acquires good title against the unconsenting true owner. Under Roman law he would not, but French law in general protects the purchaser. Anglo-American law usually protects the unconsenting true owner, but with certain exceptions. In England, but not in Scotland nor in the United States, these exceptions include the "market overt" doctrine protecting a bona fide purchaser of goods at an established fair or from any City of London shop regularly selling such goods. (*See* SALE OF GOODS.)

Gifts.—Another way of acquiring property is by gift. By classifying as conveyances gratuitous transfers of real property and chattels real, and treating testamentary dispositions under wills, Anglo-American law restricts the meaning of gifts to gratuitous transfers of personal chattels taking effect on delivery in the lifetime of the donor. Such gifts are divided into two categories: (1) gifts *inter vivos* ("between living persons") and (2) gifts *causa mortis* ("in case of death," also known as *donatio mortis causa*); the principal difference being that gifts *causa mortis* are revocable. The later Roman law assimilated *donatio mortis causa* and legacies, and permitted such gifts much more readily than do English and U.S. jurisdictions. Anglo-American law limits *causa mortis* gifts to instances in which the donor contemplates impending death from an existing illness or injury. U.S. decisions conflict as to whether such a gift may be made in contemplation of suicide. Gifts *causa mortis* fail automatically if the donor survives the peril from which he envisaged death. A majority of Anglo-American decisions permit the donor to revoke his *causa mortis* gift by any unequivocal act or a subsequent inconsistent specific bequest, even though he later dies from the contemplated peril. A gift *inter vivos* is irrevocable but is voidable where the donor lacks capacity, or where fraud or undue influence procured the gift, and fails if donee refuses to accept it. French law does not recognize gifts *causa mortis* but holds gifts *inter vivos* to be revocable for cause, notably by a child being born to the childless donor or by judicial revocation for "ingratitude" (cruelty toward, refusal to support, or attempted killing of the donor). French law requires that a gift *inter vivos* and its acceptance be embodied in formal documents, whereas Anglo-American law permits purely oral gifts but insists on delivery. Delivery normally includes delivery of possession, but signifies in this context a manifestation that the ownership and control have passed from the donor and that he has given up the right to withdraw the gift. (*See* also LEGACY.)

Other Methods of Acquiring or Losing Title.—These include:

Adverse Possession, Prescription or Limitation.—Under the majority view in the United States, paralleling a common-law doctrine applicable to land, a person openly and exclusively holding another's chattel personal under claim of right and for a specified continuous period of years may acquire ownership by operation of law. Under Roman and French law this is acquisition by prescription (*q.v.*). In England the statute of limitations protects such a holder and his successors from a suit by the past owner; a new title was not thought to arise but a 1939 statute provides that the barring of the past owner's right to sue also destroys his title.

Abandonment.—The common law permits a person to relinquish his title to a chattel (but not his ownership of land) by placing it out of his possession and control and intending never to claim it or exercise further control over it. Loss by abandonment occurs instantaneously when both of these elements coexist.

Accrual to the State.—If the owner dies intestate and without a spouse or relatives, his personal property accrues to the state. Personal property may be taken for public use where necessary, and it is sometimes forfeited because of the criminal conduct of the owner, but constitutions in the United States require compensation for eminent-domain takings and permit forfeitures only within narrow limits and under specific statutes; *e.g.*, forfeiture of automobiles used in violating liquor or narcotics laws. (*See* EMINENT DOMAIN; CONFISCATION AND EXPROPRIATION.)

Extinction of the Res.—Ownership may cease because the goods have been physically consumed or destroyed, or have lost their identity by becoming merged with real property or with other chattels. Under civil-law rules adopted by the English common law a chattel, by being greatly improved by labour or by being added to other materials, may become part of a new thing and

cease to exist apart from that new thing. Paint applied to a building or to furniture ceases to exist except as an integral part of such building or furniture. Where one owner willfully or fraudulently commingles his own goods with like goods of another owner and without the consent of the latter, resulting in a confusion of goods which renders it impossible for each owner to identify his own or ascertain his share of the commingled mass, the commingler may lose his entire interest in the mass.

Court Judgment.—Where A falsely claims ownership of something belonging to B and a court judgment establishes A's title, the judgment in reality destroys one title and creates another, but in theory it has simply vindicated the pre-existing title. Where C wrongfully converts to his own use, or to the use of a third person, the chattel of D, and D recovers judgment therefor against C in the common-law action of trover or its modern statutory equivalent, the satisfaction by C of that judgment creates a title in C. In effect, this is a purchase forced upon C by reason of his wrongful conversion of the thing.

Numerous situations arise in which an owner parts with possession of his chattel without ending his title or ownership. If he loses or mislays it, the chattel remains his; although the finder is by the common law entitled to retain possession meanwhile as against other persons, including the finder's bailee or one finding it after the first finder lost it. The English and U.S. cases show considerable conflict as to the rights of the finder as against the owner of the land on which the thing was found. Some courts stress the distinction between mislaid and lost goods; others inquire whether the place of finding was one to which the public was freely admitted or was reserved by the landowner for his private use; if the finder was an employee of the landowner and made his find as part of his duties or in a place to which he was admitted solely by virtue of his employment, the trend of decisions in the United States allows the landowner permanent possession of the thing as against the finder. In both England and the United States the landowner is normally protected as against a trespassing finder. (*See* also SALVAGE.)

Bailment.—Apart from transactions involving a transfer of ownership, the most important legal relationship regarding chattels personal is termed bailment (*q.v.*). Chattels real cannot be the subject of bailments. A bailment arises in almost any situation in which one person (the bailee) lawfully has possession of the goods of another (the bailor). Bailments may be either for the sole benefit of the bailor (as where one friend gratuitously stores another's goods), for the sole benefit of the bailee (as where one person gratuitously lends his watch to another), or for mutual benefit (as where the owner lets another use his goods for an agreed rental; or where the bailee is to store, transport or improve the goods for and at the expense of the owner). For some purposes the finder may be treated as a gratuitous bailee. An involuntary bailment may arise where the goods of one man come into another's possession without the latter's consent. The indispensable element of a bailment is possession by the bailee. If the repairman comes to the house to fix the clock, he is no bailee; if the owner leaves the clock at the repair shop, a bailment exists. Railroads, van companies and other common carriers are bailees of the goods entrusted to them for shipment. Particularly in the United States, to lessen income taxes and to reduce the amount of capital they must invest, countless companies have become bailees of automobiles, ships, machinery or equipment instead of buying them.

Although bailments may arise without either a written agreement or a contract, these "lease" bailments usually involve a formal written lease (so-called by analogy to a lease of land, but the transaction remains a bailment), and many clauses in such instruments are directly copied from written leases of land. In many instances, therefore, litigation involving such bailment documents is decided by analogy with the corresponding rule regarding leases of iand. In some jurisdictions certain bailment clauses are unenforceable as against public policy; others will be given effect but only if specifically agreed to and even then will be narrowly construed. Agreements freeing a bailee from liability for his negligence illustrate both of the foregoing categories.

In a bailment, title remains in the bailor and, in the absence of contrary agreement, he is entitled to any profits or increase in value, and to the offspring of bailed animals. Unless he agrees to be an insurer of the safety of the goods, the bailee is liable only if their destruction, loss or damage results from his failure to care for them properly. The measure of his duty of care depends in part on whether the bailment was for his sole benefit or for the sole benefit of the bailor, or for mutual benefit; in part, it depends on whether the bailee held himself out as engaged in a "common calling" (that is, innkeeper, common carrier or public warehouseman) or whether a statute or the specific agreement altered the ordinary rule of liability.

One type of bailment, made for the express purpose of giving the bailee a lien on the goods as security for performance of an obligation, usually an obligation to pay money, is known as pledge (*see* PAWNBROKING).

Actions at Common Law.—The Anglo-American law of personal property was shaped considerably by the common-law forms of personal actions. To illustrate: if A chopped down B's tree, B could choose from a variety of personal actions. B could either: (1) sue A for trespass to the land, recovering the amount by which the loss of the tree reduced the land value; (2) sue A in *trespass de bonis asportatis* for the value of the tree after severance; (3) sue A in trover for conversion of the severed tree; or (4) by replevin recover the severed tree itself. If A had sold the tree to C, B could still recover from A in any of the foregoing except replevin, or could instead (5) sue C in trover or (6) sue A in assumpsit (as if A had sold the tree for B).

Property is used throughout this article in its usual and practical sense, as referring to things and intangibles, ignoring the theory that in a strictly technical sense property is neither land nor goods but rather the interest or estate ("bundle of rights, privileges, powers and immunities") which a person has in such land or goods as against other persons.

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PERSONNEL MANAGEMENT: *see* INDUSTRIAL RELATIONS; OFFICE MANAGEMENT; PSYCHOLOGY, APPLIED: *Industrial Psychology*.

PERSPECTIVE is the method used in drawing to portray three dimensions on a two-dimensional surface.

History.—Artists have been experimenting since the Stone Age in their attempts to express a feeling of space and solidity. A reindeer herd was etched on a fragment of bone 15,000 years ago, and the illusion of distance was created by showing the legs and antlers as if seen beyond the fully sketched animals of the foreground. The artist of ancient Egypt discovered that his main perspective problem was showing a single important object in the necessary three dimensions. This he expressed in his own way by drawing a combination of plan and side view. A Pharaoh carrying a circular tray of sacrificial offerings was drawn in this manner. The top view of the tray is shown in half by means of a semicircle. On this half-tray is the sacrificial food as it would appear when viewed from above. This stylized method of expressing a third dimension persisted in Egyptian drawing for 3,000 years.

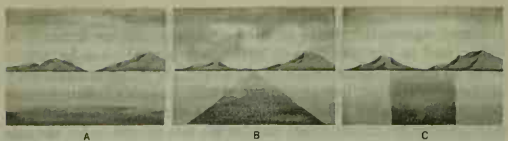

FIG. 1.—A SIMPLE PERSPECTIVE DRAWING OF TREELESS LEVEL COUNTRY, WITH PERSPECTIVE AND NONPERSPECTIVE RENDERING OF A HIGHWAY

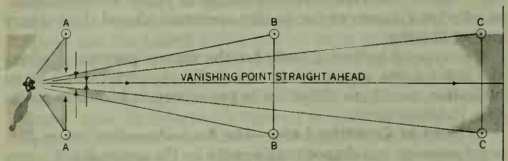

FIG. 2.—LOOKING AT A LEVEL HIGHWAY (TOP VIEW): AS DISTANCE INCREASES, THE HIGHWAY APPEARS TO DIMINISH IN BREADTH

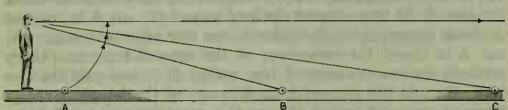

FIG. 3.—LOOKING AT A LEVEL HIGHWAY (SIDE VIEW): THE HIGHWAY APPEARS TO RISE

In America, northwest Indian artists developed a unique method of showing the front view together with both the left and right sides of a person or an animal. The creature was drawn as if it were split down the back and then flattened out like a hide. Each side of the head and body thus became a profile facing the other.

Chinese artists created landscapes that had excellent feeling of distance and space by skillfully arranging the natural contours of land, water and foliage. When buildings were drawn it was necessary to show the parallel horizontal lines of the construction. Isometric drawing was used. Isometric drawing is a simulation of perspective drawing wherein parallel lines are drawn parallel, instead of converging as in true perspective. Often foliage was used in the drawing to crop these lines before they extended far enough to cause the building to appear warped. These isometric arrangements made an attractive pattern of interposing line.

The early European artist used a perspective which was an individual interpretation of what he saw rather than a fixed mechanical method. It was not until the first half of the 15th century that the Italian painters made perspective drawing an exact science by the use of the horizon line and the vanishing point.

At the beginning of the Italian Renaissance the mathematical laws of perspective were discovered by a Florentine architect, Filippo Brunelleschi (1377–1446), who worked out some of the fundamental principles. Masaccio (1401–*c.* 1428) began using the method and within a short period brought about an entirely new approach in painting. A style was soon developed using configurations of architectural exteriors and interiors as the background for religious paintings. This gave the new science the opportunity to expand freely. One of Brunelleschi's contemporaries Paolo Uccello (1397–1475) compiled these principles into book form and in doing so became the original authority in the field of perspective projection.

In modern times, perspective has an important part in the work of artists as well as in idea presentations of architects, engineers, landscape specialists and industrial designers. It furnishes an opportunity to view the finished product long before it is begun.

Technique.—The simplest perspective drawing that can be made is a single horizontal line across the paper. The word horizontal in itself suggests the natural horizon (*i.e.*, the distant line where the earth or sea apparently meet the sky). By drawing this horizontal line the artist has created the illusion of space and distance as far as the eye can see. A sailboat added and a few clouds above the line complete a picture of the sea in the distance meeting the sky. If the sails of the boat shut from view a segment of the horizon, this places the horizon farther in the distance than the boat.

In a level treeless country a distant mountain range may be seen beyond the horizon (fig. 1A). The curve of the earth's surface is so gradual that it gives the impression of being flat. Yet mountains can be seen beyond this curvature. The superstructure of ships at sea can be sighted long before the hull is seen. A distant island appears to rise out of the sea as it is approached. The horizon therefore is seen as a continuous line between the observer and distant objects. This line is curved, but the curvature is so slight it is usually ignored in drawing.

The colours of distant objects are softened by the atmosphere into bluish tones. This atmospheric colour effect in itself creates an impression of distance and is called aerial perspective.

A highway built across the plain may be drawn as two straight lines meeting at a point on the horizon (fig. 1B). These lines

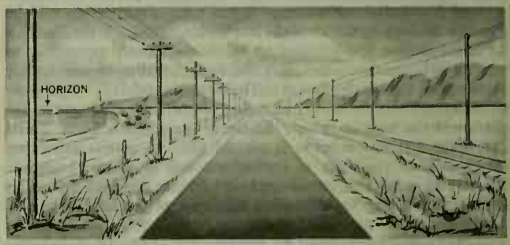

FIG. 4.—THE PERSPECTIVE OF PARALLEL LINES

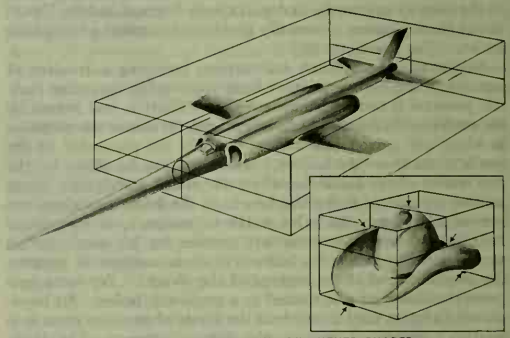

FIG. 5.—THE PERSPECTIVE OF CURVED SHAPES

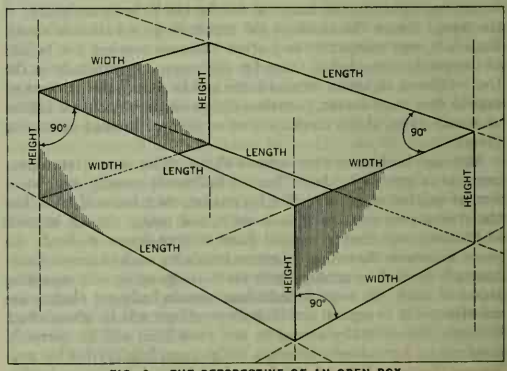

FIG. 6.—THE PERSPECTIVE OF AN OPEN BOX

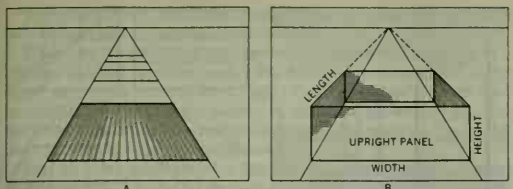

FIG. 7.—ONE-POINT PERSPECTIVE

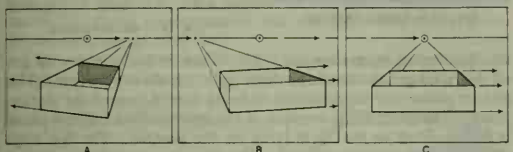

FIG. 8.—THE ESTABLISHING OF VANISHING POINTS

represent the two curbs which are uniformly parallel throughout their lengths. Why are the curbs drawn as converging lines rather than parallel lines, as in fig. 1C?

Fig. 2 shows the top view of a person standing in the centre of the highway. For him to see both curbs near his feet his eyes must take in a wide area at the section marked AA. Twenty feet beyond, at section BB, he sees the same width but it appears considerably narrower than at AA. As he looks beyond to CC it appears still narrower and when he looks as far as he can in the distance, to the horizon line, he sees that the width has narrowed to a mere point. Beyond this point no more highway is visible. This point is called the vanishing point.

The side view of the same situation is shown in fig. 3. The person must look down in order to see the highway near his feet at section A. To look at B, the section 20 ft. beyond A, it will be necessary to raise his eyes. This is also true for section C, and so on, until he is looking straight ahead along a line that is level with his eyes. He is then looking directly at the vanishing point of the highway. Fig. 4 illustrates how level highway appears to rise to eye level at the horizon.

Two conclusions may be drawn: (1) The natural horizon and the artist's eye level are at the same height. This is true whether he is lying on the ground or sketching from an airplane. The horizon seems to rise to meet the eye level. (2) The vanishing point of a system of horizontal parallel lines is always on the horizon line. There can be systems of parallel lines in a picture that do not meet at the vanishing point. One system is made up of upright or perpendicular lines. The other system comprises the horizontal lines which are parallel to the horizon. A general rule covers these systems: parallel lines do not converge to a vanishing point if they are parallel to the picture plane (the surface on which the picture is executed).

In nature there are very few square corners but man's most common form of construction is the box. Houses and furniture, books and skyscrapers, all are modifications of box designs. A solution for most perspective problems may be derived from a proper understanding of the box. The drawing of curved forms, such as shoes, hats, automobiles and airplanes, becomes simplified when these objects are fitted into boxes (fig. 5).

The box has two upright sides, a top, a bottom and two ends—six planes in all (fig. 6). There are 8 corners where 3 planes meet at right angles to one another and 12 edges where 2 planes join. These 12 edges or intersections of the planes are represented in the drawing as lines which will be referred to in groups of four: length lines, width lines and height lines.

One-Point Perspective.—To draw a box in one-point perspective, two lines may be drawn converging at a horizon line, as in the case of the highway (fig. 1). Let a section represent the bottom of the box (fig. 7A). Upright end panels can be placed on the section lines (fig. 7B). The top and the sides can be represented by drawing two upper length lines from the top corners of the near panel to the vanishing point. The height of the far end panel is determined by the intersection of the length lines with the verticals or height lines.

The entire projection may be inverted so that the vanishing point is below the object depicted, as in Masaccio's "Trinity" at S. Maria Novella, Florence. In Florence 70 years later Leonardo da Vinci (1452–1519) painted his famous "Last Supper" using the one-point perspective. All the perspective lines of the room lead to the vanishing point at the head of Christ.

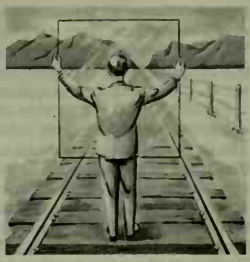

FIG. 9.—THE PICTURE PLANE

Two-Point Perspective.—If the box is rotated slightly the vanishing point of the length lines will move along the horizon accordingly (fig. 8A), until it passes out of the picture, although it will still remain on the horizon line. As the width lines move they are no longer parallel to the plane of the picture and it is necessary to establish a vanishing point for them. This point is also on the horizon line (fig. 8B). In two-point perspective there are two vanishing points: one for the width lines and one for the length lines. If the box is rotated farther until the newly established point coincides with the central position of the original vanishing point, the length lines will be parallel to the picture plane, and the box is again in the position of one-point perspective, having been rotated 90° (fig. 8C). The distance between the vanishing points in two-point perspective is governed by a simple ratio. In order to understand this it is necessary to become further acquainted with the use of the picture plane. (*See* fig. 9.)

Perspective Projection.—The picture plane is represented as an upright transparent surface. The artist stands facing it on a level plane called the ground plane. He looks through the picture plane at the object, also resting on the ground plane (fig. 10). In this instance, the object he wishes to draw is the box. The ground line (GL) is the line where the picture plane rests on the

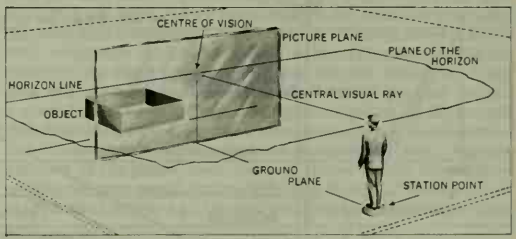

FIG. 10.—THE PERSPECTIVE ARRANGEMENT

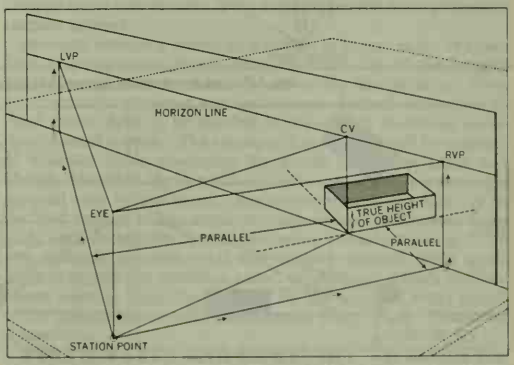

FIG. 11.—LOCATING VANISHING POINTS

ground. The artist stands on the station point (SP) and sees the scene before him from an eye level viewpoint, called the eye. When he looks directly at the picture plane (along a line perpendicular to it) he is looking along a line called the central visual ray (CVR) which lies on a plane called the plane of the horizon.

Everything that can be seen above this plane is said to be above eye level; everything seen below this plane is below eye level. The central visual ray intersects the picture plane at a point called the centre of vision (CV). A horizontal line drawn through this point is the horizon of the picture. It is the line where the plane of the horizon intersects the picture plane. If the artist is seated, the horizon is lowered; if he views the object from a stepladder, the horizon raises accordingly. The object also may be raised and the picture plane may be moved closer to the artist or back against the object. These arrangements allow a great deal of freedom.

According to theory the artist can now locate all the necessary points and lines of the object and draw them where the visual rays (VR) show them on the picture plane. The centre of vision becomes the vanishing point of a drawing in one-point perspective.

The two-point perspective arrangement can be made by rotating the object (fig. 11) to the desired view. For convenience the picture plane is placed against the corner of the object. By doing this the height is actually on the picture plane in true measurement. In this way the process of projection is made simpler and easier to visualize.

The station point is chosen at any desired distance from the object and the view from any desired height above the ground. When the eye height is established, two lines from the eye are extended parallel to the two sides of the box. The two lines form a right angle and each meets the picture plane on the horizon line. The points where they intersect the horizon line are the left vanishing point (LVP) and right vanishing point (RVP). The same points can be reached by drawing the two lines on the ground from the station point to the picture plane and then up to the horizon line (indicated by arrows, fig. 11). Then it is necessary to get all this arrangement flattened down onto one sheet of paper. The picture plane may be visualized as being moved toward the station point. The ground line remains in the new position but the plane is folded down so that it is lying on the ground. The top edge of the picture plane is ignored. The plane remains in its original position touching this trace.

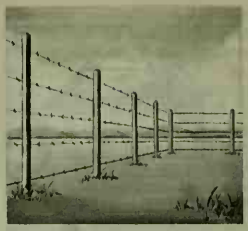

FIG. 14.—EQUAL SPACING

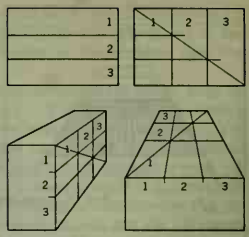

FIG. 15.—SUBDIVISIONS

All three-dimensional units can then be translated into a two-dimensional surface (fig. 12).

This method is called the architect's or office method. It is found to be adaptable to most perspective problems and it is the basis for most perspective projections.

The vanishing point is located by dropping perpendicular lines from the previously located points L and R to the horizon (fig. 13A). The side elevation is placed so that it rests on the ground line. A horizontal line from the top of this elevation to the central line gives the true height of the box. Lines from the top and bottom of this height line extended to the vanishing points will give the near corner of the box in true perspective, with the sides of the box extending to the vanishing points. It is then necessary to find where the sides of the box actually end.

A line is drawn from the station point to the right-hand corner of the plan. It intersects the picture plane at a point indicated by the arrow (fig. 13B). A line is drawn to the left corner in the same manner. The space between the two arrows measures the extent of the box as it would be seen on the picture plane. Perpendicular lines from these arrows drawn downward through the sides of the box cut the sides off at the correct place. The perspective picture is completed by drawing lines to the vanishing points from the established corners of the box.

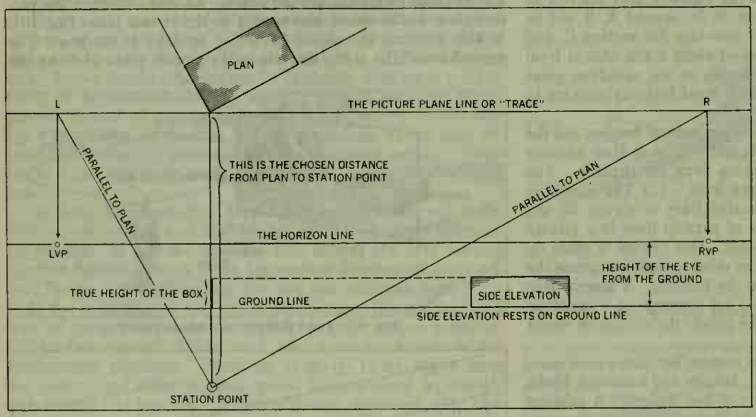

FIG. 12.—COMPLETE PERSPECTIVE ARRANGEMENT

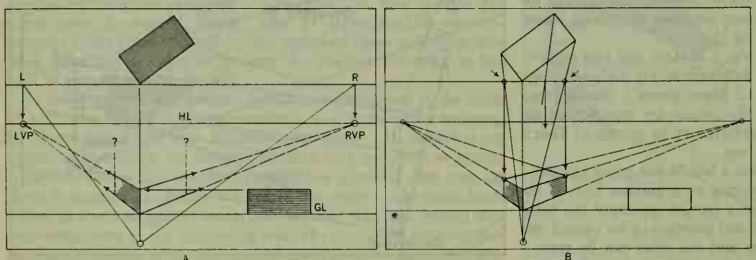

FIG. 13.—PERSPECTIVE PROJECTION

Division of Space.—If a line divided into equal parts is drawn in perspective, the parts become smaller as they recede (fig. 14). The simplest division is two equal parts. A square, rectangle or line may be divided into halves by the use of intersecting diagonals.

The point of intersection becomes the central point and a line drawn through this point parallel to the sides is the line of division. When the rectangle is drawn in perspective this method of dividing still holds true; the true centre is the point where the diagonals intersect.

These divisions in turn may be subdivided into quarters and then into eighths and sixteenths, if desired.

When the space cannot conveniently be subdivided into halves, another method may be used. To divide a rectangle into three equal parts with vertical lines (fig. 15), it should be first divided by length lines into three parts. A diagonal is then drawn. If the vertical lines are drawn where the diagonal intersects the length lines the correct spacing is obtained.

Fig. 16 is an example of a facade with seven columns drawn in perspective. Irregular divisions also can be projected in the same manner. These methods follow the principle of dividing measurable lines (*i.e.*, lines parallel to the picture plane) and of translating these measurements into corresponding divisions on the receding perspective line.

There is another method of subdivision in perspective in which a high or low vanishing point is used. It can be understood by

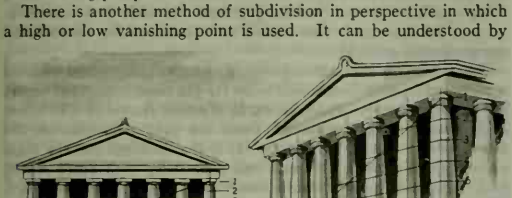

FIG. 16.—FACADE IN PERSPECTIVE

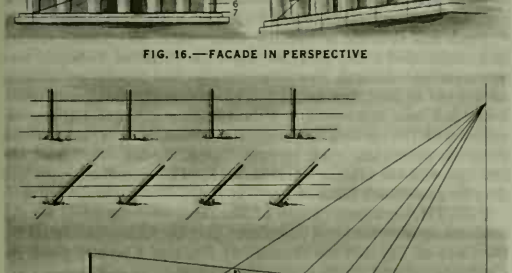

FIG. 17.—CONTINUOUS SPACING

drawing a fence in which all the posts lean at the same angle along the line of the fence (fig. 17). The posts will be parallel to one another and will all point to a vanishing point in the sky (or below the horizon if leaning in the opposite direction). This point will be somewhere directly above (or below) the vanishing point of the fence. To verify this, tilt the posts more and more until they finally lie end to end on the ground. It will be found that their vanishing point has moved down in a perpendicular line until it is the same as the vanishing point of the original fence. Using the draftsman terminology, this perpendicular line on which the vanishing points fall is the vanishing trace of the vertical plane of the fence. An axiom applied to this form of projection is that parallel lines in a plane have their vanishing points in the vanishing trace of the plane.

If the diagonal drawn between the first two posts is extended to intersect the vanishing trace, the successive posts can be located by the use of this point of intersection as the common vanishing point of all the diagonals.

Three-Point Perspective.—This system incorporates in addition to the two horizontal vanishing points a third vanishing point to which all vertical planes relate. It is of limited use.

See ARCHITECTURAL RENDERING; DRAWING (TECHNIQUES OF); DRAWING, ENGINEERING; DESCRIPTIVE GEOMETRY; *see* also references under "Perspective" in the Index.

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PERSPIRATION. Perspiration is an inclusive term referring to any water, either in vapour or visible form, which is given off by the normal skin. There are two sources: the epidermis and the sweat glands. The average adult loses about 500 g. of water vapour via the transepidermal route every 24 hours. This type of water loss is called insensible perspiration and involves no chemicals besides water. The mechanism of loss is obscure, but it would appear that the water loss, which is constant, is associated with the growth and aging process of the epidermal cells as they form keratin. Only factors affecting the epidermal cells have an influence on the rate of epidermal water loss.

The common usage of the word perspiration disregards the above vapour loss and relates it solely to the secretion from the eccrine sweat glands. These glands are distributed over the entire skin surface of man. Totaling approximately 2,000,000 in number, they show marked regional differences in density. The palm and sole may present over 2,500 per square inch, whereas the back may have fewer than 500 per square inch. Each gland is a simple coiled tubular unit. The secretory coil is deep in the dermis and from it the sweat duct extends up through the dermis and epidermis.

The sweat pore is not visible except on the palms and soles. The glands provide surface water for evaporative cooling of the body under heat stress, 540 cal. being lost per litre of sweat evaporated. In cool environments the glands remain entirely at rest.

However, once the skin temperature or body temperature becomes elevated, many of the glands are instantly stimulated to secrete. This stimulation is caused by autonomic nerves which are under control of the thermoregulatory centre of the hypothalamus of the brain. In areas which have been denervated (*e.g.*, by sympathectomy, or by neural changes in leprosy) sweating does not take place. The total sweat rate may range from zero to 2,000 g. per hour. Often sweating rates are excessive since only the sweat which evaporates cools the body. Eccrine sweat is about 99% water, the chief solute being sodium chloride. The more efficiently the gland functions, the lower the salt content is. Very little salt is present in the sweat of acclimatized persons, so that a normal person rarely needs salt supplementation of his normal diet despite high sweating rates. Similarly vitamin supplementation is unnecessary since only trace amounts are lost. Eccrine sweating of the palms, soles and to a certain extent elsewhere is under a different neural control, reflecting emotional tension rather than thermal stress; *e.g.*, the cold sweat of shock or motion sickness.

Closure of the sweat pores with subsequent extravasation of trapped sweat into the skin is the cause of prickly heat, a common summer ailment.

Apocrine sweat is a second type formed in human skin. It arises from apocrine sweat glands, most of which are in the armpits and appear at puberty as an offshoot of the hair follicles. Very small amounts of sweat are continuously formed and stored in these glands, later to be expelled in response to emotional rather than thermal stimuli. The expulsive force is provided by a sheath of muscular tissue enveloping the glands. Apocrine sweat is a whitish odourless liquid which contains considerably more solid material than eccrine sweat. Surface bacteria of the skin act on the lipid content of this sweat to form odorous unsaturated fatty acids, thus accounting for the distinctive "underarm odour." In rare instances apocrine sweat may contain unusually large quantities of pigment, a condition called chromidrosis. Such reddish-brown sweat is normally produced by the apocrine sweat glands of the hippopotamus. *See* also ANIMAL HEAT; SKIN: *Cutaneous Appendages.* (W. B. SY.)

PERTH, EARLS AND DUKES OF. The Scottish title of earl of Perth was bestowed upon JAMES DRUMMOND (*c.* 1580–

1611), 4th Baron Drummond, in 1605. James was succeeded by his brother JOHN (*c.* 1584–1662), who in the Civil War was appointed commissioner of war in Perthshire for the parliament. His second but first surviving son JAMES (*c.* 1615–75), 3rd earl of Perth, also served the parliament, but later fought with the marquess of Montrose at Philiphaugh (Sept. 13, 1645) and was taken prisoner. His second but first surviving son JAMES (1648–1716) declared himself a Catholic on the accession of James II (James VII of Scotland) and during his reign largely controlled affairs in Scotland. Imprisoned (1688–93) after the revolution of 1688, in 1696 he joined the exiled king, who in March 1690 had created him (titular) duke of Perth. He was governor to Prince James (the Old Pretender) from 1696 to 1706. His son JAMES (*c.* 1673–1720), 2nd titular duke and 5th earl of Perth, was several times imprisoned and commanded the Jacobite cavalry at the battle of Sheriffmuir (Nov. 13, 1715). Attainted in 1716, he escaped to France. His son JAMES (1713–46) joined Charles Edward (the Young Pretender) in 1745, fought with him at Prestonpans, Carlisle, Stirling and Culloden, and at Derby was the only counselor to advise against a return to Scotland. After the battle of Culloden he also was attainted (1746), escaped, but died at sea. Unmarried, he was succeeded by his brother JOHN (1714–47), 4th titular duke and 7th earl, who fought at Falkirk and Culloden, escaped to France and fought for the French in the Austrian Succession War. He was succeeded by his uncle of the half-blood, JOHN (1679–1757), a son of the 1st titular duke by his second wife. John's successor, EDWARD (1690–1760), was his half brother, son of the 1st duke by a third wife. He served as a general in the French cavalry. On his death without issue the titular dukedom became extinct.

The representation of the earldom passed to Edward's cousin JAMES LUNDIN, afterward DRUMMOND (1707–81), grandson of John, 1st titular duke of Melfort (a brother of the 1st titular duke of Perth) by his first wife, Sophia, heiress of Lundin. To his third but only surviving son JAMES (1744–July 1800) the family estates were restored in 1785, and in 1797 he was created Lord Perth, Baron Drummond of Stobhall, County Perthshire, in the peerage of Great Britain. On his death without male issue, the United Kingdom peerages became extinct and the representation of the earldom passed in turn to his cousins JAMES LOUIS DRUMMOND (1750–Sept. 1800) and CHARLES EDWARD DRUMMOND (1752–1840), respectively 4th and 5th titular dukes of Melfort, great-grandsons of the 1st duke by his second wife. Both died without issue and their nephew GEORGE (1807–1902) succeeded to their claims. In his time the attainders of 1716 and 1746 were reversed and in 1853 he was declared entitled to various Scottish dignities, including the earldoms of Perth and Melfort.

George was predeceased by both his son and his grandson and on his death the earldom of Melfort became extinct or dormant and the earldom of Perth passed to his kinsman, WILLIAM HUNTLY DRUMMOND (1871–1937), who in 1893 had succeeded his father as 11th Viscount Strathallan. His half brother and successor, JAMES ERIC (1876–1951) was private secretary to the prime minister Herbert Asquith (1912–15) and to the foreign secretaries Sir Edward Grey (1915–16) and A. J. Balfour (1916–19). Known as Sir Eric Drummond (from 1916), he accompanied Balfour to the U.S. in 1917 and to the Paris peace conference, and he became secretary general (1919–33) of the League of Nations. He was ambassador in Rome (1933–39) and in 1946 became deputy leader of the Liberal peers. His son, JOHN DAVID DRUMMOND (1907–) is 17th earl of Perth and 13th Viscount Strathallan.

PERTH, the capital of Western Australia, is situated in the southwest of the state on ground rising 200 ft. (61 m.) from the right bank of the Swan river about 12 mi. (19 km.) N.E. of its mouth, which forms the inner harbour of Fremantle (*q.v.*). Pop. (1961) 94,508; metropolitan area (including Fremantle) 420,133, more than half the population of the state. The climate is of the Mediterranean type with mean monthly temperatures ranging from 23.5° C. (74° F.) in February to 13° C. (55° F.) in July, an average daily sunshine of 7.8 hr. and an average annual rainfall of 36 in. (914 mm.), falling mainly from May to October.

Though some of the streets are still narrow, the city has been largely rebuilt in the 20th century and the suburbs stretch for more than 20 mi. (32 km.) along the northern side of the river. Development of the southern side was stimulated by the opening of a new causeway over the Swan across Herisson Island in 1952 and subsequently by the building of a bridge at the narrows at the western end of Perth water. Perth contains some of the finest buildings, avenues and streets (*e.g.,* St. George's terrace) in Australia. The public buildings include an Anglican and a Roman Catholic cathedral, government house, parliament house, an observatory (1896) and the University of Western Australia (founded 1911), with its impressive Spanish-style architecture. There are many state and private schools, a technical college, two teacher-training colleges and a number of private colleges. Perth has about 6,000 ac. (2,428 ha.) of parks and gardens, including King's park (1,000 ac. [405 ha.] of bush set aside as a nature reserve), Belmont park (the state's main horse-racing centre) and the zoological gardens.

Besides being the state's political, administrative and judicial centre, Perth, with Fremantle, is by far the most important centre for trade, commerce and banking in Western Australia. It is not highly industrialized, although there are light industries on the outskirts and around Fremantle. It is the terminus for the main railway routes within the state and connecting with other states, and there is a modern international airport at South Guildford. Most of the public utilities are administered by the state government. The water supply is obtained from catchments in the Darling range, supplemented by artesian wells in summer.

Perth was founded in 1829 by Capt. (later Sir) James Stirling and constituted a city in 1856, when the Anglican bishopric was also created. Growth was slow initially, the population totaling only 8,447 in 1891, but in the preceding year the Coolgardie goldfields had been discovered and the resulting influx of settlers, together with the opening of Fremantle harbour in 1897, led to rapid progress, subsequently encouraged further by the opening of the rail link with the eastern states in 1917. The Commonwealth and Empire games took place in Perth in 1962.

PERTH, an inland county of Scotland, bounded north by the counties of Inverness and Aberdeen; east by Angus; southeast by the Firth of Tay and the counties of Fife and Kinross; south by Clackmannan and Stirling; southwest by Stirling and Dunbarton; west by Argyll; and northwest by Inverness. It is the fourth largest county in Scotland, its land area being 2,493.4 sq.mi. (6,458 sq.km.). It has a compact, roughly circular shape. The Highland boundary fault runs with the Caledonian trend northeast-southwest from near Alyth to near Aberfoyle, and is a rough boundary between lowland Perth, the southeastern third of the county, and the remaining two-thirds lying in the south-central Grampians.

Physical Features.—Highland Perth, a plateau planed across rocks metamorphosed by Caledonian folding and overthrusts, mainly Dalradian mica schists, limestones, and quartzites, is much dissected so that many summits and ridges are at about 3,000 ft. (914 m.), with higher residual heights in various rocks: Ben More, 3,843 ft. (1,171 m.) east of Crianlarich, in schists; Ben Lawers, 3,984 ft. (1,214 m.); and Schiehallion, 3,547 ft. (1,081 m.), near Loch Tay, in quartzites. Many conical hills along the Highland edge are in a belt of quartzite: Ben Venue, 2,393 ft. (729 m.), and Ben Ledi, 2,873 ft. (876 m.), in the Trossachs; Ben Vorlich, 3,224 ft. (983 m.), and Ben Chonzie, 3,048 ft. (929 m.), near Loch Earn, and others stretching northeast to the county boundary. Dissection is in blocks, valleys tending to trend east (Forth, Loch Earn, Loch Rannoch), northeast or southwest (central and Loch Tay, Glen Tilt), and southeast (Garry-Tummel-Tay, the dominant river system of Perth). Southwestern Perth was part of the great southwest Highland centre of ice dispersal during the maximum glaciation. Corrie glaciation, rock-basin lakes (Lochs Earn, Tay, Katrine, etc.), and ice-molded valleys are all common, as well as ice marginal and other moraines.

Vegetation varies from the well-studied Alpine flora of Ben Lawers and other peaks, through acid grassland (fescue–purple moor grass–bent grass–heather), which dominates in the centre and west of the county, to heather–blaeberry in the drier east and

northeast with rare survivals of the Scots pine forest association as in Black Moor of Rannoch, and residual birch and oak woods in the valleys. There are many well-wooded estates, largely artificial planting as near Blair Atholl and in the Trossachs. Wildlife includes red deer and wildcat, golden eagle, dotterel, ptarmigan, grouse, black grouse, and capercaillie.

Rainfall varies between 60 to 100 in. (1,524 to 2,540 mm.) in the southwest of Highland Perth, and 40 to 50 in. (1,016 to 1,270 mm.) in the northeast. May is the driest month but the summer months tend to be reasonably dry and sunny, particularly in the east of the area. Temperatures are naturally extremely variable.

Lowland Perth is by no means a flat plain. Hills fringing the Highlands and in the Ochils and Sidlaws represent dissected plateaus of 1,500–2,000 ft. (457–610 m.); between these uplands Strathmore, Strathallan, and the Forth Plain make up a complex lowland corridor running northeast-southwest, with surfaces of 100–500 ft. (31–152 m.), and also at about 750 ft. (229 m.) fringing and linking the hills, all cut mainly across Old Red Sandstones. On the low ground drumlins and other boulder clay deposits are dominant at the surface; in these, Highland rocks and Old Red Sandstone rocks are ground and intermixed to give the basis of a fertile, workable soil, given drainage. Some fluvioglacial sands and gravels give lighter soils, including the famous fruit-growing tracts of Strathmore and the Carse of Gowrie. Fringing the Firth of Tay are fertile heavy clays in the carse lands, and again in the Carse of Stirling, acid grasslands dominate the hills, while the lower land presents a landscape of large farmsteads among the big square fields varied by pleasant woodlands and estate parks.

The Queen Elizabeth Forest Park, created in 1953, extends for 42,000 ac. (16,997 ha.) in the counties of Perth and Stirling and includes Loch Ard forest (34,295 ac. [13,879 ha.] in both counties) and Rowardennan (in Stirling). It stretches from Loch Lomond to the fringe of the Trossachs and has 24,000 ac. (9,713 ha.) of forest land and 18,000 ac. (7,285 ha.) of moor and mountain. The Forestry Commission also controls (1962) 17 forests covering 108,757 ac. (44,014 ha.) in Perth, and 4 forests covering 16,662 ac. (6,743 ha.) that overlap into neighbouring counties. Rannoch Forest, the biggest (45,617 ac. [18,461 ha.]), is south of Loch Rannoch where is the Black Wood of Rannoch, remains of the ancient Caledonian Forest. There is a training school for foresters at Pitlochry. Part of the Moor of Rannoch is a national nature reserve (3,704 ac. [1,499 ha.]).

Mean annual rainfall in the Lowlands is below 30 in. (762 mm.) in parts of Strathmore, but 30 to 35 in. (762 to 889 mm.) is a typical figure for low-lying areas, with 40 to 60 in. (1,016 to 1,524 mm.) in the hills. Spring and early summer tend to be dry and sunny, but summer and autumn are usually sunny enough for holiday and harvest. Mean monthly temperatures in a typical low-lying station vary from about 3° C (37° F) in January to 14° C (57° F) in July. (A. T. A. L.)

History.—In A.D. 83 the Roman general Gnaeus Julius Agricola explored the lands beyond the Forth and in the following year penetrated to the Grampians. The growing lawlessness of the southern Picts and their frequent raids in the more settled country in the south, later compelled the attention of the Roman emperor Severus. But though he led a strong army to the shores of the Moray Firth, he was unable effectually to subdue the tribesmen. There were several Roman forts in the county such as those at Bochastle, Dalginross, Bertha, Fendoch, and Gourdie, as well as a legionary fortress at Inchtuthil; along the Earn there were many signal stations.

When the Romans finally withdrew from Britain, the Picts established their capital first at Abernethy and then at Forteviot. Abernethy was the centre of the Celtic Church after the conversion of the natives by St. Ninian. Palladius (deacon of the Roman Church), and other missionaries in the 5th and 6th centuries. On the burning of Forteviot by the Norsemen in the 8th century, the seat of Pictish government was removed to Scone. In the latter half of the 9th century, Dunkeld—to which Kenneth I, MacAlpin had brought some of the relics of St. Columba from Iona—became the scene of monastic activity.

The Danes periodically harried the land, but suffered a crushing defeat at Luncarty in 961. In 1054 Macbeth was defeated at Dunsinane by Siward, earl of Northumbria, who had invaded Scotland in the interest of his kinsman, Duncan's son, who, on the death of the usurper three years later, ascended the throne as Malcolm III. With Malcolm's accession the Celtic rule of the monarch of Scone came to an end. The royal burgh of Perth (*q.v.*) became the capital of Scotland at the beginning of the 12th century and remained the capital until 1452; from that time the history of the county is merged in that of the county town, with the exception of such isolated incidents as the removal of the coronation stone from Scone to Westminster in 1296, the defeat of Robert I, "The Bruce," at Methven in 1306, the Battle of Dupplin (*q.v.*) in 1332, the victory of Viscount Dundee (John Graham of Claverhouse) at Killiecrankie in 1689 and the indecisive contest at Sheriffmuir in 1715.

Doune Castle, belonging to Thomas Randolph, earl of Moray, was built in the 14th century and was a royal palace. It was restored in 1883. Blair Castle, home of the duke of Atholl, is in Scottish baronial style, with a 13th-century tower.

Among non-Roman archaeological remains are the hill fort on Dunsinane; the ship barrow of the Vikings at Rattray; weems (or earth houses) in the parishes of Monzie, Alyth, and Bendochy; standing stones near Pitlochry; and an extraordinary assemblage of sculptured stones in the museum at Meigle.

Population and Administration.—The population in 1961 was 127,056. Gaelic and English were spoken by 1,686 persons and one spoke Gaelic only. The city and royal burgh of Perth (41,196) is the only large burgh. There are 11 small burghs: Aberfeldy (1,469), Abernethy (601), Alyth (1,862), Auchterarder (royal burgh, 2,425), Blairgowrie and Rattray (5,181), Callander (1,655), Coupar Angus (2,048), Crieff (5,771), Doune (786), Dunblane (2,923), and Pitlochry (2,501). There are five county districts.

With Angus the county forms the sheriffdom of Perth and Angus, with a sheriff substitute presiding at Perth and Dunblane. For parliamentary purposes it is divided into the Perth and Western divisions (the latter including Kinross), each returning one member. There are secondary schools at Perth, Crieff, Blairgowrie, Aberfeldy, and Callander. Trinity College, in Glenalmond, and Strathallan are well-known boys' schools.

The Economy.—The arable land is chiefly in the drier regions of the east and southeast, the soil for the most part being fertile. The best heavy carse land is rich, and produces heavy crops of wheat, potatoes, sugar beet, beans, timothy, and silage crops. The principal cereal crops are oats, barley, and wheat. The county exports a big tonnage of seed potatoes and grows considerable quantities of turnips, swedes, and sugar beet. The growing of small fruit is a speciality, and Perth is the main raspberry growing county in Scotland.

There are many herds of pedigree livestock, particularly of the Shorthorn and Aberdeen Angus beef breeds. On the hills Blackface sheep are carried, and on many of the foothill farms herds of breeding beef cows are established.

The rivers and lochs abound with good salmon and trout; Tay salmon is especially famous. Hardly any of the streams have suffered pollution from industries.

Perth has valuable waterpower resources which have been developed by the North of Scotland Hydro-Electric Board. In the Tummel Valley is the greatest hydroelectric power development in Scotland. The Tummel and its tributaries, which drain an area of 710 sq.mi., are harnessed in ten power stations with an installed capacity of 250 megawatts and an average annual production of 650,000,000 units (kw-hr.) of electricity. Further development was planned at Loch Laidon in the Moor of Rannoch. The Breadalbane scheme in the mountainous area between Glen Lyon and Loch Earn comprises eight power stations served by a catchment of 202 sq.mi. The total capacity of the stations is 118 megawatts and their annual output is about 390,000,000 units (kw-hr.) of electricity. The control centre for the board's stations is situated near Pitlochry.

Dyeing and finishing works are in Perth and its vicinity. Flax and jute mills are at Blairgowrie and Rattray and cotton mills at Stanley, Deanston, and Perth. Woolens, linen, jute, and tartans

are woven at Dunblane, Alyth, Auchterarder, Aberfeldy, and Pitlochry. Whisky is distilled at Pitlochry, Aberfeldy, and Blackford, while Perth is a centre for blending and bottling.

Tourism is becoming increasingly important to Perth, with its favourable central position. Outdoor recreation is gaining in popularity, particularly winter sports (in the north), pony trekking and water skiing (in which the national championships are held on Loch Earn). Dinghy sailing is also popular on several lochs.

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(A. L. BL.)

PERTH, a city, royal and large burgh and county town of Perth, Scot., about 22 mi. (35 km.) W.S.W. of Dundee by road. Pop. (1961) 41,196. Area 6.1 sq.mi. (15.8 sq.km.). It is on the right bank of the Tay, between the meadows of the North Inch and those of the South Inch, both laid out as public parks. On the left bank of the river (crossed by three bridges) Kinnoull hill rises 729 ft. (222 m.). The Perth bridge, which crosses the Tay just below North Inch, has nine arches and was built by John Smeaton in 1766–71. The city has long been famous for its dye works. Other industries include whisky blending, the making of glassware (and particularly of gauge glasses), jute, carpet and linen manufacture. Perth is the centre of a prosperous agricultural area, with sales which attract buyers from all parts of the world.

Notwithstanding the importance of Perth in former times (it was the capital of Scotland until *c.* 1452), almost the sole relic of the past is the church of St. John the Baptist. The original building is believed to have been erected in the time of Columba, but the present choir was built *c.* 1440 and the nave *c.* 1490. In 1598 the church was divided into two churches and a third was inserted between them in the 18th century, but under Sir Robert Lorimer the whole was restored to its original form as a World War I memorial (1925–28). There, in 1559, John Knox preached his famous sermon in denunciation of idolatry, as a result of which the Dominican, Carthusian, Franciscan and Carmelite friaries were destroyed. The castle, palace and fortress have also disappeared. The tombstone of James I and his queen, who, though the king was murdered in the Dominican, were buried in the Carthusian monastery (destroyed in 1559), was afterward removed to St. John's church.

During the period between the beginning of the 12th century and the reign of James II many of the Scottish parliaments were held in a building (demolished in 1818) where the Freemasons' hall now stands. The supposed house of Catherine Glover, the "Fair Maid of Perth," still stands in Curfew Row. James VI's hospital, founded in 1569 on the site of the Carthusian monastery, was converted into workmen's dwellings. A 19th-century replica of the Mercat (market) cross, which in 1668 replaced one destroyed by Oliver Cromwell, stands opposite the city hall.

Public buildings include St. Ninian's Episcopal cathedral (1850–90); the city chambers; the county buildings (1808–20); the art gallery and museum (1935), which incorporates as its principal feature the Marshall memorial (1824) and contains the museum of the Black Watch, the collections of the Literary and Antiquarian society and the Perthshire natural history museum; and the Sandeman public library, founded by a bequest of Professor Sandeman of Owens college, Manchester. The general (convict) prison for Scotland was originally erected in 1812 as a depot for French prisoners.

Northwest of the city are the military barracks (1793–94). The burgh grammar school, supposed to date from the 12th century, was amalgamated with the Perth academy (1807) and Sharp's institute (1860).

History.—During the time that it was occupied by the Romans, a period estimated at 320 years, the city was called Victoria; its present name probably derives from the Celtic Abertha ("at the mouth of the Tay"). On the conversion of the original Pictish inhabitants and the dedication of the first church to St. John the Baptist, the town was designated St. Johnstoun, and it continued to be known indifferently by this name and that of Perth down to the 17th century. Perth is stated to have been a burgh in 1106 and was made a royal burgh by William the Lion in 1210.

During the Scottish Wars of Independence its fortifications were strengthened by Edward I (1298). Robert the Bruce several times ineffectually attempted to seize it, but in 1311 he succeeded in scaling the walls during a night attack. This was the fourth and most brilliant of the seven sieges which the city sustained. Taken by Edward III in 1335, it was recaptured in 1339. In 1396 the combat between the Clan Chattan and the Clan Quhele, described in Sir Walter Scott's *Fair Maid of Perth*, took place on the North Inch in the presence of Robert III and his queen, Annabella Drummond.

The Dominican friary (Blackfriars) was the scene of the murder of James I by Sir Robert Graham, instigated by Walter, earl of Atholl, in 1437. In consequence Perth lost its status as capital, in which it had succeeded to Scone, and the parliament courts were transferred to Edinburgh in 1482.

Gowrie house (on the site now occupied by the county buildings) was the scene of the mysterious "Gowrie conspiracy" against James VI in 1600. The town was taken by the marquess of Montrose in 1644, by Cromwell in 1651, and was occupied by Viscount Dundee, John Graham of Claverhouse, in 1689.

In 1715 the Old Pretender was proclaimed king at the Mercat cross, and the chevalier himself appeared in the city in the following January, only to leave it precipitately on the approach of the earl of Argyll.

PERTH AMBOY, a city in Middlesex county, N.J., U.S., at the mouth of the Raritan river, on Raritan bay and Staten Island sound, 29 mi. (47 km.) S.W. of New York city.

It is strategically located on the fringe of the two major metropolitan areas of the east, Philadelphia and New York. Connecting these areas with the city are an elaborate highway system, four rail lines and a harbour for ocean-going ships.

Local industry is well diversified and produces steel, nonferrous metals, petroleum products, building materials, chemicals, paints, lead, printing and electrical goods, clothing, food products and cigars.

Despite its industrialization the city stresses residential living and supports numerous parks and recreation and play areas. Public utilities (electricity and water) are municipally owned.

Perth Amboy was settled in the late 17th century and from 1684 to 1702 was the capital of the colony of East Jersey. The original name, Amboy, is of Indian origin. Later Perth was added in honour of an early proprietor, the earl of Perth. A city charter, one of the first in New Jersey, was granted in 1718. The last royal governor of the colony, Benjamin Franklin's son William, resided in the city in the governor's house (Westminster house, erected in 1764), which is one of a number of colonial buildings still standing.

The city was occupied by the British in 1776–77 and later evacuated when Gen. George Washington's troops seized northern New Jersey.

For comparative population figures *see* table in NEW JERSEY: *Population.* (W. L. CA.)

PERTINAX, PUBLIUS HELVIUS, Roman emperor Jan.–March 193, was born in Liguria on Aug. 1, 126, the son of a freed slave. After teaching in a school, he entered the army, commanding units in Syria and Britain, on the Danube and Rhine before earning distinction in the great German invasion of 169. Given senatorial rank to command a legion, he was promoted to the consular commands of Moesia, Dacia and Syria, but under Commodus fell from favour, together with the future emperor Septimius Severus, during the ascendancy of Perennis. Recalled about 186 to command the mutinous army of Britain, he was withdrawn at his own request, but in the last years of Commodus became prefect of the city of Rome, while Severus commanded the upper Danube armies.

When Commodus was murdered on Dec. 31, 192, the senate met before dawn and proclaimed Pertinax, then the senior marshal of the empire, before the praetorian guards awoke. He endeavoured

to enforce unpopular economies in both civilian and military expenditure, and was murdered by a small group of undisciplined soldiers on March 28, 193. When Severus became emperor later in the year he decreed divine honours for him and took the name Pertinax.

PERTZ, GEORG HEINRICH (1795–1876), German historian, the first general editor of the *Monumenta Germaniae historica* for which he laid down the determining principles. Pertz was born in Hanover, March 28, 1795, and was a pupil of A. H. L. Heeren at Göttingen. In 1823 he became secretary of the archives in Hanover, in 1827 royal archivist and in 1842 chief librarian in Berlin. In 1832 Pertz founded the *Hannoverische Zeitung* to promote Baron von Stein's ideas; he also sat in the Hanoverian second chamber. His enduring work, however, was done on the *Monumenta Germaniae*. This owed its inception to Stein but behind it lay a scholarly need, a new pride in the German past and a romantic interest in the middle ages. In 1819 the work was begun under the auspices of the newly founded Gesellschaft für ältere deutsche Geschichtskunde, supported by funds from both Prussia and Austria. Stein invited Pertz to help in 1819 and he journeyed through Europe examining manuscripts and making many finds. In 1823 Stein entrusted him with the general direction of the work, which was to be a critical edition of writings on German affairs (*Scriptores, Leges, Diplomata, Epistolae* and *Antiquitates*) from *c.* 500–1500. The first two volumes (Carolingian narrative sources), largely Pertz's work, came out in 1826 and 1829 and by 1873, when he was superseded, more than 20 volumes had appeared. Pertz also wrote a life of Stein (6 vol., 1849–55) but his gift was for research rather than for creative work and his biographies had less merit than his editions. He died in Munich, Oct. 7, 1876.

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PERU, a republic on the western side of South America. Its area is estimated officially to be 496,222 sq.mi. (1,285,215 sq.km.) which makes it the third largest South American country, following Brazil and Argentina. Along the Pacific ocean it extends in a general southeasterly direction from 3° 16′ S. to 18° 21′ S., with a seacoast of about 1,400 mi., but east of the Andes it reaches north to the equator. Peruvian territory borders on Ecuador and Colombia on the north, Brazil and Bolivia on the east and Chile on the south. Often in the past the territorial interests of these neighbouring countries conflicted with those of Peru, and lengthy negotiations resulted. Indistinctly defined boundaries were of little importance so long as all the territories involved had colonial status. The establishment of sovereign states, however, changed the situation fundamentally. Such factors as contradictory royal decrees, as well as the lack of accurate geographic knowledge of the areas concerned and the later economic development of certain previously unimportant frontier zones, combined to make the problem of modern boundary delimitation a complex one indeed. The frontier between Spanish and Portuguese interests along the upper Amazon, determined by the treaty of San Ildefonso in 1777, was revised by a treaty between Peru and Brazil in 1851 and further modified in 1909 by a treaty which involved Bolivia in addition to Peru and Brazil. While Peru has settled most of its frontier problems with Brazil amicably, violence has marked the boundary disputes with its Spanish-speaking neighbours, culminating in open warfare in the case of Chile and Ecuador.

The more-than-a-century-old frontier dispute with Ecuador was terminated in 1942 by a settlement on the whole favourable to Peru. In the west it retained the areas around Tumbes and Jaén which Ecuador had claimed, while in the east it was confirmed in its rights of possession to those parts of Ecuador's former claim containing navigable affluents of the Marañón and the Amazon. Despite the official settlement, however, the frontier zone remains a potential trouble spot, while Ecuador continues to clamour for access to the important waterways. In the north Peru's common boundary with Colombia follows the Putumayo river to the edge of the Leticia Trapezium, Colombia's southernmost extension, and around it to the south and east to the confluence of the Yavari (Javari) and the Amazon. The boundary then leads up the Yavari to its source, south along the water parting between the Ucayali and the Yurúa, and then irregularly to the southeast to the confluence of the Heath and the Madre de Dios. It ascends the Heath in a southerly direction to its source, continuing by an irregular line to the shore of Lake Titicaca, crossing the lake in a southeasterly direction to the Desaguadero, and thence southwest to Chile's northernmost point at 17° 30′ S. The boundary with Chile, after 46 years of bitter dispute, was finally settled in 1929, largely through the mediation of the United States. The line was drawn from the Pacific to the Bolivian border parallel to and 10 km. (6 mi.) N. of the Arica-La Paz railway.

This article is organized according to the following outline:

I. Physical Geography
  1. Geology and Surface Features
  2. Climate
  3. Vegetation
  4. Animal Life
II. Geographical Regions
  1. Desert Coast
  2. Highlands
  3. Montaña
III. The People
  1. Racial Types
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  3. Religion
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IV. History
  1. Discovery and Exploration
  2. Colonial Period
  3. Achievement of Independence
  4. Santa Cruz and Castilla
  5. Economic Depression
  6. War of the Pacific
  7. Peru in the 20th Century
V. Population
  1. Number and Distribution
  2. Composition
VI. Administration and Social Conditions
  1. Government
  2. Welfare Services
  3. Education
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VII. The Economy
  1. Production
  2. Trade and Finance
  3. Transport and Communications

There are separate articles on all the Peruvian departments and the more important cities and towns.

I. PHYSICAL GEOGRAPHY

Peru is sharply divided into three major natural regions: the Pacific coastal desert, the Andes mountains and the montaña, or eastern forested area. The coastal desert and the mountains are made up of folded and faulted geologic structures of great complexity. Though only south of latitude 14° S. does one find recent volcanic activity, the whole coastal and highland area is one of frequent earthquakes resulting from the continuing process of mountain building. Inland from the capital city of Lima the highlands are about 130 mi. (210 km.) wide, but in southern Peru they increase to about 300 mi. (480 km.) wide. There are many summits that stand more than 20,000 ft. (6,100 m.) above sea level, while off the Peruvian coast the ocean bottom is more than 20,000 ft. below sea level. The coast is one of the world's very dry regions; however the eastern plains, as well as the east-facing slopes of the mountains, receive abundant rain.

1. Geology and Surface Features.—Throughout most of the Peruvian highlands three surface elements make up the mountain landscape. These are a high-level surface of gentle slopes; clusters and ranges of high peaks standing above this surface; and profound canyons cut below the high surface.

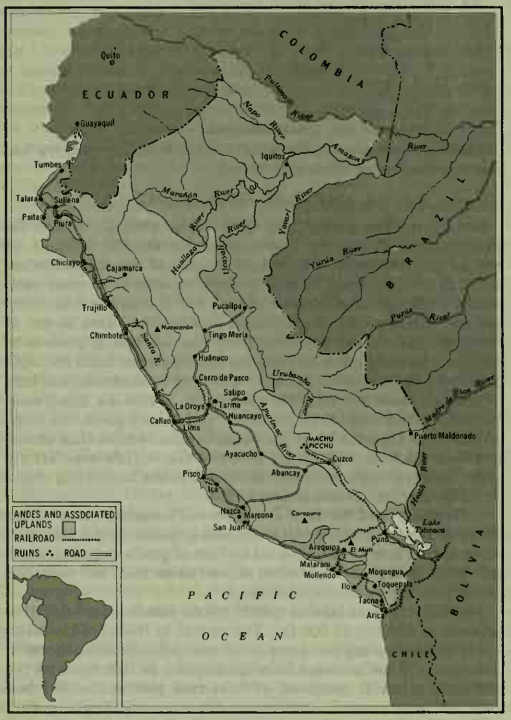
The high-level surface of gentle slopes stands at an elevation between 10,000 and 15,000 ft. The valleys in this area are broad and the streams sluggish. Long-continued denudation has stripped the cover of loose material from the hillsides so that much of the highland surface is composed of bare rock and waste-filled hollows.

The second surface element includes the clusters and ranges of

high peaks that stand upon the high-level surface as on a platform. The highest summits are between 18,000 and somewhat more than 20,000 ft. above sea level. During the Ice Age, glaciers formed at these high altitudes and produced the landforms characteristic of glaciated mountains: horns, cols, cirques, troughs, moraines and glacial lakes. Nineteenth-century writers described the highlands as made up of three or four parallel cordilleras which were joined together at a few places by mountain knots. This description is essentially incorrect. Actually the high ranges that rise from the high-level surface are short and discontinuous. They are oriented in different directions, some at right angles to the general trend of the highlands. Only the westernmost range, which forms the continental divide, is more or less unbroken, except in northern Peru. Along the southwestern side of the highlands, south of latitude 14° S., volcanic forms appear. There are numerous volcanic cones and lava flows. The best known of the volcanoes is El Misti, the cone-shaped mountain that overlooks the city of Arequipa.

The third major surface element includes the deep canyons that have been cut into the high-level surface. Often at the heads of these canyons are shallow intermontane basins, perhaps a few hundred to more than a thousand feet below the surface. These basins are of special importance because they are at a low enough altitude so that crops can be grown in them to support concentrations of farmers. Below the basins the rivers enter narrow canyons and plunge from elevations above 10,000 ft. to elevations below 6,000 ft. in relatively short distances. The great canyons, such as that of the Marañón, are so large that they cannot be viewed as a whole. Scenery, such as that presented by the Grand canyon of the Colorado river in Arizona, is encountered in few places in the Andes because all the Andean surface features are on such a vast scale. Along the canyon bottoms there are only isolated patches of level flood plain.

The highest peaks and the largest areas of high-level surface are found in southern and central Peru. Along the southern border, the high-level surface is about 15,000 ft. above sea level, and the Titicaca basin is below 13,000 ft. The surface of Lake Titicaca (*q.v.*) is 12,497 ft. (3,809 m.) above sea level. Several major streams, such as the Urubamba and the Apurímac, rise in the rugged mountain cluster known as the Nudo de Vilcanota, located just northwest of the Titicaca basin. Another extensive high area is north of Lima, where the Nudo de Pasco forms the headwaters of the Huallaga and the Marañón. A short distance to the west, the towering wall of the Cordillera Blanco overlooks the valley of the Santa river. Toward the north the elevation of the highest peaks decreases, and less and less of the high-level surface remains undissected. Along the border between Peru and Ecuador, the high-level surface entirely disappears, and there is only a complex pattern of ridges and V-shaped valleys. In this region it is possible to cross the mountains from the eastern plains to the west coast with a climb of only about 7,000 ft., but the slopes are so steep that no route of passage has ever been developed.



PHYSICAL FEATURES OF PERU

The greatest amount of dissection is found on the rainy east-facing slopes of the highlands. There the streams have cut a maze of valleys and knifelike ridges, all covered by a dense, wet forest. Along the eastern margin of the mountains the upturned rock strata form parallel cuestas with their steep slopes facing toward the Andes; these cuestas are threaded by a trellis pattern of drainage.

All of eastern Peru is a lowland plain, drained by the meandering headwater tributaries of the Amazon. The surface slopes gently away from the mountains toward Brazil. Where the eastern plains end abruptly against the base of the outermost cuesta the elevation is less than 1,000 ft. above sea level.

2. Climate.—The climatic conditions of the Peruvian coastal desert are unusual. For many years no rain falls; then in one disastrous month heavy rains create havoc in a region normally arid. In normal years, moreover, the coast is cool and damp. From June to October a thick stratus cloud hangs over the parched land, so that the sun is visible only at sunset when it drops below the cloud just before setting. Yet out of the cloud there are seldom more than a few drops of rain. Furthermore, the coastal desert is much cooler than one would expect for the latitude. The average annual temperature at Lima, for example, is 66.7° F. (19.3° C.), whereas that of Salvador in Bahia, Brazil, at the same latitude on the east coast of South America, is 76.6° F. (24.7° C.).

The reason for this cool, cloudy and arid condition is quite simple. Most of the time the prevailing southwest wind comes toward the land across the cold Peru current. The ocean water along the coast averages between 58° and 64° F. (14.4° and 17.8° C.). The air passing over this cold water is chilled. It is stable because cold, heavy air is close to the earth's surface and the warmer and lighter air is aloft. When the air rises against the front of the Andes, it does so sluggishly, forming only a thick stratus cloud (about 2,000 ft. thick). Since the water is coldest at the shore, the air passing over the water is progressively chilled until it forms a sea fog.

But at irregular and unpredictable intervals a sheet of warm water spreads southward over the Peru current. When this happens, the air passing over the water is warmed. The air aloft is then colder and heavier than the air below. This cold, heavy air sinks and the warm, light air is forced to rise. When this air strikes the mountain front, it is forced to rise suddenly and rapidly. Air rising in this way brings great quantities of rain.

In the highlands the climatic conditions are arranged in layers. Average temperatures decrease with increase of altitude. Thus Arequipa, about 8,000 ft. above sea level, has an average annual temperature of 56.8° F. (13.8° C.); Cuzco, at 11,000 ft., has an average of 51.2° F. (10.7° C.); and Vincocaya, about 14,000 ft., has an average of 35.4° F. (1.9° C.). Tropical crops such as sugar cane can be grown up to about 8,000 ft., corn (maize) to about 11,000 ft., wheat to about 12,000 ft. and potatoes to about 14,000 ft. The lower limit of permanent snow in the central Andes is about 16,500 ft., and in southern Peru about 17,000 ft. At the higher altitudes the range of temperature between the warmest and coldest months decreases but the diurnal range between day

BY COURTESY OF UNESCO "COURIER"

PERUVIAN CHILDREN ON A HEIGHT OVERLOOKING THE VALLEY OF THE URUBAMBA RIVER NEAR CUZCO

and night is very great. There sometimes are differences of 40° to 50° F. between the air temperature in the sunny places and air temperature in the shade. In the highlands the rainy season is between October and April.

The rainfall in the highlands decreases toward the south. The great arid zone of South America has its northern limit in Ecuador. From the northern border of Peru, the zone of aridity crosses the Andes diagonally and is east of the mountains south of latitude 30° S. In northern Peru the highlands are well watered and the dry area occurs only on the lower western slopes, but south of Lima the dry zone extends into the western part of the highlands. The heavy rains of the eastern side of Peru invade the highlands in the north, so that the entire border area of Peru and Ecuador except for the coastal region is very rainy. To the south the zone of heavy rains is entirely confined to the east-facing mountain slopes.

The climate of eastern Peru is equatorial. This does not mean, however, that it is correct to describe the montaña as a "steaming jungle." Temperatures are moderately high, averaging 78.3° F. (25.7° C.) for the warmest month in Iquitos, but temperatures as high as 100° F. (37.8° C.) have never been recorded. However, there is never any cool weather, and the region is monotonously warm and humid. The rainfall of eastern Peru is heavy, averaging more than 80 in. per year over much of the montaña.

3. Vegetation.—Reflecting the conditions of the climate, the vegetation of Peru is arranged in a series of north-south belts. Along the Pacific coast the climate is so dry that the land remains entirely barren, and only as one ascends the lower mountain slopes are there scattered xerophytic plants. Where streams come down from the mountains, they support a green strip of vegetation or crops. In the zone where the coastal cloud rests against the slopes of the Andes—between 2,600 ft. and 4,600 ft. E. of Lima—there is a luxuriant growth of quick-flowering plants and grasses during the season from June to October. This is known in Peru as the *loma*.

As rainfall increases on the higher slopes, the vegetation forms a complete cover over the ground. A large part of the highlands below the snow line is covered with grasses and shrubs. In the northern highlands where rainfall is ample the result is tall bunch grass and shrubs, known as paramo. Where rainfall is less abundant, there is a cover of short grass, reaching less than six inches in height at maturity. This is the *puna*. In very dry areas or where the soil is very porous, the *puna* is mixed with a resinous plant known as *tola* shrub. In the canyon bottoms where evaporation is high and rainfall low, the common vegetation is a mixture of xerophytic shrubs and scrubby woodland. But in the low, rugged country along the border of Ecuador, the valleys and ridges alike are covered by a dense rain forest. The combination of narrow valley, steep slopes and wet luxuriant vegetation makes this area a major obstacle to transportation.

The upper limit of the forest on the eastern side of the Andes is between 10,000 and 11,000 ft. above sea level. At its upper limit the forest usually consists of a dense growth of lower trees which is given the colourful name of *ceja de la montaña*, or "eyebrow of the forest." In the zone of maximum rainfall there is a mountain rain forest, where the *ceja de la montaña* is especially dense. Below this is the beginning of the lowland tropical rain forest, or selva. The highest zones of selva are about 6,500 ft. above sea level, but in some places the lowland forest ascends to only about 3,000 ft. The lower mountain slopes, the cuesta zone and the eastern plains have an almost unbroken cover consisting of a great variety of species of evergreen broadleaf trees.

4. Animal Life.—The fauna of Peru can also be classified into that of the desert coast, the highlands and the eastern plains. Also, no account of Peru would be complete without pointing to the extraordinary wealth of marine life in the coastal waters. The chemical composition of this water, together with protection from too much sunlight, provides a perfect environment for a rich growth of microscopic organisms. These organisms provide the food base for an amazing number and variety of fish. Immense schools of small fish are preyed upon from below by larger fish, and from above by an incredible number of birds. There are pelicans, cormorants, gannets and other kinds of fish-eating birds that nest on the rocky islands and promontories along the coast. The excrement from these birds is called guano; it has long been used as a fertilizer and is one of Peru's most valuable natural resources. On one small island that was carefully studied by ornithologists it was found that the bird population amounted to 5,600,000. To feed so many birds requires at least 1,000 tons of fish per day.

In the highland region, the native animals include the American camellike species—the llama, the alpaca and the wild vicuña and guanaco. Rodents include the rabbit-sized mountain viscacha and the chinchilla, which is almost extinct in Peru. The Andean condor descends to the coast for carrion. The fauna of the montaña is that of the rest of the Amazon basin (*see* AMAZON: *Fauna*).

II. GEOGRAPHICAL REGIONS

Peru is sharply marked off into three major geographical regions, each with distinctive characteristics. First is the coast, mostly desert but highly productive, where water can be supplied; second is the Andean highland, complex in its pattern of landforms, where most of the people are subsistence farmers and herders but where commercial attention is centred on the minerals; and finally there is the rainy eastern part of the country, the montaña, very thinly populated but reputed to contain vast mineral wealth yet to be tapped.

1. Desert Coast.—The desert coast of Peru extends the length of the country from the border of Ecuador to the border of Chile. The characteristics of this unusual region and their causes are treated in another section (see *Physical Geography*, above). Two facts are fundamental to an understanding of what has happened on the coast: (1) very little of the land is flat, generally only where streams emerge from the mountains and build alluvial fans; and (2) the coast is so dry that even drought-resistant plants cannot survive except within reach of the water brought by the rivers. Of the 52 streams that descend from the Andes to the

Pacific coast in Peru, only 10 carry a sufficient volume of water so that they can reach the sea throughout the year. These are the rivers that rise far back in the mountains among the snow fields. The other streams dry up entirely during the dry part of the year. In these the first trickle of water reaches the coastal region in October or November. All the streams are at flood stage from December to March, while from August to October most of the channels are dry.

The native Indians practised agriculture in this region before the arrival of the Spaniards. The highland Indians, led by the Inca, conquered earlier settlers along the coast by cutting off their water supply. The Inca engineers greatly increased the irrigable area of the coast by building irrigation canals that tapped the water high in the mountains and by terracing the valley sides. The first result of the Spanish conquest, however, was the shift of workers from the production of food to the mining of gold and silver. The Indian irrigation systems were abandoned.

Only in the late 19th and in the 20th centuries was there a return of agricultural activity to the desert coast. About 1884, British-owned corporations began to build new irrigation works and to develop plantations of commercial crops. Cotton is grown in the northernmost oases of the coast, in the department of Piura. The oases in the department of Lambayeque (centring on Chiclayo) and in the department of Libertad (centring on Trujillo) are used chiefly for the production of sugar cane and rice. Farther south, where the coastal cloud cuts out much of the sunshine, sugar cane does not grow well, and cotton again becomes the chief crop. In the department of Ica, especially around the oasis of Ica, much of the land is used to grow grapes. Olives and grapes are grown around Moquegua.

There are several ports along this harbourless coast that serve the highlands. Matarani, near Mollendo, is a major port for southern Peru, as well as for a part of northwestern Bolivia. From the port of San Juan are exported the iron ores of Marcona. Lima and its port Callao are the chief urban centres of the country. In recent years Chimbote has become an important coal-exporting and steel-manufacturing centre. In the far north Talara is a major exporting port for Peru's oil. Copper is mined at Toquepala in southern Peru. The separate communities of the coast are connected with Lima by ship and, to an increasing extent, by motor truck along the new Pan-American highway, which extends the whole length of the region.

2. Highlands.—The complex physical character of the Andes mountains is paralleled by the complex pattern of human settlement in these mountains. Most of the inhabitants are Indian farmers and herders, and most of the crops are raised for subsistence rather than for commerce. The types of crops that can be raised in any community depend to a large extent on the altitude. Where temperatures are warm, at lower altitudes, the tropical crops include sugar cane, cotton, cacao, coca, rice and corn. At elevations above 8,000 ft. the crops are corn, wheat, barley, quinoa and potatoes. The latter crop is raised at higher altitudes than any of the others, reaching about 14,000 ft. in favourable places. A large part of the Andean highlands consists of a high-level surface, mostly unsuited for agriculture because of altitude or exposure to the winds. Only in the upper parts of the valleys and in small intermontane basins can agriculture be regularly practised. These areas are densely populated. In the southern part of the highlands, where not only is the high-level surface at an altitude above 14,000 ft. but also where the climate is semi-arid, the chief use of land is for the pasture of sheep and alpacas. The city of Arequipa has become the chief depot for the concentration of wool from the highlands.

Mining is another important activity of the highlands, and although a relatively small proportion of the population is employed in this work, the mines provide the chief commercial products and make the major contribution of the highland region to the total national production of Peru. The silver ores in the vicinity of Cerro de Pasco were discovered by the Spaniards in 1630, and silver was long the chief export. Silver declined in the 19th century when competition with Mexico put many Peruvian mines out of business. But in the 20th century mining has again

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ANDES MOUNTAINS NEAR HUANCAYO

flourished, though for other minerals than silver. Most important of these is copper, but there are also mines producing vanadium, bismuth, lead, zinc and gold. To the northwest of Cerro de Pasco there are several places where coal of good quality is mined.

The eastern slopes of the Andes have long suffered from difficulty of access to markets. In several valley basins at elevations below 8,000 ft. delightful climatic conditions are found, and it has been shown that crops could be produced in abundance. But because of the high cost of transportation only products of high value per unit of weight can profitably be sent across the mountains to the coast. In 1943 the first motor highway was completed. It extends inland from Lima to La Oroya and Cerro de Pasco, and then descends from nearly 14,000 ft. above sea level to only slightly more than 6,000 ft. at Huánuco. The road continues by way of the thriving frontier town of Tingo María (about 2,000 ft.), and then east from the mountains to Pucallpa on the Ucayali river, for a total distance from Lima of 842 mi. Other roads run from Lima to Tarma and to Satipo.

3. Montaña.—The wet, densely forested, lower eastern slopes of the Andes as well as the plains east of the mountains are included in the montaña. This region is still very thinly populated, since it was even more isolated than the valley basins of the eastern Andean slopes. The chief penetration of the montaña is along the highway to Pucallpa, described above. New settlers have occupied land along the road for the 288 mi. E. from Tingo María to the Ucayali. From Pucallpa, river boats run on regular schedules to Iquitos, the chief commercial centre of the montaña. In 1954 the Peruvian government granted land to a U.S. manufacturer of heavy earth-moving machinery. On this 1,000,000-ac. grant, the company hoped to establish pioneer farmers. The land has been partly cleared by a 110-ton "tree roller" which pushes over and chews up all but the largest trees. The residue is spread on the land as a fertilizer. The machine was technically a success, but in eastern Peru where labour is cheap the machine is more costly than men with machetes, axes and hoes. In the vicinity of this colony, on the Pachitea river, a short distance south of Pucallpa, oil has been discovered at Ganza Azul.

Another road to the montaña was started in 1959 from a place on the upper Urubamba river to reach an area suitable for agricultural settlement on the Madre de Dios river. The area was selected on the basis of geographical field studies, rather than by chance.

Eastern Peru is one of the last remaining places where speculators can search for Eldorado. The myth of great wealth awaiting the discoverer has persisted since early colonial times. It is true that eastern Peru could contain vast quantities of oil and that with enough capital investment its resources might bring wealth, but development of any sort would be costly. (P. E. J.)

III. THE PEOPLE

More than one-third of Peru's approximately 11,000,000 people live in cities, towns, villages and haciendas along the coast, while fewer than 350,000 live in scattered, small communities in the extensive jungles of the montaña, east of the Andes. The rest of the population, principally several million Quechuan-speaking and about 500,000 Aymara-speaking peoples, inhabits the valleys, basins and high plateaus of the Andes mountains. More than 50% of the population is rural.

1. Racial Types.—Continual and widespread miscegenation since early colonial times has resulted in the blurring of racial distinctions, and there is difficulty in making a classification on a purely biological basis. Three major categories—Indian, white and mestizo—are recognized, but their definition depends on considerations of cultural as well as biological criteria.

Less than 15% of the population is considered "white"; *i.e.*, of predominantly European (mainly Spanish) descent and with cultural characteristics associated with Hispanic or western society. The more than 45% of the population classed as "Indian" is predominantly of indigenous biological heritage, lives in the Andean highlands or the montaña, and has lifeways which are considered non-Hispanic. Between these two extremes are the mestizos who comprise almost 40% of the population and who exhibit a variety of cultural patterns which have evolved during centuries of contact between the native and europeanized societies.

Concentrated on the central coast are also thousands of people of predominantly Negro and Asiatic stock who constitute approximately 1% of the population. They are descendants of slaves imported in colonial times, and of Chinese and Japanese agricultural labourers contracted, respectively, during the second half of the 19th and the first decades of the 20th centuries.

2. Languages.—Spanish is the official language of Peru, but in the highlands and the montaña indigenous languages are spoken by millions of people. Spanish is the language of commerce and Peruvian *criollo* culture (*see* CREOLE); Quechuan and Aymara are the mother tongues of the highlands; Arawakan, Panoan and other languages are spoken by natives of the montaña.

Most individuals classed as "Indian" are able to speak some Spanish, and many are truly bilingual. Ability to speak Spanish fluently generally indicates membership in the mestizo category, however, since it is unusual that the national language is adopted without other cultural adaptations also taking place. The expanding educational and economic systems continue to carry the Spanish language and other features of national culture to the remoter parts of the country.

3. Religion.—Roman Catholicism is state sponsored but is not uniformly practised throughout the country. The Indians of the montaña have adopted few features of Catholicism, and in most highland villages the numerous *fiestas* and saints' cults are a tangle of pagan and Catholic beliefs and performances. The greatest adherence to Catholic doctrine and ritual is found along the coast and in the larger cities of the interior.

In the southern highlands and parts of the montaña, Protestant missionaries have made substantial inroads. Nevertheless, the cycle of Catholic *fiestas* continues to characterize the religious and recreational outlet for the vast majority of the population, and throughout Peru each hacienda, village and urban centre celebrates the feast day of its patron saint.

4. Cultural Variations.—The pre-Hispanic cultures of Peru have undergone considerable change in the four centuries of contact with western society. Indians have acquired new social and economic statuses and have become integrated into the larger society as peasant farmers, day labourers and sharecroppers on haciendas, and as craftsmen and servants. While rural cultures have changed, cities and towns have also become modified; new classes of skilled and unskilled workers, office employees, tradesmen and minor government officials have arisen. Many coastal cities are thriving commercial centres geared to an export-import economy of considerable proportions; and in the highlands numerous towns serve as focuses of market activity in the distribution of regional and imported products, and continually attract people from the surrounding rural areas.

The Montaña.—Indians of the montaña, although of diverse linguistic and cultural backgrounds, generally live in small communities, farm by means of a very simple technology, hunt and fish with bow and arrow, and manufacture much of their clothing and many of their tools, weapons and household utensils in traditional ways. For the most part, they form self-contained political and socioeconomic units which are much less involved in national patterns of culture than other segments of the population. Some of these people, however, work for wages on rubber, coffee, banana and coca plantations, where they are introduced to features of western culture. Many are also being actively missionized, although native religious and folk beliefs prevail.

The Highlands.—Mestizos and Indians form the bulk of the highland peoples, most of the former living in cities and towns and the latter in numerous agricultural villages or on large food-producing or cattle-raising haciendas. Both in the villages and on the haciendas, productive techniques tend to be simple adaptations of 16th- and 17th-century Spanish patterns to native practices. Field preparation and harvesting are laborious work, usually accomplished by co-operative labour groups. Corn (maize), potatoes, *oca*, barley and wheat are among the principal crops.

Labour is abundant, wages are very low, transportation is poor and the market for produce is largely local. Most haciendas have semifeudal social and productive arrangements, cultivate their holdings on a sharecropping system, and draw on the peasant villages for additional field labour. The best lands, comprising vast estates, are in the hands of a relatively few landlords; the steep, terraced hillsides are left to the subsistence crops of the peasant villages.

Through registration with the Peruvian government many peasant villages have gained some protection for their lands against the encroaching haciendas, and also a measure of autonomy over their internal affairs. Most villages are composed of a number of large extended families which traditionally controlled the use and distribution of community land; however, notions of private ownership are weakening the old communal system. Integrative forces such as extended kinship bonds, co-operative labour, the series of religious *fiestas* and other traditional mechanisms of village solidarity are also diminishing.

The Coast.—In the coastal valleys industrial mechanized agriculture reaches its peak in production, employment of wage labour and capitalization, but in the central coastal zone the more traditional system of sharecropping is still in force. Thousands of highland villagers are contracted for seasonal labour on the coast, where they form an important complement to the nucleus of permanent agricultural workers. They generally adjust to the dominant patterns of *criollo* culture and acquire an increasing awareness of their political and economic rights through contacts

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INDIANS BAGGING WHEAT IN A FIELD IN THE MANTARO RIVER VALLEY

with the heavily unionized and labour-conscious coastal population.

As in the highlands, the best lands are controlled by wealthy landlords, and the small, traditionally oriented and collectively organized indigenous community has virtually disappeared. In most valleys there are groups of small, independent farmers who grow mixed crops for market and whose operations and outlook are geared to the economic structure of the coast. A number of government-sponsored irrigation projects have made available thousands of additional hectares of farmland for small and medium-sized proprietors, a policy designed to increase food production and achieve a more equal distribution of land.

(L. C. Fa.)

IV. HISTORY

Man has lived in Peru since at least 8000 B.C. Beginning about 1250 B.C. several advanced cultures, such as the Chavín, Chimu, Nazca and Tiahuanaco, developed in different parts of Peru; however, the area was not unified politically until, in A.D. 1438, the Incas set out from their base in Cuzco on a career of conquest which, during the next 50 years, brought under their control the area of present-day Peru, Bolivia, northern Argentina, Chile and Ecuador. Within this area the Incas established a totalitarian state which enabled the tribal ruler and a small minority of nobles to dominate an inert population. (*See* Andean Civilization.)

1. Discovery and Exploration.—Spanish interest in the west coast of South America grew after Vasco Núñez de Balboa discovered the Pacific in 1513, but it was not until 1524 that Francisco Pizarro (*q.v.*), aided by another soldier, Diego de Almagro (*q.v.*), and a priest, Hernando de Luque, undertook explorations that led to the conquest of Peru. By 1527 they were convinced of the wealth of the Inca empire. Failing to win further co-operation from Panama's governor, Pizarro returned to Spain where he received authorization from Charles I to conquer and govern the area extending 600 mi. S. from Panama. When Pizarro, accompanied by his brothers, returned to Panama, Almagro was outraged by the vast powers Pizarro had acquired for himself. Nevertheless, he continued to collaborate. Pizarro embarked for Peru in early 1531 with 180 men. Establishing a base at San Miguel on the north coast of Peru, Pizarro crossed the mountains to make contact with the Inca Atahualpa, who had recently been victorious in civil war against his brother and was then residing near Cajamarca with an army of about 30,000. Atahualpa, scornful of the tiny band of invaders, accepted Pizarro's invitation to meet in Cajamarca. There, after Atahualpa had refused to accept Spanish suzerainty, he was taken prisoner. After his agents had collected a large ransom for his promised release, Atahualpa was executed for his presumed responsibility for the murder of his half brother Huáscar. (*See* Atahualpa.) As a means of controlling the Indians, Pizarro then recognized Manco Capac, Huáscar's brother, as Inca. In Nov. 1533 the Spaniards occupied Cuzco, the Inca capital, without a struggle.

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A STREET IN CUZCO ON THE ROUTE OF ONE OF THE OLD INCA ROADS

2. Colonial Period.—The consolidation of Spanish control proceeded. The city of Quito (now in Ecuador) was subdued and Diego de Almagro left to conquer his domain of Chile. Pizarro organized a Spanish type municipal government for Cuzco and in 1535 established a new city, Lima, on the coast, to facilitate communications with Panama. Lands were allotted to the conquerors, who were provided with a labour force by grants of encomiendas, which enabled them to collect tribute from the Indians.

Serious trouble then erupted. An unsuccessful Indian rebellion led by Manco Capac in 1536 was followed by open conflict among the conquerors over the division of the spoils. Almagro, disillusioned by Chile's poverty, sought to seize Cuzco from the Pizarros. Almagro was defeated and executed in 1538, but his adherents continued to conspire with his son, and succeeded in assassinating Francisco Pizarro in 1541. However, an agent of the Spanish crown, sent to establish order, refused to recognize the younger Almagro, who was captured and executed in 1542.

But difficulties nonetheless persisted. The king of Spain, impelled by humanitarianism and by fear that the encomienda system might promote feudalism, promulgated in 1542 the New Laws. These laws threatened the existence of the encomiendas, which were so important to the conquerors. When Viceroy Blasco Núñez Vela arrived in Peru in 1544 to enforce the New Laws, the conquerors, led by Gonzalo Pizarro, revolted and executed the viceroy. Pizarro maintained power for two years until Pedro de la Gasca, a Spanish agent, undermined his power. Pizarro was executed in 1548.

It was nearly a decade before unruly conquerors were controlled under Viceroy Andrés Hurtado de Mendoza (1555–61), and not until the viceregal administration of Francisco de Toledo (1569–81) was systematic control of the huge Indian population attempted. Toledo adapted Indian institutions to the purposes of Spanish authority. Indian chieftains administered local Indian affairs according to custom but were responsible for collecting tribute and providing forced labour. Spanish agents (corregidors) were appointed to protect the interests of both crown and Indian in the Indian communities. Fearing that Manco Capac's son, Tupac Amaru, might prove dangerous to Spanish authority, Toledo ordered him executed in 1571.

By the end of Toledo's administration, the viceroyalty of Peru had assumed the form that it retained into the 18th century. Its territory included all of South America except Venezuela and Portuguese Brazil. Although ranching, agriculture and commerce were carried on, the mining of precious metals, particularly silver, was the basic industry, making the colony the most important in the Spanish empire. The discovery of the fabulous Potosí mines in 1545 had been followed in 1563 by the opening of the Huancavelica mines which produced the mercury essential to efficient processing of silver. Because the viceroyalty's mineral resources, except for the gold of New Granada (Colombia), were in Peru proper and Upper Peru (Bolivia), these areas became the most highly developed and richest. (*See* Potosí.)

The centre of wealth and power for the entire region was the viceregal capital of Lima. There, during the 16th and 17th centuries, a series of viceroys ruled over most of Spanish South America. The elaborate viceregal court was the apex of a highly stratified society based upon forced Indian labour. It attracted not only the politically oriented but also the wealthy, the artistic and the intellectual.

Lima was also important as seat of the *audiencia*, which administered royal justice, and as a religious, cultural and commercial centre. The archbishop of Lima was head of the church in Peru. Many religious orders established monasteries and convents there, and the tribunal of the Inquisition worked to extirpate religious heresy. In Lima also was the capstone of the educational system—the University of San Marcos—modeled on the University of Salamanca in Spain and offering courses in Indian languages as well as the more traditional subjects.

Adding to the wealth and importance of Lima was the privileged position which its merchants enjoyed under the monopolistic Spanish trade system. Lima, with its port of Callao, was the entrepôt for trade between Europe and the commercial centres of South America, ranging from Quito to Chile on the Pacific coast and to Buenos Aires (now in Argentina) on the Atlantic. Under the Spanish system the bulk of legitimate trade to and from these areas had to pass through merchants in Lima.

During the later 17th century Peru experienced difficulties. Some of these, such as increasing contraband trade with non-Spanish merchants, attacks by pirates and the growth of venality

among government officials, reflected the internal decay of Spain and the decline of its international power. But contributing importantly to Peruvian difficulties was the progressive decline of its production of precious metals.

Adding to Peru's problems in the 18th century was a series of governmental reforms. The Bourbon dynasty, which in 1700 had replaced the Habsburgs as rulers of Spain, undertook a program of reform during the 18th century, seeking to promote the economic development of their colonies, improve colonial defenses and provide more efficient government. The first seriously to affect Peru was the establishment of the new viceroyalty of New Granada, ending Peru's control over northern South America and resulting in its loss to New Granada of the thriving port of Guayaquil (now in Ecuador). For the next few decades Bourbon reforms improved conditions in Peru, but in 1777–78 the Spanish government established another viceroyalty, that of Río de la Plata, this time depriving the Peruvian viceroy of authority over Upper Peru and the areas of present-day Argentina, Paraguay and Uruguay. Chile was reconstituted as a virtually autonomous captaincy general. Following the disastrous loss of the silver mines of Upper Peru, the viceroyalty of Peru was still more weakened by reforms in the trade system which destroyed Lima's monopoly by permitting merchants in ports on the Atlantic and Pacific to trade directly with Spain.

To these blows was added internal strife. The Indians, who had from the time of the conquest suffered oppressive taxation and enforced labour, revolted in 1780 under Tupac Amaru II, a descendant of the last Inca and a man of wealth and education. The revolt spread throughout Peru and into Upper Peru and Ecuador. Although Tupac was captured and executed in 1781, the Indians continued to wage war against the Spaniards until 1783, causing disruption of economic life.

Nevertheless, in the late 18th and early 19th centuries Peru experienced a period of intellectual development that was the result of the influence of the utilitarian ideas of the European Enlightenment, brought to Peru in books and by European participants in scientific expeditions in 1778 and 1793. The chief manifestation of the intellectual development of Peru was the establishment of a literary and scientific club in Lima, the *Sociedad de Amantes del País*, which published a periodical, *El Mercurio Peruano de Historia, Literatura y Noticias Públicas*.

3. Achievement of Independence.—The Napoleonic invasion of Spain in 1808 sparked the Creoles (those of European descent born in America) in other Spanish colonies to struggle for independence between 1810 and 1821. But Peru remained loyal because of the conservative attitude of the Peruvian aristocracy, the presence of many Spaniards in Peru, the concentration of Spanish military power in Lima and the effectiveness of the viceroys in suppressing uprisings. Peru's independence was, consequently, achieved primarily by outsiders.

Among them was Gen. José de San Martín (*q.v.*) of Argentina, whose aims were to secure Argentine control of Upper Peru's silver from the Spanish forces which had occupied Upper Peru and to assure Argentina's independence by destroying the remaining Spanish power in South America. Because Argentine forces had previously been defeated in Upper Peru, San Martín determined to surround the Spaniards by liberating Chile and using it as a base for a sea-borne attack on Peru. Chile was freed in 1818, and a fleet was readied which enabled San Martín to occupy the Peruvian port of Pisco in Sept. 1820. When the viceroy withdrew his forces into the interior, San Martín entered Lima. Peruvian independence was declared on July 28, 1821.

Lacking power to attack the strong Spanish forces in the interior, San Martín sought aid from Simón Bolívar, who had recently liberated northern South America, but failing in this attempt returned to Argentina. Peruvians then called upon Bolívar, who assumed supreme power in Peru. At the battles of Junín (Aug. 6, 1824) and Ayacucho (Dec. 9, 1824) Spanish power was broken and Peru's independence assured. Bolívar continued to rule Peru until his return to Colombia in 1826.

Between that time and the mid-1840s Peruvians sought to govern themselves. They were handicapped by economic dislocations caused by the wars for independence, by the departure of able loyalists after Spain's defeat and by a population which was little suited to self-government. The revolution had wrought little social change so that the vast majority of the population, the mestizos and Indians, were economically depressed and illiterate, did not speak Spanish and continued to live much as had their ancestors under Inca rule. The professional and landholding minority possessed elements of education and economic independence but lacked experience in, and the traditions of, self-government. In such a vacuum political power fell to military leaders who had achieved prominence during the revolutions for independence. Their bitter rivalries, particularly those among Agustín Gamarra, Felipe Santiago Salaverry and Luis José Orbegoso, resulted in civil wars which brought Peru close to political anarchy in the early 1830s.

4. Santa Cruz and Castilla.—The ambitions of Gen. Andrés Santa Cruz, who had briefly governed Peru after Bolívar's departure and had then become dictator of Bolivia, complicated Peru's position. Santa Cruz desired to unite Peru and Bolivia into a single powerful nation. In 1835, taking advantage of Peru's disorder, Santa Cruz intervened with force. Within a year he had established the Peruvian-Bolivian confederation, with himself as president. Chile, fearing that this superstate might dominate it or at least curtail its growing commerce, declared war on the confederation in 1836. Although Argentina also declared war on the confederation, it did little active fighting, and it was Chilean forces, supported by Peruvian *émigrés*, that defeated Santa Cruz and restored independence to Peru and Bolivia in 1839.

After the collapse of the confederation, Peru lapsed into internal disorder, but in 1844 mestizo Gen. Ramón Castilla defeated rival military leaders and established undisputed control over the country. Between then and 1862 Castilla dominated Peruvian politics, giving the country unprecedented political stability and material progress. Castilla was aided by the discovery that the guano deposits, found in large quantities in Peruvian territory, had high commercial value as fertilizer. He established a government monopoly which during the next few decades brought large and progressively increasing revenues to Peru. With this wealth Castilla reorganized Peru's finances and began payment on the foreign debt. Internal communications were improved and Peru's first railroad, connecting Lima and Callao, was constructed. Attention was paid to the development of public education, and the military and naval power of the nation was strengthened. Slavery and the payment of tribute by Indians were abolished.

5. Economic Depression.—When Castilla left office in 1862, political disturbances mounted. Corrupt politicians squandered guano revenues instead of using them constructively. Peru experienced increasing financial crises. To make matters worse, a Spanish fleet, in retaliation for Peru's supposed maltreatment of Spanish citizens, seized the valuable guano-producing Chincha Islands. In the ensuing naval war, Chile, Ecuador and Bolivia joined Peru in fighting Spain. Hostilities ended when the Spanish fleet withdrew from the Pacific after the bombardment of Callao in May 1866, but a truce was not signed until 1871 and a formal peace treaty between Peru and Spain was not concluded until 1879.

In the meantime Peru's financial position deteriorated. Pres. José Balta (1868–72) found it necessary to mortgage anticipated guano receipts to meet current expenses. He then proceeded to increase Peru's indebtedness to the staggering sum of $240,000,000 (United States currency) to finance a network of costly railroads. His successor, Manuel Pardo (1872–76), Peru's first civilian president, took over a nearly bankrupt nation, and conditions became worse when the price of guano declined. Pardo sought to solve the problem by cutting military expenditures, reducing the number of government employees and establishing a government monopoly over the thriving nitrate industry in the province of Tarapacá. But Peru's financial problems had not been solved when it entered the War of the Pacific in 1879.

6. War of the Pacific.—Although this war originated in a dispute between Bolivia and Chile, Peru became involved because it had signed a treaty of alliance with Bolivia in 1873. Because Peru was the more powerful of the allies as well as Chile's traditional

rival, Peru carried the main burden of the war. Almost from the beginning, Peru suffered one major defeat after another at the hands of Chile. After Lima was captured in Jan. 1881, Chilean forces occupied the city for nearly three years while an attempt was made to impose Chilean peace terms. Finally, on Oct. 20, 1883, the treaty of Ancón was signed; under its terms Peru ceded its nitrate province of Tarapacá to Chile and agreed that the Peruvian provinces of Tacna and Arica would be occupied by Chile for ten years, at which time a plebiscite was to be held to determine their nationality. (*See* TACNA-ARICA DISPUTE.)

With its economy suffering from war's destruction and dislocation, its public debt increased and its revenues reduced by the loss of Tarapacá, Peru struggled to recover. A major step was taken in 1890 when Peru's foreign creditors organized the Peruvian corporation, which assumed responsibility for the nation's foreign debt. In return, the corporation received control of the national railroads for 66 years, together with other benefits.

7. Peru in the 20th Century.—During the next 40 years Peru's economy expanded significantly. Internal communications were improved, foreign investors exploited Peru's mineral resources, and copper and oil production rose. The opening of the Panama canal stimulated expansion of the economy, as did the large influx of United States capital in the 1920s. Peru's exports increased from $22,000,000 in 1900 to $134,000,000 in 1929, indicating the extent of economic growth.

During this period Peru was governed by an oligarchy of landowners, military figures and the newly rich. Outstanding among them was Pres. Augusto B. Leguía y Salcedo (*q.v.*; 1908–12; 1919–31), who promoted material development with the aid of U.S. capital. Although Leguía officially advocated reform, in reality he ruled as a dictator in the interests of an oligarchy that cared little for improving the condition of either the Indians or the urban workers and middle classes, which were growing in numbers as the economy expanded. The reform movement of the 1920s developed from these circumstances.

This important movement, nurtured by the ideas of the Peruvian Manuel González Prada (1844–1918) and the influence of the Russian and Mexican revolutions, was led first by Víctor Raúl Haya de la Torre (*q.v.*) and José Carlos Mariátegui. The two parted company in the mid-1920s when Mariátegui assumed leadership of the Communist party while Haya de la Torre continued to head the indigenous reform movement known as Apra (*Alianza Popular Revolucionaria Americana*). Apra's program demanded increased industrialization; regeneration of the Indian through land reform, labour organization and welfare legislation; and an "anti-imperialist" policy of nationalization of Peru's resources. Made illegal by Leguía, Apra operated clandestinely. When Leguía was overthrown in 1931, in the middle of a serious depression, Haya de la Torre became a candidate for the presidency. Haya's supporters claimed electoral victory, but his opponent, Col. Luis Sánchez Cerro, seized power and again outlawed Apra. When Sánchez Cerro was assassinated in 1933, he was replaced by Gen. Oscar R. Benavides, who was given dictatorial powers by congress when it appeared that Apra would win the election of 1936.

Benavides' successor, Manuel Prado y Ugarteche (1939–45), guided Peru through an international crisis provoked by a Peruvian invasion of Amazon territory in a dispute with Ecuador (1941) and through the difficult period of World War II when Peru sided with the Allies. In internal affairs Prado, an enlightened member of the oligarchy, extended public education, encouraged the unionization of labour and attempted to ameliorate the suffering of Peru's depressed majority. To implement his program he sought to increase Peru's productivity by encouraging rapid economic development, including hydroelectric and irrigation projects, exploitation of untapped resources and industrialization.

Prado's principles were followed during succeeding administrations, and as a result Peru's economy underwent rapid expansion in the postwar years. With this expansion came growing political and social unrest. The demands of the working and middle classes for a greater share of the national wealth in the form of higher wages and social and educational benefits became more insistent and grew in intensity under the impact of national and international inflationary pressures. These demands for socioeconomic reform were resisted by the ruling oligarchy: the more reactionary wing opposed any change that would lessen its privileges; the more liberal recognized that change was necessary if Peru were to become a modern nation but wished to proceed much more slowly than did the reformers. From these sources arose political conflicts that characterized Peruvian history from the Prado administration into the 1960s.

In 1945 Prado had permitted Haya de la Torre to again become active in Peruvian politics. The Apra party played an active role in the campaign preceding the free presidential election of 1945, but rather than nominating Haya the party joined in a coalition, the National Democratic Front, whose candidate was José Luis Bustamante y Rivero, a conservative but not a reactionary. Not only was Bustamante elected but a number of Apristas won seats in congress. Because of Apra's evident power, Bustamante gave three cabinet posts to Apristas. However, after two years of moderate progress in the areas of education, housing and economic development, conflict developed between the Apristas and the more conservative members of the government. The Aprista members of the cabinet were forced to resign in 1947 following an accusation of Aprista complicity in the assassination of the editor of the anti-Aprista newspaper, *La Prensa*. The following year Apristas in the navy attempted an unsuccessful revolt, and Bustamante retaliated by outlawing the party. More reactionary elements wished further retaliation and in 1948 seized the government by force, placing Gen. Manuel Odría in the presidency. Aprista leaders were either imprisoned or sent into exile in the attempt to destroy the Apra movement. Haya de la Torre eluded the police for a short time but was finally forced to seek asylum in the Colombian embassy in early 1949. His presence there resulted in a bitter dispute between Colombia and Peru, with the latter claiming that Haya was a common criminal who should not be granted asylum. The matter reached the International Court of Justice where a decision by arbitration failed to solve the problem; however, in 1954 Haya was permitted to leave Peru.

The major source of opposition having thus been eliminated, Odría was elected president of Peru in 1950. Dictatorial techniques were used to keep opposition under control and to maintain internal order; nevertheless, the Odría administration did not ignore the working classes. Wage increases, an extended social security program, a few low-cost housing projects and some improvements in the education system were accomplished. Odría's overwhelming concern was, however, to augment economic development. In this area his administration, assisted by technical aid from the United States, North American capital and higher prices for Peru's exports resulting from the Korean War, made significant progress. Efforts to develop agriculture brought a 25% increase in food production between 1950 and 1955. Work was begun on the construction of a steel mill at Chimbote. Highways and railroads were improved and extended to meet the needs of the expanding economy. Concessions were made to encourage foreign capital to exploit further Peru's mineral resources, with the result that oil production soared and a new copper deposit was located in southern Peru. To assure financial stability during this economic expansion the Odría administration hired a firm of United States consultants to make recommendations which were put into operation.

In 1956 Odría, lacking the full support of the oligarchy, permitted a presidential election. That the election was relatively free of government intervention was shown in the extremely poor showing of Hernando de Lavalle, who had Odría's support but ran last. Runner-up was a young architect, Fernando Belaúnde Terry, candidate of a hastily organized People's Action party, who entered the race at a late date and campaigned on a vaguely defined reform platform. Winner was former president Manuel Prado y Ugarteche, candidate of the Peruvian Democratic Movement and supported by Apra, which in spite of extreme repression had continued to organize and operate clandestinely. Following his election Prado legalized Apra, thus recognizing not only his personal political indebtedness to the party but also the im-

portance of Apra as a force in Peruvian politics.

Prado's administration sought to establish a democratic regime which would both promote economic development and bring gradual improvement in the conditions of the underprivileged. Educational facilities were extended, more lands were placed under irrigation and the Chimbote steel mill was completed. Nevertheless, the administration met serious difficulties as the 1950s drew to an end. The decline in price of Peru's major exports brought a sharp reduction in badly needed government revenue and dollar reserve. At the same time the cost of living rose steadily, arousing social discontent and precipitating a series of strikes. On several occasions, under pressure from either the left or the right, it was necessary to reorganize the cabinet. However, at the end of 1959 a degree of stability was achieved partly as a result of loans from the United States and international agencies and partly because of the success of an austerity program effected by Pedro Beltrán, who became premier in July 1959.

Elections for president and congress took place in June 1962. Of the three major candidates for president, Haya de la Torre, Belaúnde Terry and Odría, none received one-third of the popular vote, the total necessary for election. Under the Peruvian constitution, the election then went to congress for decision. The majority party in congress was Apra, the party of Haya de la Torre. However, before congress could act, the armed forces, fearing the possibility that their traditional foe Haya would be elected, seized the government by force on July 18. Pres. Prado was imprisoned, congressional sessions were suspended and the elections were annulled. Charging that the election had been dishonest, a four-man military junta headed by Gen. Ricardo Pérez Godoy took control of the government. Prado was freed and exiled, and the junta promised new elections in June 1963.

Pérez Godoy led the junta until March 1963 when he was ousted and replaced by Gen. Nicolás Lindley López. In June 1963 the general election took place, as promised by the junta. The presidential candidates again were Haya de la Torre, Belaúnde Terry and Odría. With the combined support of the Popular Action and Christian Democratic parties, Belaúnde Terry won the election, receiving about 40% of the vote. The two parties supporting him gained a plurality of congressional seats. Belaúnde Terry promised co-operation with the U.S. and the Alliance for Progress. (R. N. Bu.; X.)

V. POPULATION

1. Number and Distribution.—A census taken in 1961 enumerated a total of 10,364,620 inhabitants in Peru, about 20.9 persons per square mile. These figures do not include an unenumerated group of about 700,000 and the forest Indian population, which was estimated to be about 300,000. Since that time, due to a birth rate of about 45 per 1,000 and a death rate of less than 20 per 1,000, the total probably has increased by about 300,000 persons per year.

Peru's population is heavily concentrated in the high valleys between the ranges of the Andes and at a few locations on the Pacific coastal plain where streams from the mountains make their way to the ocean. In this coastal area the settlements centring in Lima and Callao, Trujillo, Piura, Sullana, Chiclayo, Pisco, Ica, Moquegua and Tacna deserve special mention. The extensive sections of the country which lie east of the Andes are very sparsely populated (*see* Table), although the cities of Iquitos, Lamas, Moyobamba, Pucallpa, Tarapoto, Tingo María and Yurimaguas are centres of zones having several thousand inhabitants.

The majority of Peru's people live amid rural surroundings, as is evidenced by the fact that in 1961 about 53% of the population resided in places having fewer than 2,500 inhabitants. The capital, Lima, is by far the largest city with a 1961 population of 1,715,971. Callao (161,286), Arequipa (156,657), Trujillo (99,808), Chiclayo (86,904) and Cuzco (78,289) are next in size among Peruvian cities.

2. Composition.—American Indians, whites and mixtures of the two (mestizos) constitute the overwhelming proportion of the Peruvian population (see *The People*, above).

*Area, Number of Inhabitants and Density of Population, 1961 Census**

Zones and Departments (with capitals in parentheses)	Area (in sq.mi.)	Urban Population	Total	Persons per sq.mi.
North	57,665	1,061,909	3,042,010	52.7
Ancash (Huarás)	14,019	204,595	588,511	42.0
Cajamarca (Cajamarca)	13,675	107,207	749,058	54.8
Lambayeque (Chiclayo)	6,404	186,601	347,192	54.2
Libertad (Trujillo)	8,973	245,245	587,891	65.5
Piura (Piura)	12,767	283,928	716,954	56.2
Tumbes (Tumbes)	1,827	34,333	52,404	28.7
Central	82,285	2,811,291	4,518,649	54.9
Ayacucho (Huamanga)	17,569	127,348	448,227	25.5
Callao (Callao)	29	209,187	214,186	7,385.7
Huancavelica (Huancavelica)	8,830	60,613	298,892	33.8
Huánuco (Huánuco)	13,635	81,029	361,688	26.5
Ica (Ica)	8,205	125,164	243,887	29.7
Junín (Huancayo)	12,492	241,941	506,075	40.5
Lima (Lima)	13,087	1,929,745	2,319,231	177.2
Pasco (Cerro de Pasco)	8,438	36,264	126,463	15.0
South	102,954	729,818	2,177,627	21.2
Apurímac (Abancay)	7,975	64,990	337,901	42.4
Arequipa (Arequipa)	24,528	277,851	410,911	16.8
Cuzco (Cuzco)	32,487	197,776	614,299	18.9
Moquegua (Moquegua)	6,245	24,431	58,263	9.3
Puno (Puno)	26,018	126,284	687,977	26.4
Tacna (Tacna)	5,701	38,486	69,176	12.1
East	251,390	274,821	626,334	2.5
Amazonas (Chachapoyas)	15,945	45,587	117,727	7.4
Loreto (Iquitos)	184,686	128,199	331,177	1.8
Madre de Dios (Puerto Maldonado)	30,271	6,740	14,828	0.5
San Martín (Moyobamba)	20,489	94,295	162,602	7.9
Total	496,222†	4,877,839	10,364,620	20.9

*Preliminary.
†Total includes 1,928 sq.mi. of islands and inland water.

Because of the very high birth rate and the comparatively high death rate prevailing in Peru, the population is highly concentrated in the younger years of life. Thus in 1955, 44% of the population was less than 15 years of age, 53% aged 15–64, and only 3% aged 65 or more; and there is slight likelihood that these proportions have changed significantly since that time. In 1961 the sexes were approximately equal in number, there being a ratio of 99 males per 100 females. (T. L. Sh.)

VI. ADMINISTRATION AND SOCIAL CONDITIONS

1. Government.—The country's chief executive is its president, who holds office for six years but cannot be re-elected immediately. Two vice-presidents and a cabinet of 12 assist him in his duties. The legislative authority belongs to congress, which consists of a senate and a chamber of deputies. In accordance with the constitution of 1933 and its subsequent amendments, presidential and congressional elections are held every six years when direct popular vote determines the country's government. It is the president's privilege to select his cabinet and to provide congress with panels of names which are to guide members of the legislature in appointing justices for supreme court duty and in filling high church positions, in the last case subject to Vatican approval. Voting, compulsory for all literate male citizens between 21 and 60 (married persons who have reached 18 years of age are eligible to vote), was extended during the presidential elections in 1956 to include women for the first time.

Senators and deputies are elected also by popular vote, the former in the departments, the latter in the provinces. Congress sits for four months each year and its deliberations are translated into action by 12 ministries: interior (which includes police, postal and telephone service), foreign affairs, justice and worship, public education, finance and commerce, war, navy, aviation, development and public works, public health and social welfare, agriculture, labour and Indian affairs.

Peru is divided into 12 judicial districts in which justice is administered by superior and minor courts. The highest court of the land is the supreme court at Lima, the members of which are chosen by congress.

2. Welfare Services.—Peru has a social security program providing for health and maternity benefits, compensation for workmen injured during the course of their employment, and allowances for the aged and indigent. In dealing with these and similar problems, Peru has been participating in the technical assistance programs offered by the United States on a bilateral basis and by the United Nations on a multilateral basis.

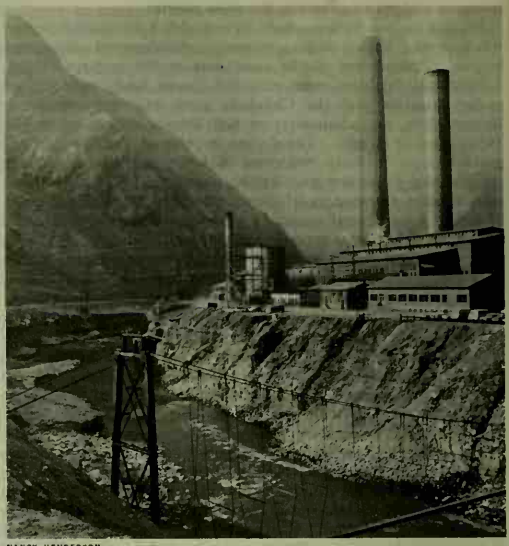
3. Education.—Primary education is free and obligatory for

children from 6 to 14. While about 88% of all primary schools are public, almost two-thirds of the secondary ones are operated by private institutions, frequently with religious affiliation, or maintained by colonies of foreign residents. There are also more than 150 trade schools, emphasizing agricultural, industrial or commercial subjects. The University of San Marcos was founded at Lima in 1551 and the first printing press was set up in that city in 1584, about half a century after it had been introduced into Mexico and 50 years before it was to appear in the regions north of the Rio Grande. In addition to the national University of San Marcos, there are three small national universities at Trujillo, Arequipa and Cuzco (in order of student enrollment) and a Roman Catholic university at Lima.

4. Defense.—Military conscription is the law of the land and, in theory, every male Peruvian citizen is obliged to serve 2 years in the active army, 10 years in the reserve army and 20 years in the national guard. The draft, however, is not usually enforced, and the active army numbers approximately 30,000 men, consisting in the main of volunteers. Army, navy and air force are U.S.-trained and, following World War II, their equipment underwent a substantial expansion and modernization, chiefly through purchases from the U.S. and Britain. The president is the supreme commander of the nation's armed forces, exercising his authority through the secretaries of war, navy and aviation. (G. I. B.)

VII. THE ECONOMY

1. Production.—Agriculture is the leading economic activity of Peru, engaging about 60% of the nation's employed population. In terms of value, cotton is the country's most important commercial product. It is of the long-staple Tangüis, Pima and Karnak varieties. Tangüis cotton is grown chiefly in the coastal valleys around Lima; the Pima and Karnak cotton is produced in the coastal valleys of northern Peru. The second most important commercial agricultural product, sugar, is cultivated chiefly in the coastal valleys near Trujillo and Chiclayo. In addition to cotton and sugar, the irrigated coastal area produces rice. The temperate zone staples—wheat, corn (maize), barley, oats, potatoes and alfalfa—are grown in the Andean highland region. The so-called Irish potato, in fact, probably originated in the Peruvian or Bolivian Andes. In the montaña east of the Andes small amounts of sugar cane, tobacco, coffee, cacao and bananas are produced. Also grown in the montaña is the coca leaf (source of cocaine), which is chewed by the Indians of the high Andes. The rubber tree *Hevea brasiliensis* is found in the province of Loreto in the upper Amazon valley, though production has not been large in recent decades. A program involving considerable technical assistance to Peruvian agriculture was begun in 1943 by the Cooperative Interamerican Service for Food Production (S.C.I.P.A.), an organization jointly sponsored by the Peruvian and U.S. governments.



NANCY HENDERSON

COPPER SMELTER NEAR OROYA IN THE CENTRAL HIGHLANDS

MINERAL RESOURCES AND THE AGRICULTURAL AND INDUSTRIAL AREAS OF PERU

Peru has a livestock industry of moderate size. Cattle raising is spread throughout the country, while sheep raising occurs on a considerable scale in the south near Lake Titicaca and Cuzco. The llama and alpaca, animals related to the camel but smaller, are raised for their wool and as beasts of burden, providing a unique aspect to the livestock industry in that part of the world. Sea birds such as the cormorant provide another novel feature. The bird droppings are left in large quantities on the exceedingly dry islands off the coast and are collected as guano, a rich fertilizer. Guano marketing has been handled by a government monopoly, the Compañía Administradora del Guano. Production of this fertilizer has been important since the middle of the 19th century, when it represented Peru's chief export.

Peru has always been a major mining country. Gold and silver have been important since colonial times; however, since the latter part of the 19th century, copper, lead and zinc have overshadowed the precious metals in importance. Peru also produces considerable quantities of tungsten, vanadium and bismuth. The chief mining company has been the United States-owned Cerro de Pasco corporation, most of whose operations have been in the Andes just east of Lima. In 1956, however, the Southern Peru Copper company began to work a new major deposit at Toquepala, south of Arequipa. Also in the middle 1950s iron ore production

in the area around Ica became commercially significant. Much of the ore began to go to the new steel mill at Chimbote, but some was exported. Peru has also mined and exported some coal. Crude oil production has occurred chiefly in the northwest corner of the country near Talara. There has also been a limited amount of production in the upper Amazon valley.

Bonito, tuna and swordfish are caught in the Humboldt current off the coast of Peru. The Peruvian coastal waters are among the favourite areas of the world for sports fishermen. The confluence off the northwest corner of Peru of the cold Humboldt current and the warm ocean current from the north provides unique and favourable fishing conditions.

The rivers that rise in the Peruvian Andes and flow east provide major opportunities for power development, but by the middle 1960s there had been little development of their hydroelectric potential. One important project has been the dam built on the Santa river in connection with the construction of the steel mill at Chimbote. Another important project, completed in 1956, was the diversion of the Chotano, a tributary of the Amazon, through a tunnel into the Chancay river above Chiclayo.

A major development in Peruvian industrialization was the opening of the steel mill at Chimbote in Aug. 1956. The manufacture of industrial explosives was also begun in that year. However, textiles and food processing have been the most important industries in the country for many years. Manufacturing has been concentrated mainly around Lima, Callao, Arequipa, Trujillo and Chiclayo. Following World War II the government of Peru took an active interest in encouraging industrialization.

2. Trade and Finance.—Peru's chief imports are heavy manufactured items such as electrical machinery, motor vehicles and iron and steel products. Other imports include chemicals and pharmaceuticals. The chief exports are cotton, sugar, copper, iron ore, petroleum and fish. The United States generally provides about 50% of Peru's imports and takes about 35% of its exports. Considerable trade is also carried on with the United Kingdom and West Germany. Peru has provided high tariff protection for its domestic textile industry and has also imposed quotas on automobile imports. But import restrictions are, in general, less rigorous than those of many other Latin-American countries.

The monetary unit of Peru is the sol. The official par value, which had been 6.5 soles per $1, was suspended in 1949, and a system which provided for fluctuating rates of exchange was established. In the mid-1960s the rate was about 25–30 soles to $1.

The Banco Central de Reservas has functioned as the central bank of Peru since the 1920s, when it was set up with the standard functions of a central bank. It has the customary credit control powers, the note issue privilege, and serves as financial agent for the government. The rediscount rate of the central bank was set at 6% in 1947.

3. Transport and Communications.—In the middle 1960s there were about 25,000 mi. of roads, of which about 5,700 mi. were surfaced. The principal highway in Peru is the Peruvian part of the Pan-American highway, which follows the Pacific coast line from Tumbes on the Ecuadoran border to Tacna on the Chilean border. Another important highway extends east from Lima over the Andes to Tingo María and Pucallpa; from there it is possible to continue by river boat to Iquitos.

The chief railroads of Peru were built between 1850 and 1880. The Southern railway extends from the port of Mollendo to Arequipa, Puno on Lake Titicaca, and Cuzco. It has been a chief means of entry to Bolivia. The Central railway was built from Lima across the Andes to Cerro de Pasco and Huancayo. The Central crosses the Andes at an elevation of 15,865 ft. Henry Meiggs made an engineering reputation as the builder of the Central and the Southern railroads. As of the mid-1960s Peru had no railroad linking the northern and southern parts of the country.

The chief port of Peru is Callao (*q.v.*). The United States-owned Grace line has been a major ocean-shipping company and an important element in the Peruvian economy since the middle of the 19th century. Much of the cargo moving through Peruvian ports is handled by foreign ships, but some is serviced by the government-owned Corporación Peruana de Vapores.

Inland waterways are nonexistent along the Pacific coast and in the high Sierras; in the montaña, however, the upper tributaries of the Amazon—the Marañon, Ucayali and Huallaga—represent, except for the airplane, the only means of effective communication. Iquitos (*q.v.*) is the chief river port in that region.

Peru has a well-developed system of airlines, both international and domestic. Especially important has been the air link across the Andes from Lima to Iquitos. The Faucett Aviation company has been the chief domestic airline.

The Compañía Peruana de Teléfonos, an International Telephone and Telegraph company subsidiary, provides telephone service in the Lima area. In the mid-1960s there were more than 2,000,000 radios and 70,000 television sets in Peru. Radio stations were maintained in many of the larger towns, and television networks were located in Lima and Arequipa.

See also references under "Peru" in the Index.

(W. C. GN.)

NANCY HENDERSON

SMALL FISHING VESSELS AT A PIER IN CALLAO, THE PRINCIPAL SEAPORT IN PERU

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PERUGIA (ancient Perusia), a city and seat of an archbishopric, and capital of the province of Perugia in Umbria, central Italy. It is 172 km. (106 mi.) N of Rome by road and is finely situated on an irregular cluster of hills, 1,617 ft. above sea level, west of the Umbrian Apennines. The view from the city embraces the Umbrian Valley, part of the central Tiber Valley, and the Lago Trasimeno Valley. Pop. (1961) 113,880 (commune). The great period of Umbrian art, in the 15th century, was centred in Perugia. There are considerable remains of the Etruscan walls with three gateways, the Marzia, the Arco d'Augusto (partly rebuilt in the 1st century B.C.), and the Trasimena (reconstructed in the 14th century). The Etruscan nucleus is enclosed by 13th-century walls, narrow, winding, and steep streets, and more modern quarters.

The town retains its five historic wards of Porta San Pietro, Porta Eburnea, Porta Santa Susanna, Porta Sant'Angelo, and Porta Sole, to which a sixth, Fontivegge, has been added. The centre of the city lies on a north-south axis formed by the Corso Vannucci. In the beautiful Piazza Quattro Novembre is the Palazzo dei Priori (Palazzo Comunale, 13th–16th centuries), bearing over the doorway two 13th-century bronze figures, the griffin, emblem of the town, and the Guelph lion. Its Sala dei Notari has 13th-century frescoes by Pietro Cavallini, and the Galleria Nazionale dell'Umbria is a remarkable collection of paintings and sculpture of the Umbrian school. The adjoining Biblioteca Comunale Augusta has a collection of manuscripts and incunabula. Also in the Piazza Quattro Novembre is the cathedral of S. Lorenzo (1345–1430) in which is the supposed white onyx espousal ring of the Virgin. In the centre of the piazza is the Maggiore Fountain (1278), a splendid work by Fra Bevignate with bas-reliefs by Nicola and Giovanni Pisano. The hall of the Collegio del Cambio (1452) in the Corso Vannucci contains a dazzling series of frescoes by Pietro Perugino and his pupils. In the Piazza Matteotti are the Palazzo dello Studio (15th century) and the Gesù Church (16th–17th centuries). Other churches of interest are S. Angelo (6th century, on a circular plan), S. Prospero (8th–16th centuries), S. Pietro (10th–16th centuries, with walnut stalls of 1535), Sta. Maria Nuova (13th–16th centuries), Sta. Agata (14th century), S. Domenico (14th century, rebuilt in the 17th), containing the monumental tomb of Pope Benedict XI, S. Ercolano (14th century), S. Severo (15th–18th centuries), with a fresco by Raphael, and S. Filippo (17th century). The oratory of S. Bernardino (1457–61) has an early Renaissance facade by Agostino di Duccio. In the former convent of S. Domenico is the Archivio di Stato and the Etrusco-Roman Museum with an important collection of Etruscan objects. The Museo del Duomo is a small medieval museum. The former convent of the Olivetans (18th century) is the central seat of the university (founded in 1308), and in the Palazzo Gallenga is the Italian university for foreigners. On the outskirts of the city are the Etruscan hypogea of San Manno and of the Volumnii (2nd century B.C.).

Perugia is served by the Foligno-Terontola railway, and the central Umbrian railway from Sansepolcro to Terni. A network of motor coach lines joins Perugia to all the provincial centres as well as to Rome, Florence, and the Adriatic riviera. The chief economic activities are agriculture, food industries (milling, *pasta* manufacture, confectionery), and the clothing industry (textiles and ready-made clothing).

The town was founded by the Umbrians and became one of the 12 Etruscan strongholds. From 310 B.C. it belonged to Rome and was the latter's auxiliary in the war with Hannibal. During the conflict between Mark Antony and Octavian (later the emperor Augustus) it was taken by the latter, burned by its citizens, and rebuilt by Augustus later. In 592 it became a Lombard duchy and subsequently was involved in many petty conflicts with neighbouring towns, Perugia usually taking the Guelph side. In 1416 the *condottiere* Braccio Fortebraccio took it; later the rival families of the Oddi and the Baglioni fought there for power. From 1540 Perugia was a possession of the church and a papal governor was installed. In 1809 the French captured it, but it was restored to the church in 1815. Perugia played an active part in the Risorgimento of June 1859 and in the following year formed part of a united Italy.

Perugia Province (area 2,446 sq.mi. [6,335 sq.km.]; pop. [1961] 555,608) comprises part of the sub-Apennines to the west of the Umbro-Marche crests of the Apennines, and is mountainous and hilly except for the flat zones of the Umbrian Valley and of the central Tiber Valley, and the Città di Castello and Gubbio Plain. The chief crops are wheat, maize (corn), olives, grapes, forage, beetroot, tobacco, and tomatoes. The main industries are printing, tobacco curing, and the production of *pasta,* building materials, agricultural machinery, and majolica. The fisheries of Lago Trasimeno are important.

Apart from Perugia city, the chief centres, all of interest artistically, are Assisi (pop. [1961; commune] 25,361), Foligno (48,684), Spoleto (38,563), Todi (19,768), Città di Castello (35,788), and Gubbio (29,976). The province is crossed by the Ancona–Rome, Foligno–Terontola, and Sansepolcro–Terni railways.

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PERUGINO (Pietro di Cristoforo Vannucci) (*c.* 1450–1523), Italian artist, the principal painter of the Umbrian school and the master of Raphael, was born at Città della Pieve, near Perugia, from which city he takes his name. Giovanni Santi, Raphael's father, says that Perugino and Leonardo da Vinci were "of an age." It is known that Leonardo was born in 1452 and entered the guild in Florence in 1472, in which year Perugino was also registered; it is likely, therefore, that he was born about 1450. On the other hand, G. Vasari implies that he was born in 1445 or 1446, but this seems less likely than Santi's date. Nothing is known for certain of his early training, but he may have been a pupil of Fiorenzo di Lorenzo in Perugia and of Piero della Francesca in Arezzo, in which case he would have been a fellow pupil of Luca Signorelli. Certainly the two men were acquainted, and an occasional influence from Signorelli is visible in Perugino's work, notably in the direction of an increased hardness of drawing (*e.g.,* "Crucifixion and Saints"; Uffizi gallery, Florence). In Florence he almost certainly worked in the shop of Andrea del Verrocchio, where Leonardo was then also active.

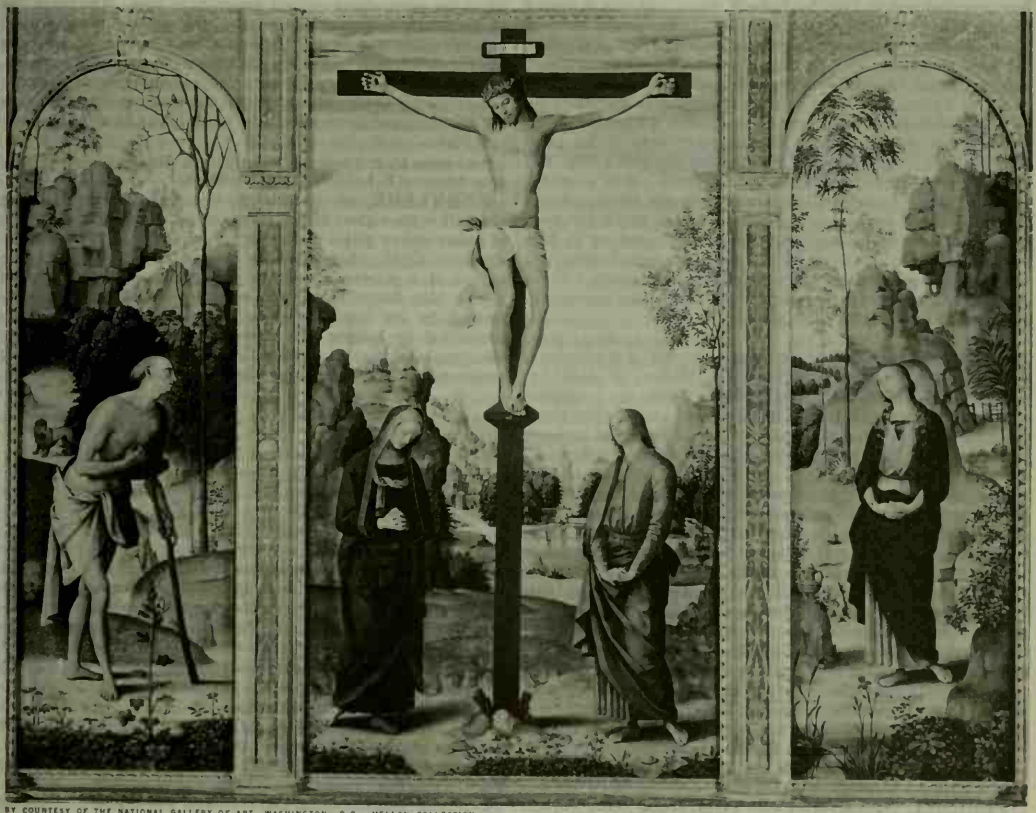
The first certain work by Perugino is a "Saint Sebastian," at Cerqueto, near Perugia, the sole survivor of a series of frescoes in the church, recorded as having been signed and dated 1478. This already shows much of his typical style, and he must have made a considerable reputation by that date, since he is next recorded in 1478–79 in Rome, working in old St. Peter's for Pope Sixtus IV. These frescoes are lost, but the same pope employed him on the fresco decoration of the Sistine chapel, and his name occurs in the documents of 1481 and 1482. Several of his frescoes have been destroyed—most notably those on the altar wall, thrown down to make way for Michelangelo's "Last Judgment"—but his most important work there, the "Giving of the Keys to St. Peter," is fundamental to his development. It shows the apostles

ranged in the foreground, watching Christ hand the keys to Peter; in the background is a centrally planned building, of the type then much in favour among advanced architects. It symbolizes the Old Dispensation, since it represents the Temple at Jerusalem, and the giving of the keys is a symbolic representation of the New, or Christian, Dispensation. The artistic importance of this fresco is very great, for it is simple and lucid in arrangement, and the first glance reveals the main action; by comparison, the frescoes by Botticelli in the same series appear both crowded and incomprehensible. It was Perugino's main claim to fame that he insisted on the qualities of simplicity and clarity that were to characterize the High Renaissance and, in particular, the work of his pupil Raphael. It cannot be denied that among Perugino's very numerous works there are several that are less lucid and simple than insipid and vacant, but his not infrequent sentimentality should not obscure his merits and his historical importance.

Immediately after completing his work in the Sistine chapel, Perugino went back to Florence, where he was given a commission to work in the Palazzo della Signoria, and in 1491 he was invited to sit on the committee concerned with finishing Florence cathedral; in the same year he signed and dated the triptych now in the Villa Albani, Rome. There are several signed and dated works from the next decade, some of the principal ones being the "Madonna and Saints" (1493, Uffizi) and the same subject, also of 1493, in Vienna; in 1494 he painted a portrait of Francesco delle Opere (now in the Uffizi), which shows that he must have been well acquainted with Flemish portraits of the later 15th century, since the influence of Hans Memlinc is unmistakable. The "Pietà" (1495; Pitti, Florence) shows the calm resignation which his style was capable of expressing.

Between 1493 and 1496 he painted a fresco in the convent of Sta. Maria Maddalena de' Pazzi, in Florence. This takes up the entire wall surface, facing the entrance, of a room in the cloister. The roof is vaulted, so that the wall is divided into three bays by the corbels supporting the vaulting; below the corbels Perugino painted piers and made it seem that the room is in fact an open loggia, looking out on an extensive and beautiful Umbrian landscape, with the Crucifixion taking place in the central bay and the two side bays occupied by gently mourning saints. For the church of S. Pietro in Perugia he painted, between 1496 and 1498, a very large altarpiece of 15 panels. The central "Ascension" is now in the museum at Lyons, France, and other important parts are in the museum at Nantes, France, and in St. Gervais, Paris. A virtually identical "Ascension" is in Sansepolcro cathedral. In 1499 he was supposed to complete an altarpiece for the Certosa at Pavia, parts of which are now in the National gallery, London, and are an epitome of motives derived from Florentine art—the central Madonna owes a good deal to Fra Filippo Lippi, the archangel Michael derives from Donatello's statue of St. George, and the Raphael and Tobias is of a type used by the Verrocchio and Pollaiuolo workshops.

On Feb. 25, 1499, Perugino's name occurs for the first time in the records of the guild of bankers at Perugia; but, as the earlier books have been lost, the commission to paint a fresco cycle in



BY COURTESY OF THE NATIONAL GALLERY OF ART, WASHINGTON, D.C., MELLON COLLECTION

"THE CRUCIFIXION WITH THE VIRGIN, SAINT JOHN, SAINT JEROME AND SAINT MARY MAGDALEN," BY PIETRO PERUGINO. IN THE NATIONAL GALLERY OF ART, WASHINGTON, D.C.

their Sala del Cambio may well have been given earlier. He received the final payment in 1507; but it is generally assumed that the frescoes were completed shortly after 1500, the date which appears opposite Perugino's self-portrait on one of the pilasters. The ceiling is decorated with an Apollo surrounded by allegories of the planets. It has been shown that these scenes depend on the illustrations in Johannes de Spira's astrolabe tables, *Astrolabium planum in tabulis ascendens* (1494), and it is thought that the iconography of the whole Sala was planned by Francesco Maturanzio, a professor of rhetoric in Perugia. He certainly wrote the Latin verses which accompany the main fresco fields, representing allegorical figures of virtues and the principal exemplars of each virtue in classical antiquity or the Christian embodiment of it. The importance of these frescoes in the history of art lies in the fact that the young Raphael was Perugino's pupil around 1500 and probably had his grounding in fresco technique there. The figures of Fortitude and Horatius Cocles are often attributed to him. At about this date Perugino also painted an "Ascension" (Vatican), in which the sleeping soldier is sometimes attributed to Raphael; and the "Marriage of the Virgin" (Caen, France) is usually dated about 1503–04, since it seems to be the prototype of Raphael's finer "Sposalizio" (1504; Brera, Milan).

From this time Perugino's art began to decline, since he frequently repeated his earlier compositions in a routine manner. Vasari says that the critical Florentines began to lampoon him, and Perugino replied that they had once praised his work, and, if he now gave the same designs, they had no right to blame him. It is certainly true that the "Chastity" (now in the Louvre, Paris) was commissioned in 1503 by Isabella d'Este and was delivered only in June 1505, after a great many letters had passed between all concerned, at which time Isabella expressed herself as satisfied, but only moderately so. In fact, Perugino left Florence about 1505 and began to retire, working principally for the less critical public of Umbria. In 1508 he made a temporary comeback by painting roundels on the ceiling of the Stanza d'Eliodoro in the Vatican; but the commission for the room went to his pupil Raphael, who, in the few years after leaving Perugino's shop, had proved himself incomparably the greater artist. It is a curious fact that one of Perugino's last commissions was the completion in 1521 of some frescoes in S. Severo, Perugia, which had been begun years earlier by Raphael. He was still working in Feb. 1523, when he died of the plague at Fontignano, near Perugia, and was buried in a field there. The fresco of the "Nativity," in the National gallery, London, comes from Fontignano and is generally supposed to be Perugino's last work.

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PERUTZ, MAX FERDINAND (1914–), British chemist, cowinner with J. C. Kendrew (*q.v.*) of the 1962 Nobel prize for chemistry for his studies on the structure of globular proteins, particularly hemoglobin, by X-ray diffraction analysis. He was born in Vienna on May 19, 1914, and studied at the University of Vienna. He began research on hemoglobin at Cambridge university in 1937 and received his doctorate there in 1940. After becoming a reader (lecturer) at the Davy-Faraday laboratory at the Royal institution, London, he was appointed director in 1947 of the Medical Research council's unit for molecular biology at Cambridge. He became a fellow of the Royal society in 1954.

Perutz developed special techniques, including the use of isomorphous derivates containing heavy elements, that made structural analysis of proteins feasible. Hemoglobin, which is responsible for the absorption and transport of oxygen in the blood, is a particularly difficult molecule to analyze structurally since it consists of four polypeptide chains (2α and 2β), each containing a heme group. One of the most important features of the crystallographic studies of Perutz and Kendrew is the elucidation of the conformation of the polypeptide chains in addition to the amino acid sequence. (D. T. EL.)

PERUZZI, BALDASSARE TOMMASO (1481–1536), architect and painter of the Italian Renaissance who first embraced high Renaissance ideals and developed into a Mannerist. He was probably born at Siena. He was a man of varied attainments, but his architecture, characterized by extreme simplicity and delicacy, was superior to his painting. A contemporary of Raphael and Donato Bramante, he first appeared in 1501 as a painter of frescoes in the chapel of S. Giovanni in Siena cathedral. His first architectural work was the Villa Farnesina (1509–11), for Agostino Chigi, which contains frescoes by Raphael and one—the "Story of Medusa"—by Peruzzi himself. In 1516 or 1517 he produced his best frescoes, those for the Cappella Ponzetti in Sta. Maria della Pace. On Raphael's death in 1520 Peruzzi was appointed architect for St. Peter's, jointly with Antonio Sangallo, the younger. About 1523 he built the classical portal of S. Michele in Bosco near Bologna. The Palazzo Ossoli (1525) and the Palazzetto Spada, both in Rome, have been attributed to him; also the Palazzo Albergati in Bologna. At the sack of Rome (May 1527) he escaped to Siena, became architect to the republic in July and architect to Siena cathedral in 1529. His most important building was the Palazzo Massimo alle Colonne (1535), in Rome. He died in Rome on Jan. 6, 1536, and was buried in the Pantheon.

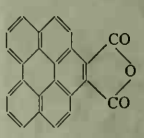
See W. W. Kent, *The Life and Works of Baldassare Peruzzi of Siena* (1925). (M. S. B.; X.)

PERVIGILIUM VENERIS, an anonymous Latin poem of 93 trochaic tetrameters catalectic, written for the eve of the festival of Venus. Date (between the 2nd and the 5th century A.D.) and authorship have occasioned much speculation: the argument from metre, which supports the otherwise ill-founded attribution to Florus (fl. 2nd century A.D.), equally points to the author (reputedly Tiberianus, fl. 335 A.D.) of the *Amnis ibat inter arva*, with which the poem shows marked similarity of tone. The poem has an irregularly recurrent refrain *cras amet qui numquam amavit quique amavit cras amet* ("Let love come tomorrow to him who has not loved, and to him who has loved let love still come tomorrow"); many have needlessly sought to impose regular strophic arrangement. Unobtrusive literary reminiscence is combined with the freshness and direct simplicity which later characterize medieval verse.

See edition by C. Clementi, 3rd ed. (1937) with bibliography; Eng. verse trans. by F. L. Lucas, *Aphrodite* (1948). (D. R. BR.)

PERYLENE, an aromatic hydrocarbon present in small amounts in the highest boiling fractions of coal tar. It crystallizes in golden-yellow plates and has a melting point of 273°–274° C. Perylene, $C_{20}H_{12}$, has also been isolated from a sulfur dioxide extract of a petroleum distillate. Its dilute solutions have an intense blue fluorescence. The structure (I) of perylene is indicated by its formation from naphthalene and from 1:1′-dinaphthyl by heating with aluminum chloride and from 1:8-diiodonaphthalene by heating with copper. This is confirmed by synthesis from 9:10-bischloromethylanthracene.

I



II

Perylene has, to a certain degree, the character of a diene and reacts with maleic anhydride in boiling nitrobenzene (*i.e.*, under oxidizing conditions) to give 1:12-benzoperylene-dicarboxylic anhydride (II), which may be decarboxylated to 1:12-benzoperylene, also a minor constituent of coal tar. Oxidation of perylene with chromic acid gives the 3:10-quinone, derivatives of which occur naturally as pigments in aphids. (J. W. CK.)

PESAH: *see* JEWISH HOLIDAYS.

PESARO (Roman PISAURUM), a town and seaport of the Marches, central Italy, capital of the province of Pesaro e Urbino, is situated on the Adriatic coast and on the right bank of the Foglia (Pisaurus) river 60 km. (37 mi.) N.W. of Ancona by road. Pop. (1961) 66,985 (commune). It is on low ground surrounded by hills and is the centre of a rich agricultural district. Pesaro is also a pleasant sea bathing resort on the main coastal railway and

road. On the western slope of the Monte di San Bartolo lies the Villa Imperiale which was built by Alessandro Sforza; its foundation stone was laid by the emperor Frederick III during his journey to Italy in 1469 and the building is noted for fine stucco ceilings, wall paintings and pavements of majolica plaques. A new palace was begun in 1530 by Girolamo Genga and his son, Bartolomeo, for Eleonora Gonzaga but it was never completed. The old walls were in 1830 transformed into a public promenade. Other buildings include a palace built in 1455–65 for the Sforza, and restored by Francesco Maria I della Rovere, duke of Urbino, in the 16th century, where antiquities, pictures and a fine collection of majolica (the best in Italy) from the old Urbino and other manufactories were preserved (they are now in the civic museums); and the fortress of Rocca Costanza (begun by Costanzo Sforza in 1474, Luciano Laurana being the architect). The cathedral has a 14th-century façade. The composer Gioachino Antonio Rossini, who was born at Pesaro, left his fortune to found a music school, the Liceo Musicale Rossini, famous for its directors and for the composers who studied there. The civic museums contain part of the collection of the Mosca museum. They also house the picture gallery and the ceramics which were once in the Palazzo Ducale (1450–1510), which survives. The Oliveriano Archaeological museum is important in the study of Italian antiquities.

Destroyed by Vitiges the Goth, the town was restored and strengthened by Belisarius, and afterward along with Ancona, Fano, Senigallia and Rimini formed the Pentapolis Maritima ("five maritime cities"). In the course of the 13th century Pesaro was sometimes under the government of the popes, sometimes under that of the emperors, but the Malatesta family, which first took root in the city about 1285, gradually became the real masters of the place. In 1445 they sold their rights to Francesco Sforza; and in 1512, through the influence of Pope Julius II, the Sforza were supplanted by his nephew Francesco Maria I della Rovere and Pesaro became the residence of the dukes of Urbino until the death of Francesco Maria II della Rovere in 1631, when it reverted to the Papal States. Pesaro, a main point at the Adriatic end of the so-called "Gothic line," suffered in World War II during the Allied advance of 1944, but fortunately many old buildings escaped with minor damage. (X.; I. Z.)

PESARO E URBINO PROVINCE (area 1,117 sq.mi. [2,893 sq.km.]; pop. [1961] 301,226) is the most northerly province of the Marches. It is mainly occupied by the Apennines and their spurs which run to the coast, intersected by valleys and drained by the parallel rivers Metauro, Foglia and Marecchia. The republic of San Marino borders it on the north. It is largely agricultural and pastoral. There was formerly a tradition of leatherworking; silk and ceramic industries are still carried on; and motorcycles, furniture and stockings are manufactured. Chief towns, besides Pesaro and Urbino (*q.v.*) are Fano (*q.v.*), Cagli, Fossombrone, Pergola and Urbania. (X.)

PESCADORES (P'ENG-HU LIEH-TAO), a group of 64 islands of volcanic and coral origin in Formosa strait separated from Taiwan (Formosa) by the 30-mi. (48-km.) wide P'eng-hu or Pescadores channel. Land area 49 sq.mi. (127 sq.km.); gross area more than 1,000 sq.mi. (2,590 sq.km.). The largest islands are P'eng-hu, Pai-sha (connected with P'eng-hu by causeway), Yü-weng and Pa-chao. Relief is low, less than 300 ft. (91 m.) above sea level, and coral reefs are common. The islands are washed by the warm Kuro Shiwo (Japan) current and the climate is frost free. Mean monthly temperatures range between 15° C. (59.5° F.), in February and 28° C. (82° F.), in July. Except for summer, prevailing winds are northerly and frequently of gale force. Almost all of the 38-in. average annual rainfall falls between June and September. Soils derived from basalt are sandy; those from coral reefs, droughty; natural vegetation is sparse.

Rich fishing grounds nearby explain the Portuguese-derived name Pescadores (fishermen's islands).

The population (1956) was 85,886, consisting primarily of Chinese from neighbouring Fukien province. More than half of the inhabitants reside on P'eng-hu island (site of P'eng-hu, the principal town).

MAJOR ISLANDS OF THE PESCADORES

Fishing and farming are the major occupations. Although 59% of the land is arable, poor soils and high winds make cultivation difficult. Millets, fruits (some exported), corn, sweet potatoes and peanuts are the chief crops.

The Pescadores were occupied by the Dutch (1622–24), by the French and ceded to Japan (1895–1945). The islands, long a dependency of Formosa (*q.v.*), became one of the 16 *hsien* of Taiwan province in 1950. (N. S. G.)

PESCARA, FERNANDO FRANCISCO DE AVALOS, MARCHESE DI (1490–1525), Spanish-Neapolitan *condottiere*, pre-eminent in the service of Spain and of the Holy Roman Empire, was born in Naples, the son of Alfonso de Avalos, 1st marchese di Pescara. At the age of six he was betrothed to Vittoria Colonna (*q.v.*), and the marriage was celebrated in 1509.

Pescara's military career began in 1512, when he fought on the Spanish side at the Battle of Ravenna and was wounded and captured by the French. He was released on payment of a ransom and a promise never again to fight against the French; but the engagement was not observed, and during the following years he rendered conspicuous service to the Spanish and imperial cause in successive Italian campaigns. He defeated the Venetians at Vicenza in 1513, took Padua in 1514, and conquered Milan in 1521 and Genoa in 1522. On the death in 1523 of Prospero Colonna, who had trained him in arms, Pescara became lieutenant general and effective commander of the imperial troops in Italy. Fresh victories followed, at Romagnano in Piedmont in 1524 and at Pavia (*q.v.*) in 1525.

It is with this Battle of Pavia, his military masterpiece, that Pescara's name is indelibly associated. The odds seemed against him. His troops were ill-paid, ill-fed, and in danger of defection to the enemy. Yet by tenacity, patience, and tact, Pescara overcame all obstacles: on Feb. 24, 1525, he defeated the French by a brilliant attack and captured their king, Francis I.

Pescara died at Milan on Dec. 2, 1525. The final months of his life were obscurely involved with the so-called conspiracy of

Girolamo Morone, lieutenant of the nominal duke of Milan, Francesco Sforza, the purpose of which was to unite Italy in alliance with France against the emperor Charles V and the Spaniards. Pescara was offered the crown of Naples and may for a time have wavered in his loyalty. In the end he betrayed the plot and had Morone arrested (Oct. 15, 1525); but on his deathbed he recommended mercy and his plea was heard.

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PESCARA, chief town of Pescara province, region of Abruzzi e Molise, central Italy, lies on the Adriatic coast at the mouth of the Pescara river 93 mi. (150 km.) S.S.E. of Ancona by road. Pop. (1961) 86,834 (commune). The town has two centres, Pescara Riviera on the right bank, and Castellamare Adriatico on the left. Notable buildings include the Tempio della Conciliazione, the house where Gabriele d'Annunzio, the poet, was born in 1863, the large post office and the governor's palace. Pescara is a seaside resort and a tourist centre and has summer festivals. It is on the railway and main road from Bologna to Bari and Brindisi. Fishing, the manufacture of machinery and textiles, and food processing are carried on. There are naval shipyards.

The Roman Aternum, the town was almost destroyed in the barbarian invasions and arose again in the early middle ages as Piscaria (*i.e.*, "abounding with fish"). It has been the scene of much fighting throughout its history and suffered damage in World War II.

PESCARA PROVINCE has a population (1961) of 229,841 and an area of 473 sq.mi. (1,225 sq.km.). Principal products are grapes, olives and vegetables. Bussi Sul Tivino has chemical, asphalt and bitumen industries; Cavamanico has medicinal waters; Popoli is known for its 15th-century Taverna Ducale; and Casauria for the Cistercian abbey of St. Clement (11th–12th centuries).

(M. T. A. N.)

PESCENNIUS NIGER: *see* NIGER, PESCENNIUS.

PESELLINO (FRANCESCO DI STEFANO [GIUOCHI]) (1422–1457), Florentine painter of the early Renaissance. He was brought up by his grandfather, the painter Giuliano il Pesello (1367–1446), and worked as his assistant until Giuliano's death, when he became associated with Fra Filippo Lippi. In 1453 he went into partnership with Piero di Lorenzo di Pratese and during this period began, for the church of S. Trinità at Pistoia, the altarpiece of the Trinity that later was moved to the National gallery, London. It was left unfinished at his death on July 29, 1457.

Pesellino excelled in the execution of paintings on a small scale and is famous for his *cassone* pictures, intended for the decoration of marriage chests, in which he illustrated, in charming tapestry-like designs, an old legend or tale; several of these are in the Gardner museum, in Boston. A number of works by Pesellino may be seen in galleries in the United States; among these are the National Gallery of Art, Washington, D.C.; the Metropolitan Museum of Art, New York city (a fine panel of the Madonna and saints); and the Museum of Art of Toledo, O.

PESHAWAR, a municipal town, district and division located in West Pakistan. The town, headquarters of the district and division, stands about 1,048 ft. above sea level near the left bank of the Bara river, 11 mi. from Jamrud and the entrance to the Khyber pass, 190 mi. E.S.E. of Kabul, Afg., and 276 mi. N.W. of Lahore. Pop. (1961) 218,691 including the cantonment. Formerly it was enclosed with a protective wall with 16 gates, but this was partially removed to allow for expansion. The cantonment, 2 mi. W., is the largest military headquarters on Pakistan's western frontier, and of great strategic importance because of its proximity to the Khyber pass (*q.v.*). For many centuries the *powindahs*, or Afghan traveling merchants, led their caravans every autumn to Peshawar from Kabul, Bukhara and Samarkand. The ancient Qissa (Kissa) Kahani bazaar (the street of storytellers) is the meeting place of merchants from many lands who deal in dried fruits, wool, woolen products, rugs, carpets, *postins* (sheepskin coats), karakullis (lambskin caps) and Chitrali *choghas* (cloaks). The historic buildings include: Balahissar, a fort built by the Sikhs on the ruins of the state residence of the Durranis, which was destroyed by them after the battle of Nowshera; Gor Khatri, once a Buddhist monastery and later a sacred Hindu temple, which stands on an eminence in the east and affords a panoramic view of the entire city; the pure white mosque of Mahabat Khan (1630), a remarkable monument of Mogul architecture; Victoria memorial hall; the museum (1906) with Gandharan sculptures and other antiquities; and government house. The government offices and modern hotels, the Peshawar club and the Sadar bazaar are in the cantonment area. There are many parks while the Chowk Yadgar and the town hall are other places of social and public assembly. *Qahwah-Khanas*, or coffee houses, are popular. There are a number of colleges affiliated to Peshawar university (established 1950) and several schools. The chief cottage industries are the manufacture of copper utensils and leather goods, especially the *chappals* (slippers) and shoes (plain and embroidered), wax and needlework, glazed earthenware, knives and small arms. The town commands the trade with Afghanistan and central Asia.

Peshawar is one of the oldest historic cities of Pakistan. Once the capital of the ancient kingdom of Gandhara (*q.v.*), it was known variously as Parashawara and as Purushapura (the seat of Purush or Porus; *q.v.*). It was also called Begram, which frequently occurs in the history of the Moguls and in classical Pashto (Pushtu) poetry. The present name Peshawar (Pesh Awar or "frontier town") is ascribed to Akbar.

History.—References to the Peshawar area occur in early Sanskrit literature and in the writings of Strabo, Arrian and Ptolemy. It once formed part of the Buddhist kingdom of Gandhara, and the area is still studded with crumbling stupas. Rock edicts of Asoka are found at Shahbazgarhi and Mansera (Mansehra). The Peshawar valley was annexed by the Greco-Bactrian king Eucratides in the 2nd century B.C. About the beginning of the Christian era it came under the Kushans, whose most powerful ruler Kanishka made Purushapura his capital. The Kushans were turned out by Hephthalites (White Huns). In the 10th century the Ghaznevid Subuktigin defeated Raja Jaipal there. Between the 15th and 16th centuries the district was occupied by Pathan tribes from what is now Afghanistan and the Mogul emperors always found difficulty in maintaining their authority over them. Peshawar was a favourite residence of the Afghan dynasty founded by Ahmad Shah Durrani, and there Mountstuart Elphinstone went as British ambassador to Shah Shuja in 1808. A few years later Ranjit Singh crossed the Indus, and Sikh authority was firmly established under Gen. Paolo di Bartolomeo Avitabile in 1834. In 1849 Peshawar passed to the British. In 1901, it became part of the Northwest Frontier province, and in 1955 of West Pakistan.

PESHAWAR DIVISION, as reorganized on Dec. 9, 1960, includes the districts of Mardan, Hazara, Peshawar and Kohat, with their special attached areas, and the Malakand, Mohmand, Khyber and Kurram agencies. Area 28,153 sq.mi. Pop. (1961) 6,372,467. Most of the Peshawar and Mardan districts constitutes a great basin, drained by the Kabul river eastward, north of the Khyber pass, until it falls into the Indus above Attock. Much of the Peshawar valley is covered with surface gravels and alluvium. In the northeast lies the mountainous Hazara district, drained by the Kunhar which constitutes the famous Kaghan valley, a growing tourist area. Similarly the Malakand and Mohmand agencies north of the Kabul river, and the Khyber and Kurram agencies and Kohat district, to the south, are intersected by many hills separated by small valleys. The Malakand pass leads into Swat state in the north, and the Kurram pass to Kabul in the west. Wheat, barley, maize (corn) and bajra are the chief food crops and sugar cane and tobacco the principal cash crops. There are power stations at Malakand and Dargai, each with an installed capacity of 20,000 kw. and at Warsak with a planned capacity of 240,000 kw.

PESHAWAR DISTRICT (area 1,646 sq.mi.; pop. [1961] 1,213,468) consists mainly of highly irrigated plains, apart from the area covered by low hills at Cherat in the southeast. Wheat, maize (corn) and sugar cane are the chief crops. The inhabitants are mostly Pathans with some Hindkis, Awans forming the most nu-

merous Hindki tribe. Nowshera, 25 mi. E. of Peshawar, is an important cantonment with industrial development. (K. S. Ad.)

PESHITTA, an ancient version of the Bible in Syriac. The word means "simple," referring to the fact that the version is without the elaborate critical apparatus of other Syriac versions. The translation of the Old Testament was accomplished over a long period of time, probably beginning in the 2nd or 3rd century. The New Testament probably dates from the late 4th century. Following the canon of the Syrian Church, the Peshitta does not have II Peter, II and III John, or Jude. The version was adopted by both the Jacobites (*i.e.*, Syrian Christians adhering to the Syrian Orthodox Patriarchate of Antioch; *q.v.*) and Nestorians (*q.v.*). The oldest firmly dated copy of any Bible manuscript in any language is a Peshitta manuscript of the Pentateuch of A.D. 442. *See* also Syriac Literature.

PESNE, ANTOINE (1683–1757), French painter of historical subjects and portraits and court painter in Berlin, was born on May 23, 1683, in Paris. After being taught by his father, Thomas Pesne, and his maternal great-uncle, Charles de LaFosse, Pesne later studied at the Paris academy, where he was influenced by the leading French portraitists, Hyacinthe Rigaud and Nicolas de Largillière. In Rome and Naples, and particularly in Venice, where he studied with Andrea Celesti, Pesne developed a marked colouristic talent. The elegant style of his early portraits was greatly influenced by the paintings of his countryman Jean Raoux, as well as by Dutch masters and the elegant pastels of the Venetian artist Rosalba Carriera.

In 1707 Pesne's full-length portrait of the Prussian ambassador to Venice, von Kyphausen, attracted the attention of Frederick I of Prussia; and the artist was appointed court painter to the royal court of Berlin, where he remained, except for short intervals, from 1710 until his death on Aug. 5, 1757. Pesne became the portraitist of the court and of the aristocracy and eminent personages of Brandenburg-Prussia. When Frederick II came of age, Pesne was able to give full scope to his colouristic gifts in mythological and allegorical ceiling paintings and murals, decorating the interiors of the palaces at Rheinsberg, Charlottenburg, Berlin and Potsdam. He continued to paint portraits, some of which achieve by their brushwork and brilliant colouring an almost impressionistic effect reminiscent of Renoir. Of special interest are the various representations of Italian and French dancers and actresses whom Frederick II engaged for the Berlin Opera. They are in the style of Watteau, but as the first European painter to give these portraits an individual character, Pesne developed here the most famous side of his work.

Bibliography.—C. F. Förster, article on Pesne in Thieme-Becker, *Allgemeinen Lexikon der Bildenden Künstler,* vol. xxvi, p. 467 ff. (1932); E. Berckenhagen *et al., Antoine Pesne,* with introduction by G. Poensgen (1958); catalogue of the Pesne bicentenary memorial exhibition in Berlin (Nov. 1957). (G. Pn.)

PESO, a monetary unit first introduced into Spain by Ferdinand and Isabella, who reformed the Spanish coinage system in 1497; it did not come into common use until the time of Charles I (1516–56; the emperor Charles V). The modern peso, equal to 100 centavos, is the monetary unit of several Latin-American countries and of the Republic of the Philippines. Originally divided into eight reales, the peso became the basis of the silver coinage of the Spanish empire after the monetary reform of 1772–86. In the Americas it was called "piece of eight" or "Spanish milled dollar," and was, in fact, equivalent to the U.S. silver dollar. It was retained as the basic coin by most of the Spanish colonies in America when they gained their independence. When these countries adopted the decimal system for their coinage, a local name was in several cases substituted for the term peso. Thus, it was renamed sol in Peru in 1863, bolivar in Venezuela, sucre in Ecuador, colón in El Salvador and Costa Rica, balboa in Panama, lempira in Honduras, quetzal in Guatemala, córdoba in Nicaragua, and boliviano in Bolivia. Other countries, such as Argentina, Chile, Colombia, Cuba, Mexico, and Uruguay, continued to use the term and the denomination peso. Even where the name was officially changed, peso continued to be used in popular speech. (Jo. M. L.)

PESSANHA, CAMILO (1867–1926), the representative in Portuguese poetry of symbolism at its purest and most genuine and the chief precursor of so-called "modernist" poetry. He was born in Coimbra, Sept. 7, 1867, the son of an undergraduate and a girl of the lower classes. He went to the grammar school in Coimbra and entered the faculty of law at the university there, concluding his studies in 1891. After being employed as an assistant to the public prosecutor in Mirandela, he was appointed head of the philosophy department at the Liceu at Macao. He went to this colony in China in 1893 and remained there, apart from two or three visits home, until his death in 1926. From the beginning Pessanha assumed oriental customs, including the opium habit, attracted to them by his somewhat passive temperament. He learned Cantonese and was one of the last Portuguese men of letters to speak the Chinese language, from which *inter alia* he translated some elegies, *Oito Elegias Chinesas,* accompanied by a preface that demonstrates his knowledge of oriental literature. He also collected Chinese *objets d'art* which he bequeathed to the Museu Machado de Castro in Coimbra. His writings on China, in particular the *Introdução a um Estudo sobre a Civilização Chinesa* and the *Elegias,* were collected in *China* (1943). Although he began to write verse in Coimbra, Pessanha was virtually unknown until 1916 when his poetry, which unites the purest symbolist spirit with the most modern poetic technique, was made known to a new generation in the pages of a progressive review, *Centauro.* Collected in the volume *Clepsidra* (1920), his poetry became a kind of breviary for the modernist poets. Musical, subtle, penetrated by the mystery of oriental poetry, Camilo Pessanha is one of the most lyrical of Portuguese poets.

See A. Dias Miguel, *Camilo Pessanha* (1956); Ester de Lemos, *A "Clepsidra" de Camilo Pessanha* (1956); J. Gaspar Simões, *Historia da Poesia Portuguesa do seculo XX* (1959). (J. G. Ss.)

PESSIMISM, a word coined in modern times (from Latin *pessimus,* worst) to denote an attitude of hopelessness toward life and toward existence, coupled with a vague general opinion that pain and evil predominate in the world; the antithesis of "optimism," which denotes an attitude of general hopefulness, coupled with the view that there is a balance of good and pleasure in the world. To describe an attitude as pessimistic need not, however, mean that it involves no hope at all: it may locate its objects of hope and of appraisal in a region beyond ordinary experience and existence; and it may also direct such hope and appraisal to the complete cessation and cancelling of existence.

Unsystematic pessimism is a reflection of material circumstances, of bodily health or of general temperament; it is characteristically expressed in the language of *Ecclesiastes* that "all is vanity." There are, however, systematic forms of pessimism, both philosophical and religious. The Orphic-Pythagorean view of the world was one of qualified pessimism, fleshly existence being regarded as a periodic penance undergone by the impure or guilty soul, until it can at last be freed from the "cycle of becoming" by ceremonial purification or by philosophical contemplation. This same qualified pessimism in regard to fleshly existence and experience is found in Platonism, for which things in this world necessarily deviate from and fall short of their ideal exemplars and for which (as in the *Phaedo*) fleshly tendencies and experiences only represent hindrances in the carrying-out of activities which will be fully performed after death. Eastern pessimism (of a qualified sort) may be illustrated in Buddhism, where all conscious personal existence is held to involve pain or ill, where the cause of such ill lies in personal striving or desire and where positive appraisal is directed to a consummation (*nirvana*) which involves the cessation of striving and of conscious personal existence. It is similarly represented in the main currents of Hindu thought, with the additional thesis that the world is not only painful and evil but also illusory. A qualified pessimism is, of course, deeply characteristic of Christianity, where our world is a fallen world, in which human reason and will are corrupted, and where it is only by redemptive action coming from beyond the world and fulfilling itself in another order that such ills can be rectified.

Philosophical pessimism was strong in the 19th century and was represented in the systems of Arthur Schopenhauer and Karl Robert Eduard von Hartmann. Schopenhauer presented a synthesis of Kantianism and Buddhism, the Kantian thing-in-

itself being identified with a blind irrational will behind phenomena; our world, being the manifestation of such an unhappy will, must itself be unhappy. In the first half of the 20th century critical philosophy tended to steer clear of the whole issue of optimism *versus* pessimism; feeling themselves incompetent to make many general assertions about the world, philosophers were particularly unwilling to make general assessments of its goodness or badness. A qualified pessimism in regard to the world and to human nature was, however, characteristic of several theological systems (*e.g.*, the theologies of Karl Barth, of Emil Brunner and of the Dutch neo-Calvinists Herman Dooyeweerd and D. H. T. Vollenhoven). Perhaps the most uncompromisingly pessimistic system ever developed is that of the existentialist philosopher Martin Heidegger for whom death, nothingness and anxiety are central topics of interest and for whom the highest possible act of human freedom is a coming to terms with death.

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(J. N. F.)

PESSINUS (PESSINOUS, PESINOUS), the most famous of the ancient holy cities of Asia Minor, situated in Galatia, below Mt. Dindymus, by the Sangarius (Sakarya) River. The ruins, discovered by C. Texier in 1834, lie around the village of Ballihisar,, 9 mi. (14½ km.) SSE of Sivrihisar in the modern Turkish *il* (province) of Eskisehir. Originally a Phrygian city, it became the capital of the Galatian tribe Tolistoagii (or Tolistobogii) and the chief commercial city of the district.

From Pessinus the image and the cult of the Anatolian Great Mother of the Gods (*q.v.*; or Cybele) were introduced to Rome in 204 B.C. The goddess, here called Agdistis, had a wealthy and celebrated temple. Her priests were also princes, who ruled not only in the city (the coinage of which, beginning about 100 B.C., was for long issued by them) but also in the surrounding country, deriving a large revenue from the temple estates; but in the time of Strabo (A.D. 19–20) their privileges were much diminished. Some time before 164 B.C. Pessinus was taken over by the Gauls, and the membership of the priestly college was then equally divided between the Gauls and the old priestly families. Like Ancyra and Tavium, the other Galatian centres, Pessinus was romanized first and hellenized afterward. With Roman encouragement it developed during the first two centuries A.D. from a tribal capital to a city of the normal Greek type. Christianity cannot be traced before the 4th century. When Galatia was divided into two provinces (3rd or 4th century A.D.), Pessinus was made the capital of Galatia Secunda or Salutaris, and it became a metropolitan bishopric. By the 9th century it seems to have been replaced by Justinianopolis, and was probably deserted by then. The ruins were largely dismantled and used for building at Sivrihisar.

PESSOA, FERNANDO ANTÓNIO NOGUEIRA (1888–1935), the greatest literary figure in Portuguese "modernism," the movement which gave Portuguese literature of the first half of the 20th century its European significance. He was born in Lisbon on June 13, 1888. His father died when Pessoa was five and his mother married the Portuguese consul in Durban, and in 1895 took him to South Africa where he was educated. In 1903 he was outstandingly successful in the entrance examination of Cape Town university, winning the Queen Victoria prize for English style. In 1905 he returned to Portugal, and enrolled at the Curso Superior de Letras in Lisbon in 1906 but ceased to follow the courses there in the following year and sought openings in commercial life, in which he displayed much initiative but a total absence of tact. He eventually settled down as foreign correspondent for various commercial firms in Lisbon. Though he tried at different times to fend for himself, he always returned to lodgings, first with an aunt and later with his half sister. A bachelor and not particularly sociable, he preferred the acquaintanceship of fellow solitaries in the cafés to the solid joys of a settled family life. A doleful existence, though sublimated by his intelligence and tempered by nostalgic evocations of his childhood, lies behind his work, most of which was unpublished at the time of his death in Lisbon, Nov. 30, 1935.

In the previous year Pessoa had published his first book in Portuguese, *Mensagem*. All that was known of his work at his death were some booklets of poems in English—a language which Pessoa, who was virtually bilingual, wrote with ease—*Antinous* and *35 Sonnets* (1918) and *Inscriptions* (1920), collected in three volumes under the title *English Poems* (1921); some literary and political manifestoes—*Aviso por Causa da Moral* (1923) and *Interregno* (1928); his editorship of the review *Athena* (1924–25) and his frequent contributions to the avant-garde reviews, especially *Orpheu* (1915), the organ of the modernist movement in which Pessoa, with Mário de Sá-Carneiro and José de Almada Negreiros, was a leading spirit. The posthumous edition of his complete works consists of eight volumes; the poems are grouped under the various names or pseudonyms which the poet employed during his lifetime, each name purporting to represent one of the different personalities which he felt to exist within himself: the personality and the style can vary, therefore, according to whether a poem is signed by Fernando Pessoa himself, "Alberto Caeiro," "Álvaro de Campos" or "Ricardo Reis." The most important volumes in the collected edition are *Poesias de Fernando Pessoa* (1942), *Poesias de Álvaro de Campos* (1944), *Poemas de Alberto Caeiro* (1946) and *Odes de Ricardo Reis* (1946), in addition to the *Mensagem* of 1934. Examples of his prose writings as a critic and thinker of a paradoxical spirit can be found in the collection entitled *Páginas de Doutrina Estética* (1946). A good selection of his work, with an introduction, is in A. Casais Monteiro, *Fernando Pessoa* (1945).

See J. do Prado Coelho, *Diversidade e Unidade em Fernando Pessoa* (1949); J. Gaspar Simões, *Vida e Obra de Fernando Pessoa*, 2 vol. (1950).
(J. G. Ss.)

PESTALOZZI, JOHANN HEINRICH (1746–1827), Swiss educator, revered in Switzerland because of his tireless efforts to aid poor, orphaned and helpless children, was born at Zürich on Jan. 12, 1746. Active even in his student days in Zürich in social and political reform, he early earned a reputation as champion of the underprivileged and exploited. He established (1774) an orphanage, where he attempted to teach neglected children the rudiments of agriculture and simple trades that they might lead productive, self-reliant lives. This philanthropic experiment failed in 1780, and Pestalozzi, in a period of despair, wrote what can be considered a key to his philosophy, *The Evening Hour of a Hermit*, a profound and moving series of reflections and aphorisms.

During the next decade he published a widely read four-volume novel, *Leonard and Gertrude*, which delineated and publicized his ideas on social, moral and political reform. When the town of Stans was destroyed and the inhabitants massacred during the Napoleonic invasion of 1798, Pestalozzi collected several dozen destitute children and cared for them under most arduous and pitiful conditions.

In 1805 Pestalozzi founded at Yverdon his famous boarding school, which flourished for 20 years, was attended by students from every country in Europe and was visited by hundreds of the most important figures of the time. Pestalozzi's overarching educational principle, elaborated in *How Gertrude Teaches Her Children* (1801), was "sense impression": accurate, clear thinking is dependent upon accurate observation of actual objects; words and ideas thus have meaning only when related to concrete things. The Yverdon curriculum, therefore, emphasized such pupil activities as drawing and writing, singing, physical exercise, group rather than individual recitations, models, collections, map making and field trips. Carefully graded instruction, allowance for individual differences, and ability groupings were novel features. An important undertaking was the teacher-training department.

Educators journeyed to Yverdon to study "the method," carried Pestalozzi's ideas throughout Europe and America and established scores of Pestalozzian schools. Froebel and Herbart learned much from Pestalozzi, as did Ritter, the geographer. The object-lesson approach used in a highly successful Pestalozzian school in England, conducted by Charles and Elizabeth Mayo, was adopted in the United States (1861) by the Oswego, N.Y., normal school

and became the guiding principle in some of the country's foremost teacher-training institutions.

Pestalozzi's greatest influence was upon Prussia. The German philosopher Fichte, indeed, told a Germany prostrated at Jena that only through a strong educational system based upon Pestalozzian principles could the country expect to recover. Pestalozzi died at Brugg on Feb. 17, 1827.

There are several German editions of Pestalozzi's collected works. His writings referred to above, and *Letters on Early Education*, have been translated into English.

BIBLIOGRAPHY.—L. F. Anderson (ed.), *Pestalozzi* (1931); J. A. Green and F. A. Collie (eds.), *Pestalozzi's Educational Writings* (1912). Of numerous biographies and commentaries, *see* Roger de Guimps, *Pestalozzi: His Life and Work*, Eng. trans. by John Russell (1880); and J. A. Green, *Life and Work of Pestalozzi* (1913). M. R. Walch's *Pestalozzi and the Pestalozzian Theory of Education* (1952) contains an excellent bibliography. (J. C. Od.)

PEST CONTROL. Man survives by constant vigilance against encroaching natural forces that he deems inimical to his own highly organized society. Although his mastery does not yet extend to the overwhelming physical phenomena on all sides, it does include an influence over the organisms that not only compete with man for food or space but also damage his possessions or attack him personally. Man therefore endures in his present state only so long as he can effectively control these competitors or pests.

Criticisms have been voiced by many biologists that man, with his limited knowledge of biotic interrelation and his myopic view of the outcome of his actions, is doing irreparable harm in many ill-advised programs of pest extermination, both to the numerous organisms beneficial, or at least innocuous, to man and to the human species itself. These cogent alarms have inspired widespread discussion and a needed reappraisal of policies and practices of pest control.

The concept of "pest" is interpreted very subjectively, of course. An ecologist would not necessarily consider several leaf-eating caterpillars on a plant as pests, whereas the gardener who cultivated the plant might very well draw up a plan of action against the intruders. And only one bat, rat or mouse is enough to qualify as a household pest. However, to truly merit the designation of pest as the term will be used in this article, an animal or plant must occur in such abundance as to present a distinct threat to man or to his interests, economically or medically.

This article examines the biological background to pest build-up, discusses the various ways, both artificial and natural that can be used to combat the competitors and draws attention to their merits and demerits. In particular, it emphasizes the need for care in the use of "blunderbuss" methods such as the exclusive or unnecessary use of chemicals; it is hoped that ways and means can be found for man to achieve his aim of increasing production with a minimum of disturbance to the soil and the fauna and flora dependent upon it.

HOW PESTS ARISE

Nature: Stability in Diversity.—In the wild, many kinds of plants intermingle to produce a complex mosaic that varies both horizontally and vertically. These plants provide the food for a number of different animals, many of which in turn become the food for a second group of feeders. This process of eating and being eaten continues upward through the various consumer levels so that the energy stored in any particular plant may be transferred through as many as four or five different types of animals to establish what is generally called a food chain. In view of the great variety of food sources it is not surprising to learn that less than two square miles of English countryside, Wytham Woods, contains at least 2,500 different species of animals. In these vast assemblages each group of the smaller plant-eating (phytophagous) animals is restricted somewhat to suitable food sources within a food chain, but many of the predacious animals, which can consume many types of prey, may participate in several food chains. Thus natural populations in diverse environments tend to be organized into complex food webs, instead of consisting of a large number of independent food chains. This intricate association of plants and animals is called a natural community. (*See* ECOLOGY, ANIMAL.)

The diversity typical of many natural communities has two important consequences. First, mixed stands of vegetation often have relatively stable populations of animals. For example, in the mixed hardwood-hemlock forest of Michigan there has been no evidence of serious insect damage for 300 years and less than 5% of the insect species are conspicuous at any one time. Second, diverse communities tend to ward off invasion by foreign species. How this is accomplished has not been established; perhaps all potential sources of existence are being utilized and an invader must partially or completely displace a native species. The stability, both qualitatively and quantitatively, of populations in a given community is not complete, of course, because the abundance of a species fluctuates, sometimes violently, and a new species will become established occasionally. But a community has typical kinds of plants and animals, each of which is present in typical average abundance—some are rare, whereas others are common or even dominant. These observations of relative stability have led to the concept of the balance of nature. The particular forces that determine this balance are a matter of intensive research and great controversy, but it is clear that the size of a population is determined by the physical and biotic agencies operating on the species.

Disruption of Nature.—Some natural processes, the occurrence of chance catastrophes, and particularly the systematic activities of man have so greatly modified the diversity of natural communities that in many areas of the earth the vegetation has become much more uniform. The tendency toward monocultures of crops and the development of agricultural practices have simplified community structure—that the simplification is relative is shown in alfalfa fields in California where over 600 species of arthropods have been found—and have separated and shortened food chains with two important consequences. First, more uniform vegetation is rather easily invaded. Many insects are imported with their traditional host plants; in a favourable climate and in the absence of their natural enemies, they often become established and prosper. Most major pests of agricultural crops are of foreign origin, and have become economically important only when introduced elsewhere. In other cases the production of new crops over large areas resulted in the transfer of hitherto innocuous insects and diseases from scattered native plants to this new and abundant source of food. (*See* the article COLORADO POTATO BEETLE for a description of how a pest may arise and spread.) Second, with more uniform plant cover some phytophagous species increase and fluctuate in abundance. As a plant species becomes dominant it is increasingly subjected to attack by its enemies; in contrast to the mixed hardwood-hemlock forest in Michigan, pure stands of hemlock, aspen, balsam fir and pine were heavily attacked by individual species of forest insects.

The increase and fluctuation in the abundance of phytophagous species in simplified communities are also accentuated by two additional factors. First, weather modifies the susceptibility and nutritive value of crop plants to the attacking species, affects the survival and development of phytophagous species, and influences the development of the host plant and the phytophagous species so that the required food may be available in large amounts and in suitable condition at the right time in some years but not in others. In addition, since each of the cold-blooded animals in a food chain responds differentially to modification of its environment, a simple food chain is easily disturbed by slight changes in weather. Second, when a variety selected for crop production forms the uniform plant cover, it permits much greater rates of increase by plant feeders than do its wild counterparts; irrigation, cultivation and fertilization enhance still further this characteristic. With this type of host plant, slight modifications in the effectiveness of the biotic and abiotic factors that determine population growth can result in a marked increase in the abundance of the phytophagous species.

Kinds of Pests.—The numbers a potential pest must reach to be considered a serious threat to man vary from species to species and depend on many other factors; *e.g.*, a single mosquito that is a

vector of malaria is more dangerous than several leaf-eating larvae. Only a small portion of the animals living in any area are pests; *e.g.*, of the many thousands of insect species in the United States, only about 10,000 species, which attack about 1,000 species of plants, are of economic significance, and of this number less than 200 are considered major plant pests. Unfortunately, these relatively few species cause damage reckoned in billions of dollars.

Most pests are invertebrate animals; they include especially insects and mites, but also nematodes, snails and slugs. Microorganisms such as fungi, bacteria and viruses are here considered with pests even though they are usually thought of as agents of disease. Among the vertebrates many kinds of rodents, rabbits and hares and elk and deer are sometimes injurious to crops. And weeds are often strong competitors of crop plants. When pests are limited to a level of abundance at which their injury is unimportant economically they are said to be controlled. Control is used here in its economic rather than its ecological sense.

As arthropods and plant diseases constitute the chief threats to the welfare of man, the development of pest control has been directed, for the most part, on restricting as much as possible the abundance of these forms. This article deals, therefore, largely with the various methods used to control these pests and some results of control.

CHEMICAL CONTROL

Nature itself practises chemical control: certain plants bear poisons thought to provide some protection against damage by other organisms; animals contain antibodies that provide protection against invasion by foreign elements; and certain microorganisms produce substances (antibiotics) antagonistic to other microorganisms. Man, however, has carried chemical control to a far more effective and potentially dangerous extreme in devising compounds of exceptional potency.

Types of Pesticides

All pesticides are alike in blocking some metabolic process; however, they differ widely in composition, potency, mode of action, speed of effect and dosage required. They are often classified according to the type of organism that they are principally intended to control, as rodenticide, insecticide, acaricide (against mites and ticks), nematicide (against roundworms), herbicide (against plants), fungicide, etc.

Insecticides.—Insecticides are usually divided into several categories depending on their mode of action on the pest species; these categories are arbitrary since a given compound may fall into two or more classes.

Stomach poisons are used against insects such as caterpillars with biting mouth parts, and are toxic only if ingested. The toxic action of inorganics such as the arsenical (paris green, lead arsenate, calcium arsenate) and fluorine compounds (sodium fluoride, cryolite) and plant compounds (ryania, nicotine, rotenone) is thought to result from inactivation of oxidizing enzymes at the cellular level. These compounds require thorough application to be effective, and largely have been replaced by synthetic contact insecticides.

Contact poisons penetrate the integument of the pest and are used against those arthropods such as aphids that pierce the surface of a plant to suck out juices. The naturally-occurring contact insecticides are nicotine, developed from tobacco; pyrethrum, from flowers of *Chrysanthemum cinerariaefolium;* rotenone, from the roots of *Derris* species and related plants; and the petroleum oils. Although these compounds were originally derived mainly from plant extracts, the toxic agents of some of them (*e.g.*, pyrethrins) have been synthesized. These insecticides are usually short-lived on plants and cannot provide protection against prolonged invasions. They are, however, effective where infestations are of short duration, provided they hit the pests directly.

The synthetic contact insecticides are now the primary agents of chemical control, large numbers of them being developed annually. Their efficiency varies widely with such factors as the particular compound, the species of pest, the host plant and the weather; but in general they penetrate the organism readily (some also act as stomach poisons) and are toxic to a wide range of species. The development of a series of chlorinated hydrocarbons was begun with the discovery of the insecticidal properties of DDT in the early 1940s. Other examples of this series are BHC, with its isomer lindane; toxaphene; chlordane; and aldrin and its epoxide, dieldrin. Some of these compounds are very stable and have long residual action. They can be used in many situations but are particularly valuable where protection is required for prolonged periods. Their stability also enables them to be used in the soil against pests such as wireworms, cutworms and leatherjackets. Their toxic action is not fully understood but apparently they affect the nerve axon, leading to a disorganization of the nervous system.

A second series, based on the organophosphates, contains compounds such as parathion, TEPP, schradan, demeton, diazinon and malathion. Most of the organophosphorus insecticides are very effective against sucking forms such as aphids and red spider mites, but some of them also act against biting arthropods. Some are relatively long lasting (*e.g.*, parathion), others decompose rapidly (*e.g.*, TEPP). Several can be used systemically, *i.e.*, they are absorbed into a plant and later kill sucking insects feeding on the plant. Demeton, dimethoate, phosphamidon and schradan are examples of systemic organophosphorus insecticides. Absorption into the plant is achieved either by spraying the leaves or by applying solutions or granules impregnated with the chemical to the soil so that intake occurs through the roots. Warble flies developing in cattle can be killed by systemic organophosphates applied to the host. The organophosphorus insecticides are often metabolized by the insects into potent compounds such as malaoxon or paraoxon that inhibit the enzyme cholinesterase. This enzyme controls the level of acetylcholine, a compound necessary in the transmission of nerve impulses; excess acetylcholine disorganizes the nervous system. A second interpretation is that the insecticides inhibit the aliesterases instead. A third and more recent series of synthetics is the carbamate group which is also thought to act as anti-cholinesterases.

Fumigants such as hydrogen cyanide, naphthalene, nicotine and methyl bromide are toxic when they enter the respiratory system of the pest. These chemicals are used mainly for killing insect pests of stored products or for fumigating nursery stock. Methyl bromide, dichloropropane and chloropicrin are also used for fumigation of the soil, principally for the control of plant parasitic nematodes (*see* Fumigation).

Repellents repel insects rather than kill them. They are used against arthropods of medical importance such as mosquitoes, bloodsucking flies and chiggers; for example, dimethyl phthalate is the active principle of some mosquito repellents. Bordeaux mixture, lime, creosote and sulfur repel plant pests.

Chemosterilants inhibit reproduction of insect pests rather than kill them. The induction of sterility in flies and mosquitoes prevents rather than reduces outbreaks. The combination of a chemosterilant and an insecticide may be a means of overcoming resistant strains.

Fungicides.—Compounds used either to prevent or to stop the development of fungal diseases on crop plants are based on such chemicals as sulfur, mercury, copper or dithiocarbamate and thiuram derivatives. Most fungicides are protectants and must be applied before diseases develop, although organomercury compounds, for example, can be used to stop incipient infections of some diseases, provided they are applied within a day or two of the onset of infection. Fungicides usually have a broad spectrum of action, though a few are more specific; *e.g.*, dinocap and sulfur against powdery mildews. Systemic fungicides are at an early stage of development, and the compounds available are very restricted in their use; most of them are antibiotics, *e.g.*, griseofulvin and cycloheximide, but some synthetic compounds are being developed.

Herbicides.—Herbicides can be broadly divided into nonselective and selective groups. Examples of the former are sulfuric acid, sodium chlorate and the recently developed bipyridyls (*e.g.*, diquat). These will kill most vegetation with which they come into contact. More important in agriculture are the selective

herbicides, many of which are based on the substituted phenoxy acids or halogenated aliphatic acids; *e.g.*, 2, 4-D, MCPA and dalapon. The individual properties of these chemicals enable them to be used selectively, some to control broad-leaved weeds in plantings of cereals, others to control noxious grasses in broad-leaved crops. The triazines, ureas and carbamates can be applied to the soil around established plants or, more usually, prior to sowing annual crops; they control germinating weeds for prolonged periods. Selectivity in this case is due partly to the inherent resistance of certain crops to these chemicals but also to the placing of the chemicals, which are usually very insoluble, where they will not affect the crop seed sown deeper down or act on roots below the zone of herbicidal action.

Other Pesticides.—Examples of pesticides used against other groups of pests include the anticoagulant warfarin in baits for the control of rodents and antibiotics for some animal diseases. And, of course, other substances are mixed with the pesticides in order to apply them or occasionally to enhance their effectiveness.

See ENTOMOLOGY: *Applied Entomology: Principles of Insect Control;* SPRAYS AND DUSTS IN AGRICULTURE.

BENEFITS AND DETRIMENTS

Effectiveness.—With the advent of the newer synthetic pesticides the control of arthropod pests in particular became much more effective. In some cases infestations of pests that were accidentally introduced into new areas were quickly and completely eliminated; in many other instances populations of target insects were reduced by as much as 99%. These new chemical control measures had a constantly increasing effectiveness in preventing crop losses, raising quality of produce, lowering costs of production and improving both the health and welfare of man and animals. In addition, pest control resulted in more stable levels of production. But it became apparent that some difficult problems associated with the use of wide-spectrum pesticides were arising.

The number of plant-feeding arthropods developing on uniform vegetation, while varying with the crop in question, is relatively small. For example, about one hundred harmful species occur on unsprayed apple trees in England; the number of these species that are sufficiently abundant to be important economically, however, is only a small fraction of that number. Treatment with wide-spectrum chemical insecticides to restrict the few species that are of economic significance has often resulted in the few surviving species causing more serious damage than they formerly inflicted, and the abundance of some of the surviving species fluctuates widely from year to year. In addition, the significance of various species as plant pests alters over the years as the program of chemical control is changed. This close relation between pest significance and chemical treatment results from the differential effects of pesticides on the various species and from the development of resistant races in the species being controlled.

Imbalance in Populations.—In spite of heavy mortality at the time of treatment, use of pesticides sometimes results in a subsequent increase in the density of the pest against which the pesticide was applied. This phenomenon, called flareback, results from the incidental destruction of natural enemies that were partially successful in limiting the abundance of the pest population. Since it takes some time for the natural enemies to re-establish themselves and become effective, the pest, temporarily free of important natural restraints, often multiplies rapidly.

A second type of imbalance occurs among plant-feeding species that are more tolerant of pesticides than are their natural enemies. These plant feeders are normally of minor importance because they are controlled at satisfactory economic levels by parasites, predators and disease; but when a wide-spectrum pesticide kills these natural enemies the hitherto unimportant plant feeders are largely released from control, increase rapidly and become pests. For example, the use of mild sulfur fungicides, particularly flotation sulfur, to control apple scab fungus in Nova Scotia resulted in a serious outbreak of the oyster-shell scale insect: the fungicide was not toxic to the scale but eliminated its two natural enemies, the parasite *Aphytis mytilaspidis* and the predaceous mite *Hemisarcoptes malus.*

Other disadvantages of pesticides are the accumulation of poisons in the soil of regions treated repeatedly and the probability of killing bees and other pollinating insects. The differential mortality of a pest and its natural enemies can also result from some of the compounds that are mixed with pesticides in order to apply them. There is limited evidence that pesticides also tend to increase pest abundance by modifying the host plant, and by altering competition between two species of plant feeders.

Development of Resistance by Pests.—Resistance to the toxicity of pesticides is occurring constantly in pests of agricultural and medical importance through the normal evolutionary processes of genetic variation and natural selection. Although resistance was a problem before the development of the synthetic pesticides, it has been greatly accentuated since these compounds were introduced. The rate at which a species develops resistance is related in part to the intensity of the selection pressure, and the newer organic insecticides exert a much more powerful pressure. Selection of a strain resistant to one insecticide can result in a degree of resistance to a related compound (positive cross-tolerance) because the mechanism of toxicity is somewhat similar in both cases. A strain may become resistant to more than one class of insecticide so that it becomes increasingly difficult to limit its numbers. Resistant strains of a species, as in the housefly, may arise independently in many areas of the world; many of these races differ in their susceptibility to the kind and amount of pesticide. Once resistance has developed it tends to persist in the absence of the pesticide for varying periods of time depending on the type of resistance and species of pest; it will gradually decline but can be very quickly restored by renewed exposure to the pesticide. Resistance has also arisen by chance in strains selected for characteristics other than resistance.

The physiological bases of resistance lie in integuments or digestive systems that are not penetrated by the poisons, in extra fatty tissues that can store the pesticide, in enzymes that detoxify the poisons to compounds that can be eliminated, in excretory systems to eliminate the pesticide or its toxic intermediate, in behaviour patterns to avoid spray deposits, or in what is called general vigour. Of these, detoxifying enzymes are probably the most important; in many cases DDT is dehydrochlorinated to the harmless compound DDE by the enzyme DDT-ase, whereas in organophosphorus-resistant houseflies enzymes degrade the toxic metabolites malaoxon and paraoxon. The presence of these characteristics, particularly of the detoxifying enzymes, depends on gene mutations that change slightly the nature of the enzymes normally produced by the insect. Resistance is usually based on single-factor inheritance—the gene locus may vary from one strain to another—or more than one factor can be involved. Degrees of resistance in strains of a species may depend on a number of different alleles at a given locus. One encouraging aspect of the resistance problem is that some beneficial insects are immune to the chemical poisons.

Effect on Wildlife.—Pesticides also present hazards to wildlife. Birds, fishes and small mammals have been poisoned by pesticides used to control insect outbreaks. The pesticides are passed up the food chains from herbivores to carnivores, in the process their concentration often being increased. The effect of insecticides on wildlife involves a number of factors, such as toxicity and persistance of a given compound, stability as it is transferred up the food chain, type of vegetation in which it is applied and species of wildlife. The chlorinated hydrocarbons aldrin, dieldrin, endrin and heptachlor are very toxic to birds and small mammals, but DDT when applied at low dosages apparently does not result in significant mortality of these higher animals. Fishes, however, have been affected by DDT even at the low rate of 0.5 lb. per acre; both the young fish and the aquatic insects on which they feed are highly susceptible. A single spraying has reduced brook trout and aquatic insect populations significantly but in about one year most species recovered. Young salmon, fry and parr, are quite susceptible, and repeated annual spraying greatly reduces their abundance and seriously disrupts the four-year cycle of this species. When spraying can be withheld the returning run and use of fish reared in hatcheries will compensate to a large extent for the excessive mortalities. Some fish may be able to develop re-

sistance to pesticides; there is some indication that mosquito fish from water near fields with a long history of treatment with chlorinated hydrocarbons showed resistance to DDT when compared with fish from areas not exposed to insecticides.

Hazards to Human Health.—In view of the widespread use of chemical pesticides it is not surprising to learn that compounds like DDT form part of the human diet. Drainage into major rivers has carried traces of pesticides so that some rivers contain about 0.2 p.p.m. (parts per million) of DDT. The residues may remain on the surface of food, be absorbed into the waxy covering of fruit and vegetables or contaminate such products as milk and cheese. From dietary sources an average-sized person in the United States in the mid-1960s contained in his body tissues about 7 p.p.m. DDT. The continued accumulation of organic pesticides in the human body is to be considered extremely undesirable, and, beyond a certain debatable limit, dangerous to health. As a means of lessening the possibility of damage to man, an acceptable daily intake of each pesticide residue, based on a lifetime consumption for man, has been established in the U.S. When these limits are not exceeded there is little danger of acute or chronic toxicity. In the case of exceptionally dangerous compounds, including carcinogens (cancer-inducers) this limit is zero; *i.e.,* no amount of such a substance is to be permitted to accumulate in body tissue. The dangers inherent in the application of pesticides can be overcome only if the directions for application of each compound are observed very closely and strictly adhered to. The possibility that exposure for long periods of time to very small amounts of pesticides and other chemicals of a modern industrial society (food additives, fallout, soot, etc.), may lead to illness or genetic change in man has become a matter of considerable controversy.

NONCHEMICAL CONTROL

Methods other than the use of pesticides have been employed successfully for a long time to protect some crops from plant pests. The expense of, and the problems arising from, chemical control methods in recent years have stimulated interest in nonchemical means of pest control, to minimize and supplement the use of modern pesticides. Most of these methods have an ecological basis.

Resistant Plants.—By selecting and breeding from the large pool of genetic variability in a species, races can be formed with characteristics desired by man; *e.g.,* the quality of wheat, the yield, time of maturing and resistance to disease such as rust have been selected by man. Similarly, plants resistant to attack by pests can be selected.

Resistance of plants to insects is based on three components: (1) physical characteristics of plants that make them undesirable to insects for oviposition, shelter or food; (2) antibiosis, in which the plant produces substances that adversely affect the biology of the insects; and (3) tolerance to insect attack. The resistance of the solid-stemmed wheats Rescue and Chinook to the wheat-stem sawfly is due to the inability of the larva of this insect to develop in anything but a hollow stem.

The selection of resistant varieties, one of the main methods of combating fungus and virus diseases of crop plants, must be unceasing to keep ahead of the development of races of the pest that can overcome a formerly resistant variety of crop.

Cultural Control.—Closely related to the development of resistant plants is the role of cultural practices in the control of plant pests, because resistance often depends on the conditions under which plants are grown. Crop rotation and cultivation are two classical means of reducing losses from plant pests. Even in areas where one crop is grown annually, agricultural practices may influence the abundance of pest species. For example, on the Canadian prairies an outbreak of the wheat-stem sawfly that began in the early 1930s and continued until the early 1950s was associated with below-normal rainfall throughout the 1930s and abetted by cultural practices such as farm mechanization, strip farming, surface tillage with preservation of stubble and the use of combine threshers and of early-maturing, rust-resistant varieties that were seeded early. In 1941 a cultural program based on trap strips, shallow tillage, rotation with immune or resistant crops and late seeding to escape infestation was established. In one area the infestation was reduced from 85% to 3% in one year. With insects of medical importance and, to some extent, agricultural and forestry importance, sanitation forms an integral part of many control programs.

Radiation.—A promising procedure in reducing populations of certain insect pests utilizes the sterilizing power of ionizing radiation. When rearing and treating techniques permit the production of insects in large numbers, sterile males with radiation-induced defects in sperm may be systematically released in numbers much greater than exist in nature. These males mate freely with native females but no progeny are produced. This process occurs more rapidly if the females by nature mate only once. The screwworm, which infests cattle, was eradicated in the southeastern United States by this method, and the technique is being tested on other insects such as the Mediterranean fruit fly, melon fly, oriental fruit fly, common malarial mosquito, boll weevil, oriental fruit moth and codling moth. Thorough knowledge of the biology of a pest is necessary before the chance of success can be determined.

In the laboratory it is possible to kill larval mosquitoes directly by high-frequency sound waves and to attract adult males to some form of trap by sound waves that simulate those produced by adult females. A more promising technique, however, is the use of sound to repel some insect species from field crops. As is well-known, bats use echolocation to find their insect food; some moths have evolved tympanal organs, or sound-sensitive receptors, that allow them to detect and avoid the sound-emitting bat. In one experiment a sound resembling that of a single bat was broadcast over experimental plots containing about 1,000 corn plants, and infestation by the European corn borer was reduced by 50% to 60%.

Transfer of Natural Enemies.—Most of the major pests of agricultural crops in North America have been imported accidentally and without their complement of natural enemies; once established, they often became more destructive than they were in their native range. In order to reduce many of these species to the level of abundance prevailing in their native environments, their natural enemies have been sought out, imported and released on that continent.

Imported enemies established in one area can be passively carried to other areas from which they might otherwise be barred by natural geographical barriers. Native pests may be spread into new areas by transportation facilities, or the distribution of a native species may be extended by the spread of crops to new areas. Their natural enemies may have to be artificially spread to provide a check on the pest populations. Occasionally native parasites become established on an imported pest. This and other natural methods, often collectively called biological control, employ living organisms as the control agents.

Until recently biological control relied largely on the use of parasites and predators. In the mid-1950s in the United States about 95 species of imported parasites and predators became established and about 390 failed to become established when used against about 77 species of pests. In addition, an attempt was made to extend the distribution of natural enemies already present or to increase their effectiveness by mass colonization or other means against another 14 species. Only a small portion of the important agricultural pests have been fully controlled by this method; most attempts have produced no measurable reduction of pest numbers. In Canada natural enemies were used against 11 crop and 36 forest pests; about one dozen pest species are considered to have been successfully controlled. Many other attempts have been partially successful in reducing crop damage.

Biological control has great potential for, when successful, it is self-perpetuating. With intensive research the use of natural enemies may become as predictable as the use of pesticides. The method is not without its complications, however. Introduction of a parasite for one pest may restrict the methods used to control another on the same host. In Kenya, for example, the coffee mealy bug, *Planococcus kenyae,* is well controlled by the parasite *Anagyrus kivuensis,* introduced from Uganda. The parasite is, however, very susceptible to the persistent insecticides (*e.g.,* DDT) that are used to control the bug *Antestiopsis lineaticollis* in the

same area. Resort must therefore be made to malathion or pyrethrum, which are of short persistence, rather less effectiveness and higher cost.

Microorganisms such as viruses, bacteria, fungi, protozoa and nematodes are important controlling agents in natural populations; some of these agents (*e.g., Bacillus* species) have been used with outstanding success in the control of insects of forest, turf and pasture. Moreover, they have the potential of being mass-produced in the laboratory and sprayed on field crops like an insecticide; they are usually harmless to man and plants; they are not affected by most insecticides; and they may greatly reduce pest numbers without seriously affecting the natural enemies.

Highly host-specific phytophagous insects have been used to solve some serious weed problems. Control of weeds refers not so much to the eradication of a pest plant as to the reduction of the species to an unimportant status. Insect enemies adversely affect the competitive ability of the pest plant so that other, more desirable vegetation becomes dominant. Weeds such as *Lantana* species, *Opuntia* species, St.-John's-wort, *Clidemia hirta*, and *Cordia macrostachya* have been reasonably controlled by introduction of certain plant-eating insects in various parts of the world.

Additional Methods.—Traps in various forms have long been used both to sample and to destroy pest populations. Some insects, attracted to particular odours, are drawn to traps to be killed by poisoned baits or merely to be collected and destroyed. Because males of some species are attracted from great distances to virgin females, sex attractants are being developed for use in such traps. The sowing of certain crops to receive, because of location or early appearance, the main oviposition of a pest species is a familiar agricultural practice.

The application of high frequency electric fields to the disinfestation of cereal products has had some success, but has not been developed extensively because insecticides and fumigants are readily available, highly effective and easy to apply. The manipulation of the environment through use of electropotential fields is just beginning to receive attention.

INTEGRATED CONTROL

The control of plant and animal pests has depended mainly on the use of pesticides because these products have been easy and economical to apply and have shown immediate, observable and highly satisfactory results initially. The widespread and persistant use of chemicals, however, has resulted in the development of a number of serious problems, which, with the advent of the synthetic contact insecticides have been greatly accentuated. The nonchemical methods of control have had spectacular successes in many individual instances but none of them has provided a general solution to the problem. Since chemical control is essential in many cases, it seems advisable to maximize its benefits and minimize its defects through carefully designed preventive programs combining pesticide application and biological control methods. This approach, called integrated control, has been receiving considerable attention as a promising means of maintaining pest populations at a level below which they are economically significant.

Requisites.—Integrated control depends on the fulfillment of several requirements. First, a detailed study of ecological relationships must be undertaken. Although only a few species are initially of economic importance in any given area, the entire complex or community of organisms, crop, weeds and environment is considered as a unit, because one species cannot be treated without affecting the others. It is therefore necessary to determine the species present in a community and something of the interactions between them. Since some natural enemies maintain their prey at low levels of abundance, whereas others are relatively ineffective, desirable relationships must be identified and fostered. Furthermore, since the interactions between species are greatly modified by environmental factors such as temperature, humidity, soil and crop, the resultant abundance of species will vary from one geographical area to another and to some extent from one year to another in the same area. Quantitative ecological surveys and analyses are constantly required.

Second, it is necessary to be able to predict the level of abundance at which economic injury will occur and to use repressive measures only when this level is approached. This level will vary with the species of pest, the crop attacked, the part of the plant attacked, and with cultural and environmental conditions. Control measures should be aimed only at reducing a pest population below economic levels; some pests must be allowed to survive to support a continuing population of natural enemies. When the permissible level of damage is very low, as in pome fruits (apple, pear, quince), control based on ecological principles is very difficult; but when higher levels of damage are acceptable, natural enemies may provide adequate protection and hence can be integrated with pesticide applications.

Third, pesticides should be as selective as possible, both from a physiological and ecological point of view. A pesticide is selective physiologically when it normally kills only certain broad groups of species. In Nova Scotia replacement of the mild sulfur fungicides by a fungicide such as ferbam re-established control of the oyster-shell scale because the latter pesticide was not detrimental to the scale insect's natural enemies. Stomach poisons or contact insecticides coated with materials that dissolve only when ingested are selective. Acaricides kill some mites but not insects. Microbial sprays, when effective, often attack individual species of insects. A given pesticide may be selective in only one situation or in one dosage; therefore the ecological conditions providing optimum effectiveness of pesticides must be determined.

Even the broad-spectrum pesticides can be used in a manner that makes them more selective. If possible damage by a widely-distributed pest is predicted in some areas, those areas only might be treated. The pest species and its accompanying natural enemies will be destroyed in the area treated, but, over-all, the parasite-predator complex will be maintained. If the natural enemies are mobile, they should be able to move into the treated areas and prevent flareback. A degree of selectivity can be achieved by applying pesticides at a time when beneficial insects are elsewhere, or are protected in some way, as a resistant stage or in a sheltered place.

The success of timing can be greatly accentuated through the proper use of pesticides with short residual action; many highly toxic phosphates can be used against a pest when beneficial biotic agents are in resistant stages such as eggs or pupae. Another aspect of timing depends on behavioural differences between pests and their enemies. If pests rest or congregate in limited areas for short times, these areas only might be treated at the appropriate time, and widespread application thus avoided. In some cases selectivity can be gained by lowering the dosage of a pesticide; at low dosages some insecticides are extremely effective on certain pests but are not detrimental to all the pests' natural enemies. Systemic insecticides absorbed by the plant and translocated to the leaves are effective only against plant feeders such as aphids, mites and thrips; as a rule they are not harmful to the parasites and predators of those pests. Some insecticides, especially systemics, can be mixed in the soil out of reach of many natural enemies. Baits, seed treatments and attractants also localize the distribution of poisons.

Fourth, the role of nonchemical methods of control, particularly the use of natural enemies, should be augmented as much as possible. While the efficiency of parasites and predators is determined to a large extent by climate, which cannot be manipulated, some aspects of herbivore-carnivore interaction can be made more significant by agricultural practices. Suitable host material may not be available throughout the year because of dry periods, for example, hence natural enemies may be greatly reduced. When conditions are favourable to the return of the pests, there is a significant time interval before the parasites and predators recover their numbers; during this period the pest population can expand uninhibited by natural enemies. Food for the natural enemies has been provided in some cases by planting alternative crops that support the pest or other hosts or prey; thus the supply of natural enemies is maintained and is available when needed. Adult parasites of many insect pests often require a feeding of nectar or pollen before they can oviposit; growing suitable flowering plants to supply these needs may increase their ability to re-

produce. Pollen is a substitute food of some predators; by providing this type of food the development of larval stages could be aided and dispersal of adults inhibited or directed. The provision of nesting sites also increases the density of beneficial predators such as birds and wasps.

In some instances the complexity of a community is deliberately increased on the assumption that greater complexity will result in greater stability of populations. As more and more plant feeders are incorporated into the system the number of generalized carnivores is greatly increased. If these carnivores migrate onto crop plants when they are infested with pests the predation of the pest population is greatly enhanced. Such complexity can be developed by sowing cover crops in orchards or maintaining hedgerows or other natural habitats within and bordering agricultural areas.

Deficiencies.—In spite of the great progress that has been made in developing integrated control programs, the approach has not been entirely satisfactory. One pest species may be difficult to control and so require a highly toxic broad-spectrum insecticide. In Nova Scotia the codling moth has one generation per year and can be controlled adequately by ryania, a relatively innocuous insecticide; but in other areas, with two or more generations per year, more toxic poisons are required. Natural enemies are not always available in sufficient numbers at the right times and are usually more effective in permanent rather than seasonal crops. Although a pest may be susceptible to low dosages of a highly selective insecticide, residues of this compound may be very dangerous to other organisms, including man, and therefore a more broadly toxic pesticide with shorter residual effects must be used. Integrated control often requires professional calibre supervision. And finally, integrated techniques are sometimes more costly than simple chemical control measures.

PROSPECT

It is impossible to tell what progress will be made in the development of highly specific pesticides. The number of pests in existence and the prohibitive cost of developing and producing a separate compound for each of them would seem to limit specificity to groups of arthropods. It is interesting to note in this connection that DDT was the first of the newer synthetic contact insecticides and yet it is still, in all probability, the most satisfactory pesticide when all aspects of its use are considered. Broad-spectrum pesticides are still required in some cases even though it is recognized that they represent a threat to the welfare of wildlife and possibly to man. In spite of detailed precautions in the applications of pesticides some side effects are to be expected. A course of moderation must be followed between the desired degree of control of pests and the deleterious effects that can be permitted on other organisms. The effects of chemicals on the whole ecosystem can only be assessed by the combined judgment of those interested in pest control, wildlife and human health.

The management of communities in the short term is concerned with quantitative variations in population densities of the numerous interacting species. This field of population ecology deals with the properties of and interactions between the species involved and how these interactions and properties are modified by geography, weather and, of course, pesticides. Inasmuch as each species has an enormous pool of genetic variability on which natural selection can act, there is a great amount of variation possible in the properties of species. The management of communities in the long term is concerned, therefore, with the qualitative changes in properties of species that control measures induce. It is important that control measures do not spawn super pests but leave us with populations that we can control. The top twelve inches of soil, and the plants that it supports, are our primary asset; this resource must be preserved at all costs.

See also the references under "Pest Control" in the Index.

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(T. BU.)

PETAH TIQVA (PETAH TIKVA, "the gate of hope"), a town in Israel 7 mi. N.E. of Tel Aviv-Jaffa. Pop. (1961) 52,771. Lying in the plain of Sharon, it is one of the oldest Jewish agricultural settlements, first planted in 1875 by Jews from Jerusalem, and in 1882 resettled by a pioneer group from Russia. The settlement was once famous for its orange groves but it was invaded by industry; it produces textiles, chemicals, asbestos, paper, furniture and processed foods. Citrus groves and vineyards still flourish along the nearby Yarkon (Yarqon or Auja) river. The municipal garden has been the settlement's centre since the foundation of the village. The town has many schools, particularly for the fundamentalist section of the Jewish population. A short distance northeast are the ruins of the ancient city of Antipatris. (No. B.)

PÉTAIN, (HENRI) PHILIPPE (1856–1951), French army officer, the marshal who was chief of state from 1940 to 1944, was born on April 24, 1856, at Cauchy-à-la-Tour in the Pas-de-Calais. He was trained as a professional soldier at Saint-Cyr and at the École de Guerre and filled the various staff posts until 1914. When World War I broke out he was already 58, had not served outside France and had known no active service. Yet, in conflict with the prevailing staff theories of the need to maintain the offensive at all costs, he had evolved views of his own about the value, in modern warfare, of defensive strategy provided that infantry were supported by the coordinated fire power of artillery. These were to prove correct once the war in France had become one of attrition.

Pétain was put in command first of an infantry brigade, then (on Oct. 25, 1914) of the XXXIII Army Corps in Artois. He distinguished himself during the offensive near Arras in May 1915, and in June was given command of the 2nd Army as a full-ranking general. In 1916, when the Germans opened the attack on Verdun, he was given the task of stopping it at all costs. He showed skill and energy in organizing, deploying, and supplying his forces, and although the operation cost France about 350,000 men he held Verdun. This made him a popular hero, and he was appointed chief of the general staff in April 1917 and commander in chief on May 15, to succeed Gen. R. G. Nivelle. The morale of the French troops had deteriorated, and it became his special task to stop mutiny. By a combination of repression and reform of grievances, he again succeeded, so that the French Army was ready to meet the final German offensive of 1918. After March 1918, with Ferdinand Foch as generalissimo to coordinate French, British, and United States forces, Pétain was in charge of the operations assigned to the French armies. He

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PHILIPPE PÉTAIN DURING WORLD WAR I

prepared the offensives of August and September and was responsible for pushing the Germans back to the Ardennes.

Pétain's achievements during World War I were, therefore, great: and between the wars, as the veteran "saviour of Verdun" and as a marshal of France (from Nov. 21, 1918), he came to be regarded as a high military authority. In 1920 Pétain was appointed vice-president of the Supreme War Council and in January 1922 he was also made inspector general of the army. After the signature of the Locarno treaties, France reduced its armed forces considerably and decided to construct along the Franco-German frontier a powerful system of fortifications called the Maginot Line. Successive governments and public opinion alike welcomed a policy designed to be thrifty with French lives in the event of another war. But on the Franco-Belgian frontier a more offensive strategy in case of German aggression was envisaged.

Pétain resigned his post on Jan. 1, 1931; but as minister of war in Gaston Doumergue's short-lived government (February–November 1934), he demanded and partly obtained some increase of defense expenditure in order to supply French forces with modern equipment.

During the period of Popular Front government in 1936, Pétain made no secret of his contempt for parliamentary institutions, of his antipathy to Socialist ideas, or of his preference for dictatorial regimes which brought strength and prestige to their countries. In March 1939 Premier Édouard Daladier appointed Pétain ambassador to Spain. When World War II broke out he was, at the age of 83, a natural focus of hopes for those who believed that the strong government needed for war might be used to overthrow the parliamentary regime of the Third Republic.

The rapid collapse of the French forces in 1940 was, in most respects, the consequence of the outdated principles on which they had been organized and of the lack of mechanized equipment needed to meet the superior weight and mobility of the German Army. In the moment of defeat, France turned to the veteran marshal, whose name still represented victory although his attitude had long been defeatist. In May the premier, Paul Reynaud, recalled him from Spain, and on June 16 Pres. Albert Lebrun asked him to form a new ministry. His task was, amid conditions of almost complete disorganization and military defeat, to make a speedy armistice with Germany. This he accomplished by June 22; and two days later he completed a similar convention with Italy. By the terms of these armistices his government was left in charge of the French fleet and colonies and was allowed to maintain an "armistice army" of not more than 100,000 men at home. France was divided into two zones: the northern part and the Atlantic coastline remained under German military occupation; the southern part and the Mediterranean coastline were under the direct administration of the French government. On July 10 the National Assembly, specially summoned at Vichy to ratify the terms of the armistices, granted Pétain emergency powers until a "new constitution" could be promulgated. (*See* FRANCE: *History*.) He made himself "chief of state," with Pierre Laval as his first premier.

From July 1940 until the liberation of France in 1944, Pétain served as chief of state for the governments of Vichy; but, in face of German restrictions, he did not promulgate a new constitution. He became the object of a cult and of much adulation. His aim was to keep France out of the war and to hold Germany as closely as possible to the terms of the armistice which, when Hitler failed to defeat Great Britain and became deeply engaged in the U.S.S.R., proved increasingly favourable to France. But this involved him in a certain amount of active collaboration with Germany, and after 1942 the pressure of German demands on French labour and supplies intensified. In February 1941 Adm. Jean Darlan replaced Laval as premier; but Laval returned to power in April 1942 and remained the real ruler at Vichy until it collapsed. It seems probable that because of senility and illness Pétain ceased to understand fully what was happening, and much was done in his name of which he was unaware. Yet, by remaining in office even after the ardent collaborationists assumed power at Vichy in January 1944, he became implicated in responsibility for their betrayals of French national interests. Pétain was arrested by the Germans on Aug. 20, 1944, and taken by them to Belfort and thence, in September, to Sigmaringen in Germany; but he voluntarily returned to France in April 1945. For his whole behaviour after 1940 he was put on trial by the provisional government under Gen. Charles de Gaulle and, on Aug. 15, 1945, a High Court of Justice, by 14 votes to 13, sentenced him to military degradation and death. The sentence was changed to life imprisonment. He was imprisoned first at Portalet, then on the Île d'Yeu in a fortress, whence, after prolonged illness, he was moved to a villa in Port-Joinville a month before his death. He died at Port-Joinville, Île d'Yeu, on July 23, 1951, an acutely controversial figure in French politics: while many regarded him as a traitor, others idolized him as a patriot who had "stood by a stricken France" and had sacrificed himself in its cause.

See also references under "Pétain, (Henri) Philippe" in the Index.

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PETALITE, a mineral species consisting of lithium aluminum silicate, is an important source of lithium (*q.v.*), the lightest metallic element. It was discovered in 1800 as cleavage masses in an iron mine on the island of Utö, near Stockholm, where it is associated with lepidolite and spodumene, also ores of lithium, and tourmaline. It is mined in Southern Rhodesia, in the trust territory of South West Africa, South Africa, and in Australia. In the United States it occurs in Maine, Massachusetts, and Wyoming.

The formula of petalite is $LiAl(Si_2O_5)_2$. In form, the monoclinic crystals approach spodumene (*q.v.*), which is also a lithium aluminum silicate with the formula $LiAl(SiO_3)_2$. There is a perfect cleavage parallel to the basal plane, and the mineral usually occurs in platy cleavage masses; because of this it was named from the Greek *petalon* ("a leaf"). The hardness is 6.5 and the specific gravity 2.4 (that of spodumene being 3.16). The mineral is colourless or occasionally reddish, varies from transparent to translucent, and has a vitreous lustre.

PETER, SAINT (SIMON PETER) (d. *c.* A.D. 64), the foremost of the 12 apostles chosen by Jesus Christ, a leader of the early church and traditionally the first bishop of Rome.

Peter in the New Testament.—Little is known of Simon Peter's life before he became a follower of Jesus. He came from Bethsaida in Galilee, a partially Greek-speaking area, which accounts for the fact that his name Simon is also found in the Hebrew form Simeon (Acts xv, 14 and II Pet. i, 1). That he is called "uneducated" (Acts iv, 13) may only mean that he lacked the formal education of a rabbi. He was married (Mark i, 30; *cf.* I Cor. ix, 5) and helping his father and his brother Andrew in a small fishing business at Capernaum on the Sea of Galilee when he first met Jesus.

His Call.—According to Matthew and Mark, Jesus at the beginning of his ministry called Peter and Andrew from their fishing to follow him, promising that he would make them fishers of men. Luke's account omits Andrew and precedes the event with a miraculous catch of fish. According to John, Peter came to Jesus through John the Baptist's movement: Andrew, a disciple of John, was directed by John to Jesus, to whom he then brought his brother, and Jesus gave him the name Cephas or Peter ("rock"). Mark and Luke, however, assign this appellation to the first mission of the 12 apostles, whereas Matthew places it later, at Caesarea Philippi, where Peter acknowledged Jesus as the Christ. This new name is closely associated with the leadership of Peter.

The Leading Disciple.—Peter occupied an outstanding place among the apostles (*see* APOSTLE). He is named first in all lists of the 12, he was the most frequent spokesman among them, and together with the brothers James and John he formed the "inner ring" that alone witnessed Jesus' raising of Jairus' daughter from

the dead, his transfiguration and his agony in the garden of Gethsemane before his arrest. The disciples are referred to as "Simon and those who were with him" (Mark i, 36; Luke ix, 45), and Jesus commanded Peter "strengthen your brethren" (Luke xxii, 32); the authenticity of this text as the genuine words of Jesus has been disputed, but it at least shows that the early church believed Peter to have held a unique place among the disciples. After Peter's confession at Caesarea Philippi, Christ called him the rock on which he would build his church and said that he would give him the keys of the kingdom of heaven (Matt. xvi, 17–19). The authenticity of this text also has been disputed, and it is discussed further below. The risen Christ's commission to Peter to shepherd his flock clearly gives Peter a position of leadership (John xxi, 15–19), though elsewhere in the Fourth Gospel the unidentified "beloved disciple" somewhat modifies Peter's pre-eminence. A further outstanding point is that Peter was the first to see the risen Christ (Luke xxiv, 34; I Cor., xv, 5), whom he had denied three times before the crucifixion.

The Early Church Leader.—After the ascension of Christ, Peter took the lead at once, as related in the Acts of the Apostles. He initiated the election of Matthias as the 12th apostle in place of the traitor Judas Iscariot, and after the descent of the Holy Spirit at Pentecost he interpreted this experience, "standing with the eleven," to the assembled Jews. He took the active part in healing a cripple at the gate of the Temple, his companion John being a mere lay figure. He was treated as leader of the group by the Sanhedrin, which imprisoned him and John, releasing them the next day with a caution. Peter pronounced sentence on the deceitful action of Ananias and Sapphira; with John he mediated the Holy Spirit to the converted Samaritans; and on the same occasion he rebuked Simon Magus for trying to buy spiritual gifts with money.

Peter traveled also to other parts, including Lydda (Lod) and Joppa, where he healed the sick. While at Joppa he was summoned to Caesarea by a Roman centurion called Cornelius who had been told by an angel in a vision to send for him. Peter meanwhile had also had a vision which included a command from heaven not to call common what God had cleansed. He immediately went to Caesarea, where he preached to Cornelius and those with him, and baptized them though they were gentiles. Peter was thus the first to admit gentiles as well as Jews to the church, an action which he afterward successfully defended before the apostles in Jerusalem.

Peter and Paul.—Although the historicity of Acts is disputed by some scholars, the substantial correctness of its information about Peter's position is borne out by the indisputable testimony of Paul's Epistle to the Galatians. Asserting his independence of human authority, Paul says that on his first visit to Jerusalem his chief purpose was to see Cephas, which shows that Peter was at that time the leader of the Jerusalem church. On the occasion of Paul's visit 13 or 14 years later, however, the position was rather different. Paul conferred with James (the brother of Jesus), Peter and John, three who "were reputed to be pillars" (Gal. ii, 9), and at the so-called apostolic council in Jerusalem James is again named first and takes charge, while Peter is the leader of the mission to the Jews, no doubt run mainly from Jerusalem.

Paul goes on to refer to another occasion in Antioch, a mixed community where the problem arose of Jewish and gentile Christians eating together. On a visit to Antioch Peter at first ate with the gentiles, but after the arrival of a delegation from James in Jerusalem he withdrew out of fear, thus drawing upon himself an outraged protest from Paul. Paul clearly did not recognize any authority of Peter over himself and his work and claimed the decision of the "pillars" as justifying his attitude.

The New Testament gives little later information about Peter. After being imprisoned by Herod and miraculously released "he departed and went to another place" (Acts xii, 17). The only further mention of him in Acts is at the Jerusalem council, where he supported the admission of gentiles to the church without circumcision (Acts xv, 7–11). He may have visited Corinth, where a party owed allegiance to him (I Cor. i, 12). For the two New Testament epistles ascribed to Peter, *see* PETER, EPISTLES OF SAINT.

Peter the Martyr.—That Peter was martyred is strongly suggested by the words addressed to him by Christ: "When you are old, you will stretch out your hands, and another will gird you and carry you where you do not wish to go" (John xxi, 18–19). I Pet. v, 1 may also hint at martyrdom, but II Pet. i, 14 is too late to count as independent testimony. If "Babylon" (I Pet. v, 13) is interpreted as referring to Rome, then the First Epistle of Peter was written in Rome.

The best evidence for the place, however, is in the First Epistle of Clement written in Rome *c.* 96: "Let us set before our eyes the good apostles: Peter, who because of unrighteous jealousy suffered not one or two but many trials, and thus having given his testimony went to the glorious place which was his due." This mention of Peter is placed just before a reference to Paul and the great multitude who "among us" suffered indignities and tortures and the "women persecuted as Danaids and Dircae." Paul was certainly martyred in Rome, and the others mentioned were martyred in the Neronian persecution. It is therefore very unnatural not to suppose that Clement is locating Peter's martyr death in Rome.

The tradition that Peter was in Rome is attested in other authors: Ignatius' epistle to the Romans implies that Peter, like Paul, held authority in the Roman church; the apocryphal Ascension of Isaiah refers to one of the 12 as being delivered into the hands of Beliar (*i.e.*, Nero, so Rome would be the place); the Roman episcopal lists make Peter the first bishop of the city; and Macarius of Magnesia quotes the Neoplatonist Porphyry as saying that Peter was crucified after shepherding the flock for a few months.

Perhaps the most interesting of the early evidence for Peter's stay in Rome is the information of Gaius, a Roman presbyter *c.* 200, quoted in Eusebius' church history: "I can point to the trophies of the apostles. If you go to the Vatican or to the Ostian road, you will find the trophies of those who founded this church." Eusebius apparently understood "trophies" as graves, though the meaning of the word is not entirely clear (but *see* below, *Shrines of Peter*).

In the 4th century St. Peter was commemorated with St. Paul on June 29, and the liturgy was celebrated in his honour not only at the Vatican shrine but also at a joint shrine for both apostles by a place called Catacumbas by the third milestone on the Appian way. The decline of the belief that relics of the apostle were located at this latter shrine caused the dedication of the church to pass to St. Sebastian (*see* below). The Roman calendar of 354 attaches the year 258 to this commemoration on June 29; possibly the year marks the foundation of the shrine on the Appian way. The reasons for the foundation remain obscure.

All this evidence taken together makes it highly probable that Peter did go to Rome and was martyred there. (Jo. Lo.)

Feast Days.—Peter and Paul are commemorated together on June 29, and Peter has other special feast days also. That of his episcopal throne (*cathedra*) is kept on Feb. 22, on which date was formerly celebrated his episcopal throne at Antioch, where he was traditionally bishop before he went to Rome. The festival of St. Peter in Chains on Aug. 1 is the dedication festival of the church in Rome of St. Peter in Chains (San Pietro in Carcere) reconstructed by Sixtus III. The commemoration of Peter's episcopal throne in Rome on Jan. 18 was abolished after 1960.

Apocryphal Material.—Various apocryphal documents dating from the 2nd century are attached to Peter's name. A "Preaching" (*Kerygma*), a "gospel" and an apocalypse have survived in fragments only. There is also the Acts of Peter, extant in fragments save for the part about his martyrdom, which contains the detail that his episcopate lasted 25 years, the legend (also mentioned by Origen) that he was crucified head downward, and the *Quo vadis* story. This relates that in time of persecution Peter was persuaded to save his life by flight, but on his way out of the city he met Jesus, whom he asked "Where are you going, Lord?" (*Quo vadis, domine?*); on receiving the answer "I am going to Rome to be crucified again" Peter instantly returned to Rome and was martyred. (X.)

Primacy of Peter.—Peter held a leading if not the leading

position among the apostles during the ministry of Jesus. He received the surname "Rock," was the first to see the risen Lord and was at any rate the *de facto* leader of the early Jerusalem church. The nature and extent of his leadership and its origin in a commission from Jesus Christ needs to be examined. When the Third and Fourth Gospels were written, it was believed that he had been entrusted by Jesus with the functions of strengthening the brethren (Luke xxii, 31–32) and leading the flock (John xxi, 15–17). But the latter passage, though good evidence for the mind of sections of the church at the turn of the 1st century, has little claim to be regarded as an authentic utterance of Jesus. The saying in Luke is more likely to be authentic, but its language is imprecise.

Peter's claim to primacy turns mainly on the authenticity and interpretation of the crucial passage Matt. xvi, 16–19: in answer to Peter's exclamation "You are the Christ, the Son of the living God" Jesus said:

"Blessed are you, Simon Bar-Jona! For flesh and blood has not revealed this to you, but my Father who is in heaven. And I tell you, you are Peter, and on this rock I will build my church, and the powers of death shall not prevail against it. I will give you the keys of the kingdom of heaven, and whatever you bind on earth shall be bound in heaven, and whatever you loose on earth shall be loosed in heaven."

Non-Roman Catholic scholars have tended to deny that this is a genuine saying of Jesus and to assert that it reflects certain local rivalries in the early church at the time when the Gospels were being compiled. The objections alleged against authenticity are the absence of the saying from the parallel passages in Mark and Luke, the use of the word *ecclesia* ("church") and the contention that the idea of building or founding a church formed no part of Jesus' teaching. The first objection has force against the context of the saying but none against its genuineness. Matthew's extra material would not fit well into the episode as related by Mark, but it is Matthew's regular practice to insert into a Markan context material derived from another source and this may very well be a piece of good tradition. The objection to the word *ecclesia* has much weakened since it has been shown that the idea of the church is thoroughly Old Testament. The early Christian community believed that it was the true continuation of the "people of God" or at any rate the true "remnant" thereof, and there is no reason why Jesus, who certainly formed a community, should not have thought and spoken in this way. He often speaks elsewhere of the "flock." The conception of founding a church is difficult only if one accepts the extreme view of Albert Schweitzer that Jesus contemplated the immediate consummation of the Kingdom of God. But on any view that allows for an intermediate period there is no serious problem, and even the language of building and the image of the rock are deeply rooted in Jewish tradition.

The genuineness of Matt. xvi, 18 may therefore be accepted even if it is not in its right context. There is a close parallel to it in John vi, 38. Both halves of the statement "You are Peter [Aramaic *Kepha;* Greek *Petros*], and on this rock [Aramaic *kepha;* Greek *petra*] I will build my church" certainly refer to Peter. On this point the Roman Catholic exegetes are right, and Protestant reluctance to admit it has been due to fear that the whole Roman position would be conceded with this one point. Against this church of which Peter is the foundation rock the powers of death (literally, the gates of Hades) will not prevail. The church thus shares in Christ's conquest of death, the apostles being primarily witnesses of the resurrection and Peter first among them as such. The metaphor of the keys (symbol of the power of administrator of the household) indicates the authority to give a judgment of acquittal or condemnation which will be valid in the kingdom of heaven.

On the other hand, the belief of the Roman Catholic Church that the authority given to Peter is continued in and confined to the bishops of Rome is nowhere stated in or implied by the New Testament. That conclusion requires the assumption that Jesus meant the church to have a visible centre concentrated in one place and one person. Starting from that presupposition one can find this centre of unity in Rome. But one cannot find it in the New Testament or the apostolic church. In fact the citation of Matt. xvi, 18–19 in the interest of Roman claims is not found until the beginning of the 3rd century (*see* also PAPACY: *The Schism of Hippolytus.*) (Jo. Lo.)

Shrines of Peter.—The earliest recoverable liturgical tradition, established at least as early as the middle of the 4th century A.D., associates St. Peter with two specific sites in Rome: the Vatican hill and, in association with St. Paul, the still-surviving church of St. Sebastian beside the Appian way. The literary record is in detail corrupt and full of obscurities, but in both cases the fact of an association of some sort has been established beyond dispute by excavation.

St. Sebastian's.—The church of St. Sebastian, founded by Constantine I and originally known as the Basilica of the Apostles (*i.e.*, of Peter and Paul), was built over the remains of a Roman cemetery of the imperial age. Within this cemetery three successive phases can be distinguished: a series of burials in an abandoned pozzolana quarry, some of them as early as the 1st century A.D.; a formally constituted funerary area incorporating the remains of this early cemetery and including a group of typical 2nd- and early 3rd-century mausoleums; and, built over the filled-in remains of both earlier phases, a funerary precinct of the second half of the 3rd century, comprising a mausoleum and several dependencies, on the walls of which (the so-called *triclia*) were found numerous *graffiti* recording the partaking of funerary banquets (*refrigeria*) in honour of SS. Peter and Paul.

The *triclia*, which was certainly built after A.D. 239, was itself replaced early in the 4th century by Constantine's church, and the tradition of an association with the two apostles was not only reaffirmed in the dedication but was also placed explicitly on record by Pope Damasus (366–384) in a metrical inscription in which he recorded that Peter and Paul had "dwelt" there, though whether in life or after death he unfortunately did not make clear. The later tradition that their bodies had lain there for a time immediately after their martyrdom may well have no more substantial basis than the obscurities of Damasus' text; certainly attempts to find confirmation of it in the archaeological evidence carry no conviction.

More plausible is the theory, based on a 4th-century record of the establishment of a joint cult of SS. Peter and Paul in 258, that the 3rd-century mausoleum was that of a well-to-do Christian and that the remains of the apostles were translated to it for safety during the great persecution of Valerian. Another suggestion, based on the absence of the name of Pope Cornelius from the document that records its institution, is that this was a schismatic, Novatianist shrine, established in rivalry to the official cult places on the Vatican hill and beside the Ostian way. There can be no certainty. In either case it is clear that after the so-called Edict of Milan, which legitimized Christianity, the significance of the association with Peter and Paul dwindled, and the dedication of the Constantinian basilica passed in time to St. Sebastian, whose body lay in the adjoining catacomb.

The Vatican.—The archaeological antecedents of the great church of St. Peter's built by Constantine I on the Vatican hill are no less complex. That in building it he believed himself to be honouring the actual grave of the apostle is proved by the formidable difficulties, both moral and physical, which he was prepared to face in order to build it where he did, terraced out from a steep hillside and obliterating a large and predominantly pagan cemetery that was still in active use. Excavation, while refuting the long-held belief that the southern half of the church rested on the substructures of the circus of Gaius and Nero (the traditional scene of Peter's martyrdom), has shown that the circus was very close, just to the south of the church; it has shown also that the focal point of Constantine's basilica was a marble-encased shrine enclosing the remains of a structure that may confidently be identified as the "trophy" of Peter which Eusebius cites as having been a well-known Christian monument more than a century before.

It is uncertain whether this "trophy," a small tabernaclelike structure of superimposed niches rather awkwardly inserted into the outer wall of a 2nd-century mausoleum, marks the actual grave

of the apostle. It was not built before about A.D. 160, and whatever was contained within the lowest recess was long ago dispersed, probably in 846 by the Saracens. It is arguable that it was no more than a cenotaph, erected by the early church to commemorate Peter's martyrdom nearby. There are, however, substantial arguments in favour of its having marked an actual grave. The mausoleums of the 2nd-century cemetery replace and have largely obliterated a number of earlier roadside graves, some of them as early as the reign of Nero; the builders of the trophy went to great pains to build it at a particular place and on a particular alignment, as if determined to mark the location of some very precisely defined object; and there are structural features of the trophy itself and of the wall into which it is built which suggest that this object may well have been a body. Whether the human bones (said to be part of the skeleton of an elderly man of robust physique) that were found within an arched-up recess in the foundations directly below the trophy came from such a grave cannot be determined. (*See* also VATICAN, THE: *History*.)

The archaeological evidence may be summarized as follows: It has not been proved that this was the site of Peter's grave. On the other hand it has been proved that since about the year 160 this spot has been the object of continuous veneration, a veneration which early hardened into a firm conviction that this was in fact the burial place of the apostle. It has moreover been shown that the surviving features of the 2nd-century shrine are consistent with, and in several respects most readily explained by, the hypothesis that it marks the site of an actual burial, which was disturbed by the builders of the adjoining mausoleum and which the contemporary Christian community rightly or wrongly identified as that of Peter. Whether, a century after Peter's death, they had good grounds for their belief cannot be decided; but that the shrine which they erected became the centrepiece of Constantine's basilica and that, situated directly beneath the high altar of the present church, it has remained the subject of continuous veneration for more than 18 centuries is a demonstrable historical fact. *See* also APOSTLE. (J. B. W.-P.)

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PETER, SAINT, OF ALCÁNTARA (1499–1562), Spanish Franciscan mystic, who devoted himself to the fostering of a severe form of Franciscan life, was born at Alcántara on the Tagus in the region of Extremadura. His father was Peter Garavito, a jurist, and his mother was Maria de Sanabria, both members of famous noble families. When he was 14 years old, Peter was sent to Salamanca to study philosophy and returned home at 16 to enter the Franciscan order. He was ordained a priest in 1524. Peter's efforts as a friar emphasized the penitential aspects of the life of St. Francis of Assisi rather than the other virtues of the saint. To carry out his desires, he wrote special instructions for those who wished to join him and founded convents, such as that of Pedrosa, unique for their isolation and discomfort, in Spain and Portugal. Later these friars, who came to be known as the Discalced or Alcantarine Friars Minor, spread to Italy, Germany and France. Peter carried on a spirited correspondence with St. Francis Borgia, St. Louis of Granada, Blessed John of Ávila, and, in particular, St. Teresa of Ávila, whom he aided in her reform of the Carmelites and whose autobiography remains one of the best sources concerning his life and spirituality. Peter is also the author of a treatise on prayer which has been translated into all the languages of Europe (English 1926). He died at Arenas near Avila on Oct. 18, 1562, and was canonized in 1669; his feast day is Oct. 19. (A. S. TR.)

PETER I THE GREAT (1672–1725), tsar of Russia from 1682 and emperor from 1721, was born in Moscow on June 9 (new style; May 30, old style), 1672, the son of Tsar Alexis by his second wife, Natalia Kirillovna Naryshkina. On the death of his elder half brother, Tsar Fedor III Alekseevich, in 1682, Peter was first acclaimed tsar; but after a *coup d'état* by the household troops (*streltsy*; *q.v.*) he was reduced to the position of co-ruler with his half brother Ivan V under the regency of the latter's sister Sophia (*qq.v.*). Though he and Ivan were crowned on July 5 (N.S.; June 25, O.S.), 1682, the sanguinary character of the *coup* affected him profoundly and left him with a traumatic hatred of the *streltsy*. Living at Preobrazhenskoye, near Moscow, he was able to enjoy greater freedom than would have been allowed him in the Kremlin. He did not shine in the schoolroom but excelled in outdoor activities. In 1689 he married Evdokiya (Eudoxia) Fedorovna Lopukhina and, through François Lefort (a Swiss soldier of fortune), came under the influence of the foreign quarter, a miniature replica of western Europe in Moscow. About this time, he became interested in sailing and shipbuilding. He played no active part in the coup carried out in his name in August 1689, whereby his tutor B. A. Golitsyn (*q.v.*) secured the deposition of Sophia. Ivan accepted Peter's supremacy, and Peter's interest in military affairs grew more and more professional between the time of his mother's death in 1694 and that of Ivan, which took place in 1696.

In 1695, when operations against the Turks were resumed at the request of Russia's Austrian, Polish, and Venetian allies, Peter laid siege to Azov, and captured it in 1696. In March 1697 he set out on a grand tour of western Europe to learn shipbuilding and to discuss unofficially further action against the Turks. After visiting Prussia, Holland, and England, he cut short his stay in Vienna on hearing of a new revolt of the *streltsy*. In June 1698, on his way home, at Rawa, he met Augustus II, king of Poland and elector of Saxony, with whom, in view of the Holy Roman emperor Leopold I's desire for peace with the Turks, he laid plans for an attack on Sweden's overseas possessions (*see* PATKUL, JOHANN REINHOLD). In Moscow, the rising having already been suppressed, he interrogated the *streltsy* and probably took a hand in the subsequent mass executions; on his orders the corpses of the rebels were hung outside the convent to which he had confined Sophia. Also in 1698, Peter, in conformity with Western usage, ordered his courtiers and ministers to shave off their beards, by tradition always left uncut; at the end of 1699 he reformed the calendar, fixing New Year's Day at Jan. 1; and in 1700 he ordered the town population to wear Western dress.

Peter's treaty of alliance with Augustus II had been signed on Nov. 21, 1699, completing the anti-Swedish coalition which was to begin the Northern War (*q.v.*); and in August 1700, immediately upon receiving the news of peace with Turkey, Peter attacked the Swedes in Livonia. After the Russian defeat at Narva (November 1700) he devoted most of his time to the conduct of the war, returning to Moscow each Christmas to attend to the most pressing domestic problems. Only from 1709 was he able to give these matters an increasing share of his time.

Early in 1710 Peter was occupied in St. Petersburg with the preparations for the wedding of his niece Anna Ivanovna to Frederick William, duke of Courland. This was the first of four important dynastic alliances arranged by Peter; the second was the marriage of his son Alexis (*q.v.*) to Sophia Charlotte of Brunswick-Wolfenbüttel in 1711; the third was that of his favourite niece, Catherine Ivanovna, to Charles Leopold, duke of Mecklenburg, in 1716; and the fourth was that of his daughter Anna Petrovna to Frederick Charles, duke of Holstein-Gottorp, in 1725. His own marriage to a Lithuanian maidservant, Marfa Skavronskaya (*see* CATHERINE I, empress of Russia), with whom he had been living from 1702, took place in February 1712.

Peter's plan to raise the Balkan Christians against the sultan involved him in war with Turkey in 1711 (*see* RUSSO-TURKISH WARS); before setting out on the ill-starred campaign, he established the senate as his collective deputy. In June 1712 he left Russia for nearly a year, spent mostly in the field in Pomerania and at conference tables in northern Europe. Also in 1712 he

transferred his family to St. Petersburg, founded by him in 1703. In 1714 he directed the naval operation at Hangö (Hanko), where the movements of the fleet under F. M. Apraksin (*q.v.*) were synchronized with the progress of the army against the Swedes on land. Early in 1716, he again went abroad for nearly two years. In June he joined a Russian squadron of galleys which put into Copenhagen in July in preparation for the abortive landing of the allies against the Swedes in Scania. October saw him in Mecklenburg and Havelberg, November in Hamburg, March 1717 in France, July in Amsterdam. In October 1717 he was back in St. Petersburg, ready to deal with his refractory son Alexis, who died in the SS. Peter and Paul fortress in July 1718 (*see* ALEXIS). In autumn 1721, he celebrated the Russo-Swedish Peace of Nystad in St. Petersburg and in Moscow with banquets, pageants, and fireworks; and on November 2 (N.S.; Oct. 22, O.S.) he assumed the title of emperor (*imperator*) of all the Russias. In the summer of 1722 he conducted an expedition against the Persians, which led to the conquest of Derbent in Dagestan and Baku in Azerbaijan.

Since childhood Peter had suffered from epileptic convulsions. In May 1724, already ill with strangury and stone, he attended his second wife's coronation in Moscow. At the end of the year, he ordered the execution of William Mons, ostensibly for peculation, in fact on suspicion of misconduct with Catherine. Peter died in St. Petersburg on Feb. 8 (N.S.; Jan. 28, O.S.), 1725, after catching cold while helping to rescue the crew of a stranded sloop.

BY COURTESY OF THE HERMITAGE LENINGRAD

BRONZE BUST OF PETER I CAST BY CARLO RASTRELLI THE ELDER IN 1723. IN THE HERMITAGE, LENINGRAD

Foreign and Military Policy.—Peter embroiled Russia in the Northern War without adequate preparation. It seems that his imagination was inflamed by the prospect of capturing the trade between East and West. An ice-free port on the Baltic would be the natural terminus of the two shortest possible trade routes leading across Russia, one from China by way of the "lakes and rivers of Siberia," the other from India, up the Indus, down the Oxus (the modern Amu-Darya, mistakenly assumed to fall into the Caspian), and up the Volga from Astrakhan. That this dream was not forgotten, even in the turmoil of the Northern War, is shown by the expeditions sent out by Peter. One went in 1715 to explore the region between the shore of the Caspian and Persia, another, in 1717, to Khiva to search for the waterway to India. There was also the expedition to the Central Asian steppes between 1714 and 1722; and finally in 1724 V. J. Bering was dispatched to investigate whether Asia and America were joined together at Kamchatka.

Though the siege and naval bombardment of Azov ended in its capture and the establishment of the fortress of Taganrog, the result was small in proportion to the outlay in men, money, and material and made Peter realize that Russia had much to learn about war (this was the principal reason for his journey to the west). On the other hand, by striking at Azov, Peter had both leaped ahead of the southward progress of the Russian frontier and made a breach in Turkey's defenses in the spot most accessible to him. But Azov was worthless so long as the outlet to the Black Sea was barred by the Turks. In trying to gain access to the Black Sea by pressing along the Prut and the Danube in the guise of deliverer of the Balkan Christians, Peter, assuming the mantle that the Polish king John III Sobieski had cut out for himself, pointed the way to the Balkans for his successors.

When, once Peter had failed to reduce Narva, it became clear that wresting Ingria from Sweden would not be a walkover, he devoted all his energies to saving a desperate situation. A capable pupil of the Swedes on land and of the British and Dutch on the sea, he completely reshaped Russia's army and created its navy. In addition to directing the strategy of the war Peter exercised personal control over recruiting, training, organization, and tactics. He was a pioneer of the modern recruiting system. From 1710 men were conscripted periodically from among the petty townsfolk and the peasantry, usually one out of 20 in a particular age group, for 25-year service in the army and the navy. In the preceding decade the infantrymen were issued flintlock muskets, basic units were reduced to a more manageable size, the proportion of cavalry was cut down to 38% of the total effectives, including the new dragoon regiments armed with muskets and capable of fighting on foot. The movements of the infantry formations in battle were made more varied and flexible; the cavalry was trained to charge at a gallop using sidearms. In 1707 the Russian cavalry under Prince A. D. Menshikov, deployed across Poland, successfully harassed the Swedes.

The strategic plan worked out by the war council and approved in 1707 by Peter consisted in fighting a limited war, withdrawing before the Swedish army while depriving it of supplies, and cutting its communications until circumstances became favourable for a decisive engagement. This came about in the Battle of Poltava, fought on July 8 (N.S.; June 27, O.S.), 1709. This battle, as well as the Northern War as a whole, the Russians won by their own exertions, and not, as is sometimes asserted, because of the mistakes made by the Swedes. Peter was in command only of an infantry battalion at Poltava, but the tactics devised by him, notably the use that he made of the redoubts, were later to receive high praise from the French marshal Maurice de Saxe.

In his conduct of the Turkish campaign of 1711 Peter was less skilful and less fortunate. The strategic plan was sound in theory but the organization proved deficient and the infantry showed itself incapable of repelling the onslaughts of the Turkish cavalry. On the Baltic, Peter's efforts to make seamen of the Russians and Russia a naval power were rewarded with success. Though Russian ships of the line did not fight any decisive naval battle, they gave indispensable support to the Russian galleys; *e.g.*, at the doubling of Hangö in 1714, after which the Russians were able to establish a base in the Åland Islands. Galleys were also used for the landings in central Sweden in 1719 and 1721 and as troop transports on the Caspian in the Persian War of 1722.

War was Peter's element and his favourite method of achieving his aims, but he recognized the value of diplomacy as its essential adjunct. He transformed the archaic ambassadorial office into a ministry of foreign affairs, an efficient instrument of policy consisting of such able advisers and negotiators as F. A. Golovin, G. I. Golovkin, B. I. Kurakin, A. I. Osterman (*qq.v.*), Y. V. Bruce (of Scots origin), and P. P. Shafirov. When faced with war on two fronts at the time of the Prut expedition he could fall back safely on this second line of defense. In the art of diplomatic deception, in making promises without meaning to keep them, for instance when he undertook to hand over Livonia to Augustus II, Peter was the equal of his rivals.

In the early phases of the Northern War the prestige of Russia was low and Russian diplomats were snubbed or ignored when offering or asking for good offices. After Poltava the situation changed radically, and within less than a decade Russia was recognized as a great power and Peter's descendants were considered worthy marriage partners for Western princelings. The appearance of 30,000 Russian troops in Mecklenburg in 1716 was the consequence of the marriage of Catherine Ivanovna. Likewise the agreements concluded in 1715 with Prussia and Hanover and supporting the claims of both these countries on the Baltic against Sweden were evidence of Russia's newfound strength.

Yet to some extent Peter's success defeated itself. Even his allies begrudged him Riga and suspected him of harbouring designs to extend his dominion along the entire eastern and southern Baltic coast from Finland to Denmark. In 1717, anxious to relieve Russia of an intolerable strain by ending the war with Sweden, Peter again resorted to diplomacy but failed in a personal effort to persuade France to reverse alliances by dropping Sweden for Russia. The Treaty of Amsterdam concluded with France in

August 1717 (to which Prussia was also a party) provided for French mediation and for the nonrenewal of France's subsidy treaty with Sweden. Peter had hoped for more and was considered to have suffered a diplomatic defeat; but even before the treaty was signed he was already in touch with Charles XII's diplomatic adviser, G. H. von Görtz, with a view to starting secret peace negotiations with Sweden. Though he antagonized George I of Great Britain by intriguing with the Jacobites, Peter skilfully exploited dissension in Sweden and in Poland, where he made common cause with Prussia over the question of the religious dissenters while preserving for himself the function of supreme arbiter in Polish domestic affairs.

Internal Policy.—The reforms of Peter the Great were a necessity imposed by the Northern War. Thus it came about that he had to perform the task of more than one monarch and generation, to prepare for war and to wage it at the same time. In the process he exhausted Russia and himself. The reform measures bear the stamp of his character: they were essentially practical, often experimental.

Peter insisted on each individual's serving the state to the best of his ability, with his person or his purse, as "money is the life-blood of war" and men, presumably, were its sinews. The civic chamber set up in 1699 was first offered to the townspeople as a form of self-government in exchange for doubling their tax liabilities. The division of the country into ten vast provinces in 1708–10 was conceived as a simplified means of tax-gathering. Each governor collected his portion and sent it directly to the department for which it was designated: the army, the navy, artillery, foreign affairs, etc. In a desperate effort to find the necessary funds, imposts, ingeniously devised by Peter's "profit-makers," were heaped upon every conceivable object; monopolies were established, commercial rights assumed by the state and leased to concessionaires; and the currency was debased.

Only after 1709 was Peter able to turn to more permanent and reliable methods of financing war. As the existing administrative organization was being bypassed, it fell into disuse and nothing was put into its place until in 1711 the senate was created to coordinate the work of the governors, the first phase in the creation of a new machinery of government. A census of the population was ordered in 1710 to provide a realistic basis for the collection of the tax on homesteads, but as it produced statistics far short of expectation, its results were ignored. Only the next census, carried out between 1717 and 1724, enabled Peter to impose a poll tax on all male peasants and petty townsmen. In Peter's last year this scarcely yielded enough revenue to cover the cost of the army and part of the navy. The poll tax was a great social leveler: for administrative convenience it fused various categories of peasants and semiurban vagrants into one vast class of serfs subjected to the local landowner who collected their tax, issued their identity cards (thus controlling their movements), and chastised them with the knout.

In addition to ready money for current expenditure, Peter had to find capital for investment in industry, the supply base of his armed forces. The class that provided capital was too small in Russia and was no doubt suspicious of the unpredictable ways of autocracy. Peter's persistent coaxing of private enterprise had little effect: it did not produce a Russian bourgeoisie any more than did the municipal law of 1721 granting a large measure of self-government to the guilds under the supervision of a chief magistrature. Characteristically, Peter demanded from the municipal magistrates unquestioning obedience alongside of initiative and self-reliance. While the primary object of the law of individual inheritance of 1714 was to prevent the fragmentation of estates, its subsidiary aim, which was to direct the disinherited sons into trade and professions after an initial period of state service, remained without practical consequences for the formation of a middle class. Its only immediate effect was the disappearance of the distinction between feudal estates and allodial or absolutely owned estates: henceforth both were the property of members of a single though not uniform class. Also in 1714 Peter replaced the periodic musters of the gentry by registration with the senate, where from 1722 all records of service were kept up to date by the chief herald. At the same time all defaulters were outlawed. Service was compulsory and began in the classroom: all adolescent nobles had to master the three R's, at one point under pain of not being allowed to marry. Promotion had to be earned by service in the ranks of the guards (including the Life Dragoons created specially for the sons of the old aristocracy) or, by those not born high enough, in other regiments.

Whereas the abolition of genealogical seniority among the boyars in 1682 under Fedor III (*see* BOYAR) had removed the bolts and bars from the door leading to the uppermost stratum of Russian society, Peter flung the door wide open to able men of obscure social origins; but once the emergency was over he slammed it behind them. In 1722 the whole of the privileged class, including the upstarts who had risen to high official positions, was organized into a hierarchy of three categories with 14 parallel grades, military, court, and civil, the status of those placed in the eight upper grades being hereditary. All promotion was by merit, and in theory all men who had proved their worth in the army, the civil service, and even in the magistracies qualified for admission to the privileged class.

Peter brought autocracy up-to-date by equipping it with an army and a bureaucracy and by putting in the place of its mystical aura the *raison d'état*—a development best illustrated by the case of his son Alexis. In one respect he carried it to new and extreme limits: in 1722 he took powers to appoint his own successor. But as Peter was physically unable to exercise the new prerogative in the hour of his death, it was arrogated by Menshikov, aided by the guards; and the latter exercised it again and again for the rest of the century. The guards, in fact, were in the van of the new class. Behind them, where the state servants and the boyars had been, stood a military and bureaucratic class separated from the mass of the people by a vast gap dotted with a mere nucleus of a middle class, productive of wealth but not of ideas. Together they made up a structure not far removed in its social polarity from that of Prussia or of Austria.

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PETER II (1715–1730), emperor of Russia from 1727, was born on Oct. 23 (new style; 12, old style), 1715, the only son of the tsarevich Alexis (Aleksei Petrovich) and Sophia Charlotte of Brunswick-Wolfenbüttel. His mother died after giving birth to him; his father was put to death in 1718; and thenceforward the orphan was kept in the strictest seclusion. On May 18 (N.S.; 7, O.S.), 1727, however, according to the terms of the supposed last will of the empress Catherine I, he was proclaimed sovereign autocrat. His education was entrusted to the vice-chancellor A. I. Osterman. Prince A. D. Menshikov (*q.v.*), who lodged Peter II in his own palace on Vasilevski Island, had intended to marry him to his daughter Maria; but the scheme was frustrated by Menshikov's fall from power in September 1727. Peter then became a tool of the Dolgoruki family, who carried him away from St. Petersburg to Moscow. Crowned in Moscow on March 6 (N.S.; Feb. 24, O.S.), 1728, the young emperor was encouraged to indulge in thoughtless pleasures. He was betrothed to Catherine, a daughter of Aleksei Dolgoruki, but died of smallpox on the day fixed for the wedding, Jan. 29 (N.S.; 18, O.S.), 1730.

See K. Waliszewski, *L'Héritage de Pierre le Grand* . . . (1900).

PETER III (1728–1762), emperor of Russia during the first half of 1762, was born at Kiel in Holstein-Gottorp on Feb. 21, 1728, the only son of Charles Frederick, duke of Holstein-Gottorp, and of Anna, eldest surviving daughter of the Russian emperor Peter the Great. In December 1741 he was designated as successor by his mother's sister the empress Elizabeth, as soon as she was established on the Russian throne. On Nov. 18 (new style; 7, old style), 1742, he was received into the Orthodox Church, exchanging his original name of Karl Ulrich Peter for that of Peter Fedorovich and being proclaimed heir to the Russian throne. On Aug. 21 (N. S.), 1745, by order of the empress Elizabeth, he was married, in St. Petersburg, to Sophia Augusta Frederica of Anhalt-Zerbst, who took the name of Catherine Alekseevna (*see* CATHERINE II the

Great). He was physically less than a man and mentally little more than a child; she was of prodigious intellect and insatiable appetite for pleasure.

Having succeeded Elizabeth on Jan. 5, 1762 (N.S.; Dec. 25, 1761, O.S.), Peter not only expressed his intention to divorce Catherine but also displayed in ever increasing measure the oddest moods, arousing by his tactless folly the contempt of the court camarilla and of the clergy. Even his manifesto of March 1 (N.S.), 1762, which relieved the gentry of compulsory military service, did not mitigate hostile feelings.

Peter abruptly reversed Elizabeth's policy with regard to Russia's participation in the Seven Years' War (*q.v.*). He had not been on the throne for two months when he made pacific overtures to the king of Prussia, Frederick the Great, to whom he habitually alluded as "the king my master." His worship of Frederick resulted in a peace and then in an offensive and defensive alliance between Russia and Prussia; and all the territory won from Prussia by Russia during the preceding five years was restored to Frederick. A series of menacing rescripts were then addressed to Vienna, in which Peter threatened war unless Austria instantly complied with all Frederick's demands. Finally he quarreled with Denmark, and the Russian army received orders to invade Denmark by way of Mecklenburg. Before the actual collision took place, however, the army received news of the *coup d'état* by which Catherine succeeded to the Russian throne in her husband's place.

Peter, who had abdicated on July 10 (N.S.), 1762, was taken into custody at Ropsha, near St. Petersburg. A few days later, on July 17 (N.S.; 6, O.S.), he was killed in a brawl, through the connivance of his custodian, Aleksei G. Orlov, and other officers.

See R. N. Bain, *Peter III* . . . (1902).

PETER (PEDRO), the name of four kings of Aragon.

PETER I (1068–1104), king from June 1094 in succession to his father Sancho V Ramirez, conquered Huesca (1096) and Barbastro (1100) from the Moors of Saragossa (Zaragoza). He was twice married but left no children and was succeeded by his brother Alfonso I.

PETER II (1174–1213), king from April 1196, was the eldest son and successor of Alfonso II. He was an impulsive and brave warrior, but vain and incautious. He married (1204) Mary, lady of Montpellier, and thus greatly extended Aragonese power in southern France. Despite the violent objections of his subjects, he had himself crowned by Pope Innocent III in Rome and declared his kingdom a feudatory of the Holy See (1204). Peter, with other Spanish kings, took a prominent part in the victory over the Moors at Las Navas de Tolosa (July 16, 1212); but he then went to support his brother-in-law Raymond VI of Toulouse against the crusader Simon de Montfort in Languedoc. There he was killed in the Battle of Muret on Sept. 12, 1213. His son James I succeeded him.

PETER III the Great (1239–1285) became king in July 1276, on the death of his father, James I. In 1262 he had married Constance, heiress of Manfred, the Hohenstaufen king of Sicily; and after the revolt of the Sicilians in 1282 he invaded the island and was proclaimed king at Palermo, despite strong Guelph and papal opposition (*see* VESPERS, SICILIAN). His Sicilian enterprise was unpopular in Aragon, where an association of nobles and some municipalities, the Unión Aragonesa, forced him to grant a privilege not only confirming the Aragonese *fueros* but diminishing some of the crown's rights. In 1285 Philip III of France invaded Aragon to dethrone Peter, but was disastrously defeated. Peter, however, died in November 1285. His great stature and physical strength were famous. Among his children were Alfonso III of Aragon, James I of Sicily (II of Aragon), and Frederick III of Sicily.

PETER IV the Ceremonious (1319–1387) was born at Balaguer, the son of Alfonso IV, whom he succeeded in January 1336. He was the most cultivated of Spanish 14th-century kings. He was also an inveterate political intriguer whose ability to dissemble was notorious. Through his voluminous correspondence, the workings of his mind are far better known than those of any contemporary Spanish ruler. Having picked a quarrel with James III of Majorca, he reincorporated the possessions of the Majorcan crown, namely the Balearic Islands and Roussillon, by force into his own dominions (1343–44). He next crushed the long-standing pretensions of the Aragonese nobles by defeating the armies of the Unión Aragonesa at Epila (1348), thereafter displaying the extreme vindictiveness that he always showed when his authority was challenged. Peter had to contend with revolt in Sardinia throughout his reign; but he succeeded, by political and military means, in preparing the future reunion of Sicily to the Aragonese crown and was recognized by the Catalan Almogávares as duke of Athens and Neopatras in 1380.

The chief event of his reign, however, was the intermittent war (1356–66) against Pedro I of Castile. Urged on by France, and by his own ambitions, Peter underwrote Henry of Trastamara's claims to the Castilian throne in exchange for a promised cession of one-sixth of Castile. The war was disastrous to Aragon, which was saved only by the intervention of the mercenary companies brought from France by Bertrand du Guesclin. Henry of Trastamara failed to honour any of his promises to Peter, and after 1369 Charles V of France took no trouble to conceal that he preferred his alliance with Castile to that with Aragon. As a result, Peter now pursued a complicatedly neutral approach to the Hundred Years' War, with some bias in favour of the English. His last years were clouded by a quarrel with his heir, the future John I, who in 1380 married Yolande of Bar instead of the Sicilian heiress chosen for him by Peter and who then let himself become the tool of French intrigues against Aragonese neutrality.

Peter IV died in Barcelona on Jan. 5, 1387. He had been married four times. (P. E. R.)

PETER, king of Castile: *see* PEDRO the Cruel, king of Castile.

PETER, kings of Portugal: *see* PEDRO.

PETER I (1844–1921), king of Serbia from 1903 and of the Serbs, Croats, and Slovenes from 1918, was born in Belgrade on July 11 (new style; June 29, old style), 1844, the third son of Prince Alexander Karageorgevich and Princess Persida, née Nenadovich. He became heir after his elder brother Svetozar's death (1847) and was in Switzerland when his father abdicated (1858). Educated in France (at the Collège Sainte-Barbe in Paris, at Saint-Cyr and at the École Supérieure de Guerre in Metz), he was commissioned in 1867 as Lieut. Kara in the French Army. In the Franco-German War, he distinguished himself at Villersexel (Jan. 1, 1871), was awarded the Légion d'honneur and was taken prisoner by the Germans, but escaped by swimming the Loire. As Peter Mrkonich, he fought against the Turks during the Hercegovinian insurrection in 1875, but Austrian intervention compelled him to leave the insurgents' encampment in 1876. Later he went to Montenegro, where in 1883 he became an honorary senator; and on July 12 (N.S.), 1883, he married Zorka, first child of Prince Nicholas of Montenegro. When his wife died in 1890, he moved to Geneva.

On June 15 (N.S.; 2, O.S.), 1903, Peter was elected king of Serbia after the assassination of King Alexander, with whom the Obrenovich dynasty became extinct. Returning to Belgrade, he was sworn in and crowned on Sept. 21 (N.S.), 1904.

His lifelong experience, his liberal education, his study of John Stuart Mill's works (he had produced a Serbian translation of Mill's essay *On Liberty* in 1868), and his respect for constitutional traditions and parliamentary rules made Peter a strictly constitutional monarch, and he did much to promote the rapid political consolidation of Serbia after the upheaval of 1903. In poor health and advanced in years, Peter in June 1914 appointed his heir Alexander (*q.v.*) to be regent for him on the eve of World War I; but his stirring proclamations to his army and the visits that he paid to the trenches, notwithstanding his crippled condition, served to encourage the national resistance. He shared in the retreat across Albania (November–December 1915), being carried in a litter. At the end of the war he returned to liberated Belgrade and was proclaimed king of the Serbs, Croats, and Slovenes on Dec. 1, 1918. He died at Topchider, near Belgrade, on Aug. 16, 1921.

See R. Chambry, *Pierre Ier, roi de Serbie* (1917); M. M. Vukićević, *Kralj Petar od rodjenja do smrti* (1922). (K. ST. P.)

PETER, two *vladike* or prince-bishops of Montenegro.

PETER I (1747–1830), born at Njegosh, succeeded his uncle Sava

in 1782. He was consecrated bishop at Karlovci on the Danube, then in Hungarian territory, in 1784 and then visited Russia. He returned to face a crisis: the pasha of Scutari had invaded the country. Peter somehow united the Montenegrin clans, and the invader was repelled. In 1788 both Russia and Austria requested Peter to join them against the Turks, but the Montenegrins derived no advantage from the war. In the 1790s, however, a Serb migration from Hercegovina filled the gap between Montenegro and its habitual ally, Brda, east of the Zeta River. In 1796 the pasha of Scutari attacked again. Peter led his men in person, and the Turks were routed. The pasha was captured and beheaded (his embalmed head was kept at Cetinje). The union of Brda with Montenegro was formally established, and Peter embodied his peoples' customary laws in a simple code of procedure.

The Treaty of Pressburg (1805) transferred Dalmatia from Austria to Napoleonic France, but, with Russian help, the Montenegrins occupied the town and fjord of Kotor and advanced to Dubrovnik. Russia, however, made peace with Napoleon (1807) and accepted the French annexation of the Dalmatian coast. French rule lasted till 1813; and then, with British naval support, Peter's men again occupied the whole fjord of Kotor. On Oct. 29 delegates from the fjord solemnly accepted the rule of the *vladika;* for a year Kotor was the capital of Montenegro. Then the great powers ordered the restoration of the fjord to Austria and Peter had to return to Cetinje (February 1815).

Peter devoted his last years to attempts to end the vendettas which disrupted his people's life. He had little success, except in uniting the clans to repel the Turks (1819 and 1821) and in enhancing his reputation as "the great and good *vladika.*" He died at Cetinje on Oct. 30 (new style; 18, old style), 1830.

PETER II (1813–1851), Peter I's nephew, was born at Njegosh on Nov. 13 (N.S.; 1, O.S.), 1813, receiving the Christian name of Rado. Succeeding his uncle in 1830, he was consecrated in 1833 as Peter II. He is renowned as a ruler, as a warrior, and, especially, as a poet. His three principal poetical works are "The Ray of the Microcosm," "The False Tsar Stephen the Small," and "The Mountain Garland." Peter II was strong enough to transfer much of the power of the local chieftains to a senate of 12 leading chiefs meeting at Cetinje under his eye. Still more important was his abolition of the office of civil governor, long hereditary in the Radonich family and an obstacle to unity. He had a yearly subsidy from the Russian emperor Nicholas I and used it to start schools and to set up a printing press at Cetinje. His rule was marked by the usual epic conflicts with the Turks, and he even had some success in limiting the inter-clan feuds of his people. He died at Cetinje on Oct. 31 (N.S.; 19, O.S.), 1851, and was buried on the summit of Mount Lovcen (Lovchen). (R. G. D. L.)

PETER OF BLOIS (*c.* 1135–*c.* 1212), author and poet, whose collection of his own letters made him famous throughout the Middle Ages, was born at Blois, the son of noble Breton parents. After studying law at Bologna and theology at Paris, he went in 1167 to Sicily, where he became tutor to the young king William II and keeper of the royal seal. His position aroused much envy and he returned to France about 1169, entering the service of Reginald, archdeacon of Salisbury, and, later, of Rotrou, archbishop of Rouen. He went to England in about 1174 and served in the household of successive archbishops of Canterbury. From about 1179 to 1183 he was chancellor of Archbishop Richard. He became archdeacon of Bath in 1182, and exchanged this for the archdeaconry of London in 1201–02. He was also canon of several churches and for a time dean of Wolverhampton. He died in 1211 or 1212.

Peter of Blois was a prolific writer, but his only work that obtained a wide circulation was his collection of letters. These were written partly in his own name and partly in the names of kings and queens, archbishops, bishops, and even popes. Among the last, the most important was the *Instructio fidei catholicae* which Pope Alexander III sent to the Seljuk sultan of Iconium, probably in 1179. There is no reason to doubt that these letters, often regarded as mere literary exercises, are substantially genuine. The first collection of about 100 letters was made late in Henry II's reign (1154–89) and its success soon encouraged the author to make considerable additions. Thereafter it attracted many apocryphal pieces.

Peter had been an excellent poet of the new school of erotic writers. But he later became ashamed of this, and only a few of his poems, mostly of a moral and satirical character, have been certainly identified. His other works include a collection of sermons, a treatise on friendship (*De amicitia Christiana*) largely pillaged from Aelred of Rievaulx, an unprinted treatise on letter writing, a lively dialogue between Henry II and the abbot of Bonneval, an anti-Jewish tract, and a series of writings designed as an incentive to the Third Crusade. The chief virtues displayed in these works are great versatility, literary skill, and a command of classical and biblical learning. The chief defects are shallowness of thought and barefaced plagiarism. Nevertheless, Peter was a serious and vivid writer and one of the best examples of the learned men of affairs who flourished in England in the late 12th century. His works were edited by P. Goussainville (1667) and reprinted in J. P. Migne, *Patrologia Latina,* vol. ccvii (1855). Of the poems there printed only no. i, ii, v, and vi are genuine, and of these no. ii should be divided into five separate poems. Other poems of Peter's are no. 29–31 in *Carmina Burana,* edited by A. Hilka and O. Schumann, vol. i (1930), and no. cviii in *Carmina medii aevi,* edited by H. Hagen (1877).

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PETER OF COURTENAY (d. 1219?), Latin emperor of Constantinople, was a son of Peter of Courtenay (d. 1183) and a grandson of the French king, Louis VI. Having, by a first marriage, obtained the counties of Auxerre and Tonnerre, he took for his second wife Yolande (d. 1219), who brought him the marquisate of Nevers. She was a sister of Baldwin I and Henry of Flanders, the first and second Latin emperors of Constantinople. When Henry of Flanders died without sons in 1216, Peter was chosen as his successor. Consecrated emperor at Rome, in San Lorenzo outside the walls, by Pope Honorius III on April 9, 1217, he embarked at Brindisi with an army and a papal legate on ships supplied by the Venetians, for whom he undertook to conquer Durazzo (Durres) from the Greek despot of Epirus, Theodore Angelus. Having failed in this enterprise, he set out along the overland route toward Thessalonica. But in the mountains near Elbasan he was treacherously seized by Theodore, and died, probably by foul means, after an imprisonment of at least two years.

See J. Longnon, *L'Empire latin de Constantinople* (1949); D. M. Nicol, *The Despotate of Epiros* (1957). (D. M. N.)

PETER I OF DREUX, called MAUCLERC (1190–1250), duke or count of Brittany from 1213 to 1237, was a French prince of the house of Capet, being the second son of Robert II of Dreux and so first cousin once removed to King Philip II Augustus, at whose court he was brought up. At first destined for the church, he was married in 1213 to Alix, daughter of the heiress Constance of Brittany by her third husband, Guy of Thouars. Philip II Augustus, who had assumed the *bail* or custody of Brittany on the murder of Alix's half brother Arthur I (*q.v.*), received Peter's homage for Brittany and transferred the *bail* to him. After Alix's death (1221), Peter retained control of Brittany as guardian of his son John I (born 1216 or 1217). Peter was styled duke by himself and by the Bretons, count by the French.

Peter energetically asserted his authority over the Breton lands. Henry of Penthièvre, a minor, who had been proposed for marriage to Alix, was forced to surrender most of his fiefs into ducal custody (1214); Conan of Léon, Henry's original guardian, was dispossessed of his chief seat (1216); and in the Battle of Châteaubriant (1223) Amaury of Craon was defeated in his attempt to take Ploërmel, which Peter held to have escheated to the ducal domain. The Frenchman Raoul, bishop of Quimper, helped to

introduce the usages of the Capetian chancery into Brittany; and Peter sought the support of the towns, granting a number of charters of privileges.

Peter was called Mauclerc ("bad clerk") either because his training for the church was abortive or because he quarreled with the episcopate. A dispute with the bishop of Nantes (Étienne de La Bruière) over Peter's imposition of a monopoly on wood, salt, and flour culminated in the excommunication of Peter and in an interdict (1219) before the duke submitted (1221). Later the duke's building of fortifications on episcopal lands led to a dispute with the bishop of Rennes (Josselin de Montauban): excommunicated again, Peter at the Assembly of Redon (1227) engaged the secular lords to refuse payment of tithes and other dues to the church and to ignore its sentences; only in 1230 was he absolved.

Having gone to England twice during the expedition of Prince Louis (1216–17; *see* LOUIS VIII), Peter went again in 1218 and obtained seizin of the earldom of Richmond in 1219. He cooperated with the French, however, against the English king's men in Poitou (1224). He also helped Louis VIII's campaign in Languedoc (1226). But on Louis VIII's death Peter joined the movement against Blanche of Castile, regent for Louis IX. His first revolt won him generous concessions (Treaty of Vendôme, March 1227); but in October 1229 he renounced his allegiance to France and did homage for Brittany to Henry III of England. There followed an English expedition to Brittany (1230); a French attack and a three-year truce (1231); and a final French attack (1234), after which Peter submitted to Louis IX. A humiliating inquest into his conduct of affairs was held at St. Brieuc in 1235.

When his son John came of age (1237), Peter had to renounce Brittany. Thenceforward he was merely count of Braine. After a first crusade (1239–40), he went again in 1248 to Egypt, fell sick, and died at sea on his way home in 1250.

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PETER DES RIVAUX (*c.* 1190–1262), Poitevin administrator under Henry III of England, the son (but not necessarily bastard) or nephew of Peter des Roches, bishop of Winchester, was born in Poitou and reached England before 1204. He became a king's clerk (1218) but was dismissed (1223) and subsequently exiled when Peter des Roches lost power. Returning to England under Henry III's protection (1230), in June 1232 he was made treasurer of the household, keeper of the wardrobe and of the privy seal as the first step in ruining the justiciar Hubert de Burgh. The latter's fall (July–November 1232) enabled Peter to begin the reorganization of royal finance and administration which Henry III and Peter des Roches intended. The entire royal administration was concentrated in Peter's hands as treasurer of the household: justiciarship, chancery, and exchequer were all completely subordinated to him; he was made treasurer of the exchequer (January 1233), keeper of wardships and escheats, keeper of many great royal castles, chief justice of the forests, sheriff of 21 shires, exercising these offices by deputies chosen by himself. Peter began a drastic and skilful overhaul of the financial and administrative system of exchequer, household, and shires which, if logically completed, would have made Henry III the richest and most absolute king in Europe. But in 1234 the English magnates, led by Archbishop Edmund Rich (St. Edmund), compelled Henry to dismiss Peter des Rivaux. Though his influence was still perceptible in later years, and he became a baron of the exchequer once more in 1253 and keeper of the wardrobe again (1257–58), his plans never matured. Dismissed by the baronial reformers in 1258, he died in England in 1262.

See T. F. Tout, *Chapters in the Administrative History of Medieval England*, vol. i, rev. ed. (1937); F. M. Powicke, *King Henry III and the Lord Edward*, vol. i (1947). (R. F. T.)

PETER DES ROCHES (d. 1238), Poitevin diplomat, soldier, and administrator, one of the ablest statesmen of his time, enjoyed a brilliant but checkered career, largely in England in the service of King John and Henry III. As bishop of Winchester from 1205 to 1238 he organized and added to the financial resources of his see.

He first appears at Richard I's court in the Touraine and Poitou, where he held his earliest ecclesiastical appointments. He went to England with King John, received English benefices, and was promoted in 1205 to the see of Winchester. His election was a result of direct royal influence. He remained in England and retained his see throughout the interdict (1208–13), filling several administrative and military roles, and helping in the negotiations between John and the pope. He became chief justiciar in 1214, but was unpopular and was replaced in June 1215. He supported John loyally during the war with the barons and was one of his executors. Peter crowned Henry III and became his tutor. As the most influential Poitevin in the country, he headed that group of alien officials and soldiers which suffered political defeat at the hands of the justiciar, Hubert de Burgh, in 1223–24. Peter himself lost his position as tutor when Henry declared his majority in 1227. He then accompanied the emperor Frederick II's crusade and reached Jerusalem. In 1230 he helped to reconcile Frederick with the pope and in the next year negotiated a truce between Henry III and the French. On his return to England in 1231 he influenced Henry III to promote his nephew, Peter des Rivaux, to numerous posts, and brought about Hubert de Burgh's fall in 1232. However, the administrative methods he advocated led to baronial opposition in 1233, and in 1234 Henry III dismissed Peter from favour and his nephew from office. Des Roches went abroad again and in 1235 served as a soldier and diplomat with Pope Gregory IX. He returned to England in 1236 and died at his castle at Farnham in June 1238.

See S. Painter, *The Reign of King John* (1949); F. M. Powicke, *King Henry III and the Lord Edward*, 2 vol. (1947). (J. C. Ho.)

PETER OF SAVOY (1203/13–1268), called "the little Charlemagne," counselor of Henry III, king of England, and uncle of Henry's queen, Eleanor of Provence, was born at Susa, the sixth (?) son of Thomas I, count of Savoy, and of Margaret, daughter of William I, count of Geneva. Placed by Thomas in the church, he renounced clerical status (1234/36) on inheriting lands from his father in Bugey and from his mother in Vaud, married his cousin Agnes (d. 1268), heiress of Faucigny, and won fame in war, diplomacy, and administration, vigorously expanding his dominions in Vaud and Valais. In 1240 Henry III invited him to England, gave him the honours of Richmond (without the title of earl) and of L'Aigle, and made him a valued counselor and ambassador. Though Peter still spent much time in Savoy, Henry used Peter's knowledge and prestige and his influence as one of the strategically placed and powerful family of Savoy to promote his own ambitions in Italy and at the papal and imperial courts. Peter acted independently in England, winning the trust of the English barons, especially of Simon de Montfort, advising Henry honestly, and openly supporting the reforms of 1258, when he joined the reforming council of 15. Alienated by Montfort's extreme radicalism early in 1260, Peter thereafter supported Henry loyally. Unexpectedly inheriting the county of Savoy (June 1263), Peter left England to dislodge a rival claimant, his nephew Thomas of Acaja, and never returned, though he helped Henry from afar. He resigned the honour of Richmond before May 6, 1266, and died at Pierre-Châtel about May 15, 1268, having greatly strengthened the influence of Savoy.

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PETER THE HERMIT (d. 1115), the Picard preacher whom later writers credited with the role in fact played by Pope Urban II in the launching of the First Crusade. He was born in the diocese, most probably in the town, of Amiens. Dedicated to religion, he is said to have attempted a pilgrimage to Jerusalem about 1093. When Urban proclaimed the crusade at Clermont in November 1095 (*see* CRUSADES), Peter began his preaching, traveling from Berry across Champagne and down the Meuse Valley to Cologne, where he arrived in April 1096. His eloquence attracted

thousands of peasants, who may however have taken the cross the more readily in order to escape from the famine then prevalent in their homelands. Leaving Cologne in May, Peter led his exclusively popular following across Europe to Constantinople, which he reached at the end of July. There he joined forces with the similar contingent led by Walter the Penniless, who had insisted on leaving Cologne in advance of him. On Aug. 5–6 the pilgrims crossed the Straits and advanced to Nicomedia (Izmit).

Unable to maintain discipline, Peter soon went back to Constantinople; in his absence the pilgrim hosts under Walter were annihilated by the Turks at Civitot (probably the modern Hersek) on Oct. 21, 1096. Peter waited in Constantinople till the princely expeditions from Western Europe were assembled there (May 1097), and accompanied their march across Anatolia. He was discouraged by the hardships attending the crusaders' siege of Antioch and was dissuaded only with difficulty from abandoning the enterprise (January 1098). When the crusaders were in turn besieged in Antioch, he was sent to challenge Kerbogha to single combat with one of the princes (June 1098). He was appointed almoner of the Christian Army in spring 1099, preached a sermon on the Mount of Olives a week before the storming of Jerusalem in July, and conducted processions in Jerusalem in August. He returned to Europe in 1100. Prior of Neufmoustier, at Huy in the diocese of Liège, Peter died there on July 8, 1115.

See H. Hagenmeyer, *Peter der Eremite* (1879).

PETER (PETERS), **HUGH** (1598–1660), English Independent minister, army preacher, and propagandist during the Civil War and Commonwealth, was born at Fowey, Cornwall. Educated at Trinity College, Cambridge, he was ordained priest in the Anglican Church in 1623. He went to London in 1626 and was appointed preacher at St. Sepulchre's, but his unorthodox views led to the suspension of his preaching licence in 1627. He was in Holland from 1629 to 1635 when he returned to England and sailed to Massachusetts where he succeeded Roger Williams as preacher at Salem in December 1636. He played a leading part in the colony's affairs and helped in the founding of Connecticut. Peter returned to England in 1641 as an agent for Massachusetts but after the Irish Insurrection (October 1641) he went to Ireland as chaplain to a company of adventurers under Alexander, Lord Forbes, which fought against the Irish rebels (June–September 1642). As chaplain to the New Model Army, Peter preached during the campaigns of 1645 and 1646.

He accompanied Oliver Cromwell to Ireland in 1649 and was present at the fall of Wexford. Appointed chaplain to the council of state (1650), he preached at Whitehall continually during the Commonwealth and Protectorate, but his protests against the Dutch War (1652–54) brought him a reprimand from Parliament. During the later years of the Protectorate, his part in civil and military affairs was less prominent. At the Restoration in 1660 he was specially exempted from the Act of Indemnity and at his trial in October 1660 was found guilty of abetting the execution of Charles I. He was executed at Charing Cross, London, on Oct. 16, 1660.

Peter's works included sermons, accounts of battles and sieges, and tracts on legal, economic, and social reforms.

See R. P. Stearns, *The Strenuous Puritan* (1954).

PETER, EPISTLES OF SAINT, two of the seven Catholic (*i.e.*, general) Epistles of the New Testament, ascribed to the apostle Peter. Since his authorship is questioned for the first epistle and rejected for the second, these epistles call for separate treatment.

I PETER

Contents and Theme.—In 5:12 this letter is called one of exhortation and declaration about the true grace of God, in which the readers must take a firm stand. This gives a good division of the main parts, which are as follows:

1:1–2	introduction
1:3–2:10	an exposition of the benefits of the Christian faith
2:11–5:11	admonitions about the right Christian life
5:12–14	concluding greetings

The readers are born anew to a living hope by the resurrection of Jesus Christ and may expect a glorious future in spite of the trials under which they suffer at the present moment, at the revelation of their Lord. Therefore they must live a holy life in accordance with God's calling, knowing for what a high price they have been ransomed—the blood of Christ. They have been born anew by the imperishable Word of God; they form a spiritual temple built on the living stone of Christ and are a royal priesthood, God's own people. As such they have to live among the gentiles. In accordance with an ethical code which is also found in other New Testament Epistles but here has a stamp of its own, the writer then exhorts his readers to subjection to the authorities, in particular slaves to their masters (recalling the sufferings of their Lord as an example) and wives to their husbands. All must live in love and holiness and not fear suffering, even unjust suffering, for Christ died for sinners and entered into his glory. They must break with the pagan way of life and glorify God through their service. Christians should suffer for Christ's sake and not for misdeeds. The elders must take good care of the people, and the younger members must be submissive.

One of the most attractive sides of this letter is the close relationship it expresses between Christian doctrine and practical life. It breathes a spirit of sure hope which is in striking contrast to the suffering and slander experienced by its recipients. But these trials are a test for the genuineness of their faith. The writer lives in expectation of the approaching end of the world and the revelation of Jesus Christ in glory (4:7; 1:5). The letter is clearly addressed to new converts, but the theory that it is a "baptismal sermon" conflicts with its character as a letter.

Authorship and Date.—Authorship and date depend upon decisions about the character of the letter. It is addressed to "the exiles of the dispersion in Pontus, Galatia, Cappadocia, Asia and Bithynia" (1:1). The term dispersion is generally explained in a symbolic sense, used of the Christians who live in exile while their true homeland is in heaven, but both the Old Testament and patristic usage make this widespread interpretation impossible. Except for one highly doubtful text (James 1:1), it is always unequivocally used for the Jewish Diaspora (*q.v.*). From 1:18; 2:9 and especially 4:3–4, it is clear, however, that the letter is addressed not to former Jews but to former pagans. These were the so-called "Godfearers," visitors of the synagogues who had not become proselytes and therefore could not be considered as members of the elect people of God, Israel. Now such persons are assured (2:9) that they do belong to the people of God and that the high epithets of the chosen people are theirs, because the sacrifice, which according to Jewish ritual must be made before a person can become a proselyte, had been offered up in the death of Jesus Christ (1:18–19; 3:18). Throughout the epistle there are numerous parallels with the terminology used in Jewish literature for the proselytes.

The letter has certain parallels with the epistles of Paul, particularly with Rom. 13:1 ff. and Ephesians-Colossians. This does not mean that the writer was dependent upon Paul, for the parallelism exists mainly in passages that have a catechetical structure. A special point in the teaching of this epistle is the preaching to the spirits in prison (3:19–22), which formed the scriptural basis for the church's doctrine of Christ's descent into hell.

The question of authorship depends partly on the dating, which is uncertain. Internal evidence gives no clear indication, and external evidence is lacking. Some scholars try to identify the sufferings expected in 1:6 and taking place in 4:12 with a known persecution of Christians, such as that under Nero in 64, Domitian in 96 or Trajan in *c.* 110. But there is no indication in the epistle that these sufferings were official persecutions organized by the state (on the contrary, the Christians' relationship to the authorities appears friendly in 2:12), and a further objection to Nero's persecution, the only one which took place in Peter's lifetime, is that the suffering is said to be worldwide (*cf.* 5:9), whereas Nero's was confined to Rome. All the passages about suffering can be best understood as referring not to persecution but to the slander to which Christians are exposed (*e.g.*, 3:13 ff.) because they are a minority with social and religious customs differing from those of the people around them.

If the "ransom" in 1:18 refers to the proselyte offering, then the epistle must date from before the destruction of the Temple in the year 70. According to 5:13 it was written in Babylon, which may be an apocalyptic name for Rome (*cf.* Rev. 14:8; 16: 19). The reference to Mark (in 5:13), whose presence in Rome is attested (*e.g.*, Col. 4:10), seems to support this interpretation, but the letter as a whole is not apocalyptic and the sequence of countries mentioned in 1:1 going from east to west in Asia Minor seems to indicate a starting point in the east, so that the eastern city of Babylon with its large Jewish colony among whom Peter might have been a missionary (*cf.* Gal. 2:7–9) could be the source of the letter.

The chief argument against Peter's authorship apart from the possible late date of the letter is that it is written in such good Greek and shows such precise knowledge of the Septuagint that it could not have been composed by an uneducated fisherman. But the author of the letter refers to his assistant Silvanus (5:12), who may have been a more learned man and perhaps was responsible for editing the work of Peter. In 5:1 the author refers to himself as "a witness of the sufferings of Christ," thus implying that he was a disciple of Jesus. It can therefore be concluded that Peter was the guiding spirit of the letter, which should perhaps be dated *c.* A.D. 60. It was used by Polycarp and Papias in the beginning of the 2nd century, was considered as authoritative by Irenaeus, Tertullian, and Clement of Alexandria at the end of the 2nd century, and since then has been an undisputed part of the canon. Doubts about its authenticity first arose in the early part of the 19th century.

II PETER

Contents and Theme.—This epistle has been called "the testament of Peter" because it gives the author's last commandments before his approaching death (1:12–15). He reminds his readers, who are not identified with any particular place, of the great grace they have received and admonishes them to escape from the corruption in the world and to live a virtuous life. Chapter 2 is a long warning against false teachers. Instead of the true Christian teaching, which follows not myths but the sure prophetic word, these heretics lead the churches astray in their licentious, ungodly life. But their destruction is certain as may be seen from various examples of false prophets in the Old Testament. They try to enslave the Christians who have escaped the defilements of the world through the knowledge of Jesus Christ. The readers should remember the words of the holy prophets and the commandment of their Lord according to which scoffers will arise in the last day and deny the return of Jesus in glory and judgment. This promised day will come, but the Lord has delayed it so far because the measure of his time is different from that of men and he wants to give time for repentance. The writer reaffirms the Christian hope for a new heaven and a new earth and exhorts his readers to be faithful and blameless.

Relationship to Jude's Epistle.—This epistle has such a close relationship to that of Jude (*see* JUDE, EPISTLE OF SAINT) that one must have borrowed from the other. Comparison of the parallel passages (1:5 and Jude 3; 2:1 and Jude 4; 3:4 ff. and Jude 5 ff.; 2:10 ff. and Jude 7; 3:2 and Jude 17; 3:14 and Jude 24) shows that II Peter has used Jude and not vice versa. The order of the Old Testament examples in Jude has been remodeled to follow the historical sequence of books. The references to noncanonical books in Jude are left out (the quotation of I Enoch in Jude 14–15 is made unintelligible in II Peter 2:11 because the concrete example of Jude 9 is missing). II Peter also shows a later development in the fact that these false teachers specially deny the second coming and final judgment which is not yet the case in Jude.

Authorship and Date.—This dependence upon Jude makes it impossible to consider the apostle Peter as the author, although the letter purports to be written by "Simon Peter, a servant and apostle of Jesus Christ" (1:1), who states that he was an eyewitness of Jesus' transfiguration (1:16–18), refers to a previous letter (3:1, which is most likely to be I Peter), and speaks about Paul as a contemporary (3:15). The case against Peter is strengthened by other observations: (1) The language is thoroughly Hellenistic, quite different from and more refined than that of I Peter. (2) The writer uses all sorts of typically Hellenistic ideas, such as "virtue" (or "excellence") of God (1:3), virtue connected with faith (1:5), "knowledge" (*gnosis* and *epignosis*) in a specific sense (1:2, 3, 6, 8; 2:20; 3:18), "partakers of the divine nature" (1:4), epopts ("eyewitnesses"), an expression of the mystery-religions (1:16). (3) In his insistence on the second coming of Christ, which began to be denied at the end of the 1st and the beginning of the 2nd century, the author seems to have in mind various Gnostic teachers (*cf.* "cleverly devised myths," 1:16), though it is not possible to identify them in any of the Gnostic groups.

In 3:16 the author seems to know a collection of Pauline epistles. This points to the beginning of the 2nd century, at which time various other books were connected with the name of Peter; *e.g.*, a "Preaching" and a "Gospel." This epistle is not quoted by any author in the 2nd century, however, and Origen, who first mentions it, calls it disputed. Though Hippolytus in the 3rd century uses the letter, Eusebius says it is "contradicted" and Jerome attests that it "is rejected by the majority." But in the course of the 4th century it was gradually accepted (*e.g.*, by Athanasius and Augustine). The Syriac translation, the Peshitta, does not contain it and the Syrian church has not accepted it.

Since the 16th century there have been doubts about its authenticity. Calvin, for instance, held that a disciple of Peter was the author. Although Roman Catholic and a number of conservative Protestant scholars have long defended the authorship of Peter, it is now generally held to be spurious on the grounds set forth in this article. The value of the letter is seen in its defense, against Gnostic spiritualization, of early Christian belief in the truth of the return and judgment of Jesus Christ. The expression "become partakers of the divine nature" (1:4) has since the 4th century deeply influenced the mystical theology of the Orthodox Church. *See* also BIBLE.

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(W. C. v. U.)

PETERBOROUGH, CHARLES MORDAUNT, 3RD EARL OF (*c.* 1658–1735), English soldier and politician who attained prominence for his eccentric and irresponsible behaviour during the War of the Spanish Succession. He began his career in the navy. He succeeded to the peerage as Viscount Mordaunt on the death of his father in 1675 and under James II he became one of the earliest supporters of William of Orange. In 1689, after William's accession to the English throne as William III, he was made a privy councillor, first lord of the Treasury, and earl of Monmouth. He remained on friendly terms with the king until 1693. Four years later he was briefly imprisoned for complicity in Sir John Fenwick's conspiracy to assassinate William III. The death of his uncle, Henry Mordaunt, on June 19, 1697, made him 3rd earl of Peterborough.

He returned to court after the accession of Queen Anne (1702) and was sent to Spain in 1705 to command an expedition in support of Archduke Charles of Austria (later the emperor Charles VI), a claimant to the Spanish crown. Peterborough besieged and took Barcelona that year and early in 1706 entered Valencia. He delayed there while Barcelona was besieged by the French and the city was only saved in April because Sir John Leake, bringing reinforcements by sea, ignored Peterborough's orders and sailed

direct to Barcelona. It seems that by this time Peterborough had lost sympathy for the archduke's cause and was instead hoping to advance the claims of the duke of Savoy, Victor Amadeus II. Peterborough visited Italy, without leave of absence, later in 1706, and although recalled in February 1707, made a long tour of Europe, arriving in England only in August. An investigation into his conduct in Spain, begun in the House of Lords in 1708, resulted in complete exoneration and a vote of thanks in 1711. Thereafter the government charged him with various diplomatic missions, chiefly to keep a troublesome man out of the country. He was made a knight of the Garter in 1713. His authority vanished after the accession of George I in 1714. His last grand intrigue was in 1717, when he went to Italy to form a league to drive out the Austrians. The mission ended inconclusively when he was arrested at Bologna, allegedly because, disguised as a woman, he had been unable to forgo wearing his Garter insignia under his skirt. He died on board his yacht off Lisbon on Oct. 25, 1735, and was buried at Turvey, Bedfordshire.

Of fierce and turbulent disposition, Peterborough seems to have been incapable of obeying orders. In his diplomatic wanderings he is said to have seen more kings than any man in Europe. His first wife, Carey, died in 1709. Later (possibly in 1722) he secretly married Anastasia Robinson, a famous singer of great beauty. He was a friend of Jonathan Swift and of Alexander Pope.

See W. Stebbing, *Peterborough* (1890); C. R. Ballard, *The Great Earl of Peterborough* (1929). (B. J. R.)

PETERBOROUGH, a city and seat of Peterborough County, Ontario, Can., on both banks of the Otonabee River, 75 mi. (121 km.) NE of Toronto. Pop. (1961) 47,185. In 1821 Adam Scott founded a sawmill and a grist mill at the site, where five falls descend a total of 50 ft. (15 m.), and it became known as Scott's Plains. In 1825 almost 2,000 Irish settlers arrived under an assisted-emigration plan directed by Peter Robinson, and the town and county were renamed in his honour. Peterborough became a commercial and manufacturing centre of the surrounding area and tourist centre of the Kawartha Lakes region. Canalization of the Otonabee as part of the Trent Canal system provided direct communication with Lake Ontario and Georgian Bay by means of the world's highest hydraulic lift lock (1904). Peterborough was incorporated as a city in 1905. Manufactures include electrical machinery, boats and marine equipment, watches and clocks, cereals, and other products. (F. G. R.)

PETERBOROUGH, a city and municipal borough in the county of Huntingdon and Peterborough, Eng., 19 mi. (31 km.) N of Huntingdon by road. Pop. (1961) 62,340. It is the seat of a bishop, and an important industrial and agricultural centre on the western edge of the Fens (*q.v.*) and on the Nene River which is navigable from there to the sea by ships of 500 tons burden. Until 1965 Peterborough was within the separate administrative county of the Soke of Peterborough (*see* below), Northamptonshire.

In the centre of the city is the Cathedral of St. Peter, the third church on the site, begun in 1118 and an important example of a large church in the Late Norman style. It is built mainly of limestone from Barnack, 10 mi. (16 km.) NW of Peterborough. The cathedral was consecrated in 1238. The west front, one of the finest of the Early English period, seems to have suffered from the builders' changes of plan, and the Perpendicular porch (1375) between the central piers, probably to strengthen the front, increases the unharmonious effect. The flanking turrets have Decorated and Perpendicular spires and pinnacles. The northwestern tower was begun in 1265 and the central tower replaced a Norman lantern in the 14th century (rebuilt 1883–86). A noteworthy feature of the interior, which is almost entirely Late Norman, is the painted ceiling (*c.* 1220) of the massive nave, probably the only surviving ceiling of the period in England. The lozenge patterns contain curious figures including a half-human, man-eating creature, a donkey, a Janus head, and kings and queens. The magnificent fan vaulting of the late Perpendicular New Building or retrochoir (*c.* 1500) is probably by John Wastell, who was responsible for the fan vaults in King's College Chapel, Cambridge. The Hedda Stone, a block of black stone with figures of the apostles in relief, is an interesting example of Saxon sculpture dated about 800. There is some fine stained glass by William Morris (1862).

The Outer Gate connects the cathedral precinct with the Market Place. It was built at the end of the 12th century but much altered in the early 14th century. Among much Victorian building the most interesting remains are the Abbot's Gate (early 13th century), with the Knights' Chamber above, St. Thomas's Chapel (*c.* 1330), the chancel of a church whose nave was pulled down and used in the building of the parish church (*see* below), the richly decorated Priory Gate (early 16th century), and the 13th-century infirmary.

Apart from the cathedral Peterborough has few interesting architectural features. The parish Church of St. John the Baptist in the Market Place was completed in 1407 in the Perpendicular style. Close by is the Market Cross (or Old Town Hall), rebuilt or enlarged 1669–72. Buildings of note near Peterborough are Thorpe Hall (1653–56), and St. Botolph's Church (1263) at Longthorpe with a bishop's chair and pointed-trefoil windows. Longthorpe Hall, a fortified house of the early 14th century, contains remarkable wall paintings of the same period.

The first bridge over the Nene at Peterborough was built in 1308. The present bridge dates from 1934. In the early 1930s a major reconstruction scheme was carried out in the centre of the city, and the town hall and municipal buildings were built. The town museum and art gallery is in Priestgate. Educational establishments include the King's School, Deacon's School, and the Girls' County School.

Peada, king of Mercia, founded the Benedictine Abbey of SS. Peter, Paul, and Andrew in the village of Medeshamstede in 655. In 870 it was destroyed by the Danes and rebuilt in the following century by Aethelwold, bishop of Winchester, with King Edgar's help. Later, because of its wealth, it was known as Gildenburgh (golden borough). At the beginning of the 11th century Abbot Elsinius made a great collection of relics, including the arm of St. Oswald. After the Norman Conquest, when William I, the Conqueror, had installed a Norman abbot, the monastery was sacked by Hereward the Wake and the Danes. The monastery and most of the town were destroyed in a fire in 1117. The town became a borough in the 12th century and a city in 1541 after the monastery had been dissolved, and the monastery church became a cathedral. The interior was badly damaged by Cromwell's troops in 1643. Catherine of Aragon is buried there and the cathedral contained the original tomb of Mary Stuart, queen of Scots.

Weaving and wool combing were important in the 14th century. With the reclamation of the Fens, Peterborough grew as a market centre, and when the town became an important railway junction in the mid-19th century industries were established. Principal engineering products are diesel engines, bakery and laundry plant, steam turbines, pumps, electric appliances, and mechanical handling equipment. Fruit and vegetables are canned, and sugar beet processed. There are large brickworks at Fletton to the south. Apart from weekly markets an agricultural show is held in July and the Bridge Fair early in October. Peterborough is in the Peterborough parliamentary division of Northampton.

The Soke of Peterborough was a separate administrative county from 1884 to 1965, but it was included in Northamptonshire for purposes of the lord lieutenancy. It stretched from Market Deeping (Lincolnshire) in the north to Peterborough in the south and comprised the rural districts of Barnack and Peterborough as well as the city of Peterborough. The part of the Soke north of the Nene is the Liberty of Peterborough, originally the area under the jurisdiction of the abbot of the monastery. Fens and marshes are in the south of the area and higher land in the north, where there are some fine Saxon churches. In the northwestern corner is the great Elizabethan mansion of Burghley House, home of the marquess of Exeter.

See N. Pevsner, *Northamptonshire* (1961).

PETER CHRYSOLOGUS, SAINT (*c.* 400/406–*c.* 450), Latin father and doctor of the church. Little is known with certainty of his life. He was born at Imola in northern Italy and

about 433 became bishop of Ravenna, the residence of the western Roman emperor. Peter was a zealous pastor, who preached regularly to his flock and, with the aid of the empress regent Galla Placidia, promoted the construction of church buildings. He was a close friend of Pope Leo the Great and was revered in both the east and the west for his eloquence and orthodoxy. In 448 Eutyches, the Monophysite heresiarch, appealed his condemnation to Peter as well as to Pope Leo. Peter's kindly reply withheld judgment but counseled obedience to the bishop of Rome. Soon afterward he retired to Imola and there died about 450. Many of his homilies survive, together with the letter to Eutyches. In the standard collection of 176 sermons, however, made in the 8th century, several are unauthentic, while other genuine homilies probably exist among the works of other authors. His sermons are short and popular, stressing the fundamental Christian doctrines and the duties of Christian life. They are not profound, original or elegant, but they reflect the needs and ideals, the virtues and vices of the times. The appellation *Chrysologus* ("Golden Orator") arose later, probably to create a western counterpart to the east's John Chrysostom. He was given the title of doctor of the church in 1729. His feast day is Dec. 4.

See G. Ganns, *Saint Peter Chrysologus: Selected Sermons* (1953).
(Jn. Sr.)

PETER CLAVER, SAINT (Pedro Claver) (1581–1654), missionary to the Negro slaves in Spanish America, was born at Verdu, Catalonia, in 1581 and entered the Society of Jesus in 1602. While studying at the college of Palma in Majorca he was inspired by the holy lay brother St. Alphonsus Rodriguez to volunteer for the missions of New Spain. In 1612 he was sent to Cartagena (in modern Colombia), where he was ordained in 1616. At Cartagena, the chief slave market of the new world, every month slave ships disembarked 1,000 or more Negro slaves. The condition of these poor wretches aboard ship and in the slave pens was horrible beyond description, and the new priest, declaring himself "the slave of the Negroes forever," dedicated his life to them. Accompanied by interpreters and carrying food and medicines, he boarded every incoming slave ship and constantly visited the slave pens, befriending and defending the oppressed, nursing the sick and dressing their sores, teaching religion and baptizing them. His heroic labours met with strong opposition, and even ecclesiastics lent their ears to charges of indiscreet zeal. Claver persevered for 38 years, baptizing, according to reliable estimates, 300,000 slaves.

He died at Cartagena Sept. 4, 1654. Pope Leo XIII canonized him on Jan. 15, 1888, and on July 7, 1896, declared him the patron of all Catholic missions to Negroes. His feast day is Sept. 9.

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PETERHEAD, a small and parliamentary burgh and seaport in the Buchan district of Aberdeen County, is the most easterly town in Scotland and lies 32 mi. (51 km.) NNE of Aberdeen city by road. Pop. (1961) 12,502. The town, built of locally quarried red granite, was founded in 1593 by George Keith, 5th earl marischal. A statue to James Keith, who was born in 1696 at Inverugie Castle (2 mi. [3 km.] NW) and became a Prussian field marshal, was presented to the burgh in 1868 by William I of Prussia and stands in front of the Town House (1788). The Old Pretender (James, prince of Wales) landed at Peterhead on Christmas Day, 1715, and, for helping him in this exploit, both the field marshal and his brother, George Keith, 10th and last earl marischal, were exiled. The estate of Peterhead was bought in 1720 by an English building company, but the company failed and the lands were acquired by the Merchant Maiden Hospital of Edinburgh, which is now administered by the Merchant Company Education Board, Edinburgh.

There is some local trade from the port which is a station of the herring fisheries and head of a fishery district, with a large herring fleet. The north and south harbours lie between the town and Keith-Inch, an island suburb, and the isthmus dividing them is pierced by a canal. In the north harbour there are a graving dock and a patent slipway. The breakwaters, enclosing about 400 ac. (162 ha.) of water (the Harbour of Refuge), were built between 1886 and 1958, principally by convict labour from the prison near Salthouse Head. The leading industries are fish curing, fish and vegetable canning, woolen manufacturing, and light engineering. There is a growing export trade in oats, potatoes and other crops, and beef from the surrounding countryside.
(A. Cg.)

PETERLOO, or the Manchester massacre, a name given in English history to a meeting held on Aug. 16, 1819, in St. Peter's Fields, Manchester. It followed a number of other large political meetings in a year of industrial depression, particularly among the handloom weavers who were new converts to radicalism. The price of food was exceptionally high, and the August meeting was intended to be a great demonstration of the discontented. Its political object was to demand the reform of Parliament, and it was attended by about 60,000 persons, including an unusually large proportion of women and children. Though none was armed and their behaviour was admittedly wholly peaceable, the magistrates, who had been nervous before the event and were alarmed by the mood and size of the crowd, ordered the Manchester yeomanry to seize the speakers immediately after the meeting had begun. The yeomanry, who were untrained Manchester "loyalists," bitter opponents of the radicals, did not confine themselves to arresting the leaders, but made a general attack upon the audience, crying "Have at their flags," and cutting them down with the edge as well as the flat of their sabres. The chairman of the bench of magistrates thereupon ordered the 15th hussars and the Cheshire yeomanry also to charge the crowd, and in ten minutes the place was cleared except for bodies. The numbers of killed and wounded were disputed; probably about 500 people were injured and 11 were killed. The news of Peterloo shocked opponents of the government throughout the country, but the government did not repudiate the magistrates.

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PETER MARTYR, a name commonly used in English for (1) St. Peter Martyr (d. 1252), killed by Cathari; (2) Pietro Martire d'Anghiera (1457–1526), Italian historian; and (3) Pietro Martire Vermigli (*q.v.*).

PETER NOLASCO, SAINT (Pierre Nolasque) (*c.* 1189–1256), founder of the order of Our Lady of Ransom (de Mercede), commonly called Mercedarians or Nolascans, was born of noble parents at Mas-Saintes-Puelles in Languedoc. The facts of his life are obscure and controversial. Declining to marry, he dedicated himself to God's service among the poor and abandoned. The belief that he took part in the Albigensian campaign or was tutor to James I, king of Aragon, has been doubted. He went to Spain, where the Moors held many Christians in slavery. Peter spent his patrimony ransoming them and got others to contribute. Later he determined to found a religious institute whose primary object would be the ransoming of Christian slaves. The extent of Raymond of Peñafort's (*q.v.*) influence on the founding of the order has been disputed by the Dominicans and Mercedarians, and consequently the date of ceremonial foundation in Barcelona is variously given as 1218, 1223, 1228 and 1234. The *documento de los sellos*, a notarial act, treating of Our Lady's simultaneous apparitions, commanding the founding of the order, to Peter himself, Raymond and James I, has been proved a forgery. Peter twice went to Africa to redeem slaves. He resigned his offices of master general and ransomer some years before his death at Barcelona on Dec. 24/25, 1256. He was canonized in 1628, and his feast day is Jan. 28. *See* also Mercedarians.

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PETERS, KARL (1856–1918), German explorer, one of the founders of German East Africa, was born at Neuhaus on the Elbe on Sept. 27, 1856. He visited London to study English principles of colonization and on returning to Berlin founded the Society for German Colonization in 1884. The same year he went to the coast of east Africa where he made treaties in favour of Germany with native chiefs. A further expedition led by Peters under the auspices of the German East Africa company in 1887, avowedly for the relief of Emin Pasha, extended the sphere of German influence. Peters reached Uganda early in 1890 and concluded a treaty with the king, but without the support of the German government. This treaty was declared void as an agreement had been reached between Germany and Great Britain by which Uganda was left in the British sphere. Back in Germany Peters published in 1891 an account of his expedition, *Die deutsche Emin Pasha Expedition* (*New Light on Dark Africa*). He was imperial high commissioner for Kilimanjaro in 1891, but in 1897 was deprived of his commission for misuse of official power in his treatment of the natives; he was reinstated in 1906. From 1899 to 1901 he explored the Fura district and Macombe's country on the Zambezi, with a view to commercial exploitation, and described his discovery of ancient cities and deserted gold mines in *Im Goldland des Altertums* (*The Eldorado of the Ancients;* 1902). Peters died at Woltorf, near Brunswick, on Sept. 10, 1918.

See H. T. Schorn, *Dr. Carl Peters* (1920).

PETERSBURG, a city of southern Virginia, U.S., 23 mi. S. of Richmond on the Appomattox river. In 1646 Ft. Henry was built at the falls of the Appomattox, the site of the present city. Maj. Peter Jones became commander of the fort in 1675; from him, directly or indirectly, Petersburg seems to have derived its name. In 1733 Col. William Byrd II surveyed the site but it was not until 1748 that an act of the colonial legislature established the town of Petersburg. In 1784 Petersburg, Blandford, Pocahontas and Ravenscroft were combined and incorporated as one town, Petersburg. During the American Revolution it was captured by British troops under William Phillips and Benedict Arnold on April 25, 1781. On May 20 Cornwallis arrived with his army and a few days later began the campaign that was to end with his surrender at Yorktown.

Petersburg was the scene of prolonged and bitter fighting during the American Civil War. In June 1864, following his costly failure to defeat Gen. Robert E. Lee at Cold Harbor, Gen. U. S. Grant moved his army to the south side of the James. The southern approaches to Richmond were blocked by Petersburg and Grant's efforts to take the city developed into a virtual siege that lasted for 10 months. On April 2, 1865, his defenses crumbling and his army in danger of destruction, Lee ordered a withdrawal from Petersburg. Richmond was evacuated on April 3 and the war was all but over. (*See* also PETERSBURG CAMPAIGN.)

Petersburg National Battlefield (formerly Military Park), scene of the "Battle of the Crater," is only one of many historic sites in and around Petersburg. Centre Hill mansion, built in 1823, was an antebellum show place; it now houses an important collection of Civil War relics. Bristol Parish Church in Blandford, built in 1737, has been restored. Adjoining it is the Confederate cemetery.

Petersburg has more than historic importance; it is a progressive city engaged in a long-range, comprehensive program of modernization and improvement. Its industrial output includes cigarettes and other tobacco products, optical lenses and frames, trunks and hand luggage, wearing apparel, and glass fibre boats. Nearby Hopewell has large plants producing industrial chemicals, paper and allied products, and man-made fibres. Petersburg has a council-manager form of government, in effect from 1920.

Virginia State College and Central State Hospital lie just outside Petersburg. Ft. Lee, the U.S. army quartermaster training command, is one-half mile east of the city. For comparative population figures *see* table in VIRGINIA: *Population.* (M. BR.)

PETERSBURG CAMPAIGN, a series of military operations in southern Virginia, 1864–65, during the final months of the American Civil War. Petersburg, an important rail centre 20 mi. S of Richmond, was a strategic point for the defense of the Confederate capital. When the 1864 campaign opened there were only two railroads still linking Virginia with the rest of the Confederacy: the Petersburg and Weldon, running due south from Petersburg, and the Richmond and Danville, extending southwest from Richmond. The Southside Railroad, connecting Petersburg with Lynchburg, intersected the Richmond and Danville at Burkeville. The severance of these lines was a major Union objective during the last year of the war.

On May 5, at the very outset of the 1864 campaign, Petersburg was endangered by the landing of Gen. Benjamin F. Butler's Army of the James at Bermuda Hundred and City Point, in close proximity to both Richmond and Petersburg. Butler, an incompetent political general, was driven back at Drewry's Bluff on May 16 by a smaller force under Gen. *Pierre G. T. de Beauregard.* (For the convenience of the reader the names of Confederates are printed in italics.) At the conclusion of the engagement the Federals found themselves confined by Confederate fortifications to the eastern end of Bermuda Hundred peninsula.

The next serious threat to the railroads did not come until mid-June. At that time Gen. *Robert E. Lee's* army, following the Wilderness–Cold Harbor operations, had been reduced by casualties and detachments to 37,000 men. There were about 7,000 troops in the Richmond garrison, while *Beauregard's* force did not exceed 8,000; the grand total was only 52,000. In contrast Gen. U. S. Grant had about 110,000 officers and men organized into one cavalry corps and six infantry corps, two of the latter belonging to Butler's Army of the James. After his bloody repulse at Cold Harbor, Grant decided to carry out a sweeping flank movement against *Lee's* communications by marching southeastward, bridging the James River, and then turning westward against Petersburg. Should Petersburg fall, *Lee* would either have to attack Grant with vastly inferior numbers or else abandon Richmond and retreat hurriedly to protect his communications. Given careful planning, the movement across the James involved few risks. By beginning the disengagement on the night of June 12 Grant was able (as he had been throughout the campaign) to steal a day's march on *Lee.* Furthermore, in heavily wooded country traversed by few roads, it was relatively easy for Grant to conceal the movement of his army from the enemy, whom he outnumbered more than two to one. Gen. William F. Smith's corps, brought from Bermuda Hundred for the Cold Harbor operation, embarked at White House to rejoin Butler. The rest of the army marched overland to Wilcox's Landing, where a pontoon bridge was built on June 14.

Lee, discovering Grant's absence on the morning of the 13th, shifted his army to the Frayser's Farm–Malvern Hill sector; there he was confronted by Union cavalry and Gen. Gouverneur K. Warren's corps, which were screening the Federal march to the James. Warren soon withdrew, but *Lee's* outnumbered troopers were unable to penetrate the opposing cavalry and locate Grant's army. *Lee* had to consider two major possibilities: Grant might, in a repetition of his former movements, make a short flank march followed by a frontal attack; or he might cross the James and attack Petersburg. *Lee* could not uncover Richmond until he received definite information that the enemy had crossed the James. Under the circumstances *Lee* had to rely almost exclusively on *Beauregard,* commanding at Petersburg, for estimates of Union strength south of the James. Unfortunately for *Lee,* the reports sent by *Beauregard* were scanty and vague. *Lee's* response was correspondingly hesitant and the result was a golden opportunity for the Federals to take Petersburg.

When Smith's corps reached Bermuda Hundred, it was ordered to cross the Appomattox River and move on Petersburg. Smith arrived before the outer defenses of the town on the morning of the 15th, when it could have been captured easily, but caution engendered by Cold Harbor plus the accidental absence of the corps artillery delayed Smith's main attack until 7 P.M., when the outer line of works was carried. *Beauregard's* men withdrew a short distance and, with the timely assistance of a division from *Lee's* army, established a new line. That night *Beauregard* stripped the Bermuda Hundred fortifications to reinforce Petersburg. Before noon on the 16th there were three Union corps on the field, W. F. Smith, W. S. Hancock, and A. E. Burnside; 53,000

men to *Beauregard's* 10,000. By failing to attack before 5 P.M., however, the Federals did no more than breach the new Confederate line. The attack was resumed on the morning of the 17th and made considerable progress, though at heavy cost; that night *Beauregard* retreated to a previously prepared position. Gen. George G. Meade ordered a general assault for the 18th but continuing confusion in the Union command delayed the advance until afternoon, by which time *Lee* was on the field with a large part of his army and severely repulsed the Federals. Thus Grant's well-executed shift south of the James was climaxed by the bungled attacks on Petersburg, where the Federals had the advantage of great odds during June 15–17. Contributing to the command failures in Grant's army was the growing disinclination on the part of both officers and men to assail entrenchments.

The Siege.—The siege of Richmond and Petersburg may be said to have begun on June 19. Both armies rapidly constructed formidable fortifications that ultimately curved from a point east of Richmond to a point southwest of Petersburg—about 35 mi. By continually extending his left flank Grant attempted to sever *Lee's* rail connections with the Carolinas, precipitating actions at Jerusalem Plank Road (June 22), Reams' Station (June 29 and Aug. 24), Globe Tavern (Aug. 18–19), Boydton Plank Road (Oct. 27), and elsewhere. Union losses were heavy but by late August Grant's fortified lines had crossed the Petersburg-Weldon Railroad and were reaching out ominously in the direction of the Southside Railroad. During this same period Union frontal assaults on the Confederate lines met with mixed success. On July 30 one of the most spectacular events of the war occurred when the Federals exploded a huge mine under a part of *Lee's* works known as Elliott's salient, about 1½ mi. S of the Appomattox. A breach was effected but the follow-up assault was mismanaged, and the Federals were finally driven back after losing 4,000 men. North of the James, Grant's most notable achievement was the capture of Ft. Harrison on Sept. 29.

At the end of the year *Lee* still held Richmond and Petersburg; success on one front, however, could not compensate for the disasters that had befallen Confederate armies elsewhere. The breakdown and destruction of Southern railroads meant that *Lee's* men were ill-fed to the point of physical exhaustion, and the lack of draft animals and cavalry mounts almost immobilized the army. Hunger, exposure, and the apparent hopelessness of further resistance led to increasing desertion, especially among recent conscripts. The major strategic problem facing *Lee* was to stop the advance of Gen. William T. Sherman, who had turned north from Savannah and by mid-March was in central North Carolina. There he was opposed by a small force under Gen. *Joseph E. Johnston*. If Sherman was to be stopped, *Johnston* had to be reinforced, and the only possible source of men was *Lee's* army. Therefore *Lee* decided to assault Grant's line a short distance south of the Appomattox. If successful the attack would force Grant to pull in his left flank, shortening the lines *Lee* had to defend and allowing him to send help to *Johnston*. In the ensuing battle of Ft. Stedman (March 25, 1865) the Confederates were driven back by counterattacks after breaching the Union line, losing about 3,500 men. *Lee* was now left with 50,000 men; Grant's strength at this time was 120,000.

Shortly after Ft. Stedman, Grant made his final stroke against the Southside Railroad by sending a flanking column 50,000 strong around the Confederate right. To meet this column *Lee* sent 10,600 infantry and cavalry—all he could spare—under Gen. *George E. Pickett* and Gen. *Fitzhugh Lee*. This force was crushed at the Battle of Five Forks (April 1). The next day Grant assaulted the thinly manned lines in front of Petersburg, broke them in several places, and drove the defenders back to the inner defenses. *Lee* immediately informed Pres. *Jefferson Davis* that Richmond and Petersburg could no longer be held; the evacuation was carried out that night.

Aftermath.—It was *Lee's* purpose to march southwestward and join *Johnston*. As his first point of reconcentration he chose Amelia Court House, 40 mi. W of Petersburg, where a supply train could meet the army. When Amelia was reached on April 4 it was discovered that, by error, the train had gone on to Richmond. The Confederates were forced to spend April 5 vainly searching the neighbouring countryside for food. This delay, aggravated by the exhaustion and starvation of men and teams, allowed the westward-marching Federals to interpose between *Lee* and *Johnston*. On the 6th the Confederate rear guard was overwhelmed at Sayler's Creek, leaving *Lee* with only 15,000 effective troops. On the 7th the Confederates reached Farmville, where *Lee* expected to find food and then move north of the Appomattox, putting the river between his army and its pursuers. Through failure of subordinates to destroy High Bridge, however, Union troops were able to follow immediately, and *Lee* was forced to resume the retreat before all of his men could be fed. His next objective was Appomattox Station on the Southside Railroad where, again, he hoped to find supplies. On the afternoon of April 8 the army reached Appomattox Court House, only 3 mi. from the railroad; at 9 P.M. *Lee* learned that his adversary had won the race: Union troops blocked further advance to the west. An attempt on the morning of the 9th to cut through to Appomattox Station failed.

The Army of Northern Virginia, with no more than 8,000 effectives, was surrounded by 50,000 Federals, with as many more quickly available. "There is nothing left for me to do," said *Lee* to his staff, "but to go and see General Grant, and I would rather die a thousand deaths." The two commanders met on the afternoon of April 9 in the Wilmer McLean house at Appomattox Court House. According to the humane terms proposed by Grant, Confederate officers and men were paroled and allowed to return to their homes. Other Southern armies surrendered in quick succession and within two months all resistance had ceased. *See* also AMERICAN CIVIL WAR.

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(L. H. J.)

PETER'S PENCE (DENARIUS OF ST. PETER, or ROMESCOT), the annual voluntary contribution made by Roman Catholics for the support of the Holy See, transmitted by local bishops and administered by a special commission of cardinals. The modern practice derives from the 19th century. During Pius IX's exile in France at the time of the 1848 revolution in Italy, a subsidy called *le denier de St. Pierre* was collected for him by a Catholic committee. In 1860 another collection was taken up at Vienna by a similar group, the Confraternity of St. Michael. This custom was derived from that begun in England in the 8th century, whereby each householder paid, on St. Peter's Day (Aug. 1) an annual tax of one penny for the support of the pope. The first written evidence for it appears in 1027 in a letter of King Canute to his people, which indicates that the custom was then well established. The exact origin is uncertain. West Saxon writers ascribe it to Ina, king of Wessex; Mercian tradition attributes it to Offa, king of Mercia (both 8th century). The tax was fairly regularly paid by the English until Henry VIII abolished it in 1534.

(G. F. D.)

PETHICK-LAWRENCE, FREDERICK WILLIAM PETHICK-LAWRENCE, BARON (1871–1961), British Labour statesman, secretary of state for India and Burma from 1945 to 1947, and a leader of the women's suffrage movement, was born in London on Dec. 28, 1871, the son of Alfred Lawrence. Educated at Eton and Trinity College, Cambridge, he had a distinguished academic career and was a noted athlete. In 1897 he became a fellow of Trinity, but soon turned to social work in the east end of London. Possessing private means, in 1901 he gained control of the *Echo* evening newspaper and was editor from 1902 to 1905. In 1901 he married Emmeline Pethick and added his wife's name to his own. A devoted couple, they became leaders in the agitation for women's suffrage. Pethick-Lawrence supported the cause with great devotion and generosity and in 1912, after a demonstration in London, was sentenced to nine months' imprisonment.

Elected to Parliament in 1923 as Labour member for West

Leicester, he became financial secretary to the treasury in 1929, but declined to support Ramsay MacDonald's coalition national government in 1931 and lost his seat. During these years he wrote and spoke on financial and economic questions and made a close study of the problem of India. He returned to Parliament as member for East Edinburgh in 1935. When Clement Attlee formed his Labour government in 1945, Pethick-Lawrence became secretary of state for India and Burma and accepted a peerage. He led the cabinet mission that visited India in March 1946 and paved the way for independence. Retiring at his own wish in 1947, he continued to be prominent in the House of Lords. Completely unselfish, he had the affection of his colleagues and was respected by all. He died in London on Sept. 10, 1961. His works include *This Gold Crisis* (1931) and an autobiography, *Fate Has Been Kind* (1943).

See V. Brittain, *Pethick-Lawrence* (1963). (A.)

PÉTION, ALEXANDRE SABÈS (1770–1818), Haitian liberator and president. Born at Port-au-Prince, the son of a wealthy French colonist and a mulatto, he received more education than most of his class. He served in the French colonial army before the revolution and then joined the revolutionary troops of Toussaint l'Ouverture (*q.v.*) and later those of the mulatto general André Rigaud. Fleeing to France after Toussaint defeated Rigaud, Pétion returned in 1802 with the French Army but then became one of the first native officers to revolt against France, in 1803. He was a leader in the revolt against the dictator Jean Jacques Dessalines (*q.v.*) in 1806, and when Henry Christophe (*q.v.*) set up a separate state in Northern Haiti, Pétion was elected president of Southern Haiti, in 1807. He was reelected in 1811 and made president for life in 1816, dying in office in 1818. He is remembered in Spanish America for his help to Simón Bolívar in the darkest days of that area's war for independence.

(D. G. Mo.)

PÉTION (DE VILLENEUVE), JÉRÔME (1756–1794), a political figure of the French Revolution, was born at Chartres on Jan. 3, 1756, the son of a lawyer. After practice as an advocate, he became the representative at Chartres of the intendant of Orléans. Then the third estate of the *bailliage* of Chartres sent him to the Estates-General of 1789. Sitting with Robespierre on the extreme left of the Constituent Assembly, he won a name for probity and strength of character, but his ability fell short of his reputation. When the Constituent Assembly dissolved itself, he and Robespierre received an ovation from the people; and in November 1791, Pétion was elected mayor of Paris.

When the Girondins, on June 20, 1792, organized an armed demonstration to intimidate Louis XVI, Pétion at first ignored the efforts of the directory of the Seine *départements* to prevent it; but finally he went to the Tuileries to protect the king and persuaded the mob to withdraw. As his relations with the directory of the *départements* grew worse, he was suspended by it from his mayoral functions on July 6; and the king confirmed this suspension on July 12. The Legislative Assembly quashed the suspension, and on Aug. 3 Pétion led a deputation from the Paris sections to ask the Assembly to depose the king. Yet on Aug. 10, during the insurrection that led to the suspension of the monarchy, Pétion had himself put under house arrest by the Commune, to avoid having to take a decision. The Commune maintained him in his functions.

Elected deputy for Eure-et-Loir, Pétion was the first president of the Convention; and at the end of September 1792 he also presided at the Jacobin Club. But his popularity waned after his refusal, in October, to accept reelection as mayor of Paris. Objecting to the supremacy of Paris over the *départements*, he rallied to the Girondins, fell under Mme Roland's influence and began to attack Robespierre. At the trial of Louis XVI he voted for appeal to the people, for the death sentence, and for reprieve.

Having encouraged the Convention to withstand a new attempt at insurrection (March 10, 1793), Pétion was one of the 22 Girondins whom, on April 15, the commissaries of the Paris sections asked the Convention to expel; and at the coup of June 2 he was expelled. Escaping arrest, he made his way first to Caen, then to Brittany, then by sea to the Gironde, where he and his friends expected a welcome. While some of the refugees were arrested and executed, Pétion and F. N. L. Buzot took to the woods before killing themselves outside a hamlet in the Commune of St. Magne. Their bodies, half-devoured by wolves, were found on June 18, 1794. (A. So.)

PETIPA, MARIUS (1819–1910), French dancer and choreographer who worked for nearly 60 years at the Imperial Theatre in St. Petersburg and had a profound influence on the nature of modern classical Russian ballet. He collaborated with Tchaikovsky on *The Nutcracker* (choreographed by his assistant, Lev Ivanov) and *The Sleeping Beauty*.

Petipa, who was born in Marseilles on March 11, 1819, and his brother Lucien (later principal dancer at the Paris Opéra) received their early training from their father, Jean, a ballet master long active in Brussels. Marius danced in Belgium, France, and the United States (he appeared in New York in 1839) before accepting an engagement in Spain, where he gathered material for ballets later produced in Russia.

He made his St. Petersburg debut in 1847 in *Paquita* and staged his first original ballet, *Un Mariage sous la régence*, there in 1858. For his wife, the ballerina Marie Surovschikova, he created *Le Marché des innocents* (1859). His first outstanding success was *La Fille du pharaon* (1862). Later, after being appointed choreographer in 1862 and chief choreographer in 1869, he produced more than 60 ballets. His versions of *Swan Lake, Raymonda,* and *Giselle* have been revived frequently. After the death of his first wife, Petipa married another dancer, Lubov Leonidova. He died at Gurzuf, Russia, on June 2, 1910.

See BALLET: *Ballet in Russia Before 1900.*

See also Lillian Moore (ed.), *Russian Ballet Master: the Memoirs of Marius Petipa* (1958). (LN. ME.)

PETITION, RIGHT OF, a legal and political term denoting the right of a citizen or subject to appeal to his government for redress of grievances.

Great Britain.—Petition in Great Britain may be made to the crown or its officers, or to either house of parliament or in certain cases to courts of justice. The right of petitioning the crown was recognized indirectly as early as Magna Carta in the famous clause, *Nulli vendemus, nulli negabimus aut differemus, rectum vel justitiam* ("To no one will we sell, to no one will we deny or delay, right or justice" art. 40.), and directly at various later periods, *e.g.*, in the articles of the House of Commons assented to by Henry IV, by which the king was to assign two days in the week for petitions (*Rot. Parl.* 8 Hen. IV, p. 585). In 1688 the case of the seven bishops, who were charged with seditious libel for petitioning the king but were found not guilty, confirmed the right, and finally the Bill of Rights in 1689 declared that, "it is the right of the subjects to petition the king, and all commitments and prosecutions for such petitioning are illegal." At first, petitions to the crown appear to have been for the redress of private and local grievances, or for remedies which the courts of law could not grant. As equity grew into a system, petitions of this kind not seeking legislative remedies tended to become superseded by bills in chancery. Statutes were originally drawn up by the judges at the close of the session of Parliament from the petitions of the Commons and the answers of the crown. Under this system of drafting, it was found that the tenor of the petition and answer were not always stated correctly. To obviate this inconvenience, demands for legislation came in the reign of Henry VI to be drawn up in the form of bills which the crown could accept or reject, but could not alter. In the same reign, the words "by authority of parliament" were added to the words of enactment, and from the time of Henry VII public legislation has been by bill and not by petition. The right to petition is thus closely interwoven with the history of parliamentary legislation.

Petitions to either house of the legislature seem to have been later in origin than petitions to the crown. They are not referred to in the Bill of Rights, but the right of petition is a convention of the constitution. Petitions to the House of Lords or the whole Parliament can be traced back to Henry III. No petition to the Commons has been found earlier than Richard II, but from the time of Henry IV petitions to the Commons were freely made.

The political importance of petitioning dates from about the reign of Charles I. The development of the practice of petitioning had proceeded so far in the reign of Charles II as to lead to the passing in 1661 of an act (13 Car. II St. 1 c. 5) against "tumultuous petitioning:" It provided that no petition or address should be presented to the king or either house of Parliament by more than 10 persons; nor should anyone procure more than 20 persons to consent or set their hands to any petition for alteration of matters established by law in church or state, unless with the previous order of three justices of the county or the major part of the grand jury.

Up to 1688, petitions to either house usually dealt only with some specific grievance. From that time dates the practice of petitioning with regard to general measures of public policy. Petitioning as a device of political agitation became very common in the later 18th century, and afforded a basis for radical organizations seeking parliamentary reform. The number of petitions presented annually increased 25-fold between 1780 and 1830, and culminated in the monster petitions for electoral reform in 1830–32 and the great Chartist petitions of 1839, 1842 and 1848. (*See* CHARTISM.)

In modern times, the presentation of public petitions plays little effective part in parliamentary affairs. Most fail to conform to the very strict tests of technical validity. Petitions to the Houses of Lords or Commons must be framed in the form prescribed by the standing orders, must be properly superscribed and must conclude with a prayer. Petitions to the Commons must be in writing, must contain none but genuine signatures and must be free from disrespectful language or imputations upon any tribunal or constituted authority. They must be presented by a member of the House, except petitions to the House of Commons from the corporation of London, which may be presented at the bar by the sheriffs. The rules as to petitions to the House of Lords are similar. Applications for leave to bring before either house bills for private or local and personal matters must under the standing orders of both houses be made by petition, and the same rule obtains as to applications for leave to be heard in opposition to such bills. (X.; D. TN.)

United States.—The right under the 1st amendment to the U.S. Constitution to petition the government for redress of grievances is one of the basic guarantees of U.S. liberty, being closely associated historically with freedom of assembly. The political theory of the American Revolutionary era emphasized strongly that the colonists were entitled to all the historic guarantees of English liberty. As one such right, freedom of petition found its way into several of the state constitutions drafted in the Revolutionary period, while Thomas Jefferson in the Declaration of Independence significantly listed the flouting of "petitions for redress" as a major grievance against the British king. In 1789, the 1st Congress incorporated the right of petition, along with freedom of religion, press, speech and assembly, in the first of a series of proposed amendments submitted to the states. Ratification of the 1st amendment thus made freedom of petition an integral part of the so-called federal Bill of Rights. Thereafter, virtually all the states incorporated guarantees of petition in their own constitutions.

The right to petition has been exercised constantly in U.S. political life, both Congress and the various state legislatures having well-defined procedures for receiving and acting upon materials of this kind.

Virtually the only constitutional argument of consequence involving petition occurred when the national House of Representatives in 1836 adopted a so-called "gag rule" against the receipt of abolitionist petitions condemning the institution of slavery. Anti-slavery Whigs under the leadership of John Quincy Adams thereafter attacked the "gag rule" (*see* GAG RULES) as a violation of the right of petition as guaranteed in the 1st amendment and finally forced its repeal in 1844.

See PETITION OF RIGHT; PRIVY COUNCIL, JUDICIAL COMMITTEE OF; REPRESENTATION; BILL OF RIGHTS, UNITED STATES.

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PETITION OF RIGHT refers to a petition by a subject asserting a right against the English crown, as in the Petition of Right of 1628, a petition of Parliament to Charles I complaining of a series of breaches of law. Until 1947 the term referred to the procedure by which a subject could sue the crown. This was abolished by the Crown Proceedings Act of 1947.

At common law the crown—a term which is, in constitutional law, merely an abstraction for the sovereign in his official capacity —could not be sued in the king's courts. The king was, historically, the supreme lord of those courts, administering justice in them between his subjects; and as the supreme lord he was not subject to their jurisdiction. Naturally his writs could not run against himself. Hence it became a practice, whenever a subject's real or personal property had come into the possession of the king or his servants without legal title, for the subject to "petition" the King in Council, praying for its restoration. The king then might or might not, at his discretion, refer the suppliant's petition to one of his courts, usually to the old Court of Exchequer, with a writ directing the judges to do what was just (*fiat justitia*).

Originally the scope of a petition of right was confined to issues of fact. When the subject relied on some title appearing by record, such as letters patent issued by the crown, he could proceed by what was known as a *monstrans de droit*. There was another method, known as a traverse of inquest of office, by which a subject might in certain cases challenge the king's title to land or chattels. These practices were consolidated in the Petition of Right Act of 1861, which regulated procedure without creating new rights or abolishing old prerogatives. It provided that anyone seeking to sue the crown should file a petition, in effect a statement of claim, with the home secretary, who invariably referred it to the attorney general for advice. If the latter advised that there was a substantial "cause for action," the home secretary endorsed it with his *fiat justitia*. If he refused it, the subject was without remedy. In practice the *fiat* was rarely refused, unless the claim appeared to be a purely frivolous one. Nonetheless, in such a case the executive, not the courts, performed a judicial function—namely that of deciding whether there was a reasonable cause for action—that in the case of litigation between subject and subject was entrusted solely to the judiciary. The grant of the *fiat* in no way prejudged the issue to be tried, and the crown was entirely free, after having granted it, to plead before the courts that action did not lie.

Once the *fiat* was granted, the proceedings entered the stage of an ordinary action between subject and subject, although particular privileges, not present in ordinary actions, existed on both sides. Among the crown's prerogatives the most important was "That the Crown is entitled to full discovery, and that the subject as against the Crown is not" (Chief Justice Sir John Rigby in *Attorney-General* v. *Newcastle on Tyne Corporation*, 1897, 2 Q.B. 384). This meant that the suppliant could not, as in an ordinary action between subject and subject, compel the other party, *i.e.*, the crown, to produce for inspection documents which might be essential to prove his case. The crown might also claim "privilege" in respect of any attempt by the suppliant to compel his witness, whether in the service of the crown or not, to disclose "matter of state." These prerogatives, among others, constituted a great advantage for the crown over the suppliant; but the latter did enjoy special privilege in certain matters, notably freedom from denial on the basis of the Limitation acts, by which action of contract must be brought within specified periods. That the suppliant might not of right demand trial by jury worked no great hardship: the question was independently determined by the judge.

Judgment was given in the ordinary manner, but the execution of the judgment was quite another matter. The courts could not decree execution against the crown and its servants. The act of 1861 provided, however, that, where judgment was in favour of the suppliant, it should be certified by the court to the treasury, which should then satisfy it out of public funds.

The rule of law that "the king can do no wrong" formerly directed that the king could not, even under a petition of right, be sued for the tortious actions of his servants. This immunity was waived in the Crown Proceedings Act of 1947, which established an entirely new pattern for remedies against the crown.

See also PREROGATIVE.

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PETITOT, JEAN (1607–1691), French-Swiss painter of miniature portraits in enamel, was born in Geneva, the son of the sculptor Faulle Petitot. He was apprenticed to a jeweler from 1622 to 1626, but about 1633 he went to France, and there probably became the pupil of Jean and Henri Toutin, the originators of the art of painting miniature portraits in enamel. In or before 1637 Petitot went to England, where he was patronized by Charles I and his court; a handful of miniatures are known from this period, all copies of portraits by Sir Anthony Van Dyck. Petitot formed high expectations of his stay in England but the Civil War disappointed his hopes, and he returned to France. There he enjoyed for many years the patronage of Louis XIV and his courtiers. A complete catalogue of Petitot's enamels would comprise many authentic portraits of the king, his family, and the most celebrated figures in his entourage, the majority based upon paintings by fashionable artists. Petitot worked in partnership with Jacques Bordier until the latter's death in 1684. On the revocation of the Edict of Nantes in 1685, Petitot, as a Protestant, was imprisoned until, worn out by fever and old age, he signed a recantation. In 1687 he was allowed to return to Geneva and was received back into the Reformed Church. He died at Vevey, Switz., in 1691.

Although priority in the discovery of the art of painting enamel miniature portraits belongs to the Toutins, it was Petitot who by his incomparable facility raised the art to a pitch never surpassed. While relying primarily on original portraits by others, he preserved to a remarkable degree the character of the presentation which he was transforming into a small jewellike roundel. The most important collections of his works are in the Victoria and Albert Museum, London, and the Louvre, Paris. His style, much imitated in his own time, called into being a vast number of 18th- and 19th-century copies or imitations. Petitot's journal gives many details about his life.

His son JEAN LOUIS PETITOT (1653–after 1699) painted portrait enamels in a style closely resembling that of his father.

(G. Rs.; X.)

PETLYURA, SYMON (1879–1926), Ukrainian patriot who led the struggle for his country's independence in the years following the Russian Revolution, was born in Poltava on May 17 (new style; 5, old style), 1879. In 1905 he was one of the founders of the Ukrainian Social Democratic Workers' Party. He published a Socialist weekly newspaper, *Slovo* (1905–09), in Kiev, and the weekly *Ukrainskaya Zhizn* (1912–14) in Moscow. He served as an officer in the Russian Army in World War I from 1914, but after the March Revolution of 1917 he joined the Ukrainian Central Council. In July he was appointed minister of defense in the first Ukrainian government. During the German occupation of the Ukraine (February–November 1918) Petlyura was politically inactive; but by mid-November he reappeared as one of the five members of the Ukrainian directorate and as *ataman* (commander in chief) of the Ukrainian Army. During 1919 the Ukraine became the theatre of confused operations of three different armies: the national Ukrainian, the Soviet Ukrainian and the White Russian. As the leaders of the last-named two rejected the idea of an independent Ukraine, Petlyura turned for help to the newly restored Poland. On April 22, 1920, he concluded a treaty of alliance with Jozef Pilsudski, the Polish head of state; but the outcome of the campaign of that year (*see* RUSSO-POLISH WAR) was such that Poland was unable to help in creating an independent Ukraine. After some months in Warsaw, Petlyura moved with his government to Paris. On May 25, 1926, he was shot dead by Shalom Schwarzbard, who said at his trial he wanted to take revenge on Petlyura for the pogroms perpetrated on the Jews of the Ukraine—pogroms for which the *ataman* had not, however, been responsible.

See A. Choulguine, *L'Ukraine et le cauchemar rouge* (1927).

(K. SM.)

PETN (pentaerythritol tetranitrate) is a powerful, sensitive high explosive and is used in medicine as a vasodilator. It was first prepared by L. Vignon and F. Gerin in 1901 but was not in systematic use prior to World War II. Its structural formula is $C(CH_2ONO_2)_4$. The manufacture involves the nitration of pentaerythritol with concentrated nitric acid and a subsequent washing to eliminate acid. Pentaerythritol, $C(CH_2OH)_4$, is synthesized by the reaction of acetaldehyde with formaldehyde, catalyzed by calcium oxide. PETN is a white crystalline powder, melting point 140° C, specific gravity 1.77. It is insoluble in water but is soluble in acetone and several other organic solvents. As an explosive it is used as an ingredient of detonators and as the charge of the detonating fuze Primacord; for use as a bursting charge of military devices it is usually mixed with other ingredients, largely TNT, to reduce its sensitivity to percussion and to make it suitable for loading by casting.

See AMMUNITION, ARTILLERY: *Propellants and Explosives;* EXPLOSIVES: *Military High Explosives.*

See A. Stettbacher, *Die Schiess- und Sprengstoffe* (1919); T. L. Davis, *The Chemistry of Powder and Explosives*, 2 vol. (1941–43).

(G. B. K.)

PETŐFI, SÁNDOR (1823–1849), one of the greatest Hungarian poets, was born at Kiskörös, Jan. 1, 1823. Petőfi had an eventful youth; he studied at eight different schools, joined for a short time a group of strolling players and enlisted as a private soldier, but because of ill health was soon dismissed from the army. He traveled extensively in Hungary, mostly on foot. As a schoolboy he displayed a keen interest in the stage and in literature, and his first poem was published in 1842. After years of vicissitudes and misery, in 1844, on the recommendation of Mihály Vörösmarty, then the leading Hungarian poet, he became an assistant editor of the literary periodical *Pesti Divatlap*. His first volume of poetry, *Versek*, appeared in the same year, and made him famous at once, though the tone of his poems scandalized many. In 1847 he married Julia Szendrey who inspired his best love poems.

BY COURTESY OF THE PETOFI IRODALMI MÚZEUM, BUDAPEST

SÁNDOR PETOFI: A LITHOGRAPH FROM THE DESIGN OF M. BARABAS, 1845

Petőfi played a leading role in the literary life of the period preceding the outbreak of the Hungarian revolution of 1848. After 1847, together with Mór Jókai, he edited the magazine *Életképek*. A fervent partisan of the French Revolution, an admirer of Pierre Jean de Béranger and Hégésippe Moreau, he castigated in violent terms the social conditions of his country, attacking the privileges of the nobles and the monarchy. Politically he was an extreme radical, an inspired agitator, but he was lacking in experience and failed to obtain a seat in the diet. His poems were glowing with political passion, and one of them, "Talpra magyar" ("Rise, Hungarian"), written on the eve of the revolution, became its anthem. During the revolution he became the aide-de-camp of Gen. Jozef Bem, then head of the Transylvanian army, who had great affection for the somewhat unsoldierly but enthusiastic poet. Petőfi disappeared during the battle of Segesvár, July 31, 1849. Public opinion refused to believe in his death and for many decades hoped to see him return.

Petőfi's poetry meant a revolution in Hungarian literature. Opposed to the fashionable literary conventions and mannerisms, he introduced a direct, unpretentious style, and a clear, unorna-

mented construction adapted from national folk songs. This simplicity was the more arresting as it was used to reveal extremely subtle emotions and political or philosophical ideas. His poetry is characterized by realism, humour and descriptive power and imbued with a peculiar vigour. Of his epic poems the *János vitéz* (1845), an entrancing fairy tale, is the most popular. Petőfi's popularity has never diminished in Hungary, and were it not for the barrier of language his name would probably take its place with those of Burns and Heine in world literature. In his homeland his poetry and his personality have remained the symbols of the people's desire for freedom.

A critical edition of Petőfi's works by B. Varjas Béla was published in six volumes, 1948–56.

See J. Horváth, *Petőfi* (1922); G. Illyés, *Petőfi* (1954). (N. Ki.)

PETRA (Arabic Batra), an ancient city situated about 16 mi. (26 km.) NW of Ma'an in the south of the Hashemite Kingdom of Jordan. The city lies on the western slopes of a plateau extending from the Wadi Nemeila (Wadi an Namlah) in the north to the Wadi Sabra (Wadi as Sabrah) in the south. The terrace on which the city is built is pierced from east to west by the Wadi Musa (the valley of Moses), one of the traditional places where Moses struck the rock and where water gushed forth. The valley is enclosed by sandstone cliffs veined with every shade of red and purple to pale yellow and eroded into fantastic shapes.

The Greek name Petra ("rock") probably replaced the biblical name Sela. The site, at once accessible and secluded, appears to have been occupied from Paleolithic times as Acheulean-type tools have been found on the upper slopes. In one of the valleys an Upper Paleolithic rock shelter has been found. The Neolithic is represented by a settlement on the road to the northern suburb of Al Barid where dwelling places, flint arrowheads, and other implements have been uncovered. Nothing further of Petra is known until the Iron Age. Evidence of the occupation of the site in the 9th century B.C. has been found on the top of Umm al Bi'ar, the massif west of the temple, but this may then have served only as a place of refuge.

Traditionally Petra was the home of the Horites, who were driven out by the Edomites. These suffered a defeat by Amaziah, king of Judah, who slaughtered survivors by casting them down from the rock (probably Umm al Bi'ar). The Edomites were replaced by the Nabataeans (*q.v.*; an Arab tribe, first mentioned in the 7th century B.C. as enemies of Ashurbanipal of Assyria). They made Petra their centre, about 312 B.C., according to Diodorus Siculus, and later achieved a monopoly of the spice trade since they commanded the routes via Gaza and Damascus to Elath (Aqaba) and Al Ula (Al 'Ala). The Nabataeans had a script akin to Aramaic, but spoke Arabic.

There were constant conflicts between the Nabataeans and the Seleucids, and Petra was sacked at least on one occasion in the 3rd century B.C. In the following years the power of this Arab tribe increased, and they sacked Damascus in 85 B.C. Petra became the capital of a state extending from Jordan to the Negev and to the Mediterranean coast at Al 'Arish, Egypt. The Romans continued the struggle begun by the Seleucids, and after the Nabataean defeat of A.D. 106 Petra became part of the Roman province of Arabia, the capital of which was transferred to the Syrian Bozrah (Bostra). The city of Petra continued to flourish for some time after the Roman occupation, until changing trade routes led to the rise of Palmyra and caused its gradual commercial decline. The inhabitants became Christians, and for a short time it was the seat of a bishopric. It was already in decline at the time of the Islamic invasion in the 7th century. In the 12th century the crusaders built a castle there called Sel. Otherwise the site was occupied only by wandering tribesmen, and it was in this condition when rediscovered for the Western world by the Swiss traveler J. L. Burckhardt in 1812.

Petra is usually approached from the east by a narrow gorge known as the Sik (Wadi as Sik), 1¼ mi. (2 km.) long. It contains certain rock-cut tombs and an arch, now ruined. Al Khaznah, one of the most impressive of the monuments, is there cut in the solid rock with a columned facade. It probably dates from the 2nd century A.D. The most noteworthy features of Petra are the tombs,

FRANK HURLEY—RAPHO GUILLUMETTE

COLUMNED FACADE OF AL KHAZNAH, ONE OF THE MANY NABATAEAN ROCK-CUT TOMBS AT PETRA, PROBABLY DATING FROM THE 2ND CENTURY A.D.

often with elaborate facades, now used as dwelling places. A paved street is situated beside the Wadi Musa and has been partly reconstructed. Excavation from 1958 onward on behalf of the British School of Archaeology in Jerusalem and the American Schools of Oriental Research has added considerably to knowledge of pre-Roman Petra. Discoveries include 3rd century B.C. houses of pisé dated by coins of Aradus in Phoenicia to 290 B.C., quantities of fine Nabataean pottery, painted and plain, stone and clay incense burners, and small stone portable altars, similar to those from the Hadhramaut and Yemen. The only free-standing building is the Qasr al Bint ("Castle of the Girl"), dating from the 2nd century A.D.

At Katuleh part of a Nabataean house of the 1st century A.D. was cleared. It was built of ashlar masonry, and its walls were still standing nearly 10 ft. (3 m.) high in places. The interior had been coated with painted and molded plaster. The Romans remodeled the city evidently on a smaller scale than its Hellenistic forerunner. A study of the town walls has shown two sets, the outermost of which is the earlier. The inner wall appears to be a Roman defensive one. The area occupied appears to have been about 1½ sq.mi. (3.9 sq.km.). Many of the tombs have inscriptions in either Nabataean or Latin indicating their owners.

The principal deity of Petra was Dushara (Dhushara) who was worshiped in the form of a crude stone block or stele. In addition to their caravan trade the Nabataeans appear to have been copper miners and smelters, as fragments of copper ingots were found in the ruins of their early structures. Copper ores are found in the Wadi al'Arabah not far from Petra.

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(M. V. S.-W.)

PETRARCH (Francesco Petrarca) (1304–1374), Italian poet, the first humanist and the first modern lyric poet, was born at Arezzo, July 20, 1304, son of a notary, Ser Pietro di Ser Parenzo of Incisa in Valdarno, and his wife, Eletta Canigiani. His father (who after 1312 is referred to as Petrarca, the surname which his son made famous), had been banished from Florence, on Oct. 20, 1302, probably as the result of personal differences with Albizzo Franzesi, a leader of the Blacks, and not, as his son allowed it to be understood, for political reasons, like Dante. Francesco remained at Arezzo for less than a year; then his family moved, to Incisa (where they stayed until *c.* 1310), to Pisa (where perhaps he met Dante) and finally to Avignon (1311), at that time the seat of the papacy, where his father hoped to find suitable employment. Owing to the difficulties of finding lodgings, the family settled at Carpentras nearby and there Francesco began his studies under the modest direction of Convenevole da Prato. In 1316, in obedience to his father's wishes, he went to Montpellier to study law. To this period, although they were certainly revised later, belong the earliest poems that have survived, those on the death of his mother (1318 or 1319: *Epistolae metricae*, i, 7). In 1320 he moved to Bologna and unwillingly continued his legal studies there until 1326. His knowledge and love of the classics increased and he was able to develop his acquaintance with the new vernacular poetry, perhaps even to experiment for himself. In 1326 he returned to Avignon, gave up his legal studies and took minor orders (which would allow him to enjoy benefices and canonries without ecclesiastical obligations).

For some years he enjoyed the life of the Avignon court where he soon made a name for himself thanks to the elegance of his culture and his first poetic attempts in Latin and the vernacular. His early youth, which had been mainly influenced by his love of God and virtue and his realization of the transitory nature of human affairs, was followed by a period of dissipation which coincides with the beginning of his most famous love affair (*Secretum meum*, iii, 6–7).

On April 6, 1327, in the church of Sta. Chiara, he first saw Laura, the lady who was to dominate his poetry, though not all his works, and still less his life, as the romantics would have us believe. Such critics, followed by the positivists, have consistently tried to give a face and a name to the "lady" of the *Canzoniere* (she has been identified with Laura di Audiberto di Noves who married Ugo di Sade, Laura di Sabran, Laura di Chiabau, Laura Colonna, etc.). The reaction is seen in the opposite tendency to see in Laura a pure symbol or *senhal* (in the language of Provençal poetry), a personification of intellectual beauty and truth. But neither the particular images that are woven into the *Rime* nor the accepted transfigurations and poetic structure imposed by literary tradition are able to reduce her to a symbol or an allegory. Yet it is useless to try and find out who she really was since Petrarch maintained silence about everything that concerned her civil status, as though he considered it of no importance. Laura lives only in his verse even though Petrarch drew his inspiration from a woman whom he had really known and loved.

At the invitation of Giacomo Colonna, a friend of his Bolognesi years, who had been appointed bishop of Lombez, Petrarch passed the summer of 1330 in that little Gascon town, "a most heavenly summer owing to the gaiety of the bishop and his companions," and then entered the service of Giacomo's brother, Giovanni, Cardinal Colonna, where he was to remain until 1347, "not serving a master, but rather a father or better still a most affectionate brother" (*Posteritati*). These were decisive years, crowded with travel alternating with periods of austere retirement, years of ambition but also of unpretentious, unremitting study and literary activity, particularly in the field of classical Latin (up to 1328). In 1333, he journeyed through France, Flanders, Brabant and the Rhineland. In Paris, thanks to a gift from Father Dionigi of Borgo San Sepolcro (his faithful friend and discreet confidant in spiritual matters) he was introduced to the *Confessions* of St. Augustine, a book which he was to use more and more as the breviary of his spiritual life; at Liège he transcribed, among other things, the Ciceronian oration *Pro Archia*, that great manifesto of the nature of poetry. These events seem almost to symbolize his mission as a stubborn advocate of the continuity between classical culture and the Christian message (as between a rich promise and its divine fulfillment) which justifies his position as founder and representative of European humanism and which can already be discerned in his two most ambitious and significant Latin works of this period, the *De viris* and the *Africa* (begun 1338 or 1339). And even before 1336 he had already begun to select, revise and copy those vernacular poems which he had been composing with increasing care during the preceding ten years.

The Mature Years.—Early in 1337 his dreams and aspirations which had been resolutely directed toward classical civilization found fulfillment in a visit to Rome. It was perhaps this deep emotional experience, which confirmed him in his faith, and the moral and religious doubts which had dramatically assailed him the previous year on his ascent of Mt. Ventoux with his brother Gherardo, that made him, when he returned to Provence, seek a refuge far from the restless, corrupt life of Avignon, full of memories of his most dissipated years (in 1337 his natural son Giovanni had been born). A few miles to the east he found the solitude of Vaucluse which was to serve as a retreat sacred to meditation and to poetry: his Helicon.

In Sept. 1340 there reached him simultaneous invitations from Paris and Rome to be crowned poet laureate, an honour which he had sought, not only from ambition but also in order that the rebirth of the cult of poetry might be celebrated after 1,000 years. For this reason he had no hesitation in preferring the Capitol to the Sorbonne and it was in the Capitol, on April 8, 1341, that he received a laurel wreath which he deposited as a symbolic gesture on the tomb of St. Peter.

From May 1341 until Feb. 1342 Petrarch was in Parma and later in the nearby solitude of Selvapiana; he then returned to Provence till the autumn of 1343. It is generally believed that at this time he passed through a "crisis" which, after a further period of dissipation in Avignon (his natural daughter Francesca was born in 1343), led him to a better-regulated life in which his spiritual need found expression in an intense concern for literary as well as moral problems. His inner torment, increased perhaps by his brother's decision to enter a Carthusian monastery, can be reduced to a conflict between his religious faith and his inability to adapt his own life to it: this is the situation so lucidly set out in the *Secretum* (42–43: "many times I thought to have shaken off my former yoke but it has bitten deep down to my bones . . . I shall die in my sin if help does not come from on High . . .").

It was therefore an evolution, both moral and literary, rather than a crisis, which made him realize that his love for Laura was wrong in spite of its purity and although it inspired him to do good, because it made him love his Creator for what he had created (and not the creature as the work of God) and was proof, therefore, of his attachment to this earth; an evolution which led him to break through the barriers of his too exclusive admiration for antiquity and to admit other and more authoritative voices. In the *De vita solitaria* (1346) the antinomy between classical and Christian culture appears almost completely resolved: "solitude," that great literary myth bequeathed by Petrarch to the humanist and modern worlds, becomes the point of contact between the *otium literatum* of the ancients and Christian asceticism; classical writers and heroes mingle with the prophets, saints and holy fathers, to such an extent that the first plan for the *De viris* was enlarged to include material from sacred as well as secular history.

Events which are fundamental to his biography as a man and a writer befell Petrarch during these years. He became sympathetically, even enthusiastically, interested in the efforts of Cola di Rienzo to realize the dream of popular government in Rome (an attitude which divided Petrarch ever more sharply from the curia at Avignon and in 1347 caused a break with Giovanni Cardinal Colonna). The terrible plague of 1348 caused the death of many friends including Laura herself (with poetic coincidence she died on April 6): the news reached Petrarch in Parma on May 19 and he noted it in his Virgil so that he might see it often and be reminded of the decay of all earthly goods. He met Boccaccio in Florence,

a very important meeting, awakening in Petrarch a consciousness of his cultural and moral mission. He made a pilgrimage to Rome for the jubilee year (visiting his birthplace and discovering Quintilian) in 1350, the year to which Petrarch assigns his final renunciation of the pleasures of the senses.

Between these landmarks, his life unfolded, crowded with diplomatic missions and dedicated to study during periods of meditation: in the autumn of 1343 he was in Rome and then in Naples on a mission to Queen Joanna on behalf of the Colonna family; from Dec. 1343 until Feb. 1345 he was again at Parma (where he wrote the *Rerum memorandarum*) and then at Bologna and Verona (where he made his great discovery of Cicero's letters *Ad Atticum, Ad Quintum, Ad Brutum*); toward the end of 1345 he returned to Avignon and took refuge in his beloved Vaucluse for two years of great spiritual and literary activity (*Bucolicum carmen, De vita solitaria, De otio religioso*); in Nov. 1347 he left for Italy, probably on a mission in favour of Cola (whom the May revolution had placed at the head of the Roman republic) but the fall of the tribune made him change his plans; he went to Verona and then to Parma where, except for occasional visits and missions, he remained from March 1348 to March 1349 (in Aug. 1348 he was appointed archdeacon of the cathedral). He then made a more permanent home in Padua where the lord of the city, Giacomo Novello da Carrara, had obtained a lucrative canonry for him. But Giacomo was assassinated (Dec. 19, 1350) during Petrarch's jubilee pilgrimage to Rome and since he was prevented from returning to Parma by some disagreement with the bishop and the suspicious tyranny of the Visconti family, to whom the city had been ceded, he felt himself possessed anew by a longing for Vaucluse. Neither Boccaccio's visit in April nor the offer he brought of a chair in the university to be established in Florence under his guidance were able to hold him back. He left in May 1351, reached Avignon in June and went straight to Vaucluse. This fourth retreat was particularly productive: the arrangement of the *Canzoniere*, on which he had already resumed work in 1348 at Parma and Padua, began to assume a more definitive form; the idea of forming a corpus of his letters which had first come to him perhaps as early as 1345 and certainly by 1349 took shape in his plan for the first collection, the *Familiari;* he continued to work assiduously on his collection of *Metriche* begun in 1350; he embarked on his polemic against the doctors, the bitter enemies of humane letters; and he revised and rewrote various earlier works (*De viris, Secretum*).

The death of his closest friends, the suspicions of Pope Innocent VI (who had succeeded the friendly Clement VI in Dec. 1352), and his increasingly bitter differences with the curia at Avignon, finally decided Petrarch to leave Provence and to return to his own country. From the alpine frontier of Montgenèvre he addressed it with moving eloquence: "Hail O most sacred land, beloved of God, hail land whom the good can trust, the proud must fear . . . Eagerly I return to you after so many years to live with you for ever; you will provide a haven of peace for my weary life." (*Epistolae metricae*, iii, 24). He found rooms in Milan where he remained, except for brief periods, during the next eight years (1353–61) in spite of harsh criticism for his acceptance of hospitality from ambitious tyrants and the enemies of Florence (the Visconti). Apart from the considerable missions entrusted to him by the Visconti (especially notable those to Venice in 1353 to negotiate peace with Genoa, to Mantua in 1354 and to Prague in 1356 where the emperor Charles IV accorded him royal honours, to Paris in the winter of 1361 on a visit to King John II after the peace of Bretigny), the Milanese period, the longest uninterrupted stay in one place during his whole lifetime, was one of the most fruitful. He completed the first proper edition of the *Rime*, applied himself with great fervour to the *Familiares*, made considerable progress with the *De remediis*, worked on the *Trionfi*, composed the *Invectiva* against Cardinal Jean de Caraman and the *Itinerarium* and revised and set in order with scrupulous care some of his earlier works.

Later Life.—During the spring of 1361, hoping to escape from the plague, he went to Padua on the invitation of Francesco da Carrara (son of his great friend Giacomo) remaining there until Sept. 1362 when, once more as a fugitive from the plague, he sought shelter in Venice, "the only stronghold in our times of liberty and peace and justice" (*Semilium rerum libri*, iv, 3). The *signoria* gave him a house on the Riva degli Schiavoni and Petrarch promised to bequeath all his books to the republic when he died. He was joined by his daughter Francesca with her husband the Milanese Franceschino da Brossano and their small daughter Eletta: the tranquil happiness of this little family gave great pleasure to their affectionate father. He was visited by his dearest and most famous friends (by the great chancellor Benintendi de' Ravegnani, by Paduan scholars, by Boccaccio, who in 1366 presented him with a long-desired Latin translation of the Homeric poems); he was invited to play an honourable part in the life and politics of the city; he worked peacefully but with great concentration at the definitive versions of the *Rime*, the *Familiares*, the *De remediis* and the *Seniles*. Nevertheless the insult he received from four young Averroists who called him "a good man . . . but illiterate and in fact an idiot" because he believed in Christian doctrines rather than those attributed to Aristotle, an insult which was ignored by Venetian public opinion, induced him to move back to Padua in 1367. He was to remain there until his death, dividing his time from 1370 onward between Padua and Arquà in the neighbouring Euganean hills where Francesco da Carrara had given him a little house, his last Helicon. He was still in demand as a diplomat: in April 1368 he accompanied the ruler and the bishop of Padua to meet the emperor Charles IV who was on his way to Italy as an ally of the league against the Visconti; later he was in Pavia and Milan for the marriage of Violante, daughter of Galeazzo, to Lionello the second son of the king of England; in 1370 he was called to Rome by Urban V and he set off eager to see the fulfillment of his great dream of a new Roman papacy, but was halted at Ferrara by a stroke. Yet he did not stop working; in addition to revision he composed the *De gestis Caesaris*, the *Invectiva* against Jean Hesdin and the final sections of the *Trionfi*.

Petrarch died during the night of July 18–19, 1374, when he was working in his little study at Arquà, and was found the next morning, his head resting on a manuscript of his beloved Virgil.

WORKS

Petrarch's literary production as poet, historical moralist and outstanding representative of the new culture is enormous. The chronology of his writings is somewhat complicated and uncertain and is made more so by the scrupulousness with which he revised and rewrote, often very extensively. Included here is a summary list with notes and, when they exist, a reference to better editions than those in his collected works (*Opera*, 1554 and 1581).

Latin Works.—*Epistolae Metricae.*—A collection in three books of 60 epistles in hexameters, dating from the verses on the death of his mother (1318 or 1319) and the earliest epistle of 1333 to the last letters composed between 1350 and 1354; he appears to have worked on the collection in three distinct phases, about 1350, 1357 and 1363. The subject matter is, naturally, very diverse: intimate confessions, autobiographical anecdotes, letters of consolation and exhortation, moral reflections, literary propositions and rhapsodies, descriptions, panegyrics, etc. (*Poemata minora*, edited by D. Rossetti, 1831).

Africa.—Petrarch began this work at Vaucluse in 1338 or 1339, pursued it with greater vigour at Selvapiana in 1341, returned to it frequently but intermittently after 1343 but never completed it: its various parts were gradually put together but its nine books (iv and ix are very incomplete) were published only after Petrarch's death, by Paolo Vergerio in 1396. It is an epic poem in hexameters which relates the history of the Second Punic War. The episode of Sophonisba, sacrificed to political expediency by her ardent lover King Masinissa, is both pathetic and dramatic; the famous lament of the dying Magone on the decay and misery of everything on earth (it was the only passage made available during the poet's lifetime) is strictly Petrarchan in inspiration; and this sentiment, together with a desolate perception of the fugacity of time, pervades the whole work, tempering with Christianity the Roman classicism of Livy and Cicero who are widely used as

sources and at times with too heavy a hand. (Critical edition by N. Festa, 1926.)

De viris illustribus.—The original plan of this work, begun in 1338 or 1339 and continued in 1341–43 as a series of biographies of famous Romans or people closely connected with Rome, was considerably modified between 1351 and 1353 so as to include famous men of all times beginning with Adam, thus achieving Petrarch's aim of emphasizing the continuity between the ideals of the Old Testament, of classical antiquity and of Christianity. Later he wrote fuller lives of Scipio and Caesar and finally, when he was in Padua, he took up the work again with the title *Quorundam virorum illustrium epithoma,* limiting it to 36 characters whose effigies were to be placed in a hall of Francesco da Carrara's palace; but he did not get further than the preface (the rest is the work of his disciple Lombardo della Seta who also completed the *Compendium* or *Breve compendium* of which Petrarch wrote only the first 14 biographies). (Edited by L. Razzolini, 1874–79.)

Secretum meum.—This autobiographical treatise was composed between the autumn of 1342 and the winter of 1343 and revised between 1353 and 1358. Not intended for publication, it is a fundamental work for the understanding of Petrarch's inner life. It consists of three dialogues between Petrarch and St. Augustine in the presence of Truth: in the first, Petrarch's secret infirmity is identified with a sickness of the will which makes him aspire to a nobler life while lacking the knowledge and will power to achieve it; in the second, Petrarch examines his conscience with regard to the seven deadly sins and finds himself guilty of all of them except envy, but especially of *accidia* (the theological definition of the sickness of the will discussed in the first book); in the third, Petrarch convinces himself of the sinfulness both of love (even when pure and directed towards a chaste woman) and of the desire for glory: that is, of the two great passions of his life. But he wearily declares himself unable to reform. The work constitutes a self-analysis of pitiless sincerity and precise autobiographical references at one of the decisive moments of his life. (Edited by E. Carrara, in Petrarca, *Prose,* 1955.)

De vita solitaria.—Written in 1346 and later revised and enlarged (one addition is definitely of 1371), the treatise, in two books, provides the theoretical basis and the description of one of Petrarch's essential myths, that of the "solitary life," in which man is able to enjoy the consolations of nature and study together with those of prayer. (Edited by G. Martellotti, in Petrarca, *Prose,* 1955.)

De otio religioso.—Written in 1347, it was revised and considerably enlarged in 1357. It is a treatise in two books on the advantages of the contemplative monastic life. It takes up the theme of *De vita solitaria* from a more strictly devout attitude and is tinged with a sharp nostalgia for purity and spiritual peace. (Edited by G. Rotondi, 1958.)

Familiarium rerum libri xxiv.—The idea of this collection of letters goes back to 1345 or more probably to 1349. The real work of arrangement was begun between 1351 and 1353 (up to book viii) and the final version was completed between 1359 and 1360 (up to book xix); in 1363–64 Petrarch returned to it, adding four books, and continued to work on it until 1366. It consists of a selection of 350 letters (the earliest dated 1325, the latest 1366, although the collection is supposed to end at 1361) which are of great importance for an understanding of Petrarch's life, both spiritual and active, and for the history of his decisive influence on European culture. As Martellotti has observed, these collections of letters represent the final stage of that progress from the contemplation of the world of antiquity as a means of escape from unpleasant realities to an intense preoccupation with the present, and the study of antiquity as foreshadowing the moral truths of Christianity. (Critical edition by V. Rossi and U. Bosco, 1933–42.)

De remediis utriusque fortunae.—This vast work, a part of which had been begun in 1354, had reached an advanced stage by 1360 and was finished in Oct. 1366 and published immediately. Petrarch probably returned to it later. It consists of two books containing 122 and 131 treatises, or discussions, between Reason, Pleasure and Hope and between Reason, Sorrow and Fear which contain respectively advice on how to attain good fortune and the remedies for bad, and which demonstrate the inconsistencies of pleasure and pain in a tone of bitter pessimism.

Senilium rerum libri.—Petrarch began his collection of the *Senili* after 1361 but never made a definitive arrangement as he did for the *Familiari.* The collection comprises 125 letters from 1361 to 1374 in 17 books.

Posteritati.—The first draft must be dated before 1367; there were important additions between 1370–72. It is an interesting autobiography in the form of a letter addressed to posterity, left unfinished and in draft form (it only goes up to 1351); it was to have formed the conclusion to the *Senili.* (Edited by E. Carrara and P. G. Ricci in Petrarca, *Prose,* 1955.)

De sui ipsius et multorum ignorantia.—Written 1367, published 1371, this is directed against the critics of Venice. Following St. Augustine Petrarch tries to show that rhetoric and poetry are the best spurs to moral action. (Edited by L. M. Cappelli, 1906.)

Other Latin Works: Prayers (1335–38). *Epistole sine nomine,* written 1342–58; collected 1359–60. (Edited by P. Piur, 1925.) *Rerum memorandarum libri,* 1343–45. (Crit. ed. by G. Billanovich, 1945.) *Bucolicum carmen,* 1346–48; definitive version 1364. (Edited by A. Avena, 1926.) *Salmi penitenziali,* 1347. (Edited by H. Cochin, 1929.) *Invectivarum contra medicum quendam libri,* 1352–55. (Edited by P. G. Ricci, 1950). *Invectiva contra quendam magni status hominem,* 1355. (Edited by P. G. Ricci, 1949.) *Itinerarium breve de Janua usque ad Jerusalem,* 1358 *et seq. Invectiva contra eum qui maledixit Italiae,* 1373. *Epistole varie;* 65 letters not included by Petrarch in his collections.

Italian Works.—*Rerum vulgarium fragmenta.*—This was Petrarch's title for the definitive collection of his Italian verse, his *Rime.* It consists of 366 compositions (317 sonnets, 29 *canzoni,* 9 sestine, 7 *ballate,* 4 madrigals) divided into two parts (263 poems described as *in vita Laura;* 103 *in morte Laura*). Naturally the first stage in the production of this work was the actual composition of the single poems (he did not include in the collection those written earlier than 1330); the second, before 1336, his first idea of making a selection; the third, between 1342 and 1347, the arrangement of the selected poems according to a certain criterion; the fourth, after the death of Laura, their division into two parts and the project of illustrating the story of his own soul (perhaps 142 lyrics on the period before Laura's death plus 29 after); the fifth, the first proper edition of the *Canzoniere* sent to Azzo da Carreggio in 1360 (about 174 plus 41); the sixth, a second edition in Jan. 1373 sent to Pandolfo Malatesta; the seventh, the definitive edition which is preserved in the Cod. Vat. Lat. 3195, partly autograph, partly transcribed by Giovanni Malpaghini under the poet's supervision. The choice of poems and the arrangement of the collection are governed by a most rigorous and exclusive standard of aesthetic taste, by a preference for an approximately chronological arrangement and by the poet's ever growing urge to express, through these verses which are chiefly concerned with his love for Laura, the story of his own soul, from the description of his falling in love to his anxious invocation to the Virgin; from his "youthful errors" to his realization that "all worldly pleasure is a fleeting dream"; from his love for this world to his final trust in God. The theme of his *Canzoniere* therefore, goes beyond the apparent subject matter, his love for Laura. For the first time in the history of the new poetry, lyrics are not considered as *nugae* or occasional verse as they had been from the troubadours to Boccaccio: Petrarch, in spite of frequent doubts and many changes of mind, still felt that the *schedulae* containing his verses were the threads holding together a marvelous new tapestry possessing its own unity and similar to that which he was constructing, on the Ciceronian model, from his letters. By selecting all that was most polished and at the same time most vigorous in the neo-Latin lyric tradition of the preceding two centuries, and filtering it through his new appreciation of the classics, he not only bequeathed to humanity the most limpid and yet passionate, precise yet suggestive, expression of love and grief, of the ecstasies and sorrows of man, but also created with his marvelous sensibility the form and language of the modern lyric. In fact, the history of the European lyric could be re-

counted in terms of action and reaction in the face of the Petrarchan experience. (Edited by G. Contini, 1949; commentaries by G. Carducci and S. Ferrari, 1899 and, 6th ed., 1957; edited by E. Chiorboli, 1924.)

Rime disperse.—This title (or sometimes *Extravaganti*) is used for those verses Petrarch did not include in his main collection, either because they were not good enough or because they were not addressed to Laura. The authenticity of many is doubtful, in some cases no longer accepted. (Edited by A. Solerti, 1909.)

Trionfi.—A poem in *terza rima* probably conceived and begun in 1351 in imitation of Boccaccio's *Amorosa visione* and possibly of Dante's *Divine Comedy*. It was written in sections and continually revised during the following years (the earliest certain dates, 1356–60, are of the *Trionfo d'Amore*, the latest, Feb. 1374, is written in the margin of the *Trionfo dell'Eternità*). Petrarch left it unfinished and it was published posthumously. It is an historical and symbolical vision of the great theme of the *Canzoniere* raised from the autobiographical to the universal, that is, from the story of one man alone, Petrarch, to that of man in himself, or rather of the whole of humanity in its progress from earthly passion to fulfillment in God. Love triumphs over the greatest men, but is captured by Chastity; which in its turn, in the person of Laura, is overcome by Death; which is conquered by Glory; which is itself annihilated by Time: only in God does everything of beauty and everything of value, love for Laura and love for glory, shine eternally beyond all space and time, and heaven and earth are reconciled according to Petrarch's noble and constant dream. (Critical edition ed. by K. Appel, 1901; to be read in conjunction with the new sections, *Un inedito petrarchesco*, edited by R. Weiss, 1950.)

Conclusion.—This summary of the essential events of his life and sketch of the chronological and spiritual development of his works will have sufficed to show the exceptional importance of Petrarch in the poetry and culture of modern and Christian Europe; never before, perhaps, has a writer had so rapid, so decisive and so far-reaching an influence. This "presence" was so effective because it made itself continuously felt, through his spoken and written conversations with his friends and disciples, and his prodigious achievement as the discoverer of so many of the treasures of classical learning and beauty, both in those texts which he actually found and in those which he re-established by his sensitive and accurate interpretation. Through his sublime poetry, and his profound spiritual and moral meditations, his historical visions and reconstructions and in the devoted work for humane studies by which he solved the age-old problem of the reconciliation of the classical with the Christian world, Petrarch shows how in the substantial identity of human souls God provides the opportunity for meetings and contacts, for the affirmation of the same truths in different ages and under different skies. The words of his beloved St. Augustine which, during the ascent of Mt. Ventoux, flashed before his mind's eye, "And men go to admire the high mountains and the immensity of the ocean and the course of the heavens . . . and neglect themselves," are truly symbolical of Petrarch's mission in life, of his thought and of his art. Never, since the great teachers of antiquity and the greatest fathers of the church, has man had so enthusiastic and sensitive an interpreter of his sorrows and his greatness, so subtle and so sympathetic an interpreter of his eternal uncertainty outside fulfillment in God. "I always feel a sense of unfulfillment in my heart," he wrote with Augustinian inspiration in the *Secretum*. It is for this reason that the figure of Petrarch towers over that age, from Boccaccio to Erasmus, which took its name from man, the age of humanism; for this reason that, from Bembo to Michelangelo and Ronsard, from Gongora and Milton to Klopstock, from Shelley and Heine to Leopardi, to Heredia, to D'Annunzio, the art which, better than any other, expresses with precision and yet with sensitivity the most constant and the noblest aspirations of man, sprang originally from the fount of Petrarchan inspiration.

For a portrait of Petrarch *see* ITALIAN LITERATURE.

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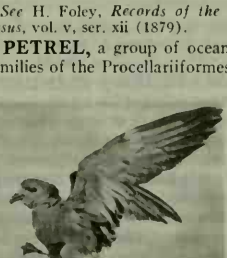
PETRE, SIR EDWARD (1631–1699), clerk to the closet to King James II of Great Britain, was born in London, the younger son of Sir Francis Petre, baronet, of Cranham. Educated in France at the Jesuit College at St. Omer, he entered the Society of Jesus in 1652 and took orders in 1671, when he returned to England. In 1679 he succeeded his elder brother in the family title and estates. In the same year he was imprisoned for suspected complicity in the "popish plot" (*see* OATES, TITUS), but he was released in 1680 by the influence of James (then duke of York). From 1679 to 1683 he was vice-provincial of the English province of the Society of Jesus. He was deep in James II's confidence, and the king's more extreme policies were attributed to him. James made many attempts to secure him a bishopric or a cardinalate, but Pope Innocent XI steadfastly refused and he had to be content with the post of clerk to the closet (1686) and membership of the privy council (1687). He is often erroneously described as James's confessor. Late in 1688 he fled abroad and had no further contact with James. He was head of the college at St. Omer from 1693 to 1697, when he was transferred to Watten in Flanders, where he died on May 15, 1699.

See H. Foley, *Records of the English Province of the Society of Jesus*, vol. v, ser. xii (1879). (J. P. K.)

PETREL, a group of oceanic birds classified in two or more families of the Procellariiformes, an order including also the albatrosses and shearwaters. There is little to support the legend that these birds, which appear to walk on the water, are named after St. Peter; the earliest English spelling (1676) was "pitteral."



ROBERT C. HERMES FROM THE NATIONAL AUDUBON SOCIETY

LEACH'S PETREL (OCEANODROMA LEUCORHOA)

Petrels make up the bulk of the Procellariiformes. The size range, from the swallowlike storm petrels (family Hydrobatidae) to the three-foot-long giant petrel (*Macronectes giganteus*), is equaled in few if any other natural groups of birds. Cosmopolitan, they occur only on salt water but extend to its uttermost

limits. Variety and abundance are greatest in higher latitudes of the southern hemisphere. Breeding grounds are almost exclusively on islands. The storm petrels, including the genera *Pelagodroma, Oceanodroma, Oceanites* and *Fregetta,* are nocturnal ashore and nest in burrows or in chinks among rocks; a few surface-breeding species occur on islands devoid of predatory enemies. The Procellariidae includes the genera *Pterodroma, Pagodroma* and *Macronectes.*

Some kinds of petrels are sedentary in the vicinity of their breeding stations. Others make very extensive migrations. For example, Wilson's petrel (*Oceanites oceanicus*), one of the seafarers' "Mother Carey's chickens," common in summer in the North Atlantic, nests in austral spring at the edge of the antarctic.

The aberrant diving petrels, composing the family Pelecanoididae, range in the southern hemisphere and breed on islands.

Petrels lay a single white egg and care for the young during their exceptionally slow growth. They feed on a wide variety of marine organisms. Only the giant petrel, which is partly a carrion eater, takes any of its food ashore or on sea ice. *See* also Albatross; Fulmar; Shearwater. (R. C. Mu.)

PETRI, OLAUS and **LAURENTIUS,** two Swedish churchmen who played decisive roles in the reformation of the Swedish church. Born at Örebro in the diocese of Strängnäs, Olaus (or Olavus) Petri (1493–1552) studied at Wittenberg (1516–18) and absorbed the reformed teaching of Luther and Melanchthon. When Gustavus Vasa was crowned king in 1523, Olaus had already attracted attention and criticism by his preaching. The Roman Catholic hierarchy were hostile to the king, who became a supporter of the reformed teaching. Laurentius Andreae, secretary and later chancellor to the king, was a friend of Olaus Petri, who preached the coronation sermon. Olaus rose in prominence and served briefly as chancellor (1531). Later he opposed the autocratic policy of the king, and both he and Andreae fell from favour and were condemned to death in 1540, the sentence being remitted for a heavy fine. Later he regained favour and was appointed pastor of Storkyrkan church in Stockholm where he died in 1552. Olaus provided most of the literature for the Swedish Reformation movement, including a Swedish New Testament (1526), hymnbook (1526), church manual (1529), the Swedish liturgy (1531), and many homiletical and polemical writings. His *Chronicle* is an important historical document.

Laurentius Petri (1499–1573) also studied at Wittenberg, returning to Sweden in 1527. He was appointed the first Protestant archbishop of Uppsala in 1531 and held this office until his death in 1573. His influence was very great, although he was less dynamic and forceful than his brother. The Swedish Bible of 1541, for which he was principally responsible, was as important for Swedish life and literature as Luther's German translation was for the German-speaking peoples. His *kyrkoordning* (church order) of 1571 defined the practice of the church, particularly its relation to government, and went far toward establishing the independence of the church from the crown which has been characteristic of most of its history.

See C. J. I. Bergendoff, *Olavus Petri and the Ecclesiastical Transformation in Sweden 1521–52* (1928); E. E. Yelverton, *An Archbishop of the Reformation* (1959). (E. M. C.)

PETRIE, SIR (WILLIAM MATTHEW) FLINDERS (1853–1942), English archaeologist remembered for his discoveries in Egypt and for introducing scientific methods of excavation, was born at Charlton, near Greenwich, on June 3, 1853. A delicate child, he was educated privately, developed an early interest in ancient weights and measures, and published *Inductive Metrology* (1875). Between 1875 and 1880 he studied sites in Britain, including Stonehenge. A long series of surveys and excavations in Egypt began (1880) with the pyramids of Giza and proceeded to the temple of Tanis (1884), the Greek city of Naukratis in the Nile delta (1885), and Daphnae and other towns (1886). Between 1888 and 1890 he worked in Al Fayyum, principally at Hawara, Illahun, and Ghurab. He next explored and excavated the pyramid and temple of Maydum. In 1894 he discovered the painted pavement at Tell el Amarna and then excavated the town of Coptos (Qift; 1895), the predynastic site of Nakada (1896), and a series of temples at Thebes (1897). From 1898–1904 he explored the great necropolis of Abydos (*q.v.*), discovering the royal tombs or cenotaphs of the earliest dynasties, and the antiquities of Dandarah. Subsequently he dug at Memphis and again in Al Fayyum, where he made a rich find of 12th-dynasty jewelry (housed since 1919 in the Metropolitan Museum of Art, New York). In 1922 Egyptian laws relating to the antiquities were made much more strict, and Petrie turned to Palestine, where he continued to excavate until 1938.

From 1892 to 1933 he was Edwards professor of Egyptology at University College, London. His excavations between 1881 and 1906 were carried out for the Egypt Exploration Fund and for private subscribers. In 1894 he founded his own fund-raising and publishing medium, the Egyptian Research Account, renamed in 1905 the British School of Archaeology in Egypt; it was dissolved in 1954.

Petrie published more than 40 large quarto volumes with numerous plates. His many books for popular reading include an autobiography, *Seventy Years in Archaeology* (1931). Essentially a practical fieldworker of great ability, he made contributions of the highest value, but had no flair for research in epigraphy. He was prone to base his theories on inadequate premises: notably his views on chronology, which are not accepted by most scholars (*see* Alphabet: *Origin*). Petrie was knighted in 1923; he died at Jerusalem on July 28, 1942.

See also Egypt: *Archaeology.*

See S. Smith, *Sir Flinders Petrie* (1943); C. M. Daugherty, *The Great Archaeologists* (1962). (W. R. D.)

PETROCHEMICALS, in the strictest sense, are chemicals derived wholly or partially from petroleum or natural gas. The definition, however, has been broadened to include the whole range of aliphatic, aromatic, and naphthenic organic chemicals, as well as carbon black and inorganic materials such as sulfur and ammonia. In many instances, a specific chemical included among the petrochemicals may also be obtainable from other sources, such as coal, coke, or vegetable products. For example, materials such as benzene and naphthalene can be made from either petroleum or coal, while ethyl alcohol may be of petrochemical or vegetable origin. This not only makes it difficult to categorize a specific substance as petrochemical or nonpetrochemical but also creates problems in making statistical analyses of the industry.

Petrochemicals find application in such diverse industries as agriculture; food processing; detergent, automobile, and paint manufacture; building construction; textiles; and synthetic rubber production. For example, a typical U.S. automobile in the 1960s utilized 11 basic polymers of petrochemical origin for more than 180 plastic parts. Consumption of plastics per vehicle amounted to 28–30 lb. In another area, the construction industry, petrochemicals found application in protective and decorative coatings, flooring, adhesives, electrical equipment, tiles and fixtures, panels and laminations, piping, moisture barriers, insulation, and roofing. Here, as in the automobile industry, many of the petrochemicals used were plastics or resins.

Development in the United States.—Any discussion of the history of the petrochemical industry necessarily begins with events in the United States, which was the cradle of this worldwide industry. The earliest activities came during World War I, when there were shortages of many chemicals needed for military and civilian uses. Among the more critical materials in short supply was toluene, which was required for the manufacture of explosives. To augment toluene supplies, several petroleum companies carried out thermal cracking operations on selected petroleum fractions and recovered small amounts of toluene and other aromatics. After the war, demands for toluene lessened, prices declined, and the petroleum-based product could not compete economically with materials available from the coking industry. Consequently, interest in petroleum-derived aromatics became dormant and remained so until World War II.

In contrast, interest in the production of aliphatics from petroleum prospered after the war. The production of isopropanol from propylene reached commercial proportions during 1919–20. The thermal cracking of liquid petroleum fractions and propane to pro-

duce ethylene became commercially feasible, and derivatives of this olefin made appearances on the American market in the early 1920s.

Ethylene and the other lower olefins, propylene and butylene, continued as the primary raw materials for petrochemicals during the 1920s and 1930s. One of the outstanding developments during this period was the chlorhydrin process for converting ethylene to ethylene glycol, which found a large market as an antifreeze for liquid-cooled automobile and aircraft engines.

By the end of the 1930s the petrochemical industry was gaining considerable momentum. Petroleum refining had reached a very large scale, making available a virtually unlimited supply of hydrocarbon raw materials. Research and product development activities were being carried out at a rapid pace. By 1940 many new petrochemicals, and the new chemical and engineering technologies associated with them, had become commercially successful. Thus, when the United States became involved in World War II, the petrochemical industry was in an advantageous position to make its contribution to the war effort. The huge demands for aviation fuel, rubber, plastics, explosives, fertilizer, solvents, detergents, etc., led to crash programs to create entirely new production techniques and facilities. Outstanding among these was the development of synthetic rubber, based on petroleum-derived olefins and diolefins, and the extension of petroleum refining operations to produce basic aromatic raw materials, including toluene for trinitrotoluene (TNT) manufacture. In 1944, at the peak of World War II, toluene production from petroleum sources reached approximately 166,000,000 gal., while only about 38,000,000 gal. were produced from coal. Thus, the area of aromatic chemicals was opened to the petrochemical industry.

After World War II, developments in the fields of plastics, man-made fibres, synthetic rubber, detergents, and chemical fertilizers were of most importance, especially the large-scale operations for the production of polyolefins such as polyethylene and the development of processes for the manufacture of stereospecific polyolefins. In the synthetic rubber industry, the development of stereospecific polymers of butadiene and isoprene and of copolymers of ethylene and propylene were significant contributions. Man-made fibres based on the nylons, which appeared commercially in 1939–40 and were reserved primarily for military applications during World War II, entered the civilian market after the war with astounding success. In addition, new fibres, such as those based on polymers of acrylonitrile (Acrilan, Orlon, Creslan, Zefran, Dynel, Verel, etc.), terephthalic acid and ethylene glycol (Dacron, Kodel, Vycron), and vinylidene chloride (Saran, Velon, Rovana, etc.) were introduced on a commercial scale. These fibres provided significant competition to such established materials as wool, cotton, and rayon.

Synthetic detergents gained consumer acceptance during World War II when the availability of soaps based on natural fats and oils was limited. Consumption of detergents expanded rapidly in the postwar period and soon surpassed the consumption of soap. Many products involving a wide variety of raw materials, largely based on petroleum, were introduced. But the domination of the detergent industry by synthetic products resulted in a shortage of glycerine, which previously had been supplied exclusively as a by-product of the soap industry. To alleviate this situation, a process to manufacture glycerine synthetically was developed; thus glycerine became a petrochemical.

Encouraged by demands of a rapidly expanding, ammonia-based fertilizer industry, producers of hydrogen derived from petroleum and natural gas turned this into a large-volume commercial product. Catalytic reforming operations, carried out by the petroleum industry in the manufacture of high-octane motor fuels, produced quantities of by-product hydrogen that were employed in the manufacture of synthetic ammonia. Since these sources of hydrogen were inadequate or, in many instances, not conveniently available, other sources, based on the partial oxidation or reforming of petroleum hydrocarbons or natural gas, were established to provide an essentially unlimited supply. Petrochemical hydrogen, the key to low-cost, ammonia-based fertilizers, provided hope of improving the food supply available to many undernourished peoples of the world.

Other products and processes that reached commercial significance in the period after World War II included epoxy resins, polyurethanes, polyacetals, polycarbonates, and the production of oxygenated chemicals by the controlled direct oxidation of propane and butane with air.

Development in Other Countries.—In comparison to activities in the United States, petrochemical operations in the rest of the world prior to World War II were negligible. Western Europe, centre of a highly-developed chemical industry based on its coal supplies, suffered a lack of developed petroleum or natural gas deposits and thus was not encouraged to turn to petroleum as a source of raw materials. Development of the petrochemical industry in Western Europe therefore hinged on the importation of large quantities of crude oil and the construction of refineries to process it. This occurred after World War II when discoveries of tremendous quantities of crude oil in the Middle East and North Africa provided convenient, low-cost sources for Europe's growing energy requirements. The first significant petrochemical operations were started in the United Kingdom in 1950–51. These soon were followed by the introduction of petrochemical activities in Italy, France, and West Germany. Developments in Italy and France were encouraged by the availability of significant indigenous natural gas deposits. Later, the petrochemical industry was established in the Netherlands, which enjoyed a strategic geographic location in the European Common Market and had large natural gas deposits.

Developments in Japan were notably rapid. As in Western Europe, petrochemical operations had to await development of petroleum refining activities based on imported crude oil. Thus the first facilities in Japan were not completed until 1957, but swift growth was seen thereafter.

Although activities in the United States, Western Europe, and Japan have been mentioned specifically, progress in other countries such as Canada and Australia was almost equally significant. Members of the Communist bloc of nations made a determined effort to expand their petrochemical activities. In general, petrochemical development in areas outside the United States followed the pattern established in that country, with initial operations based on paraffinic or olefinic raw materials.

Growth of the Industry.—Specific information on the output of petrochemicals in three major producing areas of the world, the United States, Western Europe, and Japan, indicates the phenomenal vitality of this industry. Growth in the United States, for example, increased over thirteenfold in the two decades following World War II, while plant investment increased more than 17 times. This rapid expansion was attributable to several factors, including (1) general growth in the economy and population of the countries involved; (2) replacement or supplementation of alternate raw materials derived from coal and agricultural products by lower cost, more conveniently available raw materials derived from petroleum or natural gas; and (3) development of new products which establish entirely new markets or displace alternative products from an established market.

The first factor needs no explanation, being related to an increased level of national incomes, construction activity, demand for consumer goods, etc. The second factor involves the replacement or supplementation of raw materials. For example, ethyl alcohol produced by fermentation of agricultural products supplied the major portion of the demand for this product before World War II. In the meantime, processes for the derivation of ethyl alcohol from petroleum-based ethylene were being perfected. These processes proved to be more economical than fermentation and thus synthetic ethyl alcohol largely replaced natural or fermentation ethyl alcohol for industrial uses in the United States. Numerous other products experienced a similar shift, from natural to synthetic, in the major source of associated raw materials, including benzene, toluene, xylene, methanol, ammonia, and rubber.

An outstanding example of a development mentioned above as the third factor contributing to the growth of the petrochemical industry is polyethylene. Production of this remarkable plastic material in the United States increased by a factor of 2,000 in a 20-year period. Although some of the growth in markets for

polyethylene was accounted for by the substitution of this plastic for metals and other materials in established applications, entirely new applications utilizing its unique properties also made significant contributions.

Location of the Industry.—The factors which establish specific geographic areas as centres for petrochemical operations are essentially the same as those controlling the location of other industries, including availability of raw materials, availability of markets, labour costs, construction costs, transportation facilities, and fuel and utilities costs. Usually a combination of these factors is involved.

In the United States, abundant raw materials in Texas and Louisiana was the dominant factor in establishing the Gulf Coast as the leading petrochemical production area. Supplementary factors included low construction, fuel, and utility costs, as well as the availability of low-cost water transportation. The primary factor encouraging locations in other areas of the United States having significant concentrations of petrochemical activity—California, the Midwest, and Middle Atlantic states—was the presence of large consumer markets. Of course, the availability of raw materials from petroleum refining operations in these areas was also a positive factor.

In Western Europe, Belgium, England, France, West Germany, Italy, and the Netherlands contain the main centres of production. In general, sites having access to good harbours and navigable waterways were favoured because of the industry's dependence upon imported crude oil or feedstocks and because of the wider markets available from these locations.

See also CHEMICAL INDUSTRY; PETROLEUM.

See William Haynes, *American Chemical Industry* (1954); R. F. Goldstein, *The Petroleum Chemicals Industry* (1958).

(W. E. KU.; H. A. KI.)

PETRODVORETS (formerly PETERGOF or PETERHOF), a town in Leningrad *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., and administratively under the Leningrad City Council, stands on the southern shore of the Gulf of Finland, 18 mi. (29 km.) W of Leningrad. The town has grown up round the palace and gardens built for Peter the Great in 1721. The palace, designed by J. B. A. Leblond and enlarged by Bartolomeo Rastrelli in 1752, was destroyed in World War II, but the magnificent gardens, with their 130 fountains and many pavilions, have been restored. Of special note are the Grand Cascade and the Samson fountain. (R. A. F.)

PETROGRAD: *see* LENINGRAD.

PETROKREPOST (formerly SHLISSELBURG; *Ger.* SCHLÜSSELBURG), a town in Leningrad *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., lies 25 mi. (40 km.) E of Leningrad, on the south bank of the Neva where it flows out of Lake Ladoga. The place was founded by the Republic of Novgorod in 1323, when it was known as Oreshek. Later the Swedish fortress of Noteborg was established there. Its capture in 1702 by Peter the Great was the preliminary to the foundation of St. Petersburg (now Leningrad). Renamed Shlisselburg, it served as the key fortress on the eastern side of St. Petersburg, and later as a prison. The terminus of the Ladoga lateral canals, the town has shipbuilding and repair yards. It was damaged during World War II, when it played an important role in the defense of Leningrad. The town was given its present name in 1944. (R. A. F.)

PETROL: *see* GASOLINE.

PETROL ENGINE: *see* INTERNAL-COMBUSTION ENGINE.

PETROLEUM is a mixture of gaseous, liquid, and solid hydrocarbons found in varying amounts in sedimentary rock deposits throughout the world. In its crude state petroleum is practically useless. When refined it supplies fuels, lubricants, illuminants, solvents, surfacing materials, and many other products. The fuels derived from it account for half the world's total supply of energy and are used not only to power the engines of automobiles, tractors, trucks, ships, airplanes, and missiles but also to heat buildings. Petroleum lubricates machines, and petroleum cutting oils make possible much of the drilling and grinding basic to mass production. Asphalt from petroleum covers floors, roofs, and highways. Either directly by combustion, or indirectly through the generation of electricity, petroleum supplies many people of the world with artificial light. Petroleum products are also used in man-made fibres for clothing; synthetic rubber for tires and other uses; cleansing agents, such as soap and detergents; paints and plastics; and numerous ingredients used in the production of fertilizers, insecticides, medicines, etc., and for food processing. In peacetime such applications have multiplied as scientists and engineers have developed new processes, and the further processing of by-products has given rise to a whole new industry, petrochemicals (*q.v.*). Every day the world consumes nearly 1,000,000,000 gal. of petroleum, which is thus the single most important item of international trade. Because large capital resources and continuous fresh investment are required, it is usually large public or private corporations that explore for, produce, transport, refine, and market crude petroleum and its products.

World Wars I and II demonstrated petroleum's vital importance. World War I focused attention on petroleum as a fuel and lubricant, and World War II on its additional role as a raw material in the manufacture of synthetic rubber, TNT, waterproofing greases for amphibious operations, fuels for flamethrowers, and incendiary materials.

Because it is indispensable in peace and war, crude petroleum is sought by individuals and by nations. Access to petroleum reserves is a constant concern of commercial and governmental policy. Petroleum has entered into politics and politics into petroleum.

Petroleum has also promoted economic development by bringing income for investment and social welfare to the producing countries (many less-developed countries, notably Venezuela and Kuwait, have made great progress as a result of petroleum revenues) and by providing a relatively inexpensive source of energy in areas where other energy sources are nonexistent or costly.

This article is organized along the following lines:

I. Characteristics of Crude Petroleum
  A. Physical Characteristics
  B. Chemical Characteristics
II. Technology
  A. Production
    1. Exploration
    2. Drilling
    3. Offshore Drilling
    4. Recovery
  B. Transportation and Storage
    1. Pipelines
    2. Other Means of Transport
    3. Storage
  C. Refining
    1. Purpose and Location of Refineries
    2. Separation
    3. Chemical Processing
    4. Purification
    5. Scale of Refinery Operations
    6. Petrochemicals
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III. Demand and Supply
  A. Sources of Crude Petroleum
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IV. History
  A. From Early Times to 1918
    1. United States
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  B. From 1919 to 1939
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    1. Middle East Development
    2. Social Benefits from Oil Revenue
    3. New Pattern of World Development

I. CHARACTERISTICS OF CRUDE PETROLEUM

A. PHYSICAL CHARACTERISTICS

Many scientists believe petroleum was formed from the remains of tiny aquatic plants and animals hundreds of millions of years

ago when the sea covered large areas of what are now landmasses. The animals and plants lived and died in countless numbers, sinking to the sea bed where they mixed with mud and sand in layers called marine sediment. Later, these sedimentary layers were covered by more mud and sand, which finally turned into rock. As ages passed the sea withdrew, the earth's crust heaved and buckled, burying the sedimentary deposits, and the heat and pressure caused by the overlying rock, together with decomposition of the organic life, formed oil from the animals and plants in the deep-buried layers. Petroleum is thus called a "fossil" fuel because, like natural gas and coal, it is derived from organic material. It is also commonly referred to as a "mineral" oil since it lies in the pores of underground sedimentary rocks or sand and is popularly linked with the minerals.

Characteristics of Representative Crude Oils

Origin	Field	Specific gravity Water=1.000	Colour	Depth of reservoir (ft.)	Approximate physical composition (%)*				Chemical base
					Gasoline and gas	Kerosene	Gas oil	Residuum	
California	Coalinga-Guijaral Hills	0.858	greenish black	6,814–6,908	36.6	4.4	36.0	23.0	intermediate
Pennsylvania	Bradford	0.800	green	1,816–1,849	47.4	17.0	14.3	21.3	paraffin
Oklahoma	Edmond, West	0.816	green	6,530–6,634	47.6	10.8	21.6	20.0	intermediate
Texas	Kilgore (E. Texas)	0.827	†	...	33.9	7.3	58.8		†
	Slaughter (W. Texas)	0.864	brownish	...	44.9	4.2	23.2	27.9	intermediate
Iraq	Kirkuk	0.844	reddish brown	2,750	45.3	15.7	15.2	23.8	paraffin-intermediate
Iran	Haft Kel	0.836	†	3,000–4,000	45.1	11.5	22.6	20.8	paraffin-intermediate
Kuwait	Burgan	0.860	†	3,800–4,400	39.2	8.3	20.6	31.9	paraffin-intermediate
Bahrain	Bahrain	0.861	†	1,800–2,300	26.1	13.4	34.1	26.4	intermediate
Saudi Arabia	Abqaiq	0.840	†	6,500	34.5	8.7	29.3	27.5	paraffin-intermediate
Venezuela	Bachaquero	0.950	dark brown	4,069–4,199	15.3	7.4	77.3		†

*The definitions of the products vary somewhat with location. †Not available.
Sources: A. E. Dunstan (ed.), *The Science of Petroleum*, vol. ii, p. 847; vol. v, part i (*Crude Oils*), pp. 8–23, 28, 30–34, London, Oxford University Press (1938 and 1950).

Crude petroleum contains thousands of different chemical compounds, ranging from gases to semisolid materials such as asphalt and paraffin wax. At the extreme pressure exerted underground, the gases are dissolved within the heavier components, but upon reaching the surface they may vaporize. When separated, they are called natural gas (*see* GAS INDUSTRY). Likewise, paraffin wax is dissolved in the crude petroleum, although it too may separate when cooled at the surface.

Physically, crude petroleum is a mixture of compounds boiling at different temperatures. The fraction of lightest specific gravity, comprising the gases, boils below atmospheric temperature. The next heaviest fraction, that which is normally refined into gasoline (*q.v.*), boils between roughly 30°–200° C (85°–390° F). The fraction boiling between about 140°–300° C (285°–570° F) is called kerosene (*q.v.*), while that boiling above about 300° C is called gas oil, because it was once used as a raw material in fuel-gas manufacture. The remaining and heaviest fraction is known as "reduced crude" or "residuum." Heating and diesel oils are generally derived from the gas-oil fraction, lubricating oils from both the gas-oil and reduced-crude fractions, and fuel oils, waxes, and asphalts from the reduced crude. The proportions in which the different fractions occur vary with origin, some crude oils being rich in gasoline components, others in kerosene, and still others in lubricating oils and waxes. For physical characteristics of representative crude oils, *see* Table.

B. Chemical Characteristics

Chemically, the major components of crude petroleum are hydrocarbons, compounds of carbon and hydrogen, combined in molecules of different sizes and arrangements. Small molecules (one to four carbon atoms) constitute the gases; larger molecules (from four to about ten carbon atoms) constitute gasoline; still larger molecules (up to 50 atoms) make up the light fuels and lubricating oils, and gigantic molecules (up to several hundred carbon atoms) constitute the heavy fuels, waxes, and asphalts. Accompanying the hydrocarbon gases are appreciable amounts (up to 15% each) of nitrogen, carbon dioxide, and hydrogen sulfide, as well as smaller amounts of helium and a few other gases. In the liquid hydrocarbons there are usually found traces of oxygen, sulfur, and nitrogen, either as elements or combined with the hydrocarbon molecules.

The carbon atoms in the hydrocarbon molecules may be linked in two different ways, forming either a ring or a chain. Moreover, each of the carbon atoms may have either a full or only a partial complement of hydrogen atoms, forming saturated and unsaturated molecules, respectively. Saturated ring hydrocarbon molecules, whose chemical formula is C_nH_{2n} (where C and H stand for carbon and hydrogen atoms and n is any positive integer) are called naphthenes. Naphthenes are generally unreactive, for they can combine with other materials only by substituting for one or more of their hydrogen atoms. Saturated chain hydrocarbon molecules (chemical formula, $C_nH_{2n} + 2$) are called paraffins and are equally unreactive. Unsaturated ring hydrocarbons are called aromatics, and unsaturated chain hydrocarbons (chemical formula, C_nH_{2n}) are called olefins. Both classes of unsaturated hydrocarbons are able to combine directly with other materials without having to displace any hydrogen atoms, and consequently are very reactive. Several refining processes have been developed to increase the yield of unsaturated hydrocarbons boiling in the gasoline range. Both ring and chain hydrocarbon molecules can have appendages or "radicals," containing usually carbon and hydrogen atoms but occasionally sulfur, oxygen, or nitrogen. Most prevalent are the methyl (CH_3), ethyl (C_2H_5), and propyl (C_3H_7) radicals. Substances whose molecules have the same number of atoms of each element but different internal structures are known as isomers; although they share the same chemical formulas their chemical and physical properties differ. The chemical composition and boiling range of crude petroleum varies with the source of origin, as shown in the Table (*see* also HYDROCARBON).

II. TECHNOLOGY

A. Production

1. Exploration.—The physical and chemical characteristics of a crude oil, together with the location and extent of the deposit, largely determine its value as a raw material. Exploration is most intense in those areas already yielding or showing evidence of yielding large volumes of high-quality petroleum.

Petroleum lies hidden under the earth. No physical or chemical property of petroleum has been found which enables it to be detected from the surface. Thus the exploratory techniques, geological, geophysical, and geochemical, that have been developed do not yield perfectly accurate forecasts of discovery; at best they give the geologist only an indication of how good his chances are. Only by drilling will he learn if oil actually exists in a given location.

The modern oil industry began about 1859. In its first half-century, exploration consisted in locating indications of oil on the surface of the earth. Wells were then drilled on or near the site of the seepage. Thus the oil fields of Pennsylvania, the Caucasus, Rumania, Iran, Burma, and Sumatra were opened up.

The profits from oil discoveries were so attractive that wells were often drilled by "wildcatters" in the absence of any favourable geological indications. Wildcat discoveries opened many oil fields, those in Ohio, Illinois, and Kansas in the United States being only a few. Most wildcat wells benefit from local or regional geological knowledge and from accumulated experience in the area. However, in the decade of the 1950s only about one in every eight wildcat wells was successful.

Scientific exploration developed at the beginning of the 20th

century when geologists began to map land features as indicators of favourable places to drill. Particularly revealing were outcroppings which gave evidence of alternating layers of porous and impermeable sedimentary rock. Porous rock, typically a sandstone, limestone, or dolomite, acts as a reservoir for any petroleum present. In porous rock petroleum can move, under a pressure differential, through the interstices and cracks to a point of withdrawal; *i.e.,* to the bottom of a well. Impermeable rock, typically clay or shale, acts as a trap, preventing the migration of petroleum from the reservoir. The probability of discovering useful amounts of oil is highest when the alternating strata are uplifted into domes or anticlines, for under the domes the impermeable or "cap" rock entraps all the petroleum that migrates from more distant reservoirs. The thicker the reservoir rock—the range is from a few feet to several hundred—the greater is the potential yield of oil; the more permeable the rock, the greater is the fraction of the oil trapped in the reservoir that can be recovered. (*See* PETROLOGY.)

Within a decade after 1900 most of the areas in the United States whose structures seemed promising from the surface had been drilled to the greatest depths possible with existing equipment and methods, and substantial discoveries had been made in Texas, California, Louisiana, and Oklahoma. Oil was also found in Canada, Poland, Germany, India, Peru, Mexico, and Trinidad.

In the early 1920s the era of subsurface exploration for oil began. For areas where strata were not exposed sufficiently to permit surface mapping of underground characteristics, new geological and geophysical techniques were developed.

By the 1960s the geophysical techniques—gravity, magnetic, and seismic—were being used in the search for oil. (*See* GEOPHYSICAL PROSPECTING.) The gravity technique employs the gravimeter, a sensitive instrument which can measure variations in gravitational force. These variations are produced by, among other things, varying density of the rock beneath the surface. Dense rocks, when located close to the surface, increase the pull of gravity while sedimentary rocks, being light, do not. After many gravity readings have been taken over an area, lines of equal gravitational force can be drawn on a map. From the map the slant of the strata and certain other anomalies can be detected, although precise interpretation of the subsurface character of the rocks is impossible.

The magnetic technique, like the gravity, yields on a map of the terrain lines of equal force, in this case of equal magnetic flux. Variations in the earth's magnetic field are caused by the existence of magnetic bodies under the earth. Igneous rock generally contains more magnetite and thus gives higher readings on a magnetometer. Again, as in gravity maps, interpretation is imprecise, although it does help to reveal the depth at which igneous rock replaces sedimentary. The magnetic method can be applied over land or water, and the readings can even be recorded on an instrument towed behind an airplane.

More expensive, more laborious, but more accurate are seismic methods of exploration. Seismic methods are based on the fact that shock waves traveling downward from the surface of the earth are reflected or refracted by the interfaces between the strata. Returning to the surface, the shock waves are observed by recording devices called geophones, located at different points on lines radiating from the hole in which an explosive charge is detonated. At the instant of the explosion each geophone records the shock wave traveling along the surface of the ground. At later instants the geophones receive successive signals reflected to the surface from the interfaces, or "horizons," the intervals being longer the farther the geophones are from the explosion and the slower the shock waves travel in the rock layers. All the signals received by the geophones are amplified and traced on long strips of moving film, giving a photographic record by which geophysicists interpret the depth and angle of inclination of the various strata.

According to the principle of refraction, shock waves striking a horizon at a slight angle will be contained and travel along the bed. If the rock bed is particularly dense the waves will not be damped completely and can be observed several miles from the point of explosion.

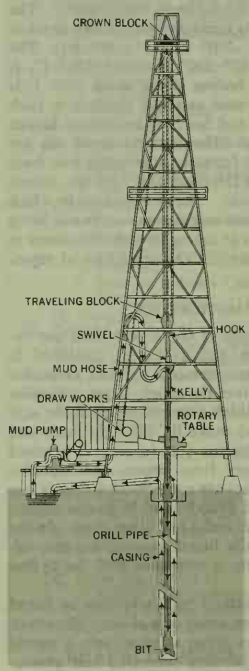
Reflection is the preferred technique in seismic exploration. It requires smaller explosive charges and less distant geophone installations, for shock waves inclined at a great angle to the strata are reflected or bounced back to the surface closer to the shot point. Both permeable and dense media will reflect shock waves, thereby yielding information about intermediate horizons.

Geochemical methods of analysis are used in an attempt to discover the presence of hydrocarbons in the soil or in air trapped in the soil. Although simple to apply, these techniques are not useful where overlying strata are extremely dense.

With information about underlying strata gained from gravity, magnetic, and seismic surveys, geologists can make inferences about the potential yield of oil from an area. But the interpretation of geophysical and geochemical data falls short of being an exact science, and the only way to tell whether or not oil lies below the surface is to drill for it.

Some wells are drilled primarily to yield oil, others primarily to yield information. Since the latter type are much simpler and cheaper, requiring less apparatus, power, and time, they are frequently carried out in advance of production drilling. Both test and producing wells yield actual samples of the underground strata. As the drill penetrates the earth the rock cuttings, flushed to the surface, can be analyzed. Geological analysis of the cuttings indicates the chemical and physical properties of the rock; continuing analyses over the course of the drilling provide a record known as a log. Periodically a core sample (a rod of solid rock cut out by a special hollow drill) is taken for a more detailed analysis in a field laboratory. There paleontologists examine embedded fossils, hoping to find those normally associated with the presence of hydrocarbons. Also, if present in quantity, crude oil can be detected by examining samples under ultraviolet light.

After a well has been drilled it may be desirable to obtain more information than is given by the geological log. Electric logs, radioactivity logs, temperature logs, and caliper logs all provide such data. The electric log records the variations in electrical resistivity attributable to different rock formations and the minute electric currents that circulate between permeable and impermeable beds. The radioactivity log, temperature log, and caliper log record, throughout the depth of the well, variations in radioactive emission, temperature, and borehole diameter, respectively. While these logs are of little use in themselves the variations can be correlated with the properties of the rock through which the well passes. For example, a decrease in resistivity would be an indication of the presence of a liquid-bearing stratum.



BY COURTESY OF THE AMERICAN PETROLEUM INSTITUTE

FIG. 1.—ROTARY DRILLING RIG WITH DIESEL POWER UNITS

2. Drilling.—Drilling for oil is a complex activity. Two methods, cable-tool and rotary, are available, although the former is no longer much used for the deep holes required in most modern oil fields. Cable-tool drilling consists in breaking up the rock by percussion. A string of tools, comprising a heavy drill bit, drill stem, and a set of links called "jars," all suspended from a cable, is lifted a few feet and then dropped onto the bottom of the hole. A slurry of mud and water, added to the hole, holds the rock chips in suspension, and the string of tools must be removed periodically so that the slurry and accumulated chips may be bailed out.

BY COURTESY OF STANDARD OIL COMPANY (N.J.)

CREW USING PIPE CLAMPS TO UNSCREW SECTIONS OF DRILL PIPE AS IT IS REMOVED FROM HOLE TO REPLACE DRILLING BIT

The time required for this operation, which is not necessary with rotary drilling, plus the slower rate of drill penetration, has made the cable-tool method practically obsolete for deep holes and it is now used mainly for shallower water wells.

The rotary drilling method requires thousands of feet of drill pipe and well casing, a derrick, a power source or prime mover, drill bits, drilling muds and chemicals, and a team of several men labouring for many weeks—all necessitating considerable capital investment. The drill bit is attached to a string of drill pipe, to the top of which is connected a tube of square cross-section called the kelly; the kelly passes through a square hole in a power-driven turntable, rotating the drill string and bit, and lengths of drill pipe are added just below the kelly as the bit progresses downward. Cuttings are removed by a circulating mud slurry which is pumped through a swivel at the top of the kelly, down the drill pipe, and out through holes in the bit, whence it carries the cuttings up the annular space around the drill pipe and into a settling pit on the surface. The drilling mud, by hydrostatic pressure, also helps prevent the collapse of unstable strata into the hole and the intrusion of water from water-bearing strata that may be encountered; however, where the hydrostatic pressure of the mud column is not sufficient, steel well casing, slightly smaller in diameter than the hole, is inserted to seal off the undesirable formations.

Drilling muds consist of a mixture of clay, usually bentonite, and water, with special chemicals added to compensate for varying composition of the water and the formation being drilled. The mud, in addition to carrying rock cuttings to the surface, also lubricates and cools the drill bit.

Power to rotate the drill string, raise and lower the drill string and casing, and operate the mud pump and auxiliary equipment is provided by the prime mover. Formerly steam engines were used, but most modern drilling rigs employ diesel power. On very deep holes, where the heaviest loads are encountered, as many as eight diesel engines may be interconnected to provide the necessary power. (*See* also DRILLING MACHINERY.)

When an oil-bearing formation is reached, either of two methods may be used to prevent the incursion of unwanted water, gas, sand, etc., from other formations. A second string of casing may be inserted inside the original casing and cemented at the bottom, or cement may be pumped down between the original casing and the hole wall. The drilling mud is then removed, the cement is perforated at the level of the oil-bearing formation, and the flow of oil can commence. For wells that flow freely, as distinct from those that have to be pumped, all that is needed is a master valve assembly, called a "Christmas tree," at the well-top to control the rate of output. Drilling is finished and the well is a producer.

Drilling for oil is expensive. Wells drilled in the early 1960s in the United States descended on the average to a depth of more than 4,400 ft. (One well in Louisiana produced oil at 31,413 ft.) At an average cost of $15 per ft., an average well thus involved an expenditure of about $65,000.

Expenditure per well within the United States rose somewhat after World War II, due partly to the general postwar rise in the cost of all goods and services and partly to the cost of exploring new areas. Compensating for much of the rise in costs, however, were improvements in drilling methods and equipment: after 1945 rates of penetration were increased by nearly 50%. In undeveloped countries where work often has to be done in desert, jungle, or swamp, and where the oil explorer has to provide all the utilities at points often remote from the seaboard or main centres of population, the drilling of a single well may involve the outlay of millions of dollars.

Drilling for oil involves many risks. If oil is found it may be of very low quality and unusable, or the volume of oil discovered may be too small for commercial exploitation, or gas may be found instead of oil and there may not be any commercial outlet for it. Even in proven fields it is not certain that a new well will produce oil. Out of 16,647 field wells completed in the United States in the first half of 1960 (a typical year), 4,295 or 26% were dry. When wells are drilled in virgin territory the chance of failure increases considerably. Out of 4,708 exploratory wells drilled in the United States during the same period, 4,090 or 87% were dry. In some other oil-producing areas of the world, where reserves have not been so extensively tapped, the chance of success may be higher, but in new territory they may be much lower.

3. Offshore Drilling.—Oil may be found under water as well as under dry land, and its recovery is sufficiently profitable to encourage off-shore drilling. The first attempts were made in California, where the coastal oil fields were observed by means of subsurface well-surveying instruments directed toward the continental shelf. Wells were drilled from shore locations on a slant to the oil pools under water.

Next, drilling in lakes, bays, and shallow-water areas of the con-

BY COURTESY OF STANDARD OIL COMPANY (N.J.)

OFFSHORE DRILLING PLATFORM IN THE GULF OF MEXICO

Platform is of the "crane-leg" type, resting on ten adjustable legs seated on the ocean floor; helicopter platform at left facilitates transportation between shore base and drilling rig

tinental shelf was made possible by the development of suitable equipment for drilling from barges and special foundations. Three types of drilling rigs (self-contained, with fixed platforms or mobile platforms, and derrick platforms with floating drilling tenders) are used for these operations. A floating drilling platform or drilling vessel later was evolved. It is anchored and relies on buoyancy instead of (as in the above cases) piles or legs driven into, or resting on, the sea bottom. The reservoir under Lake Maracaibo in Venezuela was the first extensive off-shore field to be developed. The Gulf of Mexico, the Caspian Sea, and the Persian Gulf also yield offshore oil in large quantities, and offshore drilling has taken place off Trinidad, Libya, Egypt, West Africa, British Borneo (now Malaysia), Japan, the Netherlands, and the United Kingdom.

4. Recovery.—The natural gas that accompanies crude oil in the ground is under compression, and it often provides sufficient energy to move the oil through the porous rock to the bottom of the well, and sometimes up the well to the surface. Similarly, water associated underground with the oil may be under pressure and thus provide some of this energy.

Properly conserved, these two natural forces can expel a large amount of the oil in the formation. Good engineering practices call for production methods which do not permit the pressure in the reservoir to be reduced below a minimum amount. Sometimes pressure can be maintained by controlling the rate of oil withdrawal, but it is often necessary to use other means. Sometimes the gas that comes to the surface with the oil is gathered and pumped back into the oil reservoir, where it helps to maintain pressure. Sometimes it goes to waste because there is no economic outlet for it, but whenever possible the gas is treated and then used for heating, power, or other purposes. In fields where a water drive exists, the injection of additional water into the reservoir provides an effective way of maintaining pressure and recovering more oil.

Under modern conservation methods, some fields are still flowing after 10 or 20 years of operation. However, pumping is necessary when insufficient gas or water pressure is present to move oil from the reservoir to the surface. This may occur in the first development of the field or after most of the original pressure has been depleted. In nearly 600,000 producing wells in operation in the United States, over 500,000 were utilizing artificial lift. A large percentage were classified as "stripper" wells; *i.e.,* wells which are pumped infrequently, yielding on an average slightly over 3 bbl. daily. (The barrel is equivalent to 42 U.S. or 35 imperial gallons.)

B. Transportation and Storage

Most of the world's crude petroleum is produced in areas remote from the main centres of demand; transporting it to the refineries and markets requires extensive, specialized facilities: pipelines, tankers, bulk barges, tank cars, tank trucks. The petroleum industry has successfully integrated these so as to provide a steady flow of crude petroleum and products from well to consumer.

Petroleum, being a fluid, is easy to transport, and very little loss of product is incurred in moving it about. It is also cheaper to transport petroleum in bulk over a long distance than to transport an equal amount of other energy sources. Thus petroleum moves in international trade, satisfying the main energy requirements of countries lacking indigenous resources.

The lowest transportation costs are obtained with pipelines. The next cheapest mode is by ocean tanker, where costs per barrel or ton have been reduced by building larger vessels. Petroleum products are also carried in smaller quantities in separate containers; *e.g.,* cylinders for liquefied petroleum gases and tins and barrels for kerosene and lubricants.

1. Pipelines.—Since pipelines are the cheapest form of transportation, they are used wherever possible. When the crude oil emerges from the well, it usually flows or is pumped through a pipeline to a central location where it merges with oil from other wells. These pipelines leading from individual wells to storage depots are called gathering lines. If the refining centre lies overland from the producing wells, the crude petroleum will be pumped to it through a pipeline. Long pipelines (up to 1,500 mi.) of wide diameter (up to 36 in.) carry large volumes (up to 400,000 bbl. per day) of crude oil from fields in Texas, Louisiana, and Oklahoma to refineries in the Midwest and on the East Coast of the United States; from the fields in Alberta to the Great Lakes; from fields in Saudi Arabia and Iraq across the desert to ports in Syria and Lebanon; and from fields in the Sahara to the Libyan and Algerian shores of the Mediterranean.

Although the pipeline is the cheapest mode of transportation, it requires a large and steady flow between two fixed points in order to justify the large capital expenditure involved. The major items of cost are the pipe itself, its laying over the terrain (requiring usually that a trench be made, and the pipe be coated against corrosion), and the pumping stations (situated from roughly 50 to 200 mi. apart, and equipped with large diesel engines which provide the pressure differential necessary to overcome friction and differences in elevation). The cost in the U.S. of a 30-in. diameter pipeline, 1,000 mi. long, carrying 400,000 bbl. of crude oil per day would be: capital cost of the pipeline about $150,000,000, of which the cost of the pipe represents 50%; pipe laying, 30%; pumping stations, 10%; and cost of right-of-way, surveying, etc., 10%. The economics of pipeline construction and operation is such that the largest diameter pipelines are the cheapest per barrel of product transported. Consequently, any two terminals are connected by single lines of large diameter rather than two or more parallel small lines.

Where large volumes are involved, the products of the refinery are also shipped to consuming centres by pipelines. Several grades of oil (gasolines, furnace oil, diesel oil, etc.) may even be shipped in the same line at the same time, in sequences or "slugs" of several tens or hundreds of thousands of barrels each. There is a slight amount of mixing between one product and the next, but this is small relative to the total volume shipped. Products pipelines exist primarily in areas of high consumption, *i.e.,* the Northeast and North Central United States and Western Europe.

2. Other Means of Transport.—*Tankers.*—Where a large body of water lies between the oil fields and the refinery, or the refinery and consumers, the preferred mode of transport is by tanker. Tankers are at a disadvantage compared with pipelines because their return journeys must be made empty, whereas the pipeline can always be full. The advantages of tankers, however, are that their routes are flexible and their ports of origin and destination variable. Tankers were introduced early in the history of the oil industry, being developed originally in the 1880s to carry crude oil and kerosene from the United States, then the main oil producer, to Europe, and from Russia to the Far East.

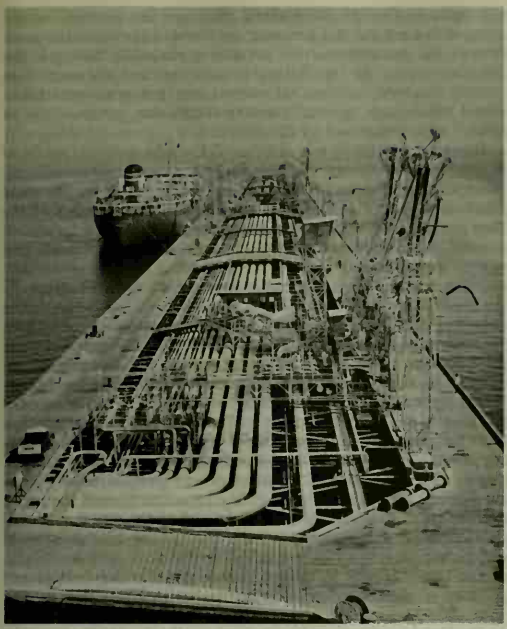
Oil tankers are built in all sizes from several hundred tons to over 100,000 tons, the former used for coastal shipments and the latter for ocean voyages. Like crude-oil pipelines, the largest tankers tend to be the most economical when used at full capacity. Japanese shipyards built, in 1962, a tanker of approximately 130,000 deadweight tons, and vessels of over 150,000 were contemplated. The building of large tankers is limited by the depth of the Suez Canal and the limited number of ports that can accommodate such vessels.

A number of countries have taken measures to promote the creation or growth of their own ocean tanker fleets, but more than half the world fleet is owned by tramp operators and more than one-third by oil companies. Some owners register their vessels in those countries which offer the greatest legal and economic advantages. Liberia and Panama are particularly attractive, approximately 20% of the world's tonnage being registered under these "flags of convenience."

Barges.—Since navigation on the ocean is easier than on confined bodies of water, tankers move faster than barges. The latter, which are used primarily for shipping finished products by inland waterways, average approximately half the speed of tankers.

Tank Cars.—Railroad tank cars, although capable of traveling at high speed, where complete direct trainloads can be dispatched, are used primarily for small or intermittent shipments.

Tank Trucks.—Road transport of petroleum by the mid-20th century showed the greatest relative increase, and by the begin-



BY COURTESY OF THE KUWAIT OIL COMPANY LIMITED; PHOTOGRAPH, B. A. CARDEW

PIER AT MINA AL AHMADI, KUWAIT, EQUIPPED WITH SPECIAL FACILITIES FOR QUICK LOADING OF PETROLEUM INTO TANKERS

ning of the 1960s there were approximately 110,000 trucks in the oil industry's service in the United States alone. Sixty per cent of these were assigned to the delivery of fuel oil, both to residences and to factories.

3. Storage.—Because the flows of crude petroleum and refined products cannot be exactly synchronized with market demand, specialized storage is provided between successive stages of production and distribution. The earth itself acts as a reservoir for crude petroleum. Disused mines and natural caverns are sometimes used to store oil or gas. Constructed storage is provided at terminals where gathering lines bring crude petroleum which continues on its journey by a cross-country line, tanker, tank car, or truck. At its destination the crude petroleum goes into storage tanks, some as large as 100,000 bbl., from which it is drawn for refining. Similarly, each refinery will have tankage devoted to the storage of products. Petroleum products are also stored at distribution depots, service stations, and retailers' premises in or near centres of population, above ground in "tank farms" and below ground in buried tanks.

C. Refining

1. Purpose and Location of Refineries.—The function of petroleum refining is to divide crude petroleum into its various boiling ranges, called "fractions," and to reconstitute and refine these fractions into different products. Where possible, refining processes are adapted to meet the demands of consumers; at the end of the 19th century, when kerosene was the major product, refiners in the United States were processing crude oil which yielded 60% to 70% kerosene, but there was little demand for gasoline or the other products. By mid-20th century, gasoline was the product in greatest demand in the United States and refiners obtained 50% yield of it. Changes in demand may bring about an adjustment in operations or a development of new processes, and even during one year a refiner's processing scheme may change: when, during the winter months in cold climates, the demand for furnace oil is high, its output will be increased to the maximum. When the demand for gasoline is high in the summer, its output will be increased. Thus, the refiner is able to meet seasonal or regional demands and reduce storage and transportation costs. Many countries find it necessary, however, to import petroleum products which local refineries cannot produce economically or to export products for which there is no home market.

A characteristic of petroleum refining has been the great technological progress. The amount of resources necessary to refine a barrel of crude oil, in terms of capital, labour, fuel, and time, was far less in the 1960s than in the 1900s or even after World War I. A rough comparison of the overall productivity at different dates in the U.S. refining industry shows the changes to be substantial. In the United States in 1919, the first year for which such figures are available, when 362,000,000 bbl. of crude oil were refined, the total number of refinery workers was approximately 59,000. Each worker on the average processed 6,100 bbl. of crude oil. In 1958, when the amount of crude oil refined was 2,776,000,000 bbl., the labour force engaged in refining had increased only to 192,000. In 1958, therefore, each worker engaged in petroleum refining processed 14,500 bbl. The increase in productivity over the 40 years, largely attributable to investment in new plant and equipment, was nearly two and a half times.

In these 40 years also the output of gasoline, the most valuable of the refineries' products, rose from 94,000,000 bbl. to 1,410,000,000 bbl. In 1919, refiners' output of gasoline represented 25% of the input of crude oil, whereas in 1958, largely because of the evolution of new processing methods, they were able to produce 44.9% gasoline of much higher quality.

Refineries are located either at the sources of crude oil, at points of transshipment, or near the product markets. In the early days of the oil industry, when kerosene, lubricating oil, and fuel oil were the only products of any value, and the volume of trade in each market was relatively small, location at the source of supply of crude oil economized on transportation costs and permitted the concentration of investment. Refineries distant from the oil fields had to transport all of the crude oil, not merely that portion represented by the marketable products. With the advent of the automobile and other developments in demand, nearly all of the products from crude oil became profitable, and what had been a disadvantage to refineries located near consumer markets changed to an advantage. Because it is cheaper to transport crude petroleum than it is to transport the smaller volumes of its individual products, market-oriented refineries have a cost advantage. Moreover, the market-oriented refinery can draw its crude oil from alternative sources, whereas a production-oriented refinery depends upon the output of a single field or area. The trend toward market-oriented refineries was particularly evident in the post-World War II era, with many new refineries being constructed all over the world.

In an oil refinery, very large volumes of petroleum are processed, yet except for small samples, taken periodically and analyzed in the control laboratory, the oil itself is never seen after it arrives at the refinery. In monitoring the performance of the equipment the operators of the refinery rely upon such indirect observations as temperature, pressure, flow rate, and liquid level. The crude oil, the semifinished products, and the final products are heated, cooled, contacted with nonorganic materials, vaporized, condensed, agitated, cracked, and polymerized continuously without human intervention.

The refinery processes can be divided into three different classes: physical separation, chemical alteration, and purification. The extent to which these three activities are carried out depends upon the pattern of demand and the characteristics of the crude oil being processed.

2. Separation.—The first class of processes, physical separation, involves distillation, carried out in distillation towers (tall, slender, cylindrical vessels fitted on the inside with a series of horizontal trays or decks). Crude petroleum, after having been pumped through the tubes of a furnace or still, where it is heated sufficiently to vaporize all but the heaviest portion, is dispelled into the distillation column from a nozzle located just above the

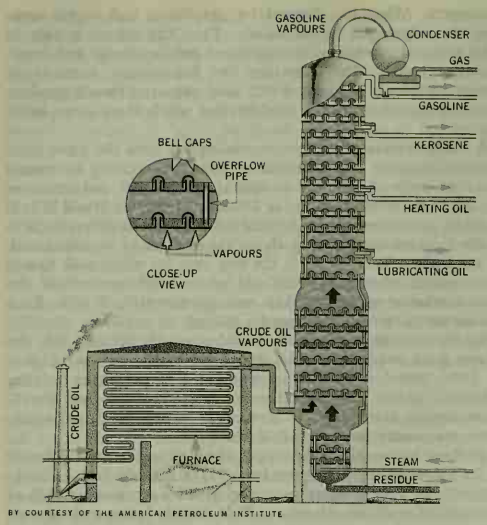


FIG. 2.—FRACTIONATING TOWER USED FOR PETROLEUM DISTILLATION

base. The vaporized portions of the crude oil rise up through the column. A temperature gradient is established throughout the tower such that the temperature is the lowest at the top and highest at the bottom. Ascending vapours condense as they rise in the tower. Condensed liquid collects on the trays whence it is withdrawn in a stream. From the top of the tower flow the gaseous vapours. Material boiling in the gasoline range is withdrawn from slightly below the top, kerosene below that, gas oil from the middle, and residuum from the bottom. Each of the streams from the distillation column then proceeds to a further processing stage.

The residuum may be redistilled in a tower operating under a near vacuum, where all but the heaviest fractions will vaporize. The refiner thereby separates residuum into light and heavy lubricating oils, and residual fuel or asphaltic material.

The second method by which proportions of crude petroleum can be separated physically into their components is by solvent extraction. Solvents are used primarily in extracting the best lubricating oil stocks from other portions of residual crude boiling in the same range. A solvent, furfural, obtained from oat hulls, is the main extractant. After extraction, the lubricants are separated from furfural by distillation.

3. Chemical Processing.—The second important class of refinery processes are those which alter the characteristics of the petroleum hydrocarbons. These chemical processes have one of three aims: to "crack" or split large hydrocarbon molecules into small ones; to polymerize or unite small hydrocarbon molecules into larger ones; or to rearrange the molecular structure.

Historically the cracking processes have been the most significant. During the 19th century cracking was used to double the yield of kerosene from crude oil. Gas oil, the raw material, was subjected to temperatures of 700°–800° F, at which point the molecules would commence to decompose.

The advent of the automobile in the early 1900s created a demand for gasoline, formerly a product of little value. The demand soon exceeded the amounts of gasoline which could be obtained merely by distilling the light fractions of crude petroleum, so that an incentive existed to obtain a greater yield of gasoline by cracking. In 1913 the first commercially successful process, named after its inventor, William M. Burton, was introduced by the Standard Oil Company (Indiana). The Burton process utilized the same temperatures that had been used in cracking for kerosene but carried out the cracking at elevated pressures, up to 75 lb. per sq.in. (psi). At atmospheric pressure, the products of decomposition are gas and kerosene; at elevated pressures the products of the cracking reaction are mainly materials boiling in the gasoline range. In the Burton process the raw materials were treated in single batches, but several new processes were introduced which made thermal cracking continuous; temperatures of 900° F were being used by the 1930s.

During the 1920s it was discovered that the gasoline produced in cracking had superior burning characteristics in automobile engines, and so what had been of advantage in increasing the yield of gasoline became also of advantage in raising the quality of the final product. With higher-quality motor gasoline the compression ratio of automobile engines could be increased and more efficient operation obtained.

The next advance was the development of catalytic cracking. Although it had long been known that some materials, known as catalysts, could increase the rate and nature of cracking without themselves being affected, it was not until 1936 that two American oil companies, Socony Mobil and Sun, adopted the process developed by a French-born engineer, Eugène Jules Houdry. Gasoline components produced by catalytic cracking were far superior to those from thermal cracking. Moreover, the yield of gasoline from a given volume of raw material was greater. Catalytic cracking units, first those following Houdry's design and later the improved versions developed by others, were rapidly installed. During World War II catalytically-cracked gasoline formed the major component of aviation fuel; after the end of the war it was used in automotive fuel, thereby raising the quality of this product still higher.

The catalysts used in catalytic cracking are mainly oxides and silicates of aluminum and magnesium, which occur naturally in such clays as bentonite and are also manufactured synthetically. In the Houdry process and its derivatives, the Houdryflow and the Thermofor Catalytic Cracking (TCC) processes, the catalyst is agglomerated into small beads. In the other major catalytic cracking process, the Fluid process, the catalyst particles are very small, forming a powder which has properties similar to those of a fluid.

Polymerizing and reforming processes have been evolved to raise the flexibility of the modern refinery and to increase the yield of gasoline. Polymerization (*q.v.*) is the reverse of cracking. Whereas cracking breaks down the heavier gas-oil or heavy fuel molecules into the lighter ones of gasoline, polymerization combines the still lighter molecules of certain gaseous by-products into molecules suitable for motor fuel. Developed in the 1930s, polymerizing processes are important adjuncts of all refineries.

The first polymerizing process introduced, called polymerization, after the reaction itself, utilized as raw materials unsaturated hydrocarbon gases, primarily propylene and butylene. Another polymerization process, alkylation, combined either of these two same raw materials with isobutane, a saturated hydrocarbon gas. Introduced a few years later than polymerization, alkylation contributed greatly to the production of aviation gasoline in World War II. Like polymerization, alkylation can increase a refinery's motor gasoline yield by approximately 5%. Both processes are similar, also, in that the polymerizing reactions are carried out in the presence of a catalyst.

The third type of chemical processing, after cracking and polymerizing, is one that alters the molecular structure of the hydrocarbon molecules. This alteration, called "reforming," is carried out in order to improve the combustion characteristics of the product. Applied primarily to low-quality gasoline stocks, usually those obtained from crude petroleum by distillation, the reforming processes can substantially improve the quality of the resulting product. Introduced in the 1930s in a process very similar to thermal cracking, reforming became more significant in 1949 when the first catalytic reforming process, "Platforming," was developed by Universal Oil Products Company. Utilizing a platinum catalyst, the Platforming process (with several derivative methods subsequently introduced by competing process development companies and the major oil companies) improves the quality of gasoline without detracting from the overall yield.

In the decades of the 1930s, 1940s, and 1950s the major force

motivating refiners, especially in the United States, was the urge to increase the quality of their motor gasoline without diminishing its yield. They were aided in this attempt not only by the development of new refining processes but also by the introduction of tetraethyl lead as an additive. In 1922 T. Midgly, Jr., and C. F. Kettering, working for General Motors, discovered a class of organic compounds which, when added to motor gasoline, would drastically reduce engine knock. Starting a few years later, tetraethyl lead, the most reactive of the class, was added commercially to gasolines in amounts up to 3 cc. per gal.

There are several measures of gasoline quality, some recording its stability, some its gum-forming tendencies, and some its burning characteristics. Perhaps the most useful single measure is the octane rating, a number on an arbitrary scale commencing at 0 (a fuel with combustion characteristics equivalent to normal heptane) and rising to above 100 (iso-octane was assigned the number 100). A fuel which is assigned the value of 90 octane therefore has combustion characteristics or "knock rating" equivalent to a fuel composed of 90% iso-octane and 10% normal heptane. Measured on this octane scale, the average quality of motor gasoline produced in the United States rose from approximately 50 in 1915 to over 90 in the 1960s. The quality of premium fuel rose even above 100 octane.

Coinciding with the rise in octane number was the rise in the compression ratio of automobiles. The combined improvement resulting from increase in gasoline quality and in compression ratios in automobile engines was most accurately reflected in engine performance. Between 1925 and 1960 automobile performance more than doubled, for regular-grade fuels from 24.0 to 53.5 ton-mi. per gal.

Tetraethyl lead was the first additive in petroleum products; many others were later developed. Additives were introduced to improve the flow of lubricating oils at both very high and very low temperatures, to reduce the oxidation of fuels (which is responsible for the formation of gum and the clogging of engine parts), to help lubricants to resist corrosion, and to act as detergents by retaining in suspension dirt and other contaminants.

4. Purification.—The third class of refinery processes includes those which purify the products. There are in crude oil many non-hydrocarbon elements, primarily sulfur, which impart undesirable properties. If left in some products these impurities would cause corrosion and unpleasant odour, and many refinery processes have been developed to neutralize or remove them: hydrogen sulfide is removed from refinery gas streams; mercaptans (complex compounds of sulfur) are removed from motor gasoline and kerosene; residual fuel may be treated to remove undesirable compounds.

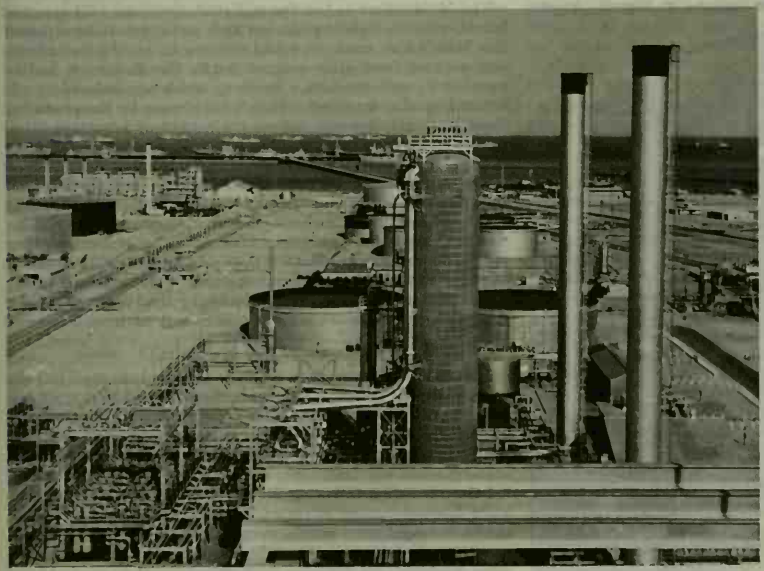
5. Scale of Refinery Operations.—The average petroleum refinery combines in one large plant many different processes, and large-scale operations are needed to make refining economically feasible. It is possible to manufacture all products in one refinery, but most refineries, as far as economically possible, produce only the products needed in their local markets. In underdeveloped countries refineries are designed with relatively little catalytic cracking and reforming capacity.

Refineries process vast amounts of material daily. Running continuously for months at a time, a single distillation unit may separate as many as 100,000 bbl. per day of crude petroleum into its different fractions. A single catalytic cracking unit may crack 60,000 bbl. per day of gas oil, in addition to recirculating large amounts of partially cracked material.

Economies accompany large-scale operation. Although the amounts of fuel and catalyst, depending as they do upon the physical and chemical properties of the crude oil, do not vary appreciably with plant size, the amounts of equipment and labour do. A catalytic cracking unit of 60,000 bbl. per day will require no more men to operate it than a unit with one-tenth its capacity. The cost of labour, per unit of product, therefore is considerably less for very large units. Although not as dramatic an example as labour costs, capital gives evidence of the same economies of scale. A 100,000-bbl.-per-day refinery, although it processes ten times as much raw material as a 10,000-bbl.-per-day unit, would cost only about eight times as much to construct. Economies of scale thus encourage the construction of large refineries, and it is usually the size of the market rather than limitations on the ability to construct and operate large pieces of equipment that sets the limit to refinery capacity.

6. Petrochemicals.—A flourishing field for the refiner is petrochemicals; *i.e.*, those industrial products whose raw materials are derived from petroleum, and particularly from refinery gases. The alternative uses of these gases are either as fuel (in the case of ethane, ethylene, and propane) or as raw materials for aviation and motor gasoline (propylene and butylene).

The major use of petrochemicals is in plastics (*q.v.*), particularly polyethylene, polypropylene, polystyrene, and alkyd, vinyl, and phenolic resins. It was expected that by 1970 plastics would consume half of the total hydrocarbon raw materials available to the petrochemical industry. Next in importance are man-made fibres such as nylon, dacron, and acetate rayon; synthetic rubbers such as Buna-S, Buna-N, butyl rubber, and neoprene; nitrogen fertilizers; detergents; protective coatings; and solvents. (*See* also PETROCHEMICALS.)



BY COURTESY OF THE KUWAIT OIL COMPANY LIMITED, PHOTOGRAPH, D. A. CARDEW

OIL REFINERY AT MINA AL AHMADI, KUWAIT. ATMOSPHERIC DISTILLATION PLANT IS IN FOREGROUND; STORAGE TANKS AND SHIP-LOADING FACILITIES IN BACKGROUND

D. MARKETING

The marketing branch of the oil industry distributes the products from each refinery to customers with differing needs.

The physical nature of the product influences the manner in which it is distributed. The majority of the petroleum products are liquids, stable under most conditions, capable of being contained in simply constructed tanks and of being pumped from one location to another. The petroleum products which offer greater problems of handling are those which fall at either end of the boiling range: gases, greases, heavy fuels, waxes, and asphalts. Liquefied petroleum gas (LPG) has to be stored and moved under pressure and is normally distributed to the consumer in small cylinders. Greases and some of the specialized lubricating oils are handled in barrels. Since the cylinders and some of the barrels are reused, the distributor has to provide for the return, cleaning, and testing of the containers. Heavy fuels and asphalts, because they congeal at normal temperatures, must often be stored and distributed in heated or insulated containers.

Petroleum distributors frequently separate industrial from consumer products. Industrial products are sold in large volumes to a few customers, while consumer products are sold in small volumes to a great number of customers and call for an extensive consumer marketing organization, *e.g.*, the gasoline service stations.

Where service stations are located within several miles of a refinery, they may be supplied directly via the refinery's tank cars or tank trucks. If they are more distant, they will be supplied by an intervening agent who buys wholesale from the refinery and distributes locally to service stations, sometimes maintaining his own intermediate storage facilities. Often the agent will also carry furnace and fuel oil, which he delivers to homes and industrial customers.

III. DEMAND AND SUPPLY

A. Sources of Crude Petroleum

Although the products of petroleum are consumed everywhere, crude petroleum is produced in relatively few places and often in areas of desert, jungle, or swamp. In 1963, a typical year, four-fifths of the total production of crude petroleum occurred in seven countries: the United States, U.S.S.R., Venezuela, Kuwait, Saudi Arabia, Iran, and Iraq.

Following World War II a dozen countries were added to the list of oil-producing countries, and on the continent of Africa, hitherto regarded as unpromising, large reserves were found in the Sahara and Libya, and smaller reserves in Nigeria, Angola, and Gabon. After costly decades of exploration in Australia oil in commercial quantities was found in Queensland in 1962. For reasons of national policy, new knowledge, new appraisal of prospects, and hopes of bigger rewards, oil may be sought in areas hitherto unexplored, but such a search is always expensive and speculative.

MAJOR PETROLEUM-PRODUCING AREAS OF THE WESTERN HEMISPHERE

Historically the world price for crude petroleum has been based upon the price, at the well, of oil from the company with the largest surplus production in the exporting area. During the 19th century and the first decade of the 20th, when the United States was the dominant producer, the base price was the price of first Pennsylvania and then Texas, crude oil. Crude oil prices elsewhere were calculated by adding to or subtracting from the U.S. price the difference in transport cost between the two sources and the market in which they were competing. When, in the 1920s, Venezuelan crude oil began to enter European markets in quantity, its price was determined on the basis of prices then existing along the U.S. Gulf Coast. Middle Eastern crude oil, when it first appeared in the Eastern Mediterranean, was priced according to the price in the Gulf of Mexico, again with allowance for the differential in freight rates between the Gulf of Mexico and the Eastern Mediterranean, on the one hand, and the Persian Gulf and the Eastern Mediterranean, on the other. After World War II, when Middle Eastern crude oil became plentiful, it met a large part of the new demand in the rapidly expanding markets in Western Europe, and, in the late 1940s, it began to reach the East Coast of the United States and Canada. By 1958 the United States was importing over 80,000,000 tons of oil a year (1,600,000 bbl. per day). Of this, 56% was crude oil and the rest petroleum products, and of these imported products nearly 70% was residual fuel oil from Venezuela which could not be provided economically from U.S. crude oils. In order to check these crude oil imports, the United States imposed import quotas, after three years of voluntary limitation by importers. The quotas made it possible for the United States oil industry to pursue the search for oil at home notwithstanding its relatively high costs and the increasing effort needed to find new oil in the country. Middle Eastern crude oil, in the limited amounts that were permitted to enter the United States market in the early 1960s, enjoyed a cost advantage over many U.S. crude oils.

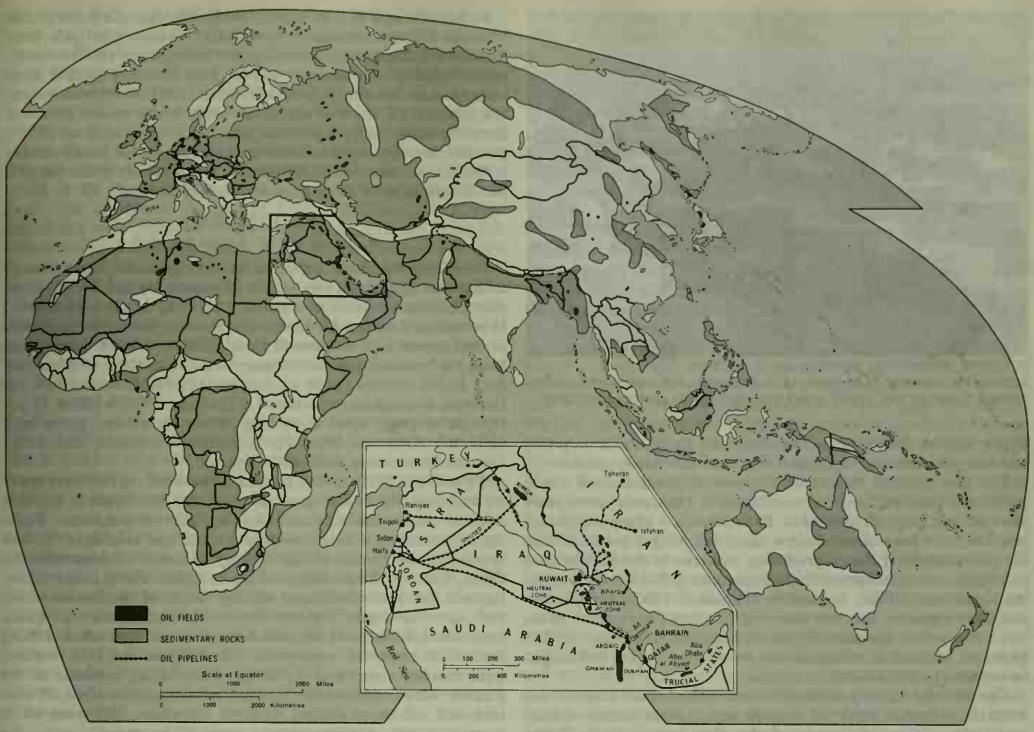
The Middle East had in the mid-1960s the largest oil accumulations, with the highest yields per well, and it was to be expected that Middle East crude oil would continue to enjoy a cost advantage over oil from other sources despite the distance it had to travel to its main markets, a handicap which was reduced by advances in tanker transport. High fiscal charges by the producing countries might, however, reduce the margin of advantage.

The total volume of oil that lies below the land and sea surfaces of the earth is unknown. The oil industry has, however, evolved the concept of "proved reserves," this being the volume of oil known to exist that can be economically recovered at current prices and by current methods. The world's proved reserves, excluding those of the Communist countries, were at the beginning of 1963 approximately 300,000,000,000 bbl. (40,000,000,000 tons); *i.e.*, equivalent to 37 years' production at the current level of demand. Demand was expected to double by the 1980s and, by the year 2000, to have reached three times the 1962 level.

B. Consumption of Products

The amounts of petroleum products that are consumed and the prices at which consumers purchase them depend in part on the original price of crude oil plus the costs of transporting, refining, and marketing; in part upon the consumers' needs; and to a considerable extent upon the level of import, sales, and other taxes (notably on motor fuels) that are levied in nearly all countries.

Industrialization following World War II was rapid, and with it the demand for fuel increased. Since the output of petroleum can be expanded more rapidly than that of other fuels, its growth was particularly impressive, although world demand for petroleum products rose virtually without interruption since the industry's earliest days. From the end of World War II up to the early 1960s, the average annual increase was about 7%, but this



SOURCES OF CRUDE PETROLEUM IN THE EASTERN HEMISPHERE

rate of growth was expected to decrease, because there would be less scope for conversion to oil from other fuels; because the demand for motor fuels in highly developed countries would not grow as rapidly as previously; and because, in some countries, natural gas was already taking the place of petroleum as a source of petrochemical products.

Four important features of the oil industry are: the wide range in the types and qualities of crude oil and the new sources which appear from time to time; the variations in the demand for the various major petroleum products; the fact that, excepting the U.S.S.R., all major oil-consuming countries are large importers of oil; and the large volume of oil that moves in international trade.

The composition of total market demand in a district, country, or region is a crucial factor in determining the demand for, and the flow of trade in, the various types of crude oil, and in determining the cost of refining operations. Two extreme instances of contrasts in the character of market demand were offered by the United States and India in the early 1960s. In the United States gasoline accounted for about half the country's total demand for petroleum products but in India only for one-sixth. In the United States the demand for kerosene was relatively insignificant (less than 5%) but in India kerosene was the dominant product and represented about 30% of total demand. Fuel oil accounted for half of Japan's oil consumption but only for a seventh of that of Australia. Though residual fuel oil accounted for only one-sixth of the total oil needs of the United States, it would not be economically feasible to provide from within the country all the fuel oil it required, hence the large imports of residual fuel oil from Venezuela into the Eastern U.S.

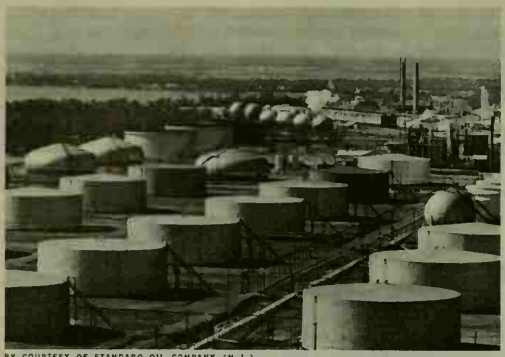
The changing rates of demand for the various petroleum products were exemplified by the Federal Republic of Germany, where in 1963 the demand for fuel oils had risen fivefold within five years, whereas the country's total demand for all petroleum products had risen at only half this rate. In the United Kingdom the demand for gas and diesel oils had nearly doubled in five years but that for gasoline had risen to only half that extent.

Modern oil refining techniques afford considerable latitude in matching refinery output to market demands, but there are technical limits as well as limiting factors of cost. In practice, the surplus or deficiency can often be most economically disposed of, or made good, by exports and imports. This has helped to bring about the international character of the industry and the worldwide integration of operations within the large oil groups. The remarkable growth in the number of oil refineries (which now exist in most countries of the world), and the imbalance between their output and local market demand, intensified the international movements of oil. Thus, to supply Western Europe with the 235,000,000 tons of petroleum products needed in 1962 for its inland requirements and ships' bunkers, it was necessary to move crude oil and petroleum products amounting to nearly 300,000,000 tons into and from Western Europe and between Western European countries.

A striking development was the increased demand for subsidiary petroleum products; *e.g.*, petrochemicals, including synthetic rubber and fertilizers, liquid gas, bitumen, wax, etc., and in some countries feedstock to gas works for the production of fuel gas.

C. Conservation and Output Control

Once a well has been drilled and oil discovered in commercial quantities, a producer has a great incentive to bring his production to a maximum. But if in times of plentiful supply all producers were to follow this course of action, crude oil output would rise greatly, leading to a drop in price. Similarly, if the natural pressure in a reservoir drops too fast owing to an excessive rate of production, the total volume of oil that can be economically with-



BY COURTESY OF STANDARD OIL COMPANY (N.J.)

PETROLEUM STORAGE TANK FARM AT A BAYTOWN, TEX., REFINERY; BUTYL RUBBER PLANT IN THE UPPER RIGHT UTILIZES PETROLEUM BY-PRODUCTS

drawn will be diminished. Therefore, the stabilization of prices and the conservation of natural resources are closely related.

The first attempt to restrict the rate of production of crude petroleum was made in the United States in 1866, only seven years after oil had been discovered in Pennsylvania. Many restriction schemes have been devised since then, including a proposal that the governments of the oil-producing countries in the Middle East and Venezuela, members of the Organization of Petroleum Exporting Countries (OPEC, formed in September 1960), should control their output. This was intended to affect prices, since effective conservation was already practised in those countries. OPEC, however, declined to entertain any restriction scheme but sought to sustain the price level.

The need for a policy of conservation in the United States arises from the nature of crude oil deposits and the legal status of mineral rights. The U.S. is one of the very few countries in the world where the property in mineral rights belongs to the surface owner. In most of the rest of the world it belongs to the state, which grants operating rights to licensees or concessionaires and collects revenues for the benefit of the community; invariably there is only one or relatively few operators in an oil field and conservation can easily be agreed upon or imposed. With the best conservation procedures (which, however, may be costly) it is possible to recover 60%, 70%, or even more of the oil lying under the ground; with unrestrained production the fraction recovered may only be 20% or 25%. Frequently, an oil field in the United States and elsewhere will be operated as a single unit, a procedure known as "unitization." Each producer withdraws oil at a rate compatible with the interests of other producers and with securing maximum total economic recovery from the field.

Restraints on output in the United States were enforced in 1935 with the support of the governments of the state of Texas (relating to the production of the oil within the state) and of the United States (relating to the movement of oil in interstate commerce). The rate of output is determined as follows: the U.S. Bureau of Mines estimates the demand, at existing price levels, for domestic crude petroleum for the next month. The production control agencies of the various states concerned, led by the Texas Railroad Commission, apply their state's share of the total demand to this figure to arrive at the desired rate of output for the state. This rate is compared with the maximum allowable rate, calculated on the basis of obtaining the best total recovery from all the oil reservoirs within the state. Each producer is then permitted to maintain his rate of output at the same percentage as that for the state as a whole. Thus if the state wishes to produce at one-third of its capacity, each producer will be entitled to the equivalent of ten days (out of a total of 30 days) "allowables." Small producers are frequently granted a minimum rate, below which their production will not be restricted, and there is no restriction on the number of wells that may be drilled.

In Kuwait and also in Saudi Arabia, the operating companies (Kuwait Oil and Aramco, respectively), whose principals have their own transportation, refining, and distribution facilities overseas, control all the oil areas and have no incentive to drill more wells than are necessary to withdraw the crude oil for which there is a demand. The entire output of Saudi Arabia comes from less than 200 wells. Output per well, which averages as low as 12 bbl. per day for the United States as a whole, is for Saudi Arabia 5,700 bbl. per day, but this disparity arises mainly from the prolific nature of most large fields in the Middle East. (J. L. E.)

IV. HISTORY

A. From Early Times to 1918

Petroleum has been exploited in various forms since remote times. Archaeological research in Mesopotamia and Persia shows that bitumen was used as a bonding material in place of mortar. It served as a setting for jewels and mosaics, to fasten the blades of implements and weapons in their handles, to caulk vessels and build roads, and for medicinal purposes. Herodotus (5th century B.C.) in his *History* (book vi, section 119) has described how oil, bitumen, and salt were procured in his time. The working of petroleum seepages dates from long before Herodotus, going back to before 3000 B.C. when the Sumerians, Assyrians, and Babylonians, successively, utilized bitumen.

To both the Persians and the Arabs the word *naft* denotes crude oil and light distillates, used centuries ago for lighting, cleaning silk and other textiles, in medicine, and for war purposes. Burning petroleum as a device to frighten the war elephants of their opponents contributed to the military successes of Alexander the Great, Timur (Tamerlane), and Nadir Shah. Early in the Christian era the Arabs developed various means of distillation which they introduced into Western Europe through Spain. In China there are references to oil, which was encountered when drilling for salt, in the third century A.D. As early as the 12th century, wells reached a depth of 3,000 ft. The drilling methods of the Chinese were described by Christian missionaries in the 19th century and influenced drilling methods elsewhere. Burmese oil is mentioned in the Chinese writings of the 13th century.

The petroleum of Baku was being exploited on a commercial scale, by the standards of the time, when Marco Polo traveled through northern Persia in 1271–73. The oil trade of Baku is described in his *Travels* (book i, ch. iv) and by later writers—Geoffrey Duckett of the Muscovy Company in 1574; John Cartwright, an English missionary, in 1600; and, of particular note, Jean (Sir John) Chardin and Jonas Hanway in the 18th century. Nevertheless, the modern petroleum industry dates from the mid-19th century. In Scotland about 1850 James Young discovered that oil could be distilled from cannel coal and shale and pioneered various refining processes. This led to the development of a Scottish shale oil industry which flourished until the 1920s and was only finally extinguished in 1962. However, the shale industry was always subject to the economic disadvantage that its operations had to begin with mining its raw material and then go through retorting as well as refining processes. These disadvantages were accentuated after Edwin Drake's successful well at Titusville, Pa., in Aug. 1859, from which the modern petroleum industry is usually dated.

After the completion of Drake's well, surrounding areas were immediately leased and extensive drilling took place. Crude-oil output in the United States increased from about 2,000 bbl. annually in the year of Drake's strike to nearly 3,000,000 in 1863, rising to just under 10,000,000 in 1874 (7 bbl. equals approximately 1 ton). In 1861 the first cargo of oil, contained in wooden barrels, was sent across the Atlantic to London. By the 1870s refineries, tank cars, and pipelines had become characteristic features of the industry, which was, however, highly speculative and not well organized.

Since its inception the oil industry has followed a discernible pattern. Throughout the latter part of the 19th century the United States and Russia were the two areas in which the most striking developments took place. The end of this period was characterized by the opening up of the Far East and the rise of

the Royal Dutch and the Shell companies. When World War I broke out the two major producers were the United States and Russia. Certain quantities were also being obtained from Indonesia, Rumania, and Mexico, and production had begun in Persia, but on a very small scale. Oil had been discovered in Venezuela in commercial quantities on the eve of the war. In the interwar period the Caribbean Basin and the Middle East assumed great importance as Russian oil faded from the world picture. During this period the attention of the world oil industry was concentrated on the more obviously promising areas, such as the United States, the Caribbean, the Middle East, and Indonesia. Europe and Africa were regarded with little interest. In the years following World War II the Middle East continued its rise with new discoveries of vast reserves. The United States, though continuing to be the biggest producer, consumed so much of its production that it became of less importance in the international trade picture. Companies began to roam much farther in the search for oil, and this resulted in significant discoveries in Europe, Africa, and Canada. A new factor of importance was the resurgence of the Russian oil industry.

1. United States.—John D. Rockefeller completely changed the character of the petroleum industry in the United States. On Jan. 10, 1870, the Standard Oil Company was incorporated in Ohio with $1,000,000 capitalization and Rockefeller as its president. By the early 1880s he had brought approximately 80% of the refining capacity of the nation and 90% of the pipelines within the scope of his organization, which also had a large interest in railway tank cars. Rockefeller integrated downward from refining, transportation, and marketing to crude-oil production (1886–90).

Petroleum products figured prominently as a U.S. export, with the European market absorbing the overwhelming proportion of U.S. petroleum exported. At the same time domestic consumption increased rapidly. In 1900 production in the United States had reached nearly 60,000,000 bbl. annually. Standard Oil's first overseas subsidiary, Anglo-American Oil Company, was organized in 1888, and at the turn of the century it owned the world's largest oil-carrying fleet. In 1900 the total net assets of the Standard Oil organization were listed as $205,408,449.09. In 1911, as a result of U.S. antitrust legislation, the organization was broken up into more than 30 companies. Rockefeller resigned as president of the Standard Oil Company (New Jersey), which had been incorporated in 1882 under a slightly different title and which was the holding company for the group.

Some of the companies which were once part of the original Standard Oil group have become, in addition to being major units in the United States oil industry, leading participants in international operations. Of particular prominence are Standard Oil Company (New Jersey), Socony Mobil Oil Company, and the Standard Oil Company of California. The Standard Oil Company (New Jersey), often known as "Jersey Standard" or "Esso," is the largest of the world's oil companies. The Socony Mobil Oil Company was, until 1955, known as Socony-Vacuum, which had itself come into being as a result of an amalgamation of two units from the old Standard Oil group—Standard Oil of New York (Socony) and the Vacuum Oil Company. Four other members of the former Standard Oil group have been traditionally prominent in the domestic American industry—Atlantic Refining, Ohio Oil Company, Standard Oil Company (Ohio), and Standard Oil Company (Indiana); all now also engage in overseas operations.

There are two American oil companies of particular note and with worldwide interests that have their origins outside the Standard organization. One, Texaco Inc., is the successor to the Texas Company, which was incorporated in 1902. The other, the Gulf Oil Corporation, was incorporated in 1907, but its origins may be said to go back to 1889, when W. L. Mellon began to acquire oil-producing property in western Pennsylvania.

2. Russia.—When the 20th century opened, production from the United States and Russia accounted for about 90% of the world's output. In 1901 a few square miles on the Apsheron Peninsula (Caspian Sea) produced 11,700,000 tons, thus surpassing the production of the United States, which in that year amounted to 9,500,000 tons. Since the total world output in 1901 was just over 22,900,000 tons, the rest of the world accounted for only 1,700,000 tons. The extraordinary development of the Baku fields was largely the work of the Swedish brothers Robert and Ludwig Nobel, who acquired their first productive well in the Baku area in 1874. They brought many changes. They introduced proper control of their wells; they took steps on behalf of their employees' welfare; introduced pipelines on the U.S. model; built refineries; put tank cars on the railways; and initiated revolutionary techniques in water transport. Before 1879 oil was carried in barrels. In 1877 Ludwig Nobel had an iron steamer put on the stocks in Sweden. The "Zoroaster" came into service on the Caspian between Baku and the Volga in 1879 and was the first of a fleet of such tankers. Moreover, by 1883, steamers and locomotives in the Caspian region did not burn coal or wood but petroleum. By 1883 Russian petroleum was reaching German markets; by 1888, Singapore. Later it was sold in the Far East through the Royal Dutch and Shell companies. The Russian Revolution of 1917 resulted in the seizure of foreign interests, and was followed by a sharp fall in production.

3. Far East. Royal Dutch/Shell.—Based upon the pioneer work of a Dutchman, Aeilko Jans Zijlker, who obtained a concession in northern Sumatra where he began drilling in 1884, "The Royal Dutch Company for the Working of Petroleum Wells in the Dutch East Indies" (name changed in 1949 to the Royal Dutch Petroleum Company) was incorporated at The Hague in 1890. Its success owes a great deal to two men, J. B. August Kessler and Henri Deterding; the latter joined the Company in 1896 and succeeded Kessler as its chief executive in 1900. The Royal Dutch began as a producing company and proceeded to build up a sales organization in the East. Its orientation was at first eastward, partly because of proximity and also because European markets were already taken up by U.S. and Russian oil.

The Royal Dutch came into competition both with Standard and with the Samuel brothers, British merchants having a long connection with trade in the East. In 1890 Marcus Samuel visited Russia to investigate the possibilities of marketing oil from there in bulk to the Orient. He succeeded in these negotiations as he did also in persuading the Suez Canal authorities to remove the ban against tankers passing through the canal. Standard had been denied permission some years earlier because of disasters which had befallen ships carrying oil. Improvements in design had taken place so that in the summer of 1892 the "Murex," the first of the Shell fleet of tankers, passed through the Suez Canal with kerosene from Batum to Singapore and Bangkok.

In 1896 Samuel bought oil properties in Borneo which he began to develop. In the following year he organized the "Shell" Transport and Trading Company, Ltd.; so named because seashells had been one of his earlier items of trade. In 1903 the Asiatic Petroleum Company was formed with its capitalization held in three equal parts—the Royal Dutch, the Shell, and the Rothschilds, who later disposed of their interest to the Royal Dutch/Shell group. The main function of this company was marketing. In 1907 Royal Dutch and Shell transferred their other properties to two new companies which they owned jointly on the basis of 60% Royal Dutch and 40% Shell. One company, Bataafsche Petroleum Maatschappij N.V., with its headquarters at The Hague, was the operating (production and refining) company. The other, the Anglo-Saxon Petroleum Company, had its headquarters in London. Its functions included transport and storage. In 1912 the Royal Dutch/Shell group made its entry into the United States by acquiring oil interests in California. In that year, too, the Royal Dutch/Shell incorporated the Roxana Petroleum Company of Oklahoma, which became the member through which the group's interests in Oklahoma and Texas were held. This was closely followed by its entry into Venezuela and the discovery of the Mene Grande field in 1914. Venezuela later became the largest exporting country and the second largest producer in the world.

4. Venezuela.—It is said that Venezuela first exported petroleum in 1539 when a barrel of crude oil was sent to the king of Spain. Pirates in the 16th century frequently used the

pitch of the Lake Maracaibo region for caulking their ships. In the late 1870s a small Venezuelan company drilled a few wells about 60 ft. deep at a seepage site in order to obtain crude for local use as an illuminant. It was the Caribbean Petroleum Company, a subsidiary of Royal Dutch/Shell, which in 1914 discovered the first field (Mene Grande) of real commercial importance. In 1917 another Royal Dutch/Shell subsidiary associate, Venezuelan Oil Concessions, Ltd., opened up the La Rosa field on the east side of Lake Maracaibo. In 1922 one of its wells flowed wild for nine days at the rate of 100,000 bbl. per day. This called attention to Venezuela as an oil country and encouraged intensive and successful exploration by various oil companies.

5. Rumania.—In Rumania the existence of oil had been known for centuries. In 1857 hand-dug wells produced 275 tons. Operations on a larger scale followed the introduction of modern drilling techniques and the infusion of foreign capital, chiefly German through the Deutsche Bank. In 1903 Rumanian production reached 412,000 tons, rising to 1,848,000 tons in 1913. During World War I the Entente authorities decided (1916) upon the destruction of as much of the oil plant in Rumania as possible. The main Allied investments affected were those of the Royal Dutch/Shell group and certain French interests. In 1917 production fell to 518,460 tons, but rose substantially in the following year to 1,222,582 tons. As a result of the German defeat its properties in Rumania were sequestered and handed over to the Allies.

6. Persia and the Middle East.—Before the outbreak of World War I the oil industry was established in Persia, the first of the great producing countries of the Middle East. It was upon the work of the French archaeologist Jacques de Morgan that William Knox D'Arcy (a wealthy Englishman who had made a fortune goldmining in Australia) based his belief in Persian petroleum as a paying commercial proposition, in spite of the failure of others before him to achieve any success. Early in 1901 D'Arcy's representative in Teheran entered into negotiations with the Persian government. Signed on May 28, 1901, D'Arcy was granted a concession for 60 years. It covered the whole of Persia except for the five northern provinces adjacent to Russia.

D'Arcy's first exploratory drilling was at Chiah Surkh in the west, where there were surface seepages of oil, but no production of commercial significance was proved by 1904, after which drilling operations were moved to southwest Persia. Oil was struck there on May 26, 1908. When further wells drilled nearby proved successful, it became evident that a major oil field had been discovered. On April 14, 1909, the Anglo-Persian Oil Company, Ltd. (APOC), was incorporated with Lord Strathcona as its first chairman. The oil field was connected by a pipeline 135 mi. long with a refinery on Abadan Island which came into operation in 1913. The financial resources of the APOC in its early days were slender, but in May 1914 the British Admiralty, of which Winston Churchill was first lord, signed a long-term contract with the company for the supply of fuel oil to the Royal Navy. Simultaneously, the British government invested £2,000,000 in the company, followed by a further £3,000,000 in 1919. Thus the company had acquired a long-term customer and finance for expansion. As a result of its investment the British government became the owner of just over 50% of the company's equity, as it has remained to the present. At the time of the original investment the government gave an assurance that it would not interfere in the ordinary commercial operations of the company.

D'Arcy had endeavoured since 1901 to obtain an oil concession in Mesopotamia (now Iraq), then part of the Ottoman Empire. His representative in Constantinople came near to success but failed to achieve it. The Anglo-Persian Oil Company, as D'Arcy's successor, persevered with negotiations against keen competition from other groups. In October 1912 the Turkish Petroleum Company was registered in London as the new name of the African and Eastern Concessions, Ltd., which had been incorporated in January 1911. This brought together the interests of the National Bank of Turkey (formed in 1910), C. S. Gulbenkian (then adviser to the sultan), the Deutsche Bank, and the Shell group. The Anglo-Persian Oil Company was not represented in this combination, but in 1914 the firm joined in a reconstituted Turkish Petroleum Company, taking half the share capital of £160,000. The other participants were the Deutsche Bank with £40,000; Anglo-Saxon (Shell) with £40,000; and Gulbenkian with 5% to be provided equally from shares of Anglo-Persian and Anglo-Saxon. On June 20, 1914, the Turkish government agreed to lease the petroleum deposits "discovered or to be discovered" in the *vilayets* of Baghdad and Mosul to the Turkish Petroleum Company. The outbreak of World War I delayed the development of the country's oil resources.

7. The Effects of World War I.—In World War I, changes already under way—such as the use of oil for fuel in ships—were greatly speeded. The diesel-engined submarine was first used on a large scale, and the gasoline-engined airplane emerged as a new weapon. After the war the automobile gained rapidly in popularity, providing a new peacetime demand for petroleum products. The emergence of petroleum as a vital war material, together with the new and widespread uses for petroleum products, made the possession of adequate supplies a matter of national interest. The U.S. government, for example, encouraged companies to undertake operations abroad.

B. From 1919 to 1939

1. Venezuela.—After World War I, U.S. interest in Venezuela was such that in 1925 about 20 companies held concessions there. Venezuela Gulf Oil Company and the Creole Syndicate undertook drilling in Lake Maracaibo, as did the Lago Petroleum Corporation, later acquired by Standard Oil (Indiana). In 1923 the British Equatorial Company struck oil in its Lake Maracaibo concession area, which the Lago Petroleum Company purchased in the following year. In 1928 Standard Oil Company (New Jersey) obtained a controlling interest in the Creole Petroleum Corporation (as the Creole Syndicate had been renamed), made it the holding company for its subsidiaries in Venezuela, and later acquired the Lago Petroleum Corporation, which had become a large producer in the Lake Maracaibo region. In 1932 the Lago properties were made part of the Creole Company, which for many years held first place among the oil producing companies of the world. In 1928 Venezuela occupied second place in world oil production for the first time. Although many companies searched for oil in Venezuela, three groups were conspicuously successful—Standard Oil Company (New Jersey); Royal Dutch/Shell; and Gulf Oil Corporation. For many years these groups accounted for well over half of Venezuela's oil production, which increased from 67,000 tons in 1920 to over 170,000,000 tons in 1963. Not until 1961 was Venezuela overtaken by Russia as the second largest producer in the world.

2. Middle East.—There was no U.S. stake in Middle Eastern oil until 1928, when participation in Iraq began. In 1919–20 the sequestered German shares of the Turkish Petroleum Company were assigned to the French government or its nominees so that the company was constituted as follows: Anglo-Persian, 47½%; Anglo-Saxon (Shell), 22½%; Compagnie Française des Pétroles, 25%; and Gulbenkian, 5%. The government of the United States protested. Insistence on the policy of the "open door" resulted in the D'Arcy Exploration Company (which Anglo-Persian had formed for participating in enterprises outside Persia) giving up half its share to a group of U.S. oil companies, receiving in return a royalty in the form of oil. The number of U.S. companies interested in participating varied. In 1928 five U.S. companies formed the Near East Development Corporation. These were Standard (New Jersey), Standard Oil of New York, Gulf Oil Corporation, Atlantic Refining and the Pan American Petroleum and Transport Company. In July 1928 the principals of the Turkish Petroleum Company were D'Arcy Exploration, 23¾%; Anglo-Saxon (Shell), 23¾%; Near Eastern Development Corporation (United States), 23¾%; Compagnie Française des Pétroles (CFP), 23¾%; and Gulbenkian, 5%. In June 1929 the Turkish Petroleum Company changed its name to the Iraq Petroleum Company, Ltd. (IPC).

In 1925 the Iraq government had granted to the Turkish Petroleum Company a concession with respect to Baghdad and Mosul

provinces. Two years later a spectacular oil strike was made near Kirkuk in northern Iraq. After the IPC's concession was revised in 1931 the company began the construction of a pipeline from the oil field to the Mediterranean. Two 12-in. lines ran together to the Euphrates, after which they separated—one branch went 532 mi. to Tripoli in Lebanon and the other 620 mi. to Haifa in Palestine. Opened officially in January 1935, this was the first of the great Middle East pipelines to the Mediterranean, and a remarkable engineering achievement.

In Persia the Masjed Soleyman field, producing 1,100,000 tons in 1919, exceeded 5,000,000 in 1928. In that year the Haft Kel field was discovered. Late in 1932 Riza Shah Pahlavi cancelled the concession. A new agreement was negotiated in 1933 and the company (renamed the Anglo-Iranian Oil Company, Ltd., in 1935, in accordance with Riza Shah's decree substituting "Iran" for "Persia") proceeded to enlarge the scope of its activities. Oil production from Iran exceeded 10,000,000 tons in 1937. In 1938 Iran as a producer was surpassed only by the United States, the U.S.S.R., and Venezuela.

In Bahrain, in the al Hasa province of what later became Saudi Arabia, and in Kuwait early interest in oil owed a great deal to the New Zealander Frank Holmes. Through the Eastern and General Syndicate, a company registered in London in 1920, Holmes hoped to sell to other organizations any concessions which he might acquire. He obtained in 1923 from King Ibn Saud permission to explore for oil in the al Hasa province; in 1924 from Ibn Saud and the ruler of Kuwait rights over the Neutral Zone; and in 1925 from the sheikh of Bahrain exploration rights covering the entire island. The first two concessions lapsed, but in November 1927 the Gulf Oil Corporation took over the option (due to expire on Dec. 7, 1927) from the Eastern and General Syndicate with respect to Bahrain. The Gulf Oil Corporation, as a member of the U.S. group associated with Turkish Petroleum, had agreed not to operate in Bahrain. This agreement went back to 1912, when the constituent groups of the Turkish Petroleum Company pledged, in the interests of orderly development, not to explore for or to develop oil anywhere in the Ottoman Empire except in association with one another. This principle was incorporated into the agreement dated July 31, 1928, to which a map was annexed showing, by means of a red line, areas in which participants in the Turkish Petroleum Company agreed not to compete with each other in exploration but to act collectively. Consequently, the Gulf Oil Corporation on Dec. 21, 1928, assigned its option rights over Bahrain to the Standard Oil Company of California, which in turn established a Canadian subsidiary (BAPCO) to hold and operate the concession. The Bahrain Petroleum Company discovered oil in 1932 and exports began in 1934.

The discovery in Bahrain had far-reaching effects in other Arab lands. Standard of California acquired from Ibn Saud rights in Saudi Arabia in 1933. Oil was struck in 1935 and exports began in 1939. In 1936 Standard of California sold to the Texas Company a half interest in its companies operating concessions in Bahrain and Saudi Arabia, as well as a half interest in other of its companies with rights in Sumatra, Java, and Netherlands New Guinea. In return Standard of California received certain payments and a half interest in Texas' marketing facilities in the Eastern Hemisphere. The California Texas Oil Company, Ltd., ("Caltex"), jointly owned by the two parent groups, was incorporated in 1936. Initially its function was marketing in the East. In January 1947 Texas sold its marketing outlets in Europe and North Africa to the California Texas Company. Subsequently the latter company built refineries in several European countries which were supplied with Middle Eastern crude oil.

In Kuwait a contest between the Anglo-Persian Oil Company and the Gulf Oil Corporation to secure a concession was resolved by the formation in February 1934 of the Kuwait Oil Company, representing equal participation by the two groups, and by a grant by the ruler of Kuwait in December 1934 giving the Kuwait Company rights covering the entire area. The first drilling efforts failed, but in April 1938 a field of vast potentiality was discovered in the Burgan area. Development, suspended during World War II, was resumed in 1945 and in the following year the first cargo was loaded for export. In Qatar, a peninsular sheikhdom on the eastern side of Saudi Arabia, an associate of Iraq Petroleum Company opened up the Dukhan field late in 1938. World War II brought a cessation of activity and oil was not exported until the end of 1949.

Although the oil industry was established in several Middle Eastern countries before World War II, the total production of that region in 1938 amounted only to 15,000,000 tons out of a total world production of 274,000,000 tons. The largest producers were the United States with 168,000,000 tons, Venezuela with 28,000,000, and the U.S.S.R. with 28,000,000. Iran ranked fourth but only accounted for about 4% of the total world crude production. Following Iran were the Netherlands East Indies, Rumania, Mexico, Iraq, Colombia, and Trinidad. During the years 1901–40 the United States accounted for 64% of the world's production; from 1926 to 1930 discoveries in Oklahoma, Texas, and California more than doubled the known reserves of the country. Russia produced, in the years 1901–40, about 10% of the world's total production; Europe, excluding Russia, produced about 3% of the total, the most important country being Rumania, which in 1938 had an output of about 4% of that of the United States. In the years between the wars, development in Rumania was such that in 1934 the production figure was 8,467,000 tons. The country ranked fourth in the world in 1935. In the Western Hemisphere, outside the United States, the biggest producer was Venezuela, where production had begun in 1917. By 1938 Venezuela was contributing approximately 10% of the world's total. In Mexico production had risen spectacularly from 1919–21, reaching in the latter year 25% of the world's entire production, but a sharp decline ensued. In 1938 Mexico expropriated the foreign oil companies. Final payment for properties expropriated was made in 1962.

C. After World War II

World War I established petroleum as an essential war material. In World War II the need for petroleum and its products reached what were then monumental proportions. Consumption during the war years accounted for one-fifth of the total production of the United States up to that time. In the latter part of the war the tonnage of petroleum products being shipped overseas by the United States was nearly double that of all other tonnage combined, including arms, equipment, food, medicine, and men. The war brought demands for many new products and constantly changing specifications. A B-29 aircraft alone used 20 different oil products. The air war demanded large quantities of 100-octane fuel, so that production increased from 75,000 bbl. daily in 1942 to nearly 600,000 in mid-1945. Oil supplied toluene for explosives and asphalt for landing strips and roads. The war brought new developments in pipeline technique, such as the 24-in. war emergency line and the 20-in. products line, each running from points in Texas to the Atlantic seaboard. After the war both were converted to natural gas transportation. In Europe by means of Pipe Line Under The Ocean (PLUTO) 1,000,000 gal. of gasoline daily was reaching France from England by 1945. In the Middle East expansion took place rapidly after the reopening of the Mediterranean to tanker traffic in 1943. In 1944 the refineries in the Middle East were turning out 89% more petroleum products than in 1938. In Iran, production, which had fallen to 6,605,000 tons in 1941 (from over 10,000,000 in 1938), reached 16,839,490 tons in 1945.

1. Middle East Development.—In the postwar years the search for oil intensified, with new companies and new nationalities represented. The most spectacular developments occurred in the Middle East, but notable results were also obtained in other areas such as North Africa, Canada, and Nigeria. The geologist E. De Golyer had estimated in 1944 the proved and semiproved reserves of the Middle East at about 18,000,000,000 bbl., an estimate which he revised upward in 1948 to a 32,000,000,000 bbl. minimum. With the new knowledge available, the "published proved" reserves for the Middle East were, in 1962, put at 194,000,000,000 bbl., or 61.1% of the world's total.

In Saudi Arabia, the California Arabian Standard Oil Company,

after 1944 known as the Arabian American Oil Company, or Aramco, had not been shut down during the war. A 50,000-bbl.-per-day refinery, completed at Ras Tanura, began operations in September 1945. Development in Saudi Arabia brought changes elsewhere. Standard Oil (New Jersey) and Socony-Vacuum obtained a 30% and a 10% interest, respectively, in Aramco and in Tapline, the company formed to build a 1,000-mi. pipeline from the Arabian fields near the Gulf to the Mediterranean port of Sidon, Lebanon. The project was completed in 1950. Saudi Arabia has one of the largest proved reserves in the world. In 1963 its production was surpassed by the United States, the U.S.S.R., Venezuela, and Kuwait.

Oil from new fields in southern Iraq was first exported in 1951, via the Persian Gulf. The resumption of operations in Kuwait was followed by phenomenal growth, one of the factors being the reduced availability of Persian oil from 1951 to 1954. Production rose from 2,185,308 tons in 1947 to 17,000,000 tons in 1950 and surpassed 37,000,000 tons in 1952. By 1953 Kuwait had overtaken Saudi Arabia as a producer and retained first place in the Middle East since that time to 1963 when it produced more than 90,000,000 tons.

In Iran, too, expansion characterized the postwar years, with production in 1950 reaching 32,000,000 tons. But events occurring in the summer and autumn of 1951 brought the Iranian oil industry to a standstill. In April 1951 Mohammad Mossadegh became prime minister, and oil was declared nationalized under a National Iranian Oil Company. Many efforts were made to resolve the deadlock, but no settlement was possible until after Mossadegh had been replaced in August 1953.

Late in 1953 the Anglo-Iranian Oil Company invited a number of major international oil companies, all with experience in the Middle East, to form a consortium for the purpose of reactivating the oil industry in conjunction with the National Iranian Oil Company (NIOC). The companies that originally formed the consortium, and their respective interests, were: Anglo-Iranian, 40% (name later changed to the British Petroleum Company, Ltd.); N. V. De Bataafsche Petroleum Maatschappij (representing the Royal Dutch/Shell group), 14%; Gulf Oil Corporation, 8%; Socony-Vacuum, 8%; Standard Oil Company (New Jersey), 8%; Standard Oil Company of California, 8%; the Texas Company, 8%; and Compagnie Française des Pétroles, 6%. Subsequently, each of the five U.S. companies transferred 1% of its holdings to a group (Iricon) of nine smaller U.S. companies. Discussions which began in Teheran in April 1954 between representatives of the consortium and the Iranian government resulted in an agreement on an essentially 50/50 profit-sharing basis. The agreement, ratified by the Iranian government in October 1954, enabled Iran to reoccupy a major position in the world oil industry with a production in 1963 of 73,000,000 tons as compared with approximately 32,000,000 in 1950 and only 2,000,000 in 1954.

The 50/50 profit-sharing formula (owner government and operating company each receiving half of operating profits) was first instituted in Venezuela in 1943, coming into operation there in 1948. Aramco introduced the concept into Saudi Arabia by an agreement which came into force in December 1950, and similar arrangements were made with Kuwait in 1951, Iraq early in 1952, and then in Bahrain and Qatar. The 50/50 basis subsequently became widely accepted both by the governments of producing countries and by the major operating companies.

2. Social Benefits from Oil Revenue.—In many of the major petroleum-producing countries oil revenue forms a very substantial part of the national income. Revenues from oil, as well as direct efforts by the oil companies themselves, have provided the means to fight diseases such as malaria in Venezuela and trachoma in the Middle East and have made possible the building of schools and hospitals and the introduction of industrial and agricultural improvements on an unparalleled scale. Since oil often occurs in undeveloped areas the oil companies themselves have had to build roads. Kuwait has provided a striking example of the transformation which can be brought about by the responsible use of oil royalties.

3. New Pattern of World Development.—Significant changes have taken place in the pattern of oil development. More companies have overseas or worldwide interests. The American Independent Oil Company (Aminoil, a combination of ten U.S. companies and individuals) obtained in 1949 from the ruler of Kuwait a concession covering that country's undivided half interest in the Neutral Zone. Shortly thereafter J. Paul Getty's Pacific Western Oil (name changed to Getty Oil Company in 1956) of Los Angeles signed an agreement with Saudi Arabia covering its interest in the Neutral Zone. This marked the beginning of a new trend which brought many companies to the Middle East for the first time. In 1958 the Japan Petroleum Trading Company Ltd. received from the governments of Saudi Arabia and Kuwait concessions over offshore areas of the Neutral Zone and formed a subsidiary, Arabian Oil Company Ltd., as an operating company. Iran also granted concessions outside the consortium area. As a result of the petroleum law of 1957 the NIOC concluded agreements both with the Italian state-owned Agip Mineraria S.p.A. (AGIP) and with a subsidiary of Standard (Indiana). Nor was such new activity limited to the Middle East. The amendment of its petroleum law by Libya in 1955 brought applications from 13 companies. The success of Esso Standard Libya Inc. with its Zeltan find in 1959 foreshadowed the rise of still another country as a major producer. North Africa and the Sahara were completely transformed in the space of a few years from a region of doubtful promise to one of intense activity. In 1963 Algeria, enjoying the fruits of the pioneer work of the French government and of oil companies in the Sahara after the end of World War II, produced over 23,000,000 tons; and Libya, where production began only in October 1961, produced 21,000,000 tons in 1963.

Drilling in marine areas became widespread following the end of World War II. As early as 1911 the Gulf Refining Company drilled a well in Caddo Lake on the Louisiana-Texas border. Overwater drilling on Venezuela's Lake Maracaibo was successfully undertaken in the 1920s and this area subsequently was extensively developed. In 1951 Creole Petroleum was operating 1,500 wells in Lake Maracaibo alone. The first offshore well in the Gulf of Mexico was begun in 1937 as a joint operation of the Superior Oil Company and Pure Oil Company. Completed in 1938, it was the first commercial oil discovery in the Gulf of Mexico.

In the Persian Gulf, Aramco was the first company to undertake marine work, and the result was the discovery of the great Safaniya field in 1951. In 1962 the Safaniya field provided nearly one-fifth of Aramco's output of 75,000,000 tons. Aramco's other offshore field, Manifa, was brought into production in 1964. The Japanese-owned Arabian Oil Company Ltd. progressed rapidly with work in the offshore areas of the Neutral Zone and struck oil in 1960. Shipments commenced in 1961 from the Khafji underwater field. Exports began in 1962 from the Umm Shaif field (about 60 mi. off the coast of Abu Dhabi) which was developed by Abu Dhabi Marine Areas Ltd. (two-thirds British Petroleum and one-third CFP). The Pan American International Oil Company, which in 1962 became the American International Oil Company (a subsidiary of Standard Oil Company [Indiana]), discovered oil off Kharg Island through its Iran Pan American Oil Company (IPAC) venture. In 1963 the Continental Oil Company, which became a major producer in Libya, obtained concessions over both onshore and offshore areas of Dubai and of Qatar. Although the most successful results were achieved in Lake Maracaibo, the Gulf of Mexico, and the Persian Gulf, marine operations were being carried on in many other parts of the world, from Brunei to the Cook Inlet Basin of Alaska. A great deal of interest was being shown in the prospects of drilling in the North Sea in the mid-1960s.

In the Western Hemisphere the United States and Venezuela over the years retained their positions as the world's two largest producers. In Canada, where interest in the oil industry was shown as early as in the United States, the results were not encouraging until the discovery in Alberta of the Leduc field in 1947, followed by Redwater in 1948. These developments radically changed the outlook of the industry in Canada. Production increased from 8,000,000 tons annually in 1952 to 36,000,000 tons in 1963. Exploration was carried out intensively by many companies, but the industry by the mid-1960s had not regained the

investment made following the Leduc discovery. Investment in the Canadian oil industry in the years from 1948 to the end of 1962 amounted to $6,600,000,000 against $5,500,000,000 income. The possibilities of the Arctic islands and the Athabasca tar sands attracted considerable interest.

Another changing factor in the world oil picture of the 1960s was the position of the U.S.S.R. At the turn of the 20th century Russia's production surpassed that of the United States for a period of four years (1898–1902) when Swedish, Dutch, British, and French capital was freely invested there. After the 1917 Revolution and the confiscation of foreign assets the country's production fell sharply. When it rose again state policy directed that petroleum resources be used in the main for domestic purposes, largely military. This policy changed in 1953 when the U.S.S.R. again began to export oil. In 1962 it exported 45,000,000 tons (including 25,000,000 tons to non-Communist countries) out of a production of 186,000,000 tons, and it was planned to increase oil production on a large scale. The Perm, Ufa, Kuybyshev area west of the Urals supplanted the Apsheron Peninsula as the major producing area, and substantial new discoveries were reported in Azerbaijan, the Ukraine, and in particular in the central Asian provinces.

In 1945 Rumania came under Soviet influence, with the subsequent nationalization of oil properties. In the span of just over a century, from its first recorded production in 1856 of 275 tons to 1962, Rumania had a cumulative production of some 285,000,000 tons. Production had become stable at about 12,000,000 tons a year by the beginning of the 1960s.

The modern petroleum industry, since Drake's Titusville well of 1859, has undergone periods of significant change. In its first half-century, the U.S. industry, latterly guided by Rockefeller, had the foremost influence, worldwide in scope. In this period, too, petroleum products were used mainly as illuminants. During the next half-century the most notable developments were the use of petroleum products as a source of power and heat, and the geographical shift of supply sources to the Middle East, following discovery and development there of new fields and extensive reserves.

See also references under "Petroleum" in the Index.

(Ro. L. G.)

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PETROLEUM WAXES. Petroleum provided the first abundant source of inexpensive waxy materials. Such waxes were among the earliest products made from petroleum, and their production continued in increasing quantities as new uses were found for them. Although these products represent in volume less than 1% of the crude petroleum refined, they are highly important in terms of their versatility in meeting an increasing number of human needs. The petroleum industry has constantly striven to develop new wax grades and large-scale, low-cost methods for preparing them. In contrast, animal and vegetable waxes continue to be high in cost and of varying chemical character and uncertain availability.

Petroleum waxes are classified in three groups: paraffin, microcrystalline, and synthetic waxes. Materials in the last group are arbitrarily included here because their properties and uses are similar to those of the first two groups, even though the synthetics are made from coal instead of petroleum. Microcrystalline waxes are differentiated from the paraffins by their greater viscosities, higher melting points, and poorly defined crystalline structure; the paraffin waxes are obtained from the lighter fractions of petroleum while microcrystalline waxes come from the heavier fractions.

Paraffin was first produced commercially in 1867, less than ten years after the drilling of the first petroleum well. Microcrystalline wax became commercially available in 1932, while synthetic paraffin prepared by the Fischer-Tropsch reaction technique (described below) has been available only since 1947.

Paraffin Waxes.—Prior to 1867, limited amounts of paraffin wax were prepared from bituminous shales for use in candle making. Even then the demand exceeded the supply because the distillation process was slow. In contrast, paraffin separation from petroleum required only chilling and filtration. The earliest paraffin-wax separation was effected by hanging canvas bags of chilled oil in a large icebox. The separated wax stayed in the bag much as does the pomace in fruit-juice production.

Basically, paraffin and microcrystalline waxes are still made in the same way. Huge modern plants and automated processing equipment do the same operations: chill the oil until the naturally occurring waxy components solidify and then filter-separate them from the fluid oil, which is recovered for other purposes. Technical progress has made the separation more efficient and less costly. To this processing have been added methods of purification by chemical treatment, decolorization by adsorbents, and fractionation of the separated waxes into grades by distillation or recrystallization, or both. Also, new crude oils with higher wax content have been discovered and earmarked for this production. But even the most modern of petroleum-wax plants is simply an extension and refinement of the methods utilizing canvas bags.

"Slack" wax was the term given to paraffin wax as it was recovered by the original methods. This grade frequently retained as much as 20% oil. When its oil content is reduced to about 3%, it is referred to as "crude scale" wax. This wax, after some decolorization, becomes "white crude scale" wax and is sold as such for many uses. Further purification improves the colour, odour, and taste, and limits the melting-point range to about 2° F (1° C) yielding "fully refined paraffin" wax. This is the generic commercial name irrespective of the refining method used.

Paraffin wax is a solid, crystalline mixture of straight-chain or normal hydrocarbons ranging in molecular weight from C_{20} to C_{30} and possibly higher. It is distinguished by its solid state at room temperature, relatively slight deformation at this temperature even under considerable pressure, and low viscosity when melted. Paraffin-wax crystals are long, narrow, and form in plates. Fully refined paraffin grades are dry, hard, and capable of imparting good gloss.

Modern commerce generally recognizes two degrees of paraffin wax refinement, crude scale and fully refined. Crude scale paraffin ranges in melting point from 118° to 135° F (48° to 57° C) and contains about 0.5% oil. Fully refined paraffin has a melting point range of 118° to 150° F (48° to 66° C), is colourless, odourless, and tasteless, and contains about 0.2% oil (standards established by the American Society for Testing Materials).

Synthetic Paraffin Wax.—The period after World War II

saw the introduction of the first commercially available synthetic paraffin waxes, produced by the Fischer-Tropsch reaction technique. In the Fischer-Tropsch synthesis, coal is burned in gas generators in the presence of oxygen and steam to produce a gas stream composed mainly of carbon monoxide and hydrogen. After purification, this gas stream is converted to hydrocarbons in the presence of a magnetic iron catalyst. Following removal of the catalyst, the resultant liquid hydrocarbons are refined and separated.

One of the products thus obtained is paraffin wax, snow-white in colour, harder than petroleum paraffin, and capable of taking a high gloss, the degree of gloss being one of the factors used in judging wax quality. The average molecular weight approximates 750, corresponding to 50 to 55 carbon atoms. Its unique character and high purity well suit it as a replacement for certain vegetable waxes and as a modifier for petroleum waxes and for some plastics, such as polyethylene. Also, synthetic paraffin wax may be oxidized to yield pale yellow, hard waxes composed of mixtures of high-molecular-weight oxygenated compounds, chiefly carboxylic and waxy acids and esters. Their unique value lies in their ability to saponify with aqueous solutions of organic and inorganic alkalies such as borax, sodium hydroxide, morpholine, and triethanolamine. These aqueous wax dispersions serve admirably as heavy-duty floor wax, for waterproofing textiles and paper, in the tanning of leather, as metal-drawing lubricants, as rust preventives, and for masonry and concrete treatment. Thus, in general, synthetic paraffin, both straight and in the oxidized form, complements rather than supplants the petroleum-derived material.

Microcrystalline Waxes.—Although the raw material from which microcrystalline waxes are separated was always present in petroleum, the introduction of these unique materials had to await other industry developments to make their separation commercially feasible. This occurred about 1930. Previously, when the heavy fractions of petroleum were used as lubricants, there was little need that they be well refined or that they be fluid at low temperatures. However, the increasing use of the motor car changed this. Crankcase lubrication demanded that the oil flow easily at low temperatures and that it have minimum tendency to carbonize in the cylinders. Wax removal was essential. Methods of separation included solvent dilution, chilling, and centrifuging, and varying combinations of these. The quality and quantity of the removed material that became available encouraged study which led to commercial production of microcrystalline waxes.

In contrast to paraffin wax, the microcrystalline grades vary widely in physical character, depending on the crude-oil source and the degree and method of refinement. Some are as ductile as beeswax, others are hard and brittle, and still others lack cohesive strength and tend to crumble easily during handling. The melting point range is higher than that of paraffin, commercial grades ranging from 145° to 200° F (63° to 93° C). In colour microcrystalline wax ranges from dark brown to cream white. Decolorization is always difficult and odour and taste have long been deterrents to the acceptance of microcrystalline wax, especially in the packaging of foods.

Petroleum Wax Uses.—From the beginning, candle making has been a large petroleum-wax consumer. While progress in artificial illumination might seem to have relegated the candle to a minor place, its utility as a portable, self-contained source of light continues. Candle production, including candles for religious and decorative uses, still requires millions of pounds of petroleum wax each year, for paraffin wax, combined with varying amounts of stearic acid, is a satisfactory material for all candles except those for liturgical use that are required to contain some beeswax.

The paper industry is by far the largest single user of petroleum wax, especially microcrystalline waxes. Chemical purity and low cost, along with freedom from odour and taste, excellent moisture-vapour and water resistance, and relative inertness, led to early widespread use of paraffin in all types of food packaging and in food handling.

Petroleum wax may be applied to the paper pulp before it is formed into sheets or after the sheet is made. Frequently, enough wax is applied to serve also as the wrapper adhesive, as in bread wrapping. In the case of dynamite, the paper is waxed both before and after the stick is formed to secure added protection against moisture.

The match industry was an early user of paraffin wax. In the wooden match, the paraffin coating impregnates the wood just below the head; it is visible after the match is struck as a clear liquid flowing away from the head as the stick is consumed. In the paper match, the paraffin-treated portion of the stick is clearly darker just below the head. In both cases, the wax helps ignite the match stick by supplying an easily vaporized hydrocarbon fuel.

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PETROLOGY is the branch of geology concerned with the investigation of the composition, structure and history of the rock masses building up the accessible portions of the earth's crust (Gr. *petros*, "rock"). Rocks are usually defined as aggregates of minerals without reference to their state of cohesion. Loose sands, clays, gravels or soils are included among rocks as being mineral masses playing an important role in field geology. On the other hand, the less soluble parts of the skeletons of animals and plants may form a considerable portion of rocks as, for example, in the case of coral limestone, lignite and chalk. Lastly, rocks may be built up almost wholly of noncrystalline material such as obsidian, pitchstone or tachylyte, representing liquids so rapidly chilled that consolidation has occurred in the glassy state. Rocks are the units with which the geologist deals in investigating the structure of the earth's crust, and some varieties cover enormous areas. Granite, sandstone and schist often form whole provinces and build up lofty mountains, while other rock types are of such rare occurrence that they are known only in one or two localities in far-removed parts of the earth's surface.

Broadly speaking, rocks are divided into three great classes, igneous, sedimentary and metamorphic. In this article discussion is confined to the nature, composition, classification and origin of igneous rocks and the methods by which they are examined. For the other groups, *see* SEDIMENTARY ROCKS and METAMORPHISM. *See* also MINERALOGY.

Following are the main subdivisions of this article:

I. Treatment of the Subject
  1. Composition of Igneous Rocks
  2. Magma
II. Methods of Investigation
  A. Analytical
    1. Macroscopic Characters
    2. Microscopic Characters
    3. Mechanical Separation of Constituents
    4. Microchemical Methods
    5. X-ray Methods
    6. Chemical Analysis
    7. Specific Gravity
  B. Rock Synthesis
    1. Pioneer Investigations
    2. Geophysical Laboratory
III. Classification of Igneous Rocks
IV. Habit of Igneous Rocks
  1. Lavas or Effusive Types
  2. Plutonic or Abyssal Types
  3. Intrusive or Hypabyssal Types
V. Chemical Characters
  1. Rock Elements
  2. Range of Composition
  3. Common Minerals and Associations
  4. Acid, Basic and Alkali Rocks
  5. Mineralogical Constitution
  6. Quantitative Classifications
VI. Petrographical Provinces
  A. Differentiation
  B. Plutonic Complexes
    1. Unmixing
    2. Fractional Crystallization
    3. Application of Laboratory Investigations
    4. Discontinuous-Reaction Series
    5. Natural Magmas
    6. Hydrothermal Systems
    7. Magmatic Assimilation
    8. Palingenesis
    9. Granitization
VII. Geographic Distribution of Igneous Rocks

I. TREATMENT OF THE SUBJECT

Below is a brief survey of that part of the science of petrology which concerns igneous rocks, with the headings under which particular subjects are treated (each italicized item has a separate article).

Igneous rocks occur as intrusions or extrusions. The plutonic or deep-seated intrusive rocks which cooled far below the surface occur as *batholiths*, bosses, *laccoliths* and *veins* (*see* ORE DEPOSITS), and include *granite*, *syenite*, *diorite*, *gabbro* and *peridotite*: related to the granites are *aplite*, *greisen*, *pegmatite* and *schorl*; to the syenites, borolanite, *monzonite*, *nephelite-syenite* and *ijolite*; to the diorites, *tonalite*; to the gabbros, *napoleonite*, *pyroxenite* and *theralite*, and to the peridotites, *picrite* and *serpentine*. The hypabyssal intrusive rocks occur as *sills*, *veins*, *necks*, etc., and are represented by *porphyry* and porphyrite, *diabase* and *lamprophyre*; to the porphyries belong *felsite* and *quartz porphyry*. The extrusive rocks are volcanic and found typically as lava flows; they include *obsidian*, *perlite*, *pitchstone* and *rhyolite*, *phonolite* and *trachyte*, *andesite*, *dacite* and *basalt* (with the related *spilite*, *tachylyte* and *variolite*), *nephelinite* and tephrite.

Intermediate between the sedimentary and igneous rocks comes the group of rocks known as pyroclastic or fragmental volcanic rocks. These include *agglomerate*, some types of *breccia* and *tuff* (*see* also VOLCANO). The agencies which affect igneous (among other) rocks and modify them are discussed under GEOCHEMISTRY, METAMORPHISM, METASOMATISM and VOLCANISM.

1. Composition of Igneous Rocks.—Though the number of recognized minerals approximates 1,500, comparatively few of these are important as rock formers, more especially if the subdivisions into which the common species are broken up are disregarded. The vast majority of the igneous rocks are built up of less than a dozen groups of minerals. These are: (1) quartz; (2) feldspars; (3) pyroxenes; (4) amphiboles; (5) micas; (6) olivines; (7) nephelite; (8) leucite; (9) iron ores; and (10) apatite. To this list, for sedimentary rocks, may be added chlorite, kaolin, montmorillonite, calcite, dolomite and a few other minerals. Metamorphic rocks are built up largely of the same minerals as igneous rocks but include special species which are foreign to the latter, partly on account of their composition and partly because they appear to require special physical conditions (stress) for their production. The mineralogical nature of a rock is primarily dependent on its chemical composition, but other factors are of first importance in determining the paragenesis of rock-forming minerals, principally the mode of origin of the rock or the physical conditions prevailing during its formation. Two rock masses may have very much the same bulk composition and yet differ fundamentally in their mineralogical assemblages. Thus, certain lamprophyres rich in biotite have much the same composition as certain leucite-basalts, a hornblendite may be similar in composition to a camptonite and so on. Igneous rocks of identical chemical composition but dissimilar mineralogical constitution are said to be heteromorphous. The governing factors are the physical conditions attending consolidation of the rock.

All crystalline rocks have consolidated from solution or from fusion. A granite arises by the consolidation of a liquid at high temperatures and great pressures; a metamorphic rock like mica schist, on the other hand, represents the recrystallization product of a clay rock under the influence of heat and stress. Throughout this conversion the rock has been essentially solid, recrystallization taking place in the presence of minor amounts of interstitial liquid. Other crystalline rocks, like rock salt, gypsum, anhydrite, etc., have been deposited from solution in water, mostly as a result of evaporation on exposure to the air. The majority of sedimentary rocks, however, consists of a mechanical aggregate of crystalline particles; such are sandstone, clay, etc. The structure of these sedimentary and all pyroclastic rocks is referred to as fragmental.

2. Magma.—All igneous rocks have solidified from a state of liquidity, the liquid that finally consolidates as rock being technically referred to as magma (Gr. *magma*, from *massein*, "to knead"). Rock magma is a complex silicate solution carrying gases; the most important part of the solution is water, which may constitute 5% to 6% of the mass. The greater part of the clouds given off by active volcanoes consists of steam, with which are associated minor amounts of other gases, the chief being carbon dioxide, carbon monoxide, hydrochloric acid, sulfur vapour, oxides of sulfur, hydrogen sulfide, hydrogen fluoride, ammonia, methane, chlorine, fluorine, hydrogen and nitrogen. When the magma consolidates the major part of these volatile constituents usually escapes. With very rapid cooling, however, the magma may solidify without crystallization as a volcanic glass, at the same time retaining much of its water. Analyses of pitchstone show not infrequently a content of 5% to 6% of water, and even higher values are recorded; on the other hand unaltered crystalline igneous rocks seldom show a water content greater than 2%. Here there is almost direct confirmation of the conclusion that the water content of the magma before crystallization is greater than the water content of the rock formed from it.

From what source is igneous magma derived? In the older conception of the earth a volcano was pictured as a safety valve for a molten interior, but a close study of igneous action, past and present, clearly negates any such interpretation. The active vents of Mauna Loa and Kilauea, Hawaii, though only about 20 mi. apart, have the summits of their lava columns at a difference of level of 10,000 ft. Yet liquid lava is erupted more frequently and in greater quantity from the higher column. Clearly these two outlets are not directly connected with a common liquid reservoir. Again, neighbouring vents, as those of the Lipari Islands north of Sicily, erupt widely different products, and each may maintain its independent behaviour regardless of what is happening to its neighbour. The conclusion is enforced that each distinct eruptive centre possesses its own reservoir, and the presence of a number of independent magma chambers underlying an eruptive region is indicated. At greater depth these are no doubt connected with some magmatic reservoir of much larger dimensions. In some such common source the close community of petrographic character revealed in the succession of liquids erupted or intruded throughout any given igneous cycle is to be traced.

II. METHODS OF INVESTIGATION

A. ANALYTICAL

1. Macroscopic Characters.—The macroscopic (Gr. *makros*, "large") characters of rocks, those visible in hand specimens without the aid of the microscope, are extremely varied and difficult to describe accurately and fully. The geologist in the field depends principally on them and on a few rough chemical and physical tests; and to the practical engineer, architect and quarrymaster they are all-important. Although frequently insufficient in themselves to determine the true nature of a rock, they usually serve for a preliminary classification and often give all the information really needed for a particular purpose. With a small bottle of acid to test for carbonate of lime, a knife to ascertain the hardness of rocks and minerals and a pocket lens to magnify their structure, the field geologist is rarely at a loss in deciding to what group a rock belongs. The fine-grained species may be indeterminable by these means, and the minute mineral components of all rocks can usually be ascertained only by microscopic examination; but it is easy to see that a sandstone or grit consists of more or less rounded, waterworn sand grains, and if it contains dull, weathered particles of feldspar, shining scales of mica or small crystals of calcite, these also rarely escape observation. Shales and clay rocks generally are soft, fine-grained, often laminated, and they not infrequently contain minute organisms of fragments of plants. Limestones are easily marked with a knife blade, effervesce readily with weak cold acid and often contain entire or broken shells or other fossils. The crystalline nature of a granite or basalt is obvious at a glance, and while the former contains white or pink feldspar, clear vitreous quartz and glancing flakes of mica the other will show yellow-green olivine, black augite and gray striated plagioclase.

2. Microscopic Characters.—When dealing with unfamiliar types or with rocks so fine-grained that their component minerals cannot be determined with the aid of a lens, the geologist is obliged to have recourse to more delicate and searching methods of inves-

tigation. With the aid of the blowpipe (to test the fusibility of detached crystals), the goniometer (to measure crystal angles), the magnet, the magnifying glass and the specific gravity balance the earlier investigators attained surprisingly accurate results. Examples of these may be found in the works of Leopold von Buch, G. P. Scrope, Charles Darwin and many others. About the end of the 18th century D. S. G. de Dolomieu examined crushed rock powders under the microscope and P. L. Cordier in 1815 crushed, levigated and investigated the finer groundmass of igneous rocks. His researches are models of scrupulous accuracy, and he was able to announce that these rocks consisted essentially of such minerals as feldspar, augite, iron ores and volcanic glass and did not differ in nature from the coarser grained rocks. W. Nicol, whose name is associated with the discovery of the Nicol prism, seems to have been the first to prepare thin slices of mineral substances, and his methods were applied by H. Witham (1831) to the study of plant petrifactions.

Petrography.—This method, subsequently of such far-reaching importance in petrology, was not immediately used for the systematic investigation of rocks, and it was not until 1858 that H. C. Sorby pointed out its value. The great work of this investigator was the production of very thin sections of rocks and their systematic examination under the high powers of the microscope. The densest, blackest rock can be made to yield a section of $\frac{1}{1,000}$ in. in thickness, so thin and transparent that fine print can be easily read through it and transmitting light so clearly that the most high-powered objectives of the microscope can be used to discern and study its minutest structures with the same facility that they can be employed upon sections of organic material prepared by the microtome. The introduction of this powerful weapon of research inaugurated a new era in petrology—that of petrography or the descriptive branch of petrology. The optical study of sections of crystals had been advanced by Sir David Brewster, Nicol and other physicists and mineralogists and it only remained to apply their methods to the minerals visible in rock sections. The pioneer workers who brought quantitative methods into the optical side of the problem were A. des Cloizeaux, K. H. F. Rosenbusch, F. Zirkel, M. Schuster, F. Fouqué and Auguste Michel Lévy.

By the second half of the 20th century optical methods for determining minerals with the petrographic microscope were highly developed.

Optical Constants.—Although rocks at mid-20th century were studied principally in microsections, the investigation of fine crushed rock powders, which was the first branch of microscopic petrology to receive attention, was still in use. A mineral whose optical properties are known can be accurately determined by immersing its powder in liquid media whose indices of refraction are known, and determining the optical constants. In the hands of a skilled petrographer the principal optical constants of a single grain of a mineral can be determined in half an hour. The chief fundamental constants measured are the principal indices of refraction, the crystallographic orientation of the directions of light vibration corresponding to those indices and the amount of absorption of light vibrating in these directions, all for one or more standard wave lengths of light. The double refraction, optical character, optical axial angle, dispersion of the optic axes and bisectrices and extinction angle are all fixed by the fundamental constants and can be estimated under the microscope.

The immersion media cover a range of optical refraction from that of water (1.333) to that of a selenium-arsenic selenide melt (3.17). The liquids are chiefly organic substances—acetone, alcohol, cinnamon oil and methylene iodide. Most minerals have refraction constants ranging in the interval 1.450–1.870, and their refractive indices may therefore be matched by a set of liquids whose refractions cover this range. The modern rotation apparatus whereby thin sections may be tilted from the horizontal so that the axis of the microscope passes through them at different angles has been of inestimable value in measuring accurately the optical constants of a single grain in a rock slice, and is widely used for the determination of feldspar and other mineral species of variable composition. A few measurements on a selected section of a mineral permit the determination of its exact chemical composition and the crystallographic orientation of the section itself. The technical methods employed for the determinations referred to above are largely founded on the use of polarized light.

3. Mechanical Separation of Constituents.—The separation of the constituents of a crushed powder in order to obtain pure samples suitable for analysis is also extensively practised. The two principal methods adopted involve either the electromagnet or heavy liquids.

By the use of an electromagnet the component minerals of a rock may be separated by varying the strength of the current. A weak magnetic field attracts magnetite, then hematite and ilmenite. Silicates containing iron will follow in definite order, augite, hornblende, tourmaline, olivine and biotite being successively attracted. The degree of attraction is not, however, proportional to the iron content. The colourless nonmagnetic minerals—quartz, feldspar, muscovite, nephelite, etc.—remain. In the modern laboratory, processes using automatic magnetic separators supplement or replace magnetic separation by hand. Electrostatic and dielectric methods of separation have also been brought into use in the isolation of mineral particles of rocks.

Separation by means of water is not much used in petrographic work. However, a preliminary "panning" as practised by miners is often useful as a means of concentrating rare minerals occurring in very small quantity in the rock before the application of the methods next to be described. Methods of separation of minerals by which they are sorted according to their specific gravities (sp.gr.) by means of heavy fluids have an extensive application. The fluids used are those which do not attack the majority of the rock-forming minerals.

Of the many liquids used, methylene iodide (sp.gr. 3.32) and bromoform (sp.gr. 2.86) are perhaps the most convenient. For more dense minerals, Clerici's solution—an aqueous solution of thallium formate—is best adopted. By concentration the specific gravity can be raised to 4.32 at 60° C. so that even the heavier rock minerals can be separated without difficulty. By dilution with water, or, in the case of methylene iodide, dilution with bromoform or benzol, successive crops of minerals may be separated in appropriate separating funnels. In this way a granite may be successively fractionated into its component minerals, biotite (sp.gr. 3.1), muscovite (2.85), quartz (2.65), oligoclase (2.64) and orthoclase (2.56). All these minerals float in methylene iodide; on dilution with benzol they are precipitated in the order given. Rocks like eclogite containing heavier minerals, such as ilmenite (sp.gr. 4.84), garnet (4.20) and diopside (3.29), may be similarly separated by means of a thallium formate-water solution. Mineral isolation using heavy liquids is commonly carried out with high-speed centrifuges, which greatly hasten settling, especially of the finest particles, and effect a more thorough separation of the minerals.

4. Microchemical Methods.—Chemical methods are frequently of great use. Weak hydrochloric acid will dissolve calcite from a crushed limestone, leaving dolomite and silicate minerals, and hydrofluoric acid may be used to extract the glassy base of volcanic and hypabyssal rocks from the pyroxenic minerals. Of much wider use, however, are microchemical methods for distinguishing minerals under the microscope. They are of special value in discriminating alkali minerals like nephelite, haüynite, noselite, analcite and sodalite in the groundmass of igneous rocks. The methods depend on selective attack by acids, the formation of distinctive precipitates and the staining of gelatinous residues. Quartz and feldspar in fine-grained rocks may be differentiated by etching with hydrofluoric acid; quartz remains clear while the surface of the feldspar grain becomes cloudy, being altered to aluminum fluosilicate, and may be stained by an aniline dye. This method is particularly useful in discriminating quartz and feldspar in fine-grained metamorphic rocks in which the feldspar is without crystal form, is untwinned and shows lack of cleavage.

5. X-ray Methods.—X-ray diffraction methods of identification have also come much into use; they may be applied to single crystals, isolated by the procedures already outlined, or to the finest aggregates, using then the technique of X-ray powder photography. (*See* MINERALOGY: *X-ray Diffraction;* X-RAYS.)

6. Chemical Analysis.—The ultimate chemical composition of a rock is of fundamental importance in determining its nature, and the chemical analysis of rocks is now widely carried out. In rock analysis of the better class as many as 25 constituents are determined and recorded. The most abundant or major constituents are stated as oxides, and any rock analysis of good quality records the content of at least nine or ten of these. They are silica, alumina, ferric and ferrous oxides, magnesia, lime, soda, potash and water. These nine oxides make up about 98% of the igneous rocks. Two other oxides are usually determined, TiO_2 and P_2O_5, as they are represented in the common minor constituents—ilmenite and apatite—titanium being also present in some pyroxenes, amphiboles and micas. Such a chemical analysis is usually sufficient to determine to which of the two great classes, igneous or sedimentary, a rock belongs and, if it is igneous, the position to be assigned to it in any of the conventional classifications. In the case of metamorphic rocks it often establishes whether the original mass was a sediment or of igneous origin.

7. Specific Gravity.—By the balance and the pycnometer the specific gravity of rocks is determined in the usual way. It is greatest in those rocks rich in iron, magnesia and the heavy metals, and least in rocks rich in alkalies, silica and water. Eclogites (sp.gr. 3.5) are among the heaviest of the silicate igneous rocks, while the vitreous lavas of high silicity like obsidian (sp.gr. 2.35) are among the lightest.

B. Rock Synthesis

The methods of investigation described above may be grouped together as analytical, in contradistinction to the synthetic investigation of rocks, which proceeds by experimental work to reproduce different rock types and thus to elucidate their origin and explain their structures.

1. Pioneer Investigations.—Though the experiments of H. B. de Saussure (1740–99) on the fusion of granites and porphyries may be said to mark the earliest beginnings of experimental petrology, the era of rock synthesis should be dated from the time of the researches of Sir James Hall (1761–1832) on the fusion of dolerites found in the neighbourhood of Edinburgh. This investigator showed convincingly that crystalline diabase (British dolerite or whinstone) could be fused and consolidated, according to the rate of cooling, either as black glass resembling natural pitchstone or as crystalline aggregates of minerals much like the diabase from which they came. Hall's most famous experiments, however, were conducted with limestones. Powdered chalk, by being heated in gastight gun barrels, was converted into a crystalline mass of calcite, thus supporting the contention of James Hutton that heat and pressure had consolidated limestones and converted them into marbles. A lapse of almost 90 years had occurred before the experiments of Hall were substantiated, when in 1878 the French petrologists F. Fouqué and Auguste Michel Lévy began their extensive researches on the synthesis of minerals and rocks by pyrogenetic methods. They succeeded in producing, by the use of a gas furnace and a nitrogen thermometer, such rocks as porphyry, basalt and diabase, at the same time obtaining the characteristic textures—porphyritic, ophitic, etc.—by modifying the conditions under which the melts were cooled. With the more siliceous or acid rocks their experiments were much less successful. They advanced for the first time in a convincing manner the explanation that for the crystallization of these rocks the gases, never absent in natural rock magmas, were indispensable mineralizing agents (mineralizers).

Later, it became known that the formation of many minerals is facilitated, or can only be accomplished, in the presence of volatile constituents such as water, borates, chlorides, fluorides, etc. Not only do these assist in promoting the fluidity of the liquid and facilitate crystallization, but they form essential constituents of some of the important minerals occurring in acid igneous rocks (micas, tourmaline, topaz, etc.).

Among the pioneers in synthetic petrology may also be mentioned H. E. Sainte-Clair Deville, H. de Sénarmont, P. Berthier, L. Bourgeois, P. G. Hautefeuille, K. Chrustschoff, C. Doelter, J. Morosewicz and J. H. L. Vogt. To Vogt is owed the first comprehensive essay toward bringing the crystallization of igneous rock magmas definitely under the known laws of solution. Beginning a study of a large series of silicate slags, more or less comparable in composition with igneous rocks, he brought together a large body of information throwing light on the order of crystallization, the composition of the eutectics and the lowering of freezing points of the minerals in slag mixtures, these results being directly applied to the elucidation of the crystallization processes in natural magmas.

2. Geophysical Laboratory.—Up to this period the synthetic work, involving as it did the measurement of the melting point of minerals and the succession of crystallization in more or less complex mixtures, though very suggestive, lacked the strictly quantitative element. Experiments were carried out on materials always containing impurities or foreign substances, and the methods adopted for the determination of fixed thermal points such as melting points, inversion points or heat changes were of doubtful precision. In 1904, with the establishment of the Geophysical laboratory at Washington, D.C., synthetic or physicochemical petrology entered upon a new quantitative era. The work of this laboratory was undertaken in order to enter upon a quantitative study of rock formation which should include those minerals and rocks which are geologically important and those which are economically useful, and those formed directly from the magma and those formed by subsequent alteration. The individual problems are in reality problems for physics and physical chemistry; but the delay in attacking them resulted from the fact that the measured relations established by the exact sciences were scarcely of adequate scope to meet the needs of large petrological questions. The great body of physical and physicochemical measurements was confined to a temperature region below 100° C. while processes operating in rocks may have occurred at temperatures up to 1,400° C., an enormous range over which to stretch the application of ordinary methods and one in which the common forms of apparatus not only fail but are themselves threatened with destruction.

The initial work of the Geophysical laboratory was primarily to extend the methods of accurate temperature measurement to include the entire field of rock formation from 0° to 1,600° C. The electric pyrometer reached such precision that an error of one or two degrees is all that need be expected in measuring temperatures up to 1,600° C.; moreover, these temperatures can be maintained quite steady for days or weeks at a time. Calorimetric measurements were improved; specific heats can be determined with great accuracy even at the highest temperatures. At the same time petrographic methods were advanced so that the crystallographic and optical constants of the very minute crystals obtained in silicate melts could be accurately measured. The investigation of mineral substances under high pressures and high temperatures combined, and in the presence of volatile constituents, also became a subject of study.

With these methods of precision available for the study of rock materials, examination of simple mineralogical systems was prosecuted. An understanding of the chemistry of the common oxides of rocks and of their combinations is essential to the progress of petrology. Experimental work was conducted on the combinations of the oxides lime, magnesia, alumina, silica; the six possible binary systems were fully worked out and the four possible ternary systems thoroughly studied, while portions of the quaternary system were successfully explored. These equilibrium studies were further extended by investigations on silicate systems containing ferric and ferrous oxide, soda and potash and by exploration of some important systems containing water. Much light was thereby thrown on the processes taking place during the consolidation of igneous magmas which, though much more complex in their constitution, yet clearly show by petrographic examination closely similar phenomena, such as are revealed in the crystallization behaviour of these simpler systems. The application of these laboratory investigations to the elucidation of the origin and evolution of igneous rock types will be considered hereafter (see *Plutonic Complexes*, below). *See* also Mineralogy: *Experimental Mineralogy.*

III. CLASSIFICATION OF IGNEOUS ROCKS

Igneous rocks are subdivided into many groups according to their composition, chemical and mineralogical, their structures and textures and their mode of occurrence. Between allied rocks there are, however, no hard and fast boundaries, for by increase or decrease in the proportions of their constituent minerals, they pass by every gradation one into the other. Similarly the distinctive textures of one kind of rock may often be traced gradually merging into those of another. Hence the definitions adopted in establishing rock nomenclature merely correspond to more or less arbitrarily selected points in a continuously graduated series. This is frequently urged as a reason for reducing rock classification to its simplest possible terms and using only a few generalized rock designations.

The earliest attempts at the classification of rocks on modern lines are to be found in the works of K. C. von Leonhard (1823) and Alexandre Brongniart (1827). These and other efforts, principally by K. F. Naumann (1850), Bernhard von Cotta (1855) and Justus Roth (1861), while being built on the criteria of composition and structure of rocks, were largely developed from purely macroscopic investigation or ultimate chemical analysis. The pioneer work of H. C. Sorby (1858) in preparing transparent microsections of rocks opened the way for the discovery of the mineral constituents and textures of the finer grained igneous rocks, and rapid advances in the knowledge of the constitution of igneous rocks followed. The classifications of F. Zirkel (1873) and K. H. F. Rosenbusch (1877) were the first products of the application of the new method of petrographic research, and in these mineral constitution was accorded first place as a basis of subdivision. The effect of microscopic study was to stress the importance of mineralogical and textural characters of rocks to the neglect of other characteristics. Rosenbusch in particular, influenced by the contention principally of K. A. Lossen (who urged the significance of the geological relations of igneous rocks, their occurrence and manner of formation), further developed his classification to express the relationship of geological occurrence and texture, and introduced in the second edition of his *Mikroskopische Physiographie* a fundamental change.

This classification is based first on geological position, then on texture and finally on mineral and chemical composition. Igneous rocks are divided thus into three great groups: (1) deep-seated rocks; (2) dike rocks; and (3) effusive rocks. Like others before it, this classification is still essentially qualitative, and at mid-20th century was the one most commonly adopted by petrographers. An exposition of Rosenbusch's classification is set forth in his *Elemente der Gesteinslehre*, revised by A. Osann (1923).

IV. HABIT OF IGNEOUS ROCKS

Igneous rocks occur essentially in two different ways; *i.e.*, either as lavas or as intrusions.

1. Lavas or Effusive Types.—The lavas have been poured out at the surface and have consolidated after ejection, under conditions which are fairly well understood, seeing that they may be examined at active volcanoes in many parts of the world; the intrusive rocks, on the other hand, have been injected from below into cracks and fissures in the strata and have cooled there beneath masses which conceal them from view until exposed by denudation at a subsequent period. The members of these two groups differ from one another in many respects, so that it is often possible to assign a rock to the one group or to the other on mere superficial inspection. The lavas (or effusive rocks), having cooled rapidly in contact with the air, are as a rule finely crystalline or have at least a fine-grained groundmass representing that part of the viscous semicrystalline lava flow which was still liquid at the moment of eruption. At this time they were exposed only to atmospheric pressure, and the steam and other gases, which they contained in great quantity, were free to escape. Many important modifications arise from this, the most striking being the frequent presence of numerous steam cavities (vesicular structure) often drawn out to elongated shapes subsequently filled up with minerals by infiltration (amygdaloidal structure). As crystallization was going on while the mass was still creeping forward over the surface of the earth, the latest formed minerals (in the groundmass) are commonly arranged in subparallel winding lines following the direction of movement, and the larger early minerals which had previously crystallized may show the same arrangement. The first generation of crystals generally forms before the lava has emerged to the surface, that is to say, during the ascent from the subterranean depths to the crater of the volcano. It has frequently been verified by observation that freshly emitted lavas contain large crystals borne along in a molten, liquid mass. The large, well-formed, early crystals are generally admitted to be porphyritic; the smaller crystals of the surrounding matrix or groundmass belong to the posteffusion stage. More rarely lavas are completely fused at the moment of ejection; they may then cool to form a nonporphyritic, finely crystalline rock, or if more rapidly chilled may in large part be noncrystalline rock, or glassy (vitreous rocks such as obsidian, tachylyte, pitchstone). A common and easily recognized feature of glassy rocks is the presence of rounded bodies (spherulites: Gr. *sphaira*, "ball") consisting of fine divergent fibres radiating from a centre; these divergent fibres consist of imperfect crystals of feldspar, mixed with quartz or tridymite; similar bodies are often produced artificially in glasses which are allowed to cool slowly. Rarely these spherulites are hollow or consist of concentric shells with spaces between (lithophysae: Gr. *lithos*, "stone"; *physa*, "bellows"). Perlitic structure, which is also found to be common in glasses, consists in the presence of concentric rounded cracks as a result of contraction on cooling (*see* PERLITE; SPHERULITE).

The phenocrysts (Gr. *phainein*, "to show"; *krystallon*, "a crystal") or porphyritic minerals are not only larger than those of the groundmass; as the matrix was still liquid when they formed they were free to take perfect crystalline shapes, not being interfered with by the pressure of adjacent crystals. They seem to have grown rapidly, as they are often filled with inclusions of glassy or finely crystalline material like the material of the groundmass. Microscopic examination of the phenocrysts often reveals that they have had a complex history. Very frequently they show successive layers of different composition, indicated by variations in colour or other optical properties; thus augite may be green at the centre and various shades of brown outside this; or it may be pale green centrally and darker green with strong pleochroism (aegirite) at the periphery. In the feldspars the centre is usually more basic and richer in lime than the surrounding faces, and successive zones may often be noted, each less basic than those which lie within it. Phenocrysts of quartz (and of other minerals), instead of sharp, perfect crystalline faces, may show rounded corroded surfaces, with the points of the crystals blunted, and irregular tonguelike projections of the matrix into the substance of the crystal; it is clear that after the mineral had crystallized it was partly again dissolved or corroded at some period before the matrix solidified. Corroded phenocrysts of biotite and hornblende are very common in some lavas; they are surrounded by black rims of magnetite mixed with pale green augite. The hornblende or biotite substance has proved unstable at a certain stage of consolidation and has been replaced by a pseudomorph of augite and magnetite which may be partially or completely substituted for the original crystal but still retains its characteristic outlines.

2. Plutonic or Abyssal Types.—The characteristics of a typical deep-seated rock similar to granite or diorite will now be considered. That these are clearly igneous is proved by the manner in which they have burst through the superincumbent strata, filling the cracks with ramifying veins; that they were at a very high temperature is equally clear from the changes which they have induced in the rocks in contact with them. But as their heat could dissipate only very slowly, because of the masses which covered them, complete crystallization has taken place and no vitreous, rapidly chilled matter is present. As they have had time to come to rest before crystallizing they are not fluidal. Their contained gases have not been able to escape through the thick layer of strata beneath which they were injected, and may often be observed occupying cavities in the minerals; they have also occa-

sioned many important modifications in the crystallization of the rocks. Because their crystals are of approximately equal size, these rocks are said to be granular; there is typically no distinction between a first generation of large well-shaped crystals and a fine-grained groundmass. Their minerals have formed, however, in a definite order, and each has had a period of crystallization which may be very distinct or may have coincided with or overlapped the period of formation of some of the other ingredients. The earlier have originated at a time when most of the rock was still liquid and are more or less perfect; the later are less regular in shape because they were compelled to occupy the interspaces left between the already formed crystals which pressed on them. The former are said to be idiomorphic (*i.e.*, having their own characteristic form, Gr. *idios*, "one's own"), the latter are allotriomorphic (Gr. *hallotrios*, "belonging to another"). There are also many other characteristics which serve to distinguish the members of these two groups. Orthoclase, or microcline, for example, is the typical feldspar of granite, while its modification, sanidine, occurs in lavas of similar composition; leucite is common in lavas, very rare in plutonic rocks; muscovite is confined to the intrusives. These differences show the influence of the physical conditions under which consolidation takes place. Fundamental studies on the thermal behaviour and polymorphism of the group of minerals and on the variable inversion temperature of rock-forming quartz shed new light on the long-known mineralogical differences between feldspars and quartz found in acid volcanic rocks and the same minerals found in plutonic rocks. The differences were interpreted as due to changes brought about in these constituents of the plutonic rocks during cooling by processes of inversion, unmixing and recrystallization from an initial character similar to that of the feldspars and quartz of the corresponding volcanic rocks. These conclusions necessitate some revision of ideas of "order of crystallization" and of the origin of mineral textures in deep-seated igneous rocks of this mineralogical character (*J. Geol.*, vol. 58, pp. 489–511 [1950]; vol. 60, pp. 107–124 [1952]). (*See* FELDSPAR.)

3. Intrusive or Hypabyssal Types.—There is a certain class of intrusive rocks which have risen upward toward the surface but have failed to reach it, and have solidified in fissures as dikes and intrusive sills at no great depth. To this type the name hypabyssal is often given in distinction from the plutonic (or abyssal) which formed at greater depths. As might be expected, the hypabyssals show structures intermediate between those of the effusive and the plutonic rocks. They are very commonly porphyritic, not rarely vitreous and sometimes even vesicular. In fact many of them are indistinguishable petrologically from lavas of similar composition. The attempt to form a special group of hypabyssal (intrusive and dike) rocks has met with much criticism and opposition. Such a group certainly cannot rank as equally important and equally well characterized with the plutonic and the effusive. But there are many kinds of rock which are not found to occur normally in any other manner. As examples the lamprophyres, the aplites and the porphyries might be cited. These never occur as lava flows or as great plutonic bosses; if magmas of the same composition as these rocks occur in either of these ways they consolidate with different assemblages of minerals or different structures.

In subdividing the plutonic, the hypabyssal and the effusive rocks, the principle is followed of grouping those together which resemble one another in mineral constitution and in chemical composition. In a broad sense these two properties are interdependent.

V. CHEMICAL CHARACTERS

1. Rock Elements.—Twelve elements (oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium, titanium, phosphorus, hydrogen and manganese) constitute about 99.6% of the earth's crust. Of these oxygen is the most abundant and constitutes 46.59% of the igneous rocks of the crust, the elements given above being placed in their order of abundance. These petrogenic or rock elements occur typically as oxides, simple silicates, aluminates, fluorides, chlorides and sulfides. In rock analyses they are stated as oxides. From a computation based on 5,159 analyses, H. S. Washington and F. W. Clarke arrived at the following as the average percentage composition of all igneous rocks: silica, 59.14; alumina, 15.34; ferric oxide, 3.08; ferrous oxide, 3.80; magnesia, 3.49; lime, 5.08; soda, 3.84; potash, 3.13; water, 1.15; titanic oxide, 1.05; phosphorus pentoxide, 0.3; manganous oxide, 0.12; inclusive 0.3. (*See* GEOCHEMISTRY: *Chemistry of the Earth: Abundance and Origin of Elements.*)

2. Range of Composition.—The known igneous rocks show a wide but limited range of composition. As the most abundant and essential rock minerals are either silica or silicates, silica shows the highest maximum and the widest range of these oxides. In some magmatic ores its content falls to zero but it rises to 78% in some acid granites; alumina varies normally between 10% and 20%, and some corundum-bearing rocks contain much more, being probably not of pure magmatic origin; iron oxides have a general range from 15% to less than 1% and magnesia from 25% to less than 1%. In some olivine rocks (dunite) it reaches a value of 48%. Lime is highest in some pyroxenites and anorthosites (20%–22%), but its general range is from 15% to zero. Soda reaches a maximum of 18%–20% in almost pure nephelite rocks (urtite) but has a general range from 15% to nearly zero. Potash usually varies from 10% to zero. Water in fresh crystalline igneous rocks seldom reaches more than 2%, but pitchstones may contain up to 10%.

3. Common Minerals and Associations.—The commonest minerals of igneous rocks are the feldspars, pyroxenes and amphiboles, quartz and the micas. From a statistical examination of 700 igneous rocks an average composition has been calculated as follows: feldspars 59.5%, pyroxenes and amphiboles 16.8%, quartz 12.0%, micas 3.8%, other minerals 7.9% (apatite 0.6%, titanium minerals 1.5%). This is clearly only an approximation. Rock minerals have been classified empirically into two groups, according as they are capable or incapable of existing in the presence of free silica; *i.e.*, into saturated and unsaturated minerals. The former group includes such minerals as the feldspars, pyroxenes, amphiboles and micas; and the latter olivine, nephelite, leucite and other feldspathoid minerals.

Certain minerals are as a matter of common observation not found together in igneous rocks. Olivine (except fayalite) and quartz do not occur in association, but are represented by rhombic pyroxene. The associations nephelite and quartz, leucite and quartz, pyroxenes or amphiboles and muscovite are almost unknown among magmatic crystallizations; on the other hand, certain mineral associations or parageneses occur frequently; thus aegirite (acmite) and arfvedsonite, nephelite and noselite, common hornblende and titanite are well known as faithful companions in igneous rocks. Again some minerals are restricted to particular magmas; melanite, melilite and certain rare zirconium-titanium minerals are almost entirely confined to the alkali igneous rocks. By inspection of a rock analysis it is frequently possible to state approximately what minerals the rock will contain, but there are numerous exceptions to any rule which can be laid down. The minerals which crystallize from an igneous magma may depend largely on the physical conditions under which the liquid consolidates; accordingly, rocks of almost identical chemical composition but with widely different mineralogical constitution are found. Such rocks, as already noted, are referred to as heteromorphous. Some familiar examples of assemblages of this character are mica syenite and leucite basalt, minette and leucite basalt, hornblendite and websterite.

Certain minerals are practically confined to deep-seated rocks, *e.g.*, microcline, muscovite, diallage and almandine garnet; on the other hand, leucite is very rare in plutonic rocks, as is also anorthoclase and the variety of potash feldspar known as sanidine. Some of these peculiarities are readily explicable, as they depend on the pressure, temperature or concentration of volatile constituents in the crystallizing magma. Others still represent a problem for solution. The subject will be referred to again in a later part of this article.

4. Acid, Basic and Alkali Rocks.—In the classification generally adopted by petrographers, the silica content of the magma

TABLE I.—*Alkali Rocks Containing Nephelite and Leucite*

Commonest minerals	Alkali feldspar Nephelite or leucite Augite Hornblende Biotite	Plagioclase (lime soda) Nephelite or leucite Augite Hornblende (olivine)	Nephelite or leucite Augite Hornblende (olivine)
Plutonic . . .	Nepbelite-syenite Leucite syenite	Essexite Theralite	Ijolite Urtite Missourite
Hypabyssal . .	Nephelite-syenite —porphyry Tinguaite	Essexite and Theralite } Diabase	Nepbelite dolerite
Volcanic . . .	Phonolite Leucitophyre	Tephrite Basanite	Nephelite basalt Nephelinite Leucite basalt

forms a basis of further subdivision of igneous rocks. The division of volcanic rocks into acid, intermediate and basic was devised in the first place by W. H. Abich (1841). When this division is applied to igneous rocks in general, those which contain most silica and which if crystallized yield free silica as quartz are erected into a group designated the acid rocks in allusion to the assumed role of silica in the mineral kingdom. Those which have low silica percentages and are rich in magnesia, lime and iron—so that quartz is absent while olivine, pyroxene or calcic feldspar are usually abundant—form the basic group. The intermediate rocks include those characterized by the general absence of both quartz and olivine.

An important subdivision of the intermediate as well as the basic group contains a very high percentage of alkalies (soda or potash or both), and consequently has minerals such as nephelite, noselite, analcite or leucite, minerals not common in other rocks. This group is often referred to as the alkali rocks. Lastly, members of a small subgroup rich in olivine (peridotite, dunite), pyroxene (pyroxenite) or calcic feldspar (anorthosite) have been called the ultrabasic rocks. They have low percentages of silica but much iron, magnesia or lime. With the exception of the last group, including also such ultrabasic lavas as augitite and limburgite and a few related rocks such as monchiquite, melilite basalt and alnöite, practically all igneous rocks contain feldspar or feldspathoid minerals. In the acid rocks the common feldspars are orthoclase, with perthite, microcline and oligoclase, all having much silica and alkalies. In the basic rocks labradorite, bytownite and anorthite prevail, being rich in lime and poor in silica, potash and soda. Augite and olivine are the common ferromagnesian minerals of the basic rocks, but hornblende and biotite are on the whole more frequent in the acid rocks.

5. Mineralogical Constitution.—The classification in Tables I and II is based essentially on the mineralogical constitution of the three great groups of igneous rocks. The alkali rocks containing nephelite and leucite are treated separately, for, though they show transitions into the corresponding intermediate and basic rocks (syenites, diorites, gabbros, etc.), they contain many minerals which are unknown in other rocks. In a purely formal classification such as is outlined here they are more conveniently considered as a distinct series. Their genetic relations among themselves and with the other rock types are considered later.

The lamprophyres form a peculiar group of hypabyssal rocks not included in the tables. They usually occur as dikes in association with granites, syenites, diorites and gabbros, and are basic differentiates of these parent rocks. Thus the minettes, vogesites and kersantites (*see* LAMPROPHYRE) occur in association with granitic or quartz diorite masses, while camptonites, monchiquites and alnöites may be found commonly as satellites of alkali plutonic masses like nephelite-syenite or essexite.

The classificatory scheme here adopted is admittedly artificial, for it subdivides rocks without particular reference to their genetic relationships. Even regarded as a classification for a utilitarian end it has many imperfections; the subdivisions are of unequal value and transitional types are not included. The latter, however, can be accommodated by further subdivision. Many of them have received special names. The quartz syenites may be interposed between granite and syenite, the tonalites between granite and diorite and so on.

The question may be asked: When is a rock entitled to be recognized as belonging to a distinct species or variety and deserving a name for itself? It must, first of all, be proved to occur in considerable quantity at some locality or, better still, at a series of localities, or to have been produced from different magmas at more than one period of the earth's history. In other words, it must not be a mere anomaly. Moreover, it should have a distinctive mineral constitution, differing from that of other rocks, or something individual in the characters of its minerals or of its structures. It is often surprising how peculiar types of rock, believed at first to be unique, turn up with identical features in widely scattered regions; alnöite, for example, occurs in Norway, Scotland, Quebec, British Columbia, New York and Brazil, tinguaite in Scotland, Norway, Brazil, Montana, Portugal, etc. This indicates that underlying all the variations in mineralogical, structural and chemical properties there are definite relationships which tend to repeat themselves, producing the same types whenever the same conditions are present.

6. Quantitative Classifications.—Various attempts have been made to introduce a quantitative element into igneous rock classification. These have followed either chemical or mineralogical lines. The principal of these is the quantitative chemical classification introduced by a group of U.S. petrographers. The chemical composition of an igneous rock is here regarded as its fundamental characteristic and a series of subdivisions is erected on this basis. Other criteria are relegated to the background. The completed rock analysis is first interpreted in terms of an ideal set of minerals which constitutes the norm, but which in reality seldom corresponds to the actual composition (mode). The rocks are then divided into groups strictly according to the relative proportions of these ideal minerals to one another. The details of the classification need not be described here as they are fully set forth in W. Cross, J. P. Iddings, *et al., Quantitative Classification of Igneous Rocks* (1903).

A quantitative element is introduced in other systems by subdividing rocks into groups by arbitrary lines based on mineral percentages: a complicated system framed on these lines was devised by A. Johannsen (*J. Geol.*, 1917, 1919). In another the prime divisions are erected on so-called "principle of silica-saturation" (S. J. Shand, *Eruptive Rocks* [1947]), while a third combines some of the features of both the quantitative chemical classification and the Johannsen system with the larger groups of the Rosenbusch system (P. Niggli, *Schweiz. Min. Petrogr. Mitt.* [1931]). In all, the effect of the introduction of the quantitative element has been to increase the artificiality of the system and by this means to obscure the genetic relations existing between rock types. For this reason these systems are unlikely to supplant

TABLE II.—*Acid and Basic Rocks*

	Acid	Intermediate		Basic	Ultrabasic
Commonest minerals	Quartz Orthoclase (and oligoclase) Mica Hornblende Augite	Little or no quartz		No quartz	Augite Hornblende Olivine (basic plagioclase)
		Orthoclase Hornblende Augite Biotite	Plagioclase Hornblende Augite Biotite	Plagioclase Augite Hypersthene Olivine	
Plutonic	Granite	Syenite	Diorite	Gabbro Norite	Peridotite Pyroxenite Hornblendite (anorthosite)
Hypabyssal	Quartz porphyry	Orthoclase Porphyry Orthophyre	Porphyrite	Diabase	Picrite
Volcanic	Rhyolite Obsidian	Trachyte	Andesite Dacite	Basalt Tachylyte	Limburgite Augitite

the qualitative classification in general use. It is indeed largely to the influence of "quantitative classifications" that the bewildering and unnecessary multiplicity of igneous rock names must be ascribed.

VI. PETROGRAPHICAL PROVINCES

As long ago as 1872 H. Vogelsang had noted that the igneous rocks of certain districts possessed textural or mineral characters in common, serving to distinguish them from the rocks of other districts. The researches of J. W. Judd (1886) and J. P. Iddings (1892) further substantiated this observation and showed that this community of petrographic character applied to the igneous rocks erupted or intruded during a particular period of igneous activity within the region. To such regions Judd gave the name petrographical provinces and Iddings employed the term consanguinity to express the genetic relationship implied in these resemblances among associated rocks. Excellent examples of such petrographical provinces or comagmatic regions, as they were termed by H. S. Washington, are the Oslo region of southern Norway, characterized by Permian alkali intrusions and extrusions; the Roman region, characterized by rocks rich in potash; the alkali province of central Montana; and the Tertiary calc-alkali province of Hungary. On a larger scale the volcanoes which girdle the Pacific (Andes, Cordillera, Japan, Philippines, etc.) and those which occur on the volcanic islands of the Atlantic illustrate the same phenomena. The consanguinity in the igneous series of a petrographical province implies that the whole assemblage is derived from some common deep-seated magma, during a period which, while necessarily prolonged, was not of vast duration in a geological sense. The assemblages of a province may and often do show a wide diversity of rock type embracing intrusions and extrusions.

Prolonged eruptions have in a few cases resulted in provinces of a somewhat monotonous character as a result of the predominance of one kind of rock. Thus the lavas of the Hawaiian Islands are mostly basaltic, as are those of Oregon, Washington and the Deccan, India, all of which form geological masses of enormous magnitude. In the Oslo district, on the other hand, the assemblages comprise (among the intrusive rocks) a wide range of type—hornblendite, essexite, larvikite, lardalite, nordmarkite, soda and potash granites.

A. Differentiation

The process by which a magma is split into a variety of partial products is known as differentiation. Its importance from the standpoint of theoretical petrology is very great; it is, in point of fact, the fundamental problem of petrogenesis. The differentiation may appear as a variation either in a single rock body or in an associated series of separate intrusions or extrusions. In the first case a single intrusion shows variation in different parts of its mass, the extreme varieties being usually connected by gradual transition. The contrasted parts are frequently arranged symmetrically with reference to the borders of the mass, forming concentric zones in bosses or laccoliths suggestive of a differentiation *in situ* connected with the cooling of the mass. Excellent examples of variation of this kind are provided by the laccolithic intrusions of the Highwood mountains of Montana. The best-known of these—the Shonkin Sag laccolith—has a chilled edge phase, a leucite basalt porphyry (or mafic phonolite) representing a quenched sample of the intruded magma, followed inward by a thick zone of shonkinite which forms an envelope to a central horizontal layer of alkali syenite.

Variation in an associated series is exemplified by the succession of lavas emitted from a volcanic focus. These may differ considerably from one another. Thus in the Berkeley hills near San Francisco, Calif., the volcanic succession is a repeated series of andesites, basalts and rhyolites. In other cases the lavas emitted are much more varied and, while no significant relations in the succession can be discerned, it is to be remembered that a significant order may be obscured by the overlapping of the flows from nearby volcanoes. In the simpler cases the order of eruption is one of increasing divergence from an initial type.

B. Plutonic Complexes

A series of plutonic rocks intimately associated and localized at a centre constitutes a plutonic complex. Such complexes often contain a great diversity of petrographical types ranging from peridotite and gabbro through diorite to acid granite. The succession of these intrusions follows an order of decreasing basicity, the later and more acid rocks usually occupying the greater part of the complex, the earlier and more basic being subordinate in amount and restricted to the borders of the mass. Excellent examples of such plutonic complexes are provided by the early Devonian instrusions of newer granites of the Scottish Highlands (*e.g.*, Garabal hill, Loch Lomond). What are the operative factors which led to differentiation?

1. Unmixing.—The possible processes leading to heterogeneity in a magma may be considered under (1) those occurring in the liquid prior to crystallization (liquid $\leftrightarrows$ liquid equilibrium); and (2) those incident on crystallization (crystal $\rightleftarrows$ liquid equilibrium). In the first group comes the process known as liquation or unmixing. Many liquids, homogeneous at high temperatures, separate with falling temperature into two or more nonconsolute fractions, and the hypothesis that igneous magmas form such immiscible fractions has been favoured by some petrologists, notably Rosenbusch, H. Bäckström and R. A. Daly. From his own studies Vogt concluded that the rock-forming silicates are freely miscible. The only known case among magmas for which immiscibility can be claimed is that of sulfide-containing silicate melts. Such a magma unmixes at a temperature above the region of crystallization of the usual sulfides, and liquid sulfides, especially those of iron, are separated as liquid drops. These, because of their greater density, sink to the floor of the magma, collecting as a distinct sulfide layer or, in some cases, the liquid layer may be injected into the surrounding rocks. These sulfide aggregates form important ore deposits (*q.v.*). It is among lavas which as a group show the various stages of quenching of liquid magmas that the evidence for immiscibility might be expected; the absence of lavas containing glassy globules of composition distinct from that of the main mass of lava goes far to show that immiscibility is not an operating factor in petrogenesis.

Experimental evidence of immiscibility in silicate liquids was indeed obtained, but the composition range of liquids which show it is unlike that exemplified by rock magmas. This limited miscibility is found in mixtures of silica with any of the oxides (lime, magnesia, ferrous oxide, alumina), but in a region of very high silica content. The minimum temperature for the existence of two liquids is in each case only a little below the melting point of silica, or in the vicinity of 1,700° C. The oxides (soda, potash, alumina) show no such immiscible region in their silica mixtures, and moreover it requires only a small proportion of any of these miscible oxides to render miscible with silica the oxides which are themselves immiscible with silica. No natural magmas are known which approximate in composition to the region of immiscibility in these melts. It is true that natural magmas contain, in addition, water, but accumulating experimental studies in hydrothermal systems had up to the 1960s given no reason to believe that fields of immiscibility extend into the composition region of natural magmatic systems.

2. Fractional Crystallization.—The second group of processes referred to above involves a crystal $\rightleftarrows$ liquid equilibrium and comprises crystallization and its converse, the assimilation of crystalline material. Knowledge of the crystallization of silicate magmas is derived from long-sustained observations of igneous rocks themselves and was greatly augmented by high-temperature experimental research on silicate melts. The great body of evidence thus accruing leads to the belief that fractional crystallization is to be recognized as a fundamental process in igneous rock differentiation—the derivation of igneous rocks of diverse but related character. Either the localization of crystallization or the localized aggregation of crystals is sufficient to produce heterogeneity in a rock magma. The first phenomenon, the localization of crystallization, was at one time thought competent to explain those cases of differentiation *in situ* exemplified by the basic marginal phases of intrusive masses. Examination of igneous rocks

early showed that minerals crystallize in a more or less definite order. In general, olivine, hypersthene and other minerals prominent in ultrabasic rocks are among the earliest minerals to separate; then follow augite, calcic plagioclase, hornblende, biotite, potash feldspar and quartz, plagioclase continuing to separate and becoming at the same time more sodic. This is the so-called normal order of crystallization, the validity of which, despite exceptions, has long been recognized. When the rule is expressed in this way the more basic minerals precede the less basic: in a somewhat modified form it was early known as Rosenbusch's law of decreasing basicity. Accordingly, it was supposed that at a cooling boundary there is a precipitation of minerals of early crystallization (basic minerals), the continued growth of many crystals being maintained by diffusion. The completion of this process results in a crystalline mass with a border phase enriched in the minerals of early crystallization.

The rate of diffusion in silicate melts has been the subject of laboratory study and the results obtained show that the possible effects are incompetent to account for the formation of border phases about large intrusions. The marginal phase indeed appears to represent rather a chilled phase having a composition close to that of the original magma, the more acid phase which it enclosed representing a differentiate formed by much slower cooling of the remainder of the magma. The relative movement of crystals with respect to the liquid from which they separated may be of two kinds: (1) movement under the influence of gravity—sinking or floating of crystals; and (2) movement by straining off or squeezing out of residual liquid by earth movement. Both of these processes can be invoked to explain the more important case of differentiation exemplified by an associated series of intrusions or extrusions. In a crystallizing magma (provided viscosity does not inhibit the free movement of crystalline material) as the first formed crystals are denser than the molten material in which they form, they should sink under the influence of gravity in the liquid. The lower regions of the rock mass into which the crystals sink become enriched, the upper regions impoverished, in the constituents of which they are formed. The sinking of crystals in silicate melts has been both experimentally verified in the laboratory and observed in nature. Darwin (1844) suggested that this process was a potent factor in producing diverse rock types. If the evidence of consolidated rock masses themselves be taken, intrusions are found in which such gravitational segregation is indubitably exemplified. Thus the concentration of early formed olivine crystals near the base of sheet- or sill-like intrusions has been observed in the case of the quartz-dolerite sill of the Palisades (Hudson river) and of the picrite-crinanite sill of the Shiant Isles (western Scotland). The Permian picrite-teschenite sills of central Scotland, while exhibiting similar phenomena of settling of olivine in place, provide, in the main, evidence of injection of crystal-charged magma of picrite following closely upon intrusion of a more liquid teschenite which now margins the sills. The role of fractional crystallization in the production of a series of related rock types within a great magma chamber is spectacularly illustrated in some of the largest intrusive complexes laid bare by erosion. These complexes occur at widely scattered localities in the world in the form of sheets of basic igneous rock of great thickness, showing a layered (banded) structure with systematic types of variation within them. Such are the intrusions of the Bushveld, Transvaal; Duluth, Minn.; Sierra Leone, west Africa; Stillwater, Mont.; and Skaergaard, east Greenland—stratiform structures often several miles thick which, despite much diversity in detail, show broad features of similarity in that systematic variation observed within them.

The interpretation of the petrologic structure of these sheets usually assumed either (1) that the complex is the result of successive sheet intrusions varying in composition; or (2) that they represent the product of crystallization of a single body of magma with gravitative sorting. Detailed examination of the Skaergaard mass made clear that this layered structure arose from fractional crystallization of a magma occupying a deep inverted cone chamber, solidification proceeding from the base upward, the solid phases accumulating like a sediment on the floor. The intrusion consists of basic rocks and comprises a marginal rock group and a central layered group. The marginal rocks show fluxion structures and banding parallel to the steeply dipping contacts. The layered group is exposed to a thickness of three kilometres, the whole of this consisting essentially of plagioclase, olivine and pyroxene, their composition as solid solution series changing gradually from the lower to the upper horizons. At the lower horizons the plagioclase is bytownite, in the upper it is an andesine-oligoclase. Olivine in the lower horizons is poor in iron, but at the top of the series is fayalite, and the pyroxenes show similar enrichment in iron in their phases as they are traced upward.

The separation of the rocks of the intrusion into marginal and layered groups and the differentiation of the latter may be explained by the fact that the liquid magma was sufficiently mobile to allow a convective circulation and equilibrium, the temperature gradient attained, however, being much less than the downward increase in the average crystallizing temperature, because of the increasing hydrostatic pressure (freezing-point gradient). Data which are available for the silicates give the approximate magnitude of these effects as $\frac{1}{2}$° C. per kilometre for the convective gradient and 3° C. for the freezing-point gradient. Accordingly, although cooling would take place from the top and flanks of the intrusion and the temperature at these points would be cooler, the solid phases would separate near or at the bottom and would gradually accumulate on the floor.

In the Skaergaard mass only the upper portions of the intrusion are laid bare, the rock types ranging from hypersthene olivine gabbros to ferrogabbros and fayalite ferrogabbros with a final residual granophyric differentiate close to the roof. The remarkable correlation in detail of the composition of crystals of solid solution series with their position in the layered mass and the ordered sequence of rock product so yielded, present in all a convincing picture of the results of fractional crystallization of a once homogeneous magma. It is not unlikely that the mechanism thus clearly made manifest for the Skaergaard intrusion characterizes other layered sheets (*e.g.*, Stillwater), although the history of some of these may be further complicated and its tracing blurred by the intervention of intimately associated intrusions.

3. Application of Laboratory Investigations.—The trend in mineral composition revealed in layered series of rocks such as that already described is illuminated by experimental laboratory study of phase equilibriums in silicate systems of related composition. The main contributions in such synthetic studies have come from the Geophysical laboratory at Washington, D.C. (see *Rock Synthesis,* above). Systems which approach in their complexity some of the simpler types of igneous rocks were explored, and the results obtained justify the conclusion that the fusion and solidification phenomena of igneous rocks are capable of systematic treatment. Starting with pure chemical substances, the melting points, dissociation temperatures and inversion points of numerous rock-forming minerals were determined and the equilibrium phenomena of two- and three-component systems involving the commoner oxides of igneous rocks were quantitatively elucidated.

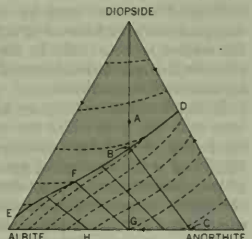
This study embraced the binary and some of the ternary systems of the oxides lime, magnesia, ferrous oxide, alumina, soda, potash and corundum with silica, and was extended to the exploration of certain plane sections of four- and five-component systems. The investigation of mineral inversions provided data throwing light on the temperature of igneous magma. Such of these inversions as are enantiotropic, or reversible, and take place without appreciable lag can be appropriately used as geological thermometers.

The study of binary and more complex systems has shown that the eutectic relation—for so long given a pre-eminent role in discussions of the crystallization of igneous rocks—is but one of several relations that may obtain between two or more components. Crystallization processes are normally complicated by solid solution and incongruent melting. The former phenomenon is widespread, for most of the major constituents of igneous rocks—feldspars, pyroxenes, olivines, amphiboles and micas—are members of complex solid solution series. (*See* MINERALOGY: *Nature of Minerals: Solid Solution.*)

In systems of three components the crystallization phenomena are often complex: occurrence of inversion points in one or more of the components, the formation of binary or ternary compounds with congruent or incongruent melting, and the formation of isomorphous mixtures, limited or unlimited, among the phases, are some of the many complications met with in the silicate systems investigated. Ternary systems that have been studied include those mixtures from which the phases plagioclase, pyroxene, olivine, silica and the alkali alumina silicates, potash-soda feldspars, leucite and nephelite, are precipitated.

The crystallization phenomena in a system involving the first two of the phases indicated above—diopside-albite-anorthite—may be taken as an example. The equilibrium diagram is shown in the accompanying figure. The crystallizing phases are diopside and plagioclase. These mixtures are therefore comparable with simple basaltic or gabbroic magmas on the one hand and simple dioritic (augitediorite) magmas on the other, according to the nature of the plagioclase.

Consider the crystallization of a liquid whose composition is represented by the point A (50% diopside, 50% plagioclase—Ab_1An_1). Crystallization begins with a separation of diopside (supposed to be a simple mineral and not an isomorphous mixture, as it would usually be in rocks) at about 1,275° C. At 1,235° C. the excess of diopside (B) has separated out, and feldspar begins to crystallize. It has about 80% anorthite (C). Thereafter diopside and feldspar both crystallize, but as the composition of the liquid travels along the line DBE from B to F the composition of the feldspar changes from C to G (if it is supposed that all the early feldspar which is unduly rich in anorthite is stage by stage resorbed). The resulting rock has the mineral composition above stated; but if resorption of feldspar is incomplete the last-formed feldspar is richer in albite and has a composition H. The feldspar crystals in that case are zonal with basic centres. If at any time crystallization is suddenly brought to an end a glassy groundmass will be formed, which is richer in soda and silica than the original magma and contains zoned feldspar crystals. This is exceedingly like what takes place in many basaltic lavas. Again, if the original mixture had been richer in feldspar, so that the composition point lay below the line DE, feldspar would have crystallized out first. Original compositions near B then yield early both diopside and plagioclase phases and quenching at this stage would show both enveloped in a glassy base. This is in keeping with observations on glassy basalts which exhibit plagioclase and pyroxene of early crystallization set in preponderant glass.



EQUILIBRIUM DIAGRAM OF CRYSTALLIZATION PHENOMENA

The separation of liquid from crystals can be accomplished not only by zoning but also by the sinking of crystals from the upper layers of the liquid. The resulting liquid is enriched in albite and, under favourable circumstances, the final liquid may approach the albite-diopside eutectic of composition 97% Ab, 3% diopside. The analogy with the differentiation course of gabbroic magma is clear. A mixture rich in diopside and anorthite-rich plagioclase, corresponding to an anorthite-rich gabbro or eucrite, may pass to an assemblage rich in more acid plagioclase with subordinate diopside, corresponding to an augite-diorite.

4. Discontinuous-Reaction Series.—The continuous-reaction relation between crystals and liquid in the systems just studied is of fundamental importance in the crystallization history of magmas. This reaction is common to all solid solution series, and such solid solutions are called continuous-reaction series. Very similar effects, however, are produced by another type of crystallization phenomenon revealed in synthetic melts. In this case an early precipitated phase reacts at a certain temperature with the surrounding liquid and a new phase is precipitated, a reaction process of a discontinuous kind. This reaction is illustrated in the system forsterite (olivine)-silica. Here there are three solid phases, forsterite, protoenstatite ($MgSiO_3$) and cristobalite (SiO_2). The orthorhombic pyroxene, protoenstatite, has an incongruent melting point and dissociates at 1,557° C. into forsterite and liquid. From all melts of composition between Mg_2SiO_4 and $MgSiO_3$, the first phase to crystallize is forsterite, which continues to separate until the temperature of 1,557° C. is reached, when the olivine reacts with the liquid to form protoenstatite. When equilibrium is established the resulting crystalline mass consists wholly of olivine and pyroxene. If, however, the opportunity for reaction is inhibited, either by the sinking of olivine crystals or by their enclosure in the reaction product, the course of crystallization is extended and the third phase, silica, is precipitated giving a mass composed of residual olivine, pyroxene and silica.

A reaction relation of this type may effect a series of compounds in a crystallizing melt. These, arranged in their order of succession, constitute a discontinuous-reaction series. The combined effects of discontinuous and continuous reaction are revealed in the related ternary systems diopside-forsterite-silica. Here the magnesia pyroxene forms a complete series of solid solutions (monoclinic pyroxenes) with diopside; they form a continuous-reaction series, the crystals in equilibrium with the liquid being relatively enriched in the magnesian end member ($MgSiO_3$). The effect of hindering the reaction relations is now twofold, the residual liquid (or upper layers of the liquid if sinking of crystals prevails) is enriched in silica and the diopsidic pyroxene, as a result of the offset in composition.

The lowest point of formation of liquid in the system (there is no ternary eutectic) is the binary eutectic diopside-silica. In ternary silicate systems containing ferrous oxide, *e.g.*, in the system MgO-FeO-SiO_2, fractional crystallization effects a concentration of iron in the residual liquid which for some initial compositions may yield, according to the degree of fractionation, crystalline aggregates of ferriferous pyroxene and silica or ultimately iron-rich olivines and silica.

5. Natural Magmas.—That reaction processes of these kinds operate in natural magmas is clearly demonstrated. They are seen among minerals in zoned crystals of solid solutions like the plagioclase feldspars and the complex pyroxene phases, or in the resorbed borders of magnesian olivines with their pyroxenic mantles; their cumulative effects may be revealed in the graded sequences in mineral compositions in a layered intrusion, such as that of Skaergaard, crystallizing upward from its base, or in the association of related but contrasted rock types, whether these be the contrasted parts of gravitationally differentiated sills or the contrasted separate intrusions of a plutonic complex.

The normal calc-alkali magma, more complex in composition than the synthetic melts investigated, contains other components, including water, and from these natural melts mineral phases such as amphiboles and micas with constitutional hydroxyl are precipitated. Petrographic data make it clear that these too take part in the reaction process.

The principal minerals of these igneous rocks can in fact be arranged as reaction series, such that any member is produced from the preceding member by reaction with liquid magma, as already instanced by the reaction pair, olivine-pyroxene. The plagioclase feldspars together with potash feldspar form one series and the olivines, pyroxenes, amphiboles, micas and quartz constitute another. Inspection of this order will reveal that it is in essence the "normal order" already recognized in the rule formulated long ago by Rosenbusch.

A basic magma quickly cooled may give rise simply to basic plagioclase and pyroxene or yield by fractional crystallization a differentiation chain embracing all the minerals enumerated above, the continual offset in composition of the residual liquid in which water accumulates being accomplished by appropriate removal of crystals through gravitative settling, squeezing out or filtering off of interstitial liquid by earth movement during crystallization.

6. Hydrothermal Systems.—The extrapolation of experimental equilibrium studies based on data obtained from anhydrous silicate systems, such as the foregoing, to natural rocks, led to

great advances; nevertheless the evidence that many igneous rocks have crystallized in the presence of water vapour and in fact contain hydrous mineral phases made clear the limited applicability of the experimental results, directly to the interpretation of the crystallization history of the more siliceous and alkaline rock assemblages. Experimental attack on hydrothermal systems followed later and an outline of the scope of these researches is now presented.

Before World War II quantitative phase equilibrium studies in silicate systems containing volatiles, particularly water, had been few. G. W. Morey and C. N. Fenner had worked out the system H_2O-K_2SiO_3-SiO_2 (report, 1917) and at a later date R. W. Goranson had demonstrated the solubility of water in a liquid of granite composition (report, 1931). During and immediately after the war the great interest in certain crystalline phases, especially quartz, had stimulated a great deal of hydrothermal work and radically new equipment was developed. The first systematic study of a silicate system comparable with a natural assemblage—the system MgO-SiO_2-H_2O—was completed in 1949. This study opened a new era of conquest of the wet mineral silicate and in many respects laid the groundwork for much of the later investigations in the hydrothermal field. This work demonstrated that no liquid appeared in the ternary system even at 1,000° C. and at a water vapour pressure of 40,000 lb. per square inch, thus throwing new light on the problem of emplacement of peridotites and serpentines in the upper crust. Most of the postwar hydrothermal studies were in fact carried out under pressure temperature (PT) conditions below that at which a liquid (melt) phase appears and above the critical temperature of water. These studies are therefore largely concerned with crystal $\rightleftarrows$ vapour equilibrium. Examples of such subsolidus studies were those of SiO_2-H_2O, CaO-SiO_2-H_2O, MgO-Al_2O_3-SiO_2-H_2O, and numerous researches dealing with the synthesis and stability of individual mineral groups—feldspars, garnets, micas, amphiboles, nephelite-kalsilite, analcite and several carbonate systems. These investigations proved of particular importance in the study of rock metamorphism (*q.v.*) and some had their application also in the interpretation of phase relations in the cooling history of the igneous rocks.

The most significant liquidus studies related to the petrographically important system of the alkali feldspars ($NaAlSi_3O_8$-$KAlSi_3O_8$) and of these with SiO_2—*see* especially O. F. Tuttle and N. L. Bowen, "Origin of Granite in the Light of Experimental Studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2," *Mem. Geol. Soc. Amer.*, 74 (1958). These are the systems which approach in composition the great group of natural rocks, the syenites and granites. The outstanding feature of the researches was the evidence found to support the indications that a complete series of solid solutions existed between potash and soda feldspars at elevated temperatures, but that in the subsolidus region a solvus existed with two feldspars existing side by side. Homogeneous synthetic feldspars thus exsolved at lower temperatures in confirmation of the accepted theory of most natural perthites. In the ternary system with silica at high water-vapour pressures the liquidus has a thermal trough near the centre toward which all liquids moved on crystallization.

This minimum had a composition in the range common for granites, a result in harmony with a long-held view of the magmatic origin of this rock type. The investigation of more basic assemblages of simple gabbroic or eucritic composition, *e.g.*, the system diopside-anorthite, under high water pressure revealed a marked lowering of the liquidus and a change in the composition of the binary eutectic, with the implication that water is markedly soluble in gabbroic magma, as had been shown earlier for the granitic liquid system.

7. Magmatic Assimilation.—Heterogeneity in a magma may derive through a crystal liquid equilibrium not only by the spontaneous process of fractional crystallization and reaction but also by reaction of liquid magma with its wall rock or with what foreign inclusions it may incorporate. This process, known as assimilation, may lead to the development of a diversity of rock type and is to be recognized as an important factor in petrogenesis.

It seems probable that the heat effect connected with the solution of solid rock by a liquid magma is always negative, solution being accompanied by absorption of heat, usually of the order of the latent heat of melting. Simple solution would then demand large amounts of heat, which are only available if the liquid possesses great superheat. Intruding magmas, however, can scarcely be at a temperature much above their crystallization range. Such effects of magma upon its enclosures as are observed must therefore be attributed to processes of reaction and precipitation.

The concept of the reaction series finds fruitful application in the study of this problem. Enclosures of rock fragments in a magma may be divided broadly into two classes, those of igneous and those of sedimentary origin. The first class is built normally of minerals which are members of the reaction series. The magma itself, saturated with a given member of such a series, is effectively supersaturated with all earlier members of that series. If the inclusion is built of these earlier members the magma cannot in consequence dissolve them. It can, however, react with them and transform them into the member with which it is saturated, often by passing through other members of the series as intervening steps.

These changes effected by subtraction of material from the magma induce withdrawal precipitation of the phase with which the magma is saturated. In the course of the reaction the inclusion itself is often disintegrated and may come to be completely incorporated in the liquid.

With an inclusion built up of members of the reaction series later than that with which the magma itself is saturated, the process is one of reactive solution—the inclusion becoming part of the liquid at the expense of precipitation of the magma saturated phase. On the liquid, the resultant effect is a pushing onward along the normal course which fractional crystallization in the process of cooling might accomplish. In these reactions no phase foreign to the reaction series is normally precipitated, and there may result locally rock types scarcely distinguishable from types derivable by fractional crystallization. Plutonic complexes with their range of associated intrusions—basic to acid—often show clear evidence of extensive hybridization by reaction of a later (more acid) magma upon an earlier (more basic) consolidated product, the rock types found near the border approximating in composition and structure to a range of igneous rocks of a normal differentiation series while being in fact the result of hybridization brought about by action of liquid (acid) magma upon a basic (gabbroic) rock.

The monzonitic and tonalitic margins of granitic masses of some igneous complexes may be traced to the hybridizing influence of acid magma on an earlier plutonic rock of basic or ultrabasic composition of which all superficial traces may have disappeared. The newer granite complexes of Scotland provide convincing demonstration of hybridizing processes of this nature. The effects of reaction of igneous magmas upon sediments set a more difficult problem, since sedimentary material may not belong to the reaction series.

In many cases the incorporation of sediments in a magma, while yielding adjustments in the composition and relative proportions of existing phases, may effect but little modification in the general course of fractional crystallization. On the other hand, extended incorporation of certain types of sedimentary material may lead to the precipitation of new mineral phases not normally met with in igneous rocks.

Gabbro magma assimilating shales or slates may pass first into norite by precipitation of rhombic pyroxene and basic plagioclase, at the expense of clinopyroxene, and eventually yield cordierite norites. Rocks of this character are well developed in Aberdeen county and elsewhere. Basaltic magma, through assimilation of limestone, may give products rich in melilite and wollastonite and yield, at least locally, an alkali fraction from which nephelite is precipitated. Whether basic magma through this mechanism can generate alkali rocks on a large scale is a question yet to be determined. That their production is not limited to this mechanism, however, is clearly attested by the geological environment and petrographical relations of many examples of this group of rocks.

Assimilation processes clearly play a significant role in the development of some rock assemblages, and among these are to be expected rock types which exhibit in both composition and structure the characteristics of normal igneous rocks. The full contribution of these processes has yet to be evaluated though a limit to their action is prescribed if magmas in general possess little superheat.

8. Palingenesis.—The apparent dominance of granodiorites and granites in orogenic belts led some petrologists to entertain the view that these particular rocks have been derived by remelting of the granitic layer and the intrusion of the resulting liquid to higher levels. This possibility cannot be denied; yet it is to be remembered that a granitic differentiate as a late residual liquid subject to filter pressing during mountain building might well come to dominate in volume the upper regions of a magmatic tract laid bare by erosion. It is conceivable, however, that some granites may have their immediate origin in such refusion and perhaps also that a process of partial refusion may affect siliceous sediments subject to deep burial in the cores of geosynclines. As distinct from the juvenile granites derived by fractional crystallization, granites supposedly originating in this way have been referred to as palingenetic and the process of refusion as palingenesis (Gr. *palin*, "again," *genesis*, "birth"). The genetic link between granitic and basic (basaltic) material remains, for the dominantly mafic character of the crust makes it evident that the sial or granitic layer must ultimately have been derived from such basic material.

9. Granitization.—The aqueous and alkali-bearing residual liquids emanating from granitic magma during its later consolidation stages are known to penetrate into the surrounding rocks. Where these rocks are argillaceous, metasomatism by the alkali solutions acting upon the micaceous minerals of the sediment may result in the feldspathization of such pelitic rocks, transforming them into assemblages analogous in composition to the parent rock from which these solutions came. This is the process of granitization. With such processes there is frequently a merging of the parent intrusive with an igneous-looking rock which is metasomatic in origin.

In the more speculative accounts of the process the parent intrusive itself has been regarded as formed in the same manner and the existence of a genuine igneous intrusive denied, but such an extreme view seems unlikely to be correct. A survey of the problems of granite emplacement with special reference to North America was made by A. F. Buddington (*Bull. Geol. Soc. Amer.*, vol. 70, pp. 671–747 [1959]).

VII. GEOGRAPHIC DISTRIBUTION OF IGNEOUS ROCKS

A study of the geographical distribution of igneous rocks has shown that the earth's surface may be mapped out into more or less definite petrographical provinces, each with its own community of petrographical characters. Strongly contrasted provinces may exist almost side by side, as is seen in the Tertiary Bohemian and Hungarian provinces standing on either side of the Carpathian range, the one characterized by a suite of igneous rocks rich in alkali, the other comprising an assemblage relatively rich in lime, magnesia and iron oxide. The chain of volcanoes that fringes the shores of the Pacific from Tierra del Fuego to Alaska and thence by Japan and the Philippines to Java and Sumatra represents a province of a larger order, characterized by rocks which have so much similarity in many important features that they are certainly of allied origin. These rocks are all of Tertiary and Recent Age; their eruptions began in Eocene or Miocene times and have continued with more or less frequent intermissions up to the present day. The igneous rocks of the Atlantic islands from the Azores to Tristan da Cunha comprise an assemblage of types strikingly different from the igneous rocks of the eastern Pacific borderland. Each of these magmas has been taken as a type, and they are referred to as the Pacific and Atlantic magmas. Chemically the Atlantic (or alkali) rocks are characterized by high percentages of alkalies (potash and soda) in relation to silica and alumina, and mineralogically by the presence of alkali minerals, especially feldspathoids (nephelite, sodalite, analcite, etc.). The Pacific (subalkali or calcic) rocks, on the other hand, show relatively more abundant lime, magnesia and iron oxides.

Certain suites of rocks characterized by high potash content and, mineralogically, by the presence of leucite or abundant potash feldspar and micas, have been separated from the Atlantic suite, though they are perhaps not of co-ordinate importance. Rocks of this character are illustrated by the Quaternary province of the Roman region; Vesuvius belongs to a line of volcanoes (extending from Lake Bolsena to the Campi Flegrei, or Phlegraean fields) that have poured out lavas of this character. They are sometimes known as the Mediterranean suite.

When one turns to the igneous rocks of older geological periods the same contrasted suites can be recognized. The midland valley of Scotland has been the theatre of igneous action both in Lower Devonian and Carboniferous times. The igneous assemblages of the two periods show, however, a striking contrast. The earlier lavas are distinctly of the Pacific type, including andesites, basalts and rhyolites, while the Carboniferous extrusions and dike rocks include trachytes, teschenites, picrites and monchiquites—an Atlantic assemblage. Petrographical provinces are therefore clearly not permanent.

Study of the geological relations of igneous rocks clearly reveals that there is a general correspondence in both time and space between igneous action and movements of the earth's crust, whether these be simply vertical movements of elevation and depression or tangential movements of folding and overthrusting which build up great mountain chains. As in crustal movements so in igneous action, periods of activity have alternated with periods of quiescence. The movements of compression which led to the folded mountain chains fringing the Pacific were accompanied and followed by widespread volcanism, and the movements of depression which in Tertiary times led to the formation of the Great Rift valley of east Africa were attended and followed by a great suite of volcanic eruptions. The interdependence of igneous action and crust movement is even of a still more intimate kind, for not only the distribution of igneous rocks, but the distribution of different kinds of igneous rock is seen to stand in unmistakable relation to the great tectonic structures of the earth. The examples referred to above are illustrative of this conclusion. The volcanoes of the Pacific cordillera erupted calcic andesites and basalts, and are associated with granodiorite and quartz-diorite intrusions; the eruptions associated with the African Rift valley are in contrast, being of alkali type and including soda trachytes, phonolites, and related alkali lavas. Whether attention is confined to Tertiary igneous rocks or extended to those of earlier date, the conclusion is enforced that rocks of the Pacific suite are closely associated with folded mountain chains and appear in regions subject to movements of compression and lateral thrust, and that the Atlantic or alkali suites are associated with regions of subsidence, subject to tension and faulting. The volcanic rocks of oceanic islands are dominantly olivine basalts and with these, though in minor development, are associated typical Atlantic differentiates—trachyte and phonolite. More siliceous lavas have not been frequently reported, but their occurrence with basalts and trachytes in an oceanic environment attests an intimate genetic relationship and adds support to the theory that granitic differentiate can derive from parental basaltic magma. Quartz trachyte or alkali rhyolite have been thus recorded in the inner Pacific at Easter Island and in Tutuila (Samoa), in the south Atlantic (Bouvet Island) and in the Indian ocean (Kerguelen archipelago).

The tectonic environment of rocks of the Mediterranean suite is less clearly defined. In general their spatial arrangement in relation to the Pacific and Atlantic suites reflects their intermediate position. They are characteristic of the region lying between the orogenic zones and the forelands or regions of subsidence. The position of the potassic Roman province in relation to the Alpine orogenic zone and the alkali (Atlantic) basin of the west Mediterranean illustrates this association clearly.

Between many calcic, sodic and potassic suites no sharp line of division is to be recognized, and in their relative distribution

upon the face of the globe may be seen the influence of tectonic processes as an external factor exerting a profound influence on the trend of differentiation. *See* also references under "Petrology" in the Index.

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PETRONIUS ARBITER (GAIUS or ? TITUS PETRONIUS) (d. A.D. 66), Roman voluptuary, poet and the reputed author of the *Satyricon,* the first western European novel. Tacitus gives a graphic account (*Annals,* xvi, 18–19) of his character and the manner of his death. He was an able man, who distinguished himself as governor of Bithynia and consul; but his chief talent lay in the pursuit of pleasure, in which he displayed such exquisite refinement as to earn the unofficial title of the emperor Nero's "arbiter of elegance" (*arbiter elegantiae*). Being suspected of conspiring against the emperor, he was ordered to commit suicide; his last hours were passed in amusements, social pleasures and the composition of a scurrilous catalogue of Nero's debaucheries.

The identification of this Petronius with the author of the *Satyricon* is, notwithstanding all that has been urged to the contrary, reasonably certain. The atmosphere of the work and the internal evidence point to the Neronian period, and it seems unlikely that two different men of the same name and so similar in character and outlook can have existed at the same time.

The *Satyricon* (properly perhaps *Satyrikon liber,* "Book of Satyrlike Adventures") is a "picaresque" romance. It relates the wanderings and escapades of a disreputable trio of adventurers, the narrator Encolpius ("Embracer"), his friend Ascyltos ("Scot-free") and the boy Giton ("Neighbour"—a euphemism). The surviving portions probably represent about one-tenth of the complete work. Some semblance of unity is imparted to the episodic narrative by a wrath motif recalling the *Odyssey* and the *Aeneid:* the narrator is pursued by the enmity of Priapus, whose divinity he apparently offended in a lost portion of the work. The *Satyricon* has obvious affinities with the later Greek prose romances, particularly in the rhetorical flavour which pervades it, but its immorality, or rather amorality, sets it in a class apart from them. Its tone recalls the notorious predilection of Nero and his court for low life and suggests that it may have been composed specially for their amusement. Its literary ancestry is complex and can only be guessed at. The loose narrative framework encloses a number of detached tales of the so-called "Milesian" type, the ancestor of the smoking-room story, a classic instance being the famous "Widow of Ephesus" (*Satyricon,* ch. 111–112); in this the *Satyricon* resembles the later *Metamorphoses* of Apuleius. Other features, however, recall the "Menippean" satire (represented in Latin by M. Terentius Varro): namely, the mixture of prose and verse in which it is composed; and the digressions in which the author airs his own views on various topics having no connection with the plot.

The most remarkable of these digressions, which are the only parts of the work which may properly be called satire, is the passage relating to contemporary epic poetry (ch. 118); it is followed by a hexameter poem of 295 lines on the civil war between Caesar and Pompey, apparently intended as a criticism (not a parody) of Lucan. Whether Petronius had a Greek model or whether the fusion of genres represented by the *Satyricon* was his own invention must, in the present state of the evidence, remain uncertain.

The longest and the best episode is the so-called *Cena Trimalchionis* or "Banquet of Trimalchio" (ch. 26–78), a description of a dinner party given by Trimalchio, an immensely rich and vulgar freedman (former slave) of oriental origin, to a group of friends and hangers-on. Its length appears disproportionate even to the presumed original size of the *Satyricon* (though the story of Cupid and Psyche in Apuleius offers a partial analogy), and it has little or no apparent connection with the plot. The scene is a Greco-Roman town in Campania, possibly Puteoli (Pozzuoli), and the guests, mostly freedmen like their host, are drawn from what corresponded to the *petit bourgeois* class. Trimalchio is the quintessence of the parvenu, a figure familiar enough in ancient satirical literature, but especially so in the 1st century A.D., when freedmen as a class were at their most influential. The setting exemplifies a literary form stemming from Plato's *Symposium* and already employed for satirical purposes by Horace (*Satires,* ii, 8).

Two features distinguish Petronius' *Cena* from other ancient examples: its extraordinary particularity and realism and the figure of Trimalchio. It is obvious that the table talk of the guests in the *Cena* is based on personal observation of provincial societies. The speakers are beautifully and exactly characterized and their dialogue, quite apart from the invaluable evidence for colloquial Latin afforded by the vulgarisms and solecisms in which it abounds, is a humorous masterpiece. Trimalchio himself, with his vast wealth, his tasteless ostentation, his affectation of culture, his superstition and his maudlin lapses into his natural vulgarity, is more than a typical satirist's figure. That some of his idiosyncrasies are taken from life is proved by Seneca's description of Calvisius Sabinus (*Epistles,* xxvii, 5); and, if due allowance is

made for comic exaggeration, little about him is actually incredible. As depicted by Petronius, however, he is one of the great originals of literature, fit company for Shakespeare's Falstaff or R. S. Surtees' Jorrocks. Development of character for its own sake was hardly known in ancient literature: the emphasis was always on the typical, and the classical rules as expounded by, for instance, Aristotle and Cicero, laid down that character was secondary to more important considerations such as plot. Petronius, in his treatment of Trimalchio, transcended this almost universal limitation in a way that irresistibly recalls Dickens, and much else in the *Cena* is Dickensian—its exuberance, its boisterous humour (rare in ancient literature, where wit predominates) and its loving profusion of detail.

The rest of the *Satyricon* is hardly to be compared with the *Cena*. It offends not so much by its indecency as by the selfish and flippant hedonism which colours it throughout (a debased Epicureanism: *see* the poem at the end of ch. 132). This, allied to a Latin of unmatched grace and elegance, earned for Petronius (from Justus Lipsius) the title *auctor purissimae impuritatis*, "writer of the purest impurity." The few poems transmitted separately from the *Satyricon* under Petronius' name do nothing to enhance his reputation. To the middle ages he was known as the author of moral maxims, preserved in fragmentary excerpts; his popularity in modern times dates from the publication in 1664 of the previously unknown *Cena Trimalchionis*, discovered in a manuscript at Trau (Trogir) in Dalmatia.

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PETRONIUS MAXIMUS: *see* MAXIMUS.

PETROPAVLOVSK, capital of the North Kazakhstan *oblast* in the Kazakh Soviet Socialist Republic, U.S.S.R., is situated at the point where the Ishim River is crossed by the Trans-Siberian Railway. Pop. (1959) 131,453. In addition to the processing of food and clothing, its industries include timber and brick making. There are various technical training establishments, a museum, a musical institute, and a theatre. (G. E. WR.)

PETROPAVLOVSK-KAMCHATSKI, a town and administrative centre of Kamchatka *oblast* in the Russian Soviet Federated Socialist Republic, U.S.S.R., stands on the eastern Pacific coast of the Kamchatka (*q.v.*) peninsula and has a good natural harbour on the northeastern shore of the landlocked Avachinskaya Gulf. Pop. (1959) 85,582. The town was founded in 1740 during V. J. Bering's Kamchatka expedition. In 1854, during the Crimean War, an Anglo-French attack on Petropavlovsk was repulsed. The modern town is a whaling centre and has a shipyard, timber mills, and engineering works. Freighters and fishing boats are built, and fishing nets are made. It is the terminus of the only road in the peninsula, through the valley of the Kamchatka River. It has a pedagogic institute. (R. A. F.)

PETRÓPOLIS, a city of the state of Rio de Janeiro, Brazil, in an elevated valley of the Serra de Estrêla or dos Orgãos mountains, 2,634 ft. (803 m.) above sea level, is 27 mi. (43 km.) N of Rio de Janeiro, with which it is connected by railway and highway. It was founded in 1845 by Julius Frederick Knoeller, and was sponsored by Dom Pedro II, the Brazilian emperor for whom it was named. The emperor was attracted to the city's relatively cool climate—5° C. (9° F.) lower than Rio de Janeiro during the summer—and held court there during the warmer months, attended by public officials and members of the diplomatic corps.

The ornate royal palace, surrounded by luxuriant gardens, houses the Museu do Imperio (Museum of the Empire) that contains many of the possessions of John VI of Portugal, who resided in Brazil for several years, and of the two Brazilian emperors, Dom Pedro I and Dom Pedro II. The cathedral of the town is of 13th-century French Gothic design. There is a variety of manufacturing industries in the city and a short distance away are rich farm lands. Pop. (1960) 93,849. Quitandinha palace, a leading resort centre, is about 3 mi. (5 km.) S of Petrópolis on the highway to Rio de Janeiro. (J. J. J.)

PETROZAVODSK, a town and the capital of the Karelian Autonomous Soviet Socialist Republic, U.S.S.R., stands on the western shore of Lake Onega, south of the outfall of the Shuya River and 185 mi. (318 km.) NE of Leningrad. Pop. (1959) 136,294. The town (its name means "Peter's factory") was founded in 1703 by Peter the Great as an ironworks to supply ordnance to his new capital of St. Petersburg (now Leningrad) and the Baltic fleet. The metallurgical industry still persists and has been joined by timber working (furniture, prefabricated houses, and skis), ship repairing, fish canning, brewing, and distilling. Petrozavodsk is on the main Leningrad-Murmansk Railway, with a branch line to Suoyarvi and Finland. There are a university, a pedagogic institute, the Karelian branch of the Academy of Sciences, and many other scientific and educational establishments. (R. A. F.)

PETRUCCI, OTTAVIANO DE' (1466–1539), Italian printer of music, whose collection of chansons, *Harmonice Musices Odhecaton A* (1501), was the first book of part music to be printed from movable type. Born at Fossombrone, near Ancona, he moved to Venice about 1490. He held music printing monopolies first at Venice, where he worked from 1498 to 1511, and later at Fossombrone. In 1536, at the request of the Venetian Senate, he returned to Venice, where he died in 1539. His 61 music publications contain Masses, motets, chansons, and *frottole* by many of the foremost composers of the 15th and early 16th centuries, Josquin Després, Jean d'Okeghem and Loyset Compère among them. He also published the first book of printed lute music, Francesco Spinaccino's *Intabolatura de Lauto* (1507). (D. Po.)

PETRUS AUREOLI (PIERRE AURIOL, ORIOL OR D'ORIOL) (*c.* 1280–1322), French Franciscan, theologian, and philosopher known honorifically as *Doctor facundus*, "the eloquent teacher," was born near Gourdon in Quercy. Having studied in Paris and taught in Bologna and Paris, he became provincial of his order for Aquitaine (*c.* 1320) and archbishop of Aix-en-Provence (1321). Criticizing both Thomas Aquinas and Duns Scotus, he promoted an individualistic empiricism, supported by a nominalistic-conceptualistic doctrine of universals which in some ways anticipated William Ockham (*q.v.*). His *Commentary on the Sentences* was first printed in Rome, two volumes (1596–1605).

See A. Teetaert, "Pierre Auriol," in A. Vacant (ed.), *Dictionnaire de théologie catholique*, xii (1934). (L. M.-Po.)

PETTY, SIR WILLIAM (1623–1687). English political economist and statistician, one of the founders of economic thought and demographic and economic statistics, was born at Romsey, Hampshire, May 26, 1623. Having studied medicine at the universities of Leiden, Paris and Oxford, he was in turn seaman, medical student, physician, professor of anatomy at Oxford, professor of music in London, inventor, surveyor and landowner in Ireland and a member of Parliament. He died in London on Dec. 16, 1687.

A protagonist of the empirical scientific doctrines of the newly founded Royal Society, of which he was a founder-member, Petty was one of the leading pioneers of political arithmetic; *i.e.*, "the art of reasoning by figures upon things relating to government." His *Essays on Political Arithmetick* and *Political Survey or Anatomy of Ireland* (1672) presented population estimates and rough calculations of social income. His methods seem crude and audacious by modern standards, but Petty was not unaware of their limitations. His ideas on monetary theory and policy, including the quantity theory, were developed in *Verbum Sapienti* (1665) and *Quantulumcunque concerning Money, 1682* (1695). But his main contribution to political economy was *Treatise of Taxes and Contributions* (1662), in which he expounded what should be the main economic functions of the state. In doing so he touched on the fundamental problem of the theory of value, treating the labour

necessary for production as the main determinant of exchange value and seeking a standard of value in the necessary sustenance of a man for a day. Petty—an advocate of religious toleration—favoured allowing scope to the natural forces of individual self-interest and "rather complying with the motions of nature than contradicting it with vehement administratives." But unlike liberals after Adam Smith he considered the maintenance of a high level of employment by monetary and fiscal policies and by public works to be a duty of the state.

See *Economic Writings of Sir William Petty,* ed. by C. H. Hull, 2 vol. (1899). (T. W. H.)

PETUNIA, the common and generic name of popular garden plants of the nightshade family (Solanaceae), native to South America, mostly from Brazil and Argentina. They are sticky herbs, with soft, flabby leaves and weak, straggling stems. Petunias may be divided into two main divisions: bushy types, both high (7–15 in.) and dwarf (4–6 in.), used as bedding plants; and sprawling or weak-stemmed types, often called balcony petunias, useful for window boxes. Modern petunia varieties have typically funnel-shaped flowers, only slightly asymmetrical, and variously crisped, fringed, or ruffled; double varieties have also been developed. Amply watered and in a sunny location, these showy plants will bloom profusely all summer, yielding blossoms of pure white and cream through various shades of red and blue to deep violet; variegations are not uncommon. Some of the large-flowered types are easily beaten down by rain and should be staked.

ROCHE

BALLERINA, HORTICULTURAL VARIETY OF GARDEN PETUNIA (PETUNIA HYBRIDA)

All the petunias are annuals and are not frost-hardy. They may be started from seed sown indoors and just barely covered with fine-grained soil eight to ten weeks before outdoor planting is safe. When warm weather has arrived, both seeds and seedlings can be planted outdoors in almost any ordinary garden soil. They do well in almost any temperate locale. (N. Tr.; X.)

PETWORTH, a town of West Sussex, Eng., lies 14 mi. (23 km.) NE of Chichester by road. Pop. (1961) 2,347. Petworth (Peteorde in Domesday Book, Puetewurth in 1181) under Edward the Confessor was an alodial manor held by Edith (probably his queen), and in 1086 Robert Fitz-Tetbald held it of Roger de Montgomery, earl of Shrewsbury. Later it became one of the principal seats of the family of Percy. Standing in a large park is Petworth House (National Trust) with a 13th-century chapel; the manor house was almost wholly rebuilt between 1688 and 1696 by the duke of Somerset. The south front was rebuilt in 1869–72. It is remarkable for its magnificent collection of pictures and its wood carvings by Grinling Gibbons and Jonathan Ritson (1776?–1846). (L. F. S.)

PEUTINGER TABLE, a copy of a Roman map, made in A.D. 1265 by a monk of Colmar on 12 sheets of parchment. Eleven sheets are now in the Hofbibliotek in Vienna. The dimensions are 268 x 13½ in. (6.82 x 0.34 m.). The copy was found by Conradus Celtis in 1494 and bequeathed by him to his friend Konrad Peutinger (1465–1547) of Augsburg.

The shape of the map, an elongated rectangle, obviously causes a grave deformation of the Roman world, the distances from north to south being compressed and those from east to west being unduly extended. The sea is even more restricted than the land, so that the Mediterranean becomes a narrow canal. Errors, major and minor, are therefore multitudinous. For example Thessalonica lies directly east of Piraeus and the Nile runs mainly west to east. The map is in six colours (black, red, green, yellow, blue, and rose); features and facilities in towns are indicated by small sketches.

Opinions have differed as to how closely the lost original depended on Roman itineraries and world maps, such as the map of Agrippa (the table goes beyond the frontiers of the Roman Empire to the east). The dependence cannot be denied and may have been fairly close. *See* also Map: *History: Greece and Rome.*

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PEVENSEY, a village in the Hailsham rural district, East Sussex, Eng., 5 mi. (8 km.) E of Eastbourne, consists of two parts: the old village, once an important seaport and a limb of the Cinque Port of Hastings, now a mile from the sea; and Pevensey Bay, a small holiday resort on the coast. Pop. (1961) 2,151. The Roman Anderida (*c.* 250) was a fort of the Saxon shore and the remains of its walls and towers are one of the finest examples of Roman building in England. William I landed at Pevensey in 1066 and soon afterward Robert, count of Mortain, built a castle within the Roman walls. The gatehouse, towers, and walls of the inner courtyard were added in the mid-13th century. Pevensey was from Saxon times the head of the Rape of Pevensey, and the Early English church of St. Nicholas, the tiny courthouse, and the Mint House show its past importance. It was a borough from Saxon times until 1883. From the 13th century onward the silting up and reclamation of the Pevensey Levels brought about the port's decline. *See* also Sussex. (G. C. B.)

PEWEE, more properly called wood pewee (*Contopus virens*), is a common bird of the American tyrant flycatcher family (Tyrannidae). Smaller than a sparrow, it is olive brown above and whitish below, with two whitish wing bars. The pewee is a gentle, unsuspicious species that perches on a dead branch in open woodland and turns its head constantly as it looks for flying insects. These it captures with a graceful looping flight, punctuated by an audible snap of its broad, flat bill. The little flycatcher then returns to the original branch or a new observation post. Periodically its call is heard, a plaintive "pee-a-wee," and sometimes a descending "pee-er." In the same shady woods, usually saddled on a bare horizontal limb and camouflaged with lichens, is the shallow nest, woven of fine grass, moss, and strips of inner bark. There are two or three creamy white eggs, wreathed about the large end with brown and lavender, which hatch after an incubation of 13 days. The young are fed and cared for in the nest for 15 or 16 more days by both parents before fledging. The eastern wood pewee (*Contopus virens*) breeds in eastern North America and is replaced in western North America by the very similar western

ALLAN D. CRUICKSHANK FROM NATIONAL AUDUBON SOCIETY

EASTERN WOOD PEWEE (CONTOPUS VIRENS), A COMMON BIRD OF THE AMERICAN FLYCATCHER FAMILY. "PEE-WEE" IS A CLOSE APPROXIMATION OF THE BIRD'S CALL

wood pewee (*C. sordidulus*). Both winter as far south as northwestern South America. (W. J. Be.)

PEWTER, an alloy, the basis of which is tin. Modern pewter is a tarnish-resistant alloy composed of approximately 91% tin, 7.5% antimony, and 1.5% copper; the best grades contain no lead. The copper adds ductility and desirable working properties while antimony serves to whiten the alloy and to impart a hardness unknown to old pewter. Old pewter, first used nearly 2,000 years ago by the ancient Orientals and Romans, contained sufficient lead to cause the surface to darken with age. There are two schools of thought among pewter collectors: some prefer the dark satin-like sheen of old pewter while others prefer modern pewter which retains its brightness indefinitely and lends itself to a whole gamut of finishes from a crisp bright finish to a soft satin sheen.

Pewter played an important part in the development of civilization as a medium for artistic expression and as a material from which domestic utensils were fashioned. Pewter exceeds most other metals in ductility and ease of working. It may be stretched, compressed, and bent into almost any desired shape; and it does not harden or stiffen sufficiently on coldworking with tools for annealing to be necessary. Modern methods of manufacture differ considerably from those of the early craftsmen, which involved casting, turning, and hammering. Much of the flat and hollow ware is spun on a lathe instead of being cast; the stamping press is used frequently to produce such shapes as oval trays and gravy boats. Casting methods are still essential for making handles, feet, knobs, and hinges and for heavy ornamental pieces. Pewter articles can be hammered into shape, the surface can be raised or stretched, surface lines can be emphasized by chasing and embossing, and decorative effects can be achieved by etching. Machine methods for polishing have added interesting possibilities in new and artistic finishes.

Modern Pewter.—Modern pewter is somewhat softer than brass or bronze. In spite of its softness, it must be classed as one of the most durable metals and as one which will resist oxidation almost indefinitely. Utensils made from pewter have a high resistance to almost all weak acids: food and drink may be served in them without fear of chemical action.

Modern pewterware falls into two types: antique and modern. For the person who prefers antique pewterware, there are reproductions of early masterpieces of the American colonial period. For instance, a complete line of Williamsburg reproductions are available, some of which are actually cast from original molds. For those who desire modern pewterware, there is a wide variety of articles such as coffee and tea services, plates, trays, water jugs, tankards, candelabra, serviette rings, bowls, flasks, cigarette and jewelry boxes, spoons, trophies, ship models, pepper and salt shakers, ashtrays, and communion cups. Most modern manufacturers, in adapting original designs or producing new designs, have kept the bold simple lines which are the chief charm of pewter.

The revival of interest in pewter can be attributed to several factors. For example, the public has become educated to the charm and beauty of nontarnishing pewter; contemporary craftsmen are using pewter in new ways and in striking designs. Working with pewter has been introduced as an important activity in industrial arts courses in the schools and the home workshop.

Collections.—The historical background of old pewter is extensive and many historical collections can be seen in museums throughout the world. Famous collections are on display in the Victoria and Albert Museum in London, the Smithsonian Institution in Washington, D.C., and the University of Copenhagen in Denmark. There are more than a dozen large pewter collections in the United States. (*See* list of museums, B. N. Osburn and G. O. Wilber, *Pewter*, 1947.)

History.—Specimens of Roman pewter excavated in England leave no doubt that pewterware was made in England by the Roman legions. From the Renaissance, the use of pewter in England had been firmly established in the church and for domestic purposes. Pewter chalices had replaced wooden vessels before the end of the 11th century; until the 15th century it was customary to bury a pewter chalice with the priest. After the Reformation and throughout the 17th and 18th centuries, a large number of pewter vessels were found, especially flagons, alms dishes and collection plates. It was customary for every pewterer to strike his "touch" or mark: these marks were made with a steel die into which some ornamental design with the initials of the maker had been cut. The mark indicated membership in a guild called the Worshipful Company of Pewterers, chartered by the crown in 1503. Records of touchmarks were destroyed in the great fire of 1666. The activities of the company prospered and pewterware became an important household item. Plates, saucers, tankards, mugs, candlesticks, and mustard pots are excellent examples of some commonly used articles in English homes until the period when china and porcelain appeared. During World Wars I and II many valuable pieces of pewter relegated to the attic were sold for scrap and lost forever. It is surprising that so much pewter has survived and that it is possible to form a representative collection of pewter items from at least the late 17th century to the middle of the Victorian era.

Much fine pewterware was made in other parts of continental Europe. The earliest known date on a pewter article made in Holland is 1331. In the 17th century, pewter played an important part in middle-class homes and in the inns. The modern pewter industry continues the old tradition. Century-old, well-tried models are still being made but craftsmen have given new shapes to the classic material by harmoniously combining usefulness and beauty. Dutch pewterware is plentifully available and is exported to all countries into which importation is allowed.

The manufacture of pewterware began in Sweden before the end of the 13th century. Guild rules existed as early as 1485 when pewterers were required to stamp their wares. A rose-and-crown mark, much in evidence in the 17th century, denoted the highest quality. The artistically brilliant period of pewter in Sweden was the 18th century when it served widely for table wares and candlesticks. The decline occurred as in other countries but manufacture was revived in 1924.

Germany had established a pewter industry at Augsburg and Nürnberg in the 14th century. During the next four centuries, pewter was the most versatile metal available and wares of every kind were made. The treatment of pewter in relief was quite common as, for example, the plates with portraits of emperors or medallions of Biblical scenes. German hostels afforded much in the way of tankards and drinking vessels. After World War II, the pewter industry in Germany had revived strongly in the towns of Regensburg, Württemberg, Diessen and Nabburg.

The rise of pewter in France and Belgium was contemporary with that in other European countries. In France the most interesting period was the 16th century. Highly ornamented pieces have been found which were associated with the name of François Briot, the greatest of French pewterers. His well-known Temperantia salver and ewer are covered with ornament in relief. On the ewer are figures of the cardinal virtues, while on the dish are figures of Minerva and the seven arts, with the four elements and Temperance in the centre. Fine examples of his work are preserved in the Cluny Museum, Paris. Little of the ancient pewter remains in Belgium because so much disappeared during the repeated wars and invasions.

Pewter was used much in the households of colonial America. The earliest pewterers came from England, bringing their traditional styles with them. The period which marked its greatest production was the 150 years between 1700 and 1850. Boston, New York and Philadelphia were the main centres of manufacture. Every kind of utensil was made which was in any way requisite for domestic purposes: plates, bowls, spoons, tankards, candlesticks, and lamps were made in enormous quantities. With the advent of cheap pottery, particularly plates, the pewterers turned their efforts to the manufacture of coffee pots and these became the mainstays. In the 20th century, there came a revival of interest in colonial period pewter; several firms took up the manufacture of antique reproductions and then branched into new designs which found favour. It is apparent that in spite of other available materials, pewter retained its hold and popularity upon American taste long after it had ceased to interest the European public. During World War II and for a number of years thereafter, the manufac-

ture of pewter was not allowed because tin was reserved for essential purposes. Restrictions were removed in 1953 and manufacturers made up lost ground by leaps and bounds. Since then, the world production of modern pewterware has exceeded the amount of pewter produced in any similar period in the history of the industry. *See* also ANTIMONY; TIN.

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PEYOTISM is the use by American Indians of peyote (*e.g.*, mescal: *Lophophora williamsii*), spineless cacti native to northern Mexico and southwestern U.S. The word peyote seems to be a Spanish version of the Nahuatl term *peyotl*. When eaten, peyote produces extraordinary psychophysiological effects that vary with the social situation. Effects reported from laboratory studies differ from those observed under ritual conditions. The medically active principle in peyote is mescaline (3,4,5-trimethoxyphenethylamine), an alkaloid drug classified by pharmacologists as a hallucinating agent (*see* NEUROPHARMACOLOGY AND PSYCHOPHARMACOLOGY).

Of the two major forms of peyotism, the old peyote complex is the earlier form; it flourished prior to the 20th century. Peyote was used primarily as medicine and to induce visions by individuals seeking supernatural revelation. It was also used in groups as an auxiliary in tribal dancing rites, evidently to induce a trance state. Little is known about the origin and distribution of the old peyote complex; however, peyote is depicted in pre-Columbian remains in Mexico. Documents from the 16th to the 18th century report the old peyote complex as extending from southern Mexico to northern New Mexico and Oklahoma. In the 1960s the old peyote complex existed in Mexico with diminished importance.

The peyote religion is a more recent form of peyotism that developed during the second half of the 19th century. The religion is practised by a voluntary organization, with a rite of prayer, singing, and quiet contemplation, centred on peyote as a symbol of spirits being worshiped and as a sacrament. Peyotism as a fully developed religion probably originated about 1885 among Kiowa and Comanche in Oklahoma from an earlier Apache peyote rite. After 1891 it spread rapidly and became the most widespread indigenous Indian religion, extending from the Great Lakes to the Cascade and Sierra Nevada mountains in the U.S. and to the Rocky Mountains of Canada. Groups practising the peyote religion were incorporated in 1918 as the Native American Church in Oklahoma. In the 1960s this church claimed 200,000 members.

Peyotism has the basic traits usually found in religions: a doctrine, ethics, and ritual. Most peyotists consider themselves Christians, holding peyotism to be the Indian version of Christianity; they accept the Trinity and ethics of white Christians.

Doctrine of the Peyote Religion.—Peyotist doctrine or religious theory consists of a belief in the existence of power, spirits, and incarnations of power, and is stated by peyotists as follows:

Power.—Power is the Indian equivalent of mana (*q.v.*). It is an immaterial and invisible supernatural force that produces characteristic physical effects and can be transferred from one thing to another under the proper ritual conditions. Man needs power to be successful and healthy; without it he becomes unsuccessful and ill. Spirits are immaterial personifications of power. The peyotist pantheon consists of what may be called white and Indian spirits.

White Spirits: the Trinity.—God is equated with the Great Spirit and acknowledged as the supreme being and the ultimate source of all power; he controls the destiny of everything in the universe, including man. Whether he is held to be the creator spirit as well depends upon the tribe. In some tribes Jesus Christ is the culture hero (often equated with the traditional culture hero) who gave the white version of Christianity to the whites and peyotism to the Indians. In other tribes Jesus is a guardian spirit, rejected by the whites who murdered him, who now looks after the equally rejected Indians. Another of Jesus' roles is that of intercessor spirit between God and man; the Holy Ghost has been adopted as part of the Trinity.

Indian Spirits.—The spirit called Waterbird is usually identified as the snakebird (*q.v.*). Some equate Waterbird with the traditional Indian thunderbird, others with the white Christian dove. Most often it has the role of a messenger spirit that carries man's prayers to God. In many tribes peyote itself is personified as Peyote Spirit, generally with the guardian spirit aspect of Jesus in white Christianity. Peyote Spirit is a compassionate male being, always benevolent, sympathetic, and helpful.

Incarnations.—Incarnations are material embodiments of power, and peyote is the prime incarnation. It was given to the Indians by God because he took pity on them for being a poor, weak, helpless, and ignorant subject people. When one eats peyote he absorbs and can use its power. Peyote eating thus is a sacrament.

The next most important incarnation of power is the ritual water drunk at midnight and in the morning. Water is needed by all living things, and therefore all water is sacred; the water is prayed over and blessed so that it acquires additional power. The morning water is particularly sacred because it is brought in and prayed over by the wife or other close female relative of the leader. She represents womanhood as the source of human life ("the mother of us all"). In some tribes she also symbolizes Peyote Woman to whom the rite was revealed.

The foods used in the morning communion breakfast (usually corn, meat, and fruit) also contain power, for they represent the nutrients needed for human life.

Ethics and Eschatology.—Peyotists are expected to follow a way of life called the Peyote Road, an ethical code with four main parts:

Brotherly Love.—Members should be honest, truthful, friendly, and helpful to one another. This is conceived as a spelling out of the Golden Rule (*q.v.*).

Care of Family.—Married persons should not engage in extramarital affairs and should cherish and care for each other and their children. Money should be spent on the family as a whole, rather than selfishly.

Self-Reliance.—Members should work steadily and reliably at their jobs and earn their own living.

Avoidance of Alcohol.—There is a maxim: "Peyote and alcohol don't mix."

Ritual.—Characteristically, but not always, the rite (called a meeting) is held in a Plains-type tepee. The all-night ceremony usually lasts from about 8 P.M. on Saturday to 8 A.M. on Sunday and essentially involves prayer, solo and unison singing, eating the sacramental peyote, and contemplation.

The worshiper eats peyote under the proper ritual conditions in order to obtain power to commune effectively with God and the other spirits. Concentration on such communion is designed to lift the worshiper to an exalted level of spiritual sublimity. In the Great Plains culture area the individual traditionally went off in isolation, subjected himself to ordeals so that he would be pitied, and prayed until some spirit appeared in a vision to give him personal power. Peyotism changes the pattern somewhat since there is a collective rite; but most of the time is spent in contemplation —in a kind of collective isolation. Most persons do not find peyote pleasant to take, and find it difficult to sit on the ground all night in one position. These are peyotist equivalents of the traditional ordeal. In the prayer for assistance God and the other spirits are asked for pity and help through peyote. The worshiper is expected to put away all evil thoughts, to be conscious of his inadequacy, humble, sincere in wanting the benefits of peyote, and to concentrate on the effort.

The successful worshiper experiences a revelation that in most cases takes the form of a vision in which he sees or hears a spirit. In some cases the revelation takes the form of a mystical state, described as the unification of all immediate experience with God.

In either circumstance the individual has a vividly direct experience, rather than revelation obtained from inference or hearsay. It may be interesting to know what others have to say; but all that really matters to the true peyotist is what he has directly experienced—what has been revealed to him personally by peyote. "The only way to find out about peyote is to take it and learn from peyote yourself."

Usually the visions are of God, Jesus, or some other spirit presenting a revelation that is related to the personality and problems of the individual. One peyotist may be comforted by learning more of peyote doctrine or may see or hear departed loved ones. Another may be shown how to solve some problem in daily life; or he may be reproved for evil thoughts and deeds and warned to repent.

Peyotists express these results of contemplation as "learning from peyote," and consider peyote an inexhaustible teacher. A stock statement is: "You can use peyote all your life, but you'll never learn all there is to know about peyote. Peyote is always teaching you something new." Peyote is also believed to be a universal panacea for bodily as well as spiritual ills. Peyotist etiology is based upon traditional Indian beliefs: disease is produced either by insufficient power or by a foreign object. Thus the sick person is told to eat enough peyote to absorb the amount of power needed to restore health; in more serious cases to pray to God and other spirits for power over and above that which is obtained from eating the peyote. The invalid may do this for himself, but in the most serious illnesses a doctoring meeting is held so that others can help pray. The sick person may vomit as a result of eating peyote; in this way it is held that the foreign object which caused the disease is ejected from the body; the patient then eats more peyote to obtain the power necessary for health. (Vomiting is believed also to purge one of spiritual uncleanness.)

Legal Status.—Peyote religion has long been controversial. In 1620 the inquisitor of New Spain prohibited the use of peyote by all Christians. Starting in Oklahoma in 1899, and continuing to the California antipeyote law of 1958, the use or sale of peyote was prohibited by 15 states. By the 1960s some of these states (Oklahoma, Iowa, Montana, New Mexico, Texas, and Utah) had revised their laws to allow peyote in religious services. In the Arizona Superior Court (Flagstaff), a law prohibiting the use of peyote was declared (1960) "unconstitutional as applied to the acts of this defendant in the conduct of her religious beliefs" in the case of peyotist Mary Attakai. In 1961 the Arizona Supreme Court dismissed an appeal of the case. In 1962 three Navaho Indians were prosecuted in the Superior Court of San Bernardino County for using peyote in a religious ceremony contrary to California law. By 1964 the California Supreme Court had set aside their suspended sentences, comparing the practice of carrying peyote in beaded bags with the use of religious medallions and stating: "To forbid the use of peyote is to remove the theological heart of peyotism."

Despite some state laws, the U.S. Congress has rejected nine bills (from 1916 to 1937) that would have prohibited use, sale, and transportation of peyote. However, persons shown to be addicted to peyote can be sent to federal narcotic hospitals under a 1929 law. By the 1960s no such cases had been found; evidence was not available that peyote produces addiction. A Navaho Tribal Council ordinance of 1940 prohibiting peyote on the reservation has been upheld three times in federal courts. In each case (the third was in a Washington, D.C., Court of Appeals, 1962) the court denied itself jurisdiction over Navaho Tribal Council legislation regarding religion.

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(J. S. SR.; O. C. ST.)

PFEFFER, WILHELM (FRIEDRICH PHILIPP) (1845–1920), German physiological botanist whose work on osmosis marked an epoch in investigations on the properties of semipermeable membranes and water solutions (*see* SOLUTIONS: *Osmotic Pressure*). He was born in Grebenstein near Kassel on March 9, 1845. After earning a degree in botany and chemistry from Göttingen University in 1865, he spent the next several years studying botany and pharmacy at Marburg University. He continued his botanical studies as a private assistant to Nathanael Pringsheim at Berlin (1869–70) and to Julius von Sachs at Würzburg University (1870–71). In 1871 he returned to lecture at Marburg and in 1873 was appointed lecturer of a higher rank at Bonn University. In 1877 he became a professor at Basel University and later held similar positions at the universities of Tübingen (1878) and Leipzig (1887).

Pfeffer made significant contributions in the following areas of plant physiology: respiration, photosynthesis, protein metabolism, tropic and nastic movements. In 1881 he published the first part of his *Handbuch der Pflanzenphysiologie* (English translation by A. J. Ewart, *Physiology of Plants*, three volumes, 1906), which prevailed for many years as an important text. He died Jan. 31, 1920, in Leipzig. He published more than 100 papers and books.

(W. J. MCI.)

PFITZNER, HANS ERICH (1869–1949), German composer who upheld traditional ideals during the post-Wagnerian era. Born in Moscow on May 5, 1869, he was a pupil at Frankfurt of Iwan Knorr. Between 1892 and 1934 he held posts as teacher and conductor in several German towns, including Strassburg, where he was director of the conservatory and of the opera. His operas include *Der arme Heinrich* (Mainz, 1895), *Die Rose vom Liebesgarten* (Eberfeld, 1901), and *Palestrina* (Munich, 1917), the last being his best-known work. Influenced by the nationalist movements in European music after World War I, Pfitzner was held to reaffirm a specifically German character, though most of his works are written in a traditional Romantic style. Between 1915 and 1919 he attacked modern tendencies in pamphlets on the music drama and contemporary music. His works were widely played in Germany but made little impression in other countries. He died at Salzburg on May 22, 1949.

PFORTE (or SCHULPFORTE), formerly a Cistercian monastery (of which remains can still be seen), later a famous German boarding school. It lies 2 mi. SW of Naumburg, Saxony, German Democratic Republic. The monastery, which had the name Monasterium Sanctae Mariae de Pforta (or *apud Portam*), was established in 1137. In 1540 it was dissolved by Henry of Saxony and in 1543 his successor, Maurice, founded there one of his three Protestant "princely" schools (*Fürstenschulen*), the others being at Grimma and Meissen. The school provided a humanist classical education. Its pupils include Paul Gerhardt, C. F. Gellert, Klopstock, Lessing, Ranke, and Nietzsche. From 1935 to 1945 it was a school for the training of a Nazi elite. After World War II it became a high school for boy and girl boarders receiving a scientific, modern language, or classical education.

See W. Hirschfeld, *Das Zisterzienserkloster Pforte* (1933); F. Heyer, *Aus der Geschichte der Landesschule Pforte* (1944); R. Pahncke, *Geschichte des Zisterzienserklosters Pforte* (1956).

PFORZHEIM, a town of West Germany in the *Land* (state) of Baden-Württemberg, Federal Republic of Germany. It is situated on the northern edge of the Black Forest, where the Nagold and Würm join the Enz River, 31 km. (19 mi.) SE of Karlsruhe by rail. Pop. (1961) 82,532. The inner town, destroyed during the war, has been rebuilt with broad thoroughfares and open spaces along the rivers. Notable buildings include the castle church of St. Michael (13th–15th century), the church of St. Martin (14th century) and the Reuchlin House (containing both history and jewelry museums). Pforzheim has been the main centre of the German jewelry and watch industry since the 18th century; other manufactures include machinery, radio and television apparatus, and paper. The town was a Roman settlement

(Portus), had the status of a city shortly after 1195, and was occasionally the residence of the margraves of Baden-Baden (*q.v.*) and Baden-Durlach. The humanist Johann Reuchlin was born there in 1455, and its Latin School was famous. The town was sacked during the Thirty Years' War and the War of the Grand Alliance. (HE. W.)

PHAEDO (5th–4th century B.C.), Greek philosopher, founder of a short-lived school of philosophy at Elis in the Peloponnese, was born at Elis late in the 5th century B.C. Taken prisoner in the war with Sparta (400–399), he was sold as a slave. In Athens he became acquainted with Socrates, one of whose pupils redeemed him from slavery. Plato named one of his dialogues after him (*see* PLATO: *The Earlier Dialogues*), but Athenaeus says that Phaedo disclaimed all responsibility for the role ascribed to him in it. Aeschines also wrote a dialogue called *Phaedo*. After Socrates' death, Phaedo returned to Elis and set up his own school, of which his pupil Pleistanus became head on Phaedo's death but which Menedemus (*q.v.*) subsequently transferred to Eretria. Phaedo's main interest seems to have been in ethics. Of his own dialogues, all of which are lost, the best known were the *Zopyrus* and the *Simon*. U. von Wilamowitz-Moellendorff tried to reconstruct the content of these from references in later texts.

PHAEDRA, in Greek legend, the wife of Theseus and stepmother of Hippolytus, whom she tried to seduce. *See* HIPPOLYTUS.

PHAEDRUS (fl. 1st century A.D.), Roman fabulist of uncertain date, whose work, though ignored by classical Roman writers, was apparently the first of its kind in Latin and attained great popularity in the middle ages. It seems probable that he was born *c.* 15 B.C. and lived at least until the reign of Claudius. His birthplace was Thrace, whence he went early to Italy and received the customary training in Greek and Latin, studying among other authors, Euripides, Simonides, Ennius and Virgil. A slave by birth, he became a freedman in Augustus' household, but, as the prologue to book iii of his *Fabulae Aesopiae* states, later fell foul of Tiberius' minister Sejanus and was prosecuted and punished. "The fable," wrote Seneca *c.* A.D. 43, "has not been tackled by the Roman genius." If one presses the word "Roman" and recollects Phaedrus' foreign extraction, this statement need not imply ignorance of Phaedrus. The Phaedrus mentioned by Martial (iii, 20, 5) has been identified, but on uncertain grounds, as the fabulist. Fables are placed by Quintilian (i, 9, 2) on the curriculum of the young, but, though "Aesop" is named, Phaedrus is not. Unless Martial's Phaedrus is the same man, the earliest reference to him is in the works of Avianus, who about the end of the 4th century composed 42 fables in undistinguished elegiacs.

Though Ennius, Lucilius and Horace had introduced fables into their poems, Phaedrus was the first writer to latinize whole books of fables. His contribution consists of free versions in iambic metre of Greek prose fables then circulating under the name of "Aesop." His iambic senarius, or six-foot line, conceivably influenced by that of Publilius Syrus, is nearer the rough vigour of Plautus than the monotonous artificiality of Seneca: spondees frequently replace iambs in the second and in the fourth feet. Phaedrus' latinity, apart from a few instances of slipshod syntax and vulgar speech, is close to the Augustan norm. Abstract expressions (*e.g.*, *majestas ducis* = "the emperor") smack of the Latin of the silver age. Original poetic imagery is wanting, and epithets are mainly conventional. Phaedrus plumes himself on his brevity; for this as for his simplicity he merits praise.

The popularity, both in Europe and in the east, of the literary beast fable needs no emphasis. (*See* FABLE.) Even the ubiquitous moral tag subtracts little from enjoyment of such favourites in the Phaedrian corpus as "The Fox and the Sour Grapes," "The Wolf and the Lamb," "The Lion's Share," "The Two Wallets" and "The Pearl in the Dung-heap." Phaedrus considers himself a genuine artist, the pioneer of a genre unattempted by his Roman predecessors, whose poems, combining charm with a serious didactic purpose (*utilitas*), are assured of immortality. His stories are enlivened by various references to contemporary Roman society, and some could be interpreted, especially if the cap fitted, not merely as social but as political satire.

The Recovery of the Text.—Avianus states that Phaedrus wrote five books of fables only; and the first printed edition of Phaedrus, published by Pierre and François Pithou at Troyes in 1596, in fact had its contents divided into five books. At the beginning of the 18th century, however, there was discovered at Parma a manuscript of Nicolaus Perottus (Niccolò Perotto or Perotti; d. 1480), the humanist archbishop of Siponto, containing 64 fables of Phaedrus, of which 30 were new. These new fables were published by G. A. Cassitto in 1808 and next, more correctly, by C. Jannelli in 1809; but these editions were superseded by the discovery of a much better preserved manuscript of Perottus in the Vatican, published by Angelo Mai in 1831. The authenticity of these new Phaedrian fables was for some time disputed, but is now generally accepted, though it is impossible to assign them to their original places in the five books. They are usually printed as an appendix.

Knowledge of Phaedrus' works, meanwhile, can be further extended by a careful investigation of the prose versions of his fables current in the middle ages. Of these the oldest collection existing seems to be that known as the *Anonymus Nilanti*, so-called because first edited by J. F. Nilant (at Leiden in 1709). For his edition Nilant used a manuscript of the 13th century, but the collection itself is associated with a little-known writer called Romulus and may have been made in the Carolingian period or even earlier. Later such collections are the Adhemarian, made by Adhémar de Chabannes; and the Weissenburg, from the monastery of SS. Peter and Paul at Wissembourg in Alsace. After a detailed examination of these three medieval collections, Carl Magnus Zander (*see* bibliography) restored 30 more fables to the iambics of Phaedrus.

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PHAER (PHAYER), **THOMAS** (1510?–1560), English writer, best known for a translation of Virgil's *Aeneid* (1558) which is less medieval in tone than those of Gavin Douglas (1553) and the earl of Surrey (1557). Educated at Oxford and at Lincoln's Inn, London, Phaer was a doctor (M.D. 1559) and lawyer as well as a writer and describes himself as "solicitor to the king and queen in the marches of Wales." He translated, with original additions, a medical text by Jehan Goeurot under the title *The Regiment of Lyfe* (1544). He also contributed to *A Myrroure for Magistrates* (1559) and has been credited with *Natura Brevium Newly Corrected in Englisshe* (1532) and *A Newe Book of Presidentes* (1543). *Seven First Bookes of the Eneidos of Virgill Converted in Englishe Meter* appeared in 1558; it was extended to nine books in 1562. The task, left unfinished at his death (Aug. 1560 at Kilgerran, Pembrokeshire) was completed by Thomas Twyne (1584). (H. H. Ds.)

PHAETHON, in Greek mythology, the son of Helios, the sun-god, and the nymph Clymene. His name means "shining" or "radiant." Taunted with illegitimacy, he appealed to his father, who swore to prove his paternity by giving him whatever he wanted. Phaethon asked to be allowed to drive the chariot of the sun through the heavens for a single day. Helios begged him to ask for something else, as the difficulties and dangers of such a task were insuperable for mortal man. Phaethon insisted, however, and Helios, bound by his oath, let him make the attempt. He set off, but was entirely unable to control the horses of the sun chariot, which came too near to the earth and began to scorch it. To prevent further disaster Zeus hurled a thunderbolt at Phaethon, who fell to the earth at the mouth of the Eridanus, a river later identified with the Po. There his mourning sisters, the Heliades, were transformed into poplars and their tears became amber. The story is fully told in the first and second books of Ovid's *Metamorphoses* and in the 38th book of Nonnus' *Dionysiaca*.

PHAGOCYTOSIS is the process by which living cells ingest or engulf other cells or particles. The phagocytic cell may be a free-living, unicellular organism, such as an amoeba, or one of the body cells, such as a leukocyte (white blood cell). The particles commonly phagocytized include bacteria, tissue cells (usually dead), protozoa, various dust particles, pigments, and other minute

foreign bodies. In the simpler forms of animal life, such as amoebae and sponges, phagocytosis is a means of feeding; in higher animals phagocytosis is chiefly a defensive reaction against infection.

To Elie Metchnikoff is due the chief credit for recognizing the importance of phagocytosis in protecting the body against infectious agents. In man and in vertebrates generally, the most effective phagocytic cells are the macrophages (large phagocytic cells) and the granular leukocytes (small phagocytic cells). The macrophages occur especially in the liver, spleen, and lymph nodes, where their function is to free the blood and lymph of bacteria and other particles. Macrophages are also found in all tissues as wandering amoeboid cells, and a cell related to the macrophage is found in the blood (*q.v.*). The smaller type of phagocyte (granular leukocyte) is carried along by the circulating blood until it reaches an area of infection, where it crawls through the blood vessel wall, being directed toward the invading bacteria by means of substances given off by the bacteria.

This directed movement is known as chemotaxis.

Before phagocytosis is accomplished, the phagocyte and particle must adhere to each other, and whether this is possible depends largely on the chemical nature of the surface of the particle. On less virulent bacteria ordinary proteins from the blood form a surface film to which leukocytes adhere, and phagocytosis follows. But virulent bacteria are ingested with more difficulty. Leukocytes, instead of adhering to them, succeed only in pushing them away. If, however, the leukocytes succeed in pushing them against a firm surface, such as the lining of a blood vessel, the bacteria may not be able to slip away and are ingested. This process is known as "surface phagocytosis." Other virulent bacteria may not be phagocytized until their surfaces are coated with peculiar globulins (proteins) formed by the body in response to the presence of that kind of bacterium. Such globulins are called antibodies, and antibodies are of great importance in establishing immunity of the body to diseases. (*See* also IMMUNITY AND IMMUNIZATION.)

The manner in which a phagocytic cell ingests a particle varies somewhat with the size of the particle. Small particles, such as bacteria or minute grains of charcoal, seem to be ingested in an instant. At one moment they appear through the microscope to be adherent to the surface of the phagocyte; at another moment they are inside it. Larger objects such as clumps of bacteria or tissue cells are phagocytized by a more prolonged response of the leukocyte. The cell flows around the object until it has been completely engulfed.

The results of phagocytosis are digestion and destruction of the particle by means of enzymes inside the phagocyte. This is the chief means by which the body gets rid of bacteria and other microorganisms. If the particle is indigestible, however, as is a grain of carbon, it eventually may be ejected by the phagocyte. Also, ingested living organisms, such as tubercle bacilli, may be resistant to the intracellular digestive enzymes and not only survive but multiply within the phagocyte. In moving about, the phagocyte may then carry such bacteria into other parts of the body and therefore actually assist in the spread of disease instead, as is more usual, of defending the body against infection.

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PHAGOCYTOSIS OF STREPTOCOCCI BY A LEUKOCYTE, SURROUNDED BY ERYTHROCYTES

It is possible to mimic phagocytosis by means of a demonstration of nonliving models. A drop of chloroform is suspended in water and a bit of clean thread of glass is placed in contact with the chloroform. Under these conditions, the glass is not taken up by the chloroform. Then the glass thread is coated with shellac and, since the chloroform is able to spread on the shellacked surface, the drop of chloroform phagocytizes the glass thread. Finally the chloroform dissolves the shellac and then ejects the uncoated glass thread.

See also BACTERIAL AND INFECTIOUS DISEASES; INFLAMMATION.

See Stuart Mudd, Morton McCutcheon and Balduin Lucké, "Phagocytosis," *Physiol. Rev.*, 14:210–275 (1934); J. Berry and T. T. Spies, *Medicine, Baltimore*, 28:239 (1949); M. R. Smith and W. B. Wood, Jr., *J. Exp. Med.*, 103:509 (1956). (M. McC.)

PHALANGER, a name applied to small to medium-sized, woolly-coated pouched mammals of the family Phalangeridae, native to Australia (where they are called opossums or possums), New Guinea and nearby islands. They have long, often prehensile tails, large claws and opposable, nailless, first hind toes. They are nocturnal in habit and feed on fruit, leaves and blossoms, though a few are insect-eaters. Several possess gliding membranes between the fore and hind limbs.

AXEL POIGNANT

PETAURUS SCIUREUS, A FLYING OPOSSUM OF THE PHALANGER FAMILY

Included among the arboreal gliding species are the flying opossums or sugar gliders, *Petaurus*, with several species on the Australian continent, the Aru Islands and New Guinea, and a parachuting form, the minute pygmy glider or feather tail (*Acrobates pygmaeus*) of eastern Australia.

The cuscuses (*Phalanger*) are arboreal animals the size of cats. The tail is prehensile. They inhabit the Solomon Islands, ranging thence to Timor and the Celebes. Nearly allied to these are the Australian forms, of which the common or brush-tailed phalanger (*Trichosurus vulpecula*), about the size of a small fox, is the best known. Others of the family include the pen-tailed phalangers (*Distoechurus*) and the long-snouted phalangers or honey possums (*Tarsipes*). The greater gliders (*Schoinobates*) and the ring-tailed opossums (*Pseudocheirus*) compose, with the koalas, the subfamily Phascolarctinae, which is sometimes elevated to a family. *See* MARSUPIAL.

PHALARIS, tyrant of Akragas (modern Agrigento) in Sicily *c.* 570–554 B.C., notorious for his cruelty, was responsible for the building of the Temple of Zeus Atabyrios in the citadel and took advantage of his position to make himself despot. Akragas seems to have prospered under his rule; its splendid planning probably belongs to his time. He fought against the Sicans and extended the territory of Akragas.

In a bronze bull, designed by Perilaus or Perillus, his victims were roasted alive, their shrieks representing the bellowing of the bull. Perilaus himself is said to have been the first victim. A bull of some kind seems historical, though probably embellished by fiction. Phalaris was overthrown by Telemachus, the ancestor of Theron (tyrant *c.* 488–472), and, it is said, was burned in his own bronze bull.

The later sophists perversely represented Phalaris as a naturally humane and cultured man. Lucian wrote two *Phalaris* speeches; the famous 148 *Letters of Phalaris* were proved by Richard Bentley (*q.v.*) to have been written by a sophist or rhetorician (possibly Adrianus of Tyre, d. *c.* A.D. 192) hundreds of years after the death of Phalaris. Before their exposure by Bentley the letters were highly thought of, *e.g.*, by Sir William Temple in his *Essay on Ancient and Modern Learning* (1692), though others, such as Politian and Erasmus, perceived that they were not by Phalaris.

For the letters *see* R. Hercher, *Epistolographi Graeci*, pp. 409–459 (1873); R. C. Jebb, *Bentley*, ch. 4–5 (1882). *See* also T. J. Dunbabin, *The Western Greeks*, ch. 10 (1948), for history.

PHALAROPE, the name for three species of shorebirds constituting the family Phalaropodidae. The lobed membranes on their toes and their denser plumage, features that distinguish them from sandpipers, enable phalaropes to swim freely. Males, which in the reproduction season are less brightly coloured than females, incubate the eggs.

The red phalarope, or grey phalarope of the British (*Phalaropus fulicarius*), and the northern phalarope, or red-necked phalarope (*Phalaropus* or *Lobipes lobatus*), nest throughout the Arctic and subarctic latitudes, while Wilson's phalarope (*Steganopus tricolor*) breeds only in North America, from British Columbia to central California and northwestern Indiana. After breeding, all the phalaropes spread southward over the oceans; many traverse the Equator, Wilson's even reaching the Falkland Islands.

(J. P. Ch.)

PHALLICISM (Phallism), a form of worship in which adoration is paid to the fertility and generative function, often symbolized by the male organ (phallus). The same principle is at the root of the nature worship of Asia Minor, in which the chief deity, the Great Mother of the Gods (*q.v.*), was the personification of the earth's fertility. Similarly in India worship is paid to divine mothers; the phallus is called *linga* or *lingam*, with the female counterpart called *yoni;* the *linga* symbolizes the generative power of Shiva (*see* Hinduism: *Gods*) and is a charm against sterility. The rites classed together as *Shakti puja* represent the adoration of the female principle (*see* Shaktism).

Phallic emblems are found in many parts of the world; for example, the serpent has been interpreted as a sexual symbol in Judeo-Christian religions (*see* Adam and Eve). The tendency, however, to identify all obelisklike stones and tree trunks, together with rites like circumcision, as remains of phallic worship has met with much criticism, and the best modern view is that phallicism never developed into an organized cult.

See also Aphrodite; Cabeiri; Dionysus; Priapus; Priapea.

See E. S. Hartland, "Phallism," in *Encyclopaedia of Religion and Ethics* (1928); G. R. Scott, *Phallic Worship* (1951).

PHANARIOTES, the general designation of the principal Greek families resident in the Phanar; *i.e.*, in the Greek quarter of Constantinople (Istanbul) under Turkish rule, where the ecumenical patriarchate of the Orthodox Eastern Church still has its seat. Members of these families served as dragomans (interpreters) to the Sublime Porte and to foreign embassies from 1669 and were appointed hospodars of one or other of the Danubian principalities (Moldavia and Walachia, vassal states of the Ottoman Empire) in the period 1711–1821, which is therefore known as the Phanariote period in the history of Rumania (*q.v.*). Leading Phanariote families were those of Argyropoulos, Cantacuzino, Mavrokordatos, and Ypsilantis.

See E. R. E. (Rizos Rangabé), *Livre d'or de la noblesse phanariote et des familles princières de Valachie et de Moldavie* (1904).

PHANIAS (Phainias) (fl. *c.* 300 B.C.), Greek philosopher, of Eresus on the island of Lesbos, was a pupil of Aristotle and a friend of Theophrastus, whom he joined in the Peripatetic School. He is mentioned as the author of works on logic, in which he probably followed Aristotle's doctrine; he also wrote, as Theophrastus did, on botany; and there are remains of works by him on poets, on the Socratic philosophers, and on history. His *Prytaneis of Eresus* was a history in which events in the Greek world in general were included, the chronology being determined by the series of the successive magistrates of his native place. In his *Tyrants of Sicily* he seems to have dealt with Western history against a panhellenic background. *See* also Peripatetics.

See the texts ed. by Carl Müller, *Fragmenta historicorum graecorum*, vol. ii (1848); also R. Laqueur, "Phainias," in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. xix (1938).

(F. Wi.)

PHARAOH, the Hebrew form of the Egyptian *Per-a'o*, "the great house," signifying the royal palace, an epithet applied in the New Kingdom and after, as a title of respect, to the king himself (*cf.* the use of "the Sublime Porte" to designate the sultan of Turkey). In the 22nd dynasty the title was added to the king's personal name; the biblical "Pharaoh Hophra" is in accordance with contemporary native usage. The Assyrian form was *Pir'u*.

In official documents the full titulary of the Egyptian king contained no fewer than five names. The first and oldest identified him as the incarnation of the falcon-god Horus, ; it was often written inside a square called *serekh*, depicting the facade of the archaic palace. The second name, "Two Ladies," , placed him under the protection of Nekhbet and Buto, the vulture and uraeus goddesses of Upper and Lower Egypt; the third, "Golden Horus," , signified perhaps originally "Horus victorious over his enemies." The last two names, written within a ring or "cartouche," , are generally referred to as the praenomen and nomen and were the ones most commonly used; the praenomen, preceded by , "King of Upper and Lower Egypt," usually contained a reference to the king's unique relationship with the sun-god Re, while the fifth, or nomen, was preceded by "Son of Re," or by "Lord of the Two Lands." This latter name was given him at birth; the rest were conferred upon him at his coronation, when his protocol was proclaimed.

Pharaoh was referred to in narrative as "His Majesty," or "the good god" or "the sovereign," or simply by the impersonal "One went . . ." as a circumlocution of respect. In accordance with the concept of divine kingship his person was sacrosanct, and his insignia—diadems, crowns, sceptres, staves—had magic properties.

See H. Frankfort, *Kingship and the Gods* (1948); Hugo Müller, *Die formale Entwicklung der Titulatur der aegyptischen Könige*, Aegyptologische Forschungen 7 (1938). (M. S. Dr.)

PHARISEES, a Jewish sect of the second commonwealth. Its origins are obscure. According to rabbinic tradition, the Pharisees were in the direct line of transmitters of the Oral Law from Ezra and the men of the Great Sanhedrin. Their more immediate ancestors were the pietistic group of *Hasidim* who, in the middle of the 2nd century B.C., helped spearhead the Maccabean revolt (*see* Maccabees). They gradually disappeared as a distinct movement after the fall of Jerusalem in A.D. 70, only because virtually the whole Jewish people accepted their ideology.

According to Josephus, the Pharisees, in contrast with the Sadducees, believed in retribution after death and personal resurrection, and also espoused a combination of free will and predestination. Far more important, however, was the Pharisees' insistence on the binding nature of Oral Law, which, in their opinion, had been revealed to Moses simultaneously with the written Torah and had co-ordinate authority with it.

The polemical utterances in the Gospels (for instance, Matt. xxiii, 15; Mark vii, 6), apparently aimed at the more rigid faction of the house of Shammai (*q.v.*), created the image of the Pharisees as religious hypocrites—an image from which only modern research has been able to free them. *See* Jewish Sects During the Second Commonwealth; *see* also references under "Pharisees" in the Index.

See Louis Finkelstein, *The Pharisees: the Sociological Background of Their Faith*, 2nd rev. ed., 2 vol. (1940); Salo W. Baron, *A Social and Religious History of the Jews*, 2nd rev. ed., especially vol. ii, p. 35 ff., p. 342 ff., with bibliography (1952). (S. W. B.; X.)

PHARMACOLOGY. In the broadest sense, pharmacology is the study of the changes produced in living animals by chemical substances (except foods); the animals may include any species from a microorganism to man.

The term pharmacology is used sometimes, in a more restricted sense, to refer to the study of the action of drugs, that is, agents used to treat diseases. This represents the most important application of pharmacology and explains its place among the medical sciences. It is clearly distinguished from pharmacy, the art of preparing drugs for use, but is closely related to therapeutics, the application of drugs to the treatment of disease, and to toxicology, the study of poisons and poisonings; both of these may be considered to be specialized applications of pharmacology. In a

practical sense, pharmacology is the experimental science on which therapeutics is based, since the safe and effective use of drugs in the treatment of diseased patients is possible only after careful observations of their effects in the laboratory.

Origins of Pharmacology.—Attempts to use drugs to alleviate disease are as old as the history of man, but until the last century they were based mainly on superstition, magic, religion or at best on trial and error. European medicine before A.D. 1500 was characterized by rigid adherence to the medical doctrines of the ancient Greeks—principally those of Galen (*c.* A.D. 130–*c.* 200), whose prolific writings, about a hundred volumes in all, represented some original observations, many elaborate recipes for prescriptions and a great many dogmatic "explanations." The writings of Galen were accepted as absolute authority for more than a thousand years, to such an extent that original observations and experimentation were not only discouraged but often actually forbidden. The first among many successful rebels against Galenism was Paracelsus (Theophrastus Bombastus von Hohenheim, *c.* A.D. 1490–1541), a truly bombastic iconoclast who wandered through northern Europe, always in trouble with the local authorities, but overcoming the objections of his contemporaries by his therapeutic successes. He was an original thinker and daring innovator who introduced many new remedies and advocated simple prescriptions with one or a few ingredients rather than the dozens handed down from Galen.

In the next 300 years, there was a steady accumulation of information on the structure and functions of the body both in health and disease. However, therapeutics remained an "art" rather than a science, and, although the term "Pharmakologie" was used in 1692 by S. Dale in London, it meant merely the description of substances used in medicine. The pharmacopoeias (official volumes containing descriptions and outlining standards for drugs) included such remedies as dried vipers, foxes' lungs, and moss from the heads of criminals who had been hanged in chains, along with some herbs of real value. The concept of systematic laboratory investigation of drug action did not arise until about 1850; it was not until then that the public was made aware of the necessity for animal experimentation (by François Magendie, the French physiologist). Observations of the action of chemicals on the animal body became possible only after the new physiologists developed sensitive methods for the measurement and recording of changes in the function of the body. An equally important contribution was the striking development of chemistry. It was difficult to experiment with the crude drugs and extracts available because their potency varied from one batch to another. The situation began to change during the first half of the 19th century, when the new chemists in France and Germany isolated many active substances—morphine, strychnine, atropine, quinine and many others —from their crude plant sources.

As these pure chemicals became available (and later, as thousands of new chemical compounds were synthesized in the rapidly expanding German dye industry), more and more studies of drug action were made. The first students of pharmacology were physiologists who became curious about the effects of the substances on heart rate, respiration or other of the physiological functions they were studying—or who used the compounds as tools to study physiological problems. The first laboratory devoted exclusively to experimental pharmacology was that of Rudolph Buchheim at Dorpat (now Tartu, Est.) in 1846–47; he contributed the idea that the effects of drugs on the body should be explained as well as described.

Pharmacology as an independent experimental science was really founded and firmly established by the German Oswald Schmiederberg (1838–1921). He defined its purpose—the study of the damage brought about in living organisms by chemically acting substances (except foods, whether used for therapeutic purposes or not). He wrote a textbook of pharmacology, helped to found the first journal devoted to reports of pharmacological experiments, and, most important, headed a school at Strasbourg which attracted students from all over the world. His school was the nucleus from which independent departments of pharmacology were established in universities all over the world.

Methods and Purposes of Pharmacology.—The work of pharmacologists is closely related to that of other biological scientists. In order to understand the changes produced in living animals, pharmacologists must understand, and be able to measure, the normal operations of the animal body—physiology. They must also understand pathology, the study of changes in structure and function resulting from injury or disease. The recognition and description of such changes may require not only gross observations on living animals but also microscopic examination of tissues or cells, or chemical determinations on body fluids or excretions. If pharmacologists study the effectiveness of such drugs as antiseptics or antibiotics, they must use the concepts and methods of bacteriology. If they are attempting to find the ingredients responsible for the actions of crude plant drugs, they may find themselves involved in both chemistry and botany. Their work is often related to biochemistry (chemistry of living things), since they study effects of foreign substances on cells or chemical systems of the body.

During the earlier years of the new science, its workers became aware that a relation exists between the chemical structure of a compound and the effects it produces in the body. Since that time, increasing emphasis has been placed on this phase of pharmacology and many studies describe the changes in action resulting from small changes in the chemical structure of the drug. Since most agents of medical interest are organic chemicals (complex structures containing carbon atoms), pharmacologists who engage in such studies must have an understanding of organic chemistry.

The development of atomic resources for peacetime uses after World War II brought pharmacologists into a new area of investigation. One of the major problems of pharmacology has always been the difficulty of determining the fate of foreign compounds in the body. The doses of most potent drugs and poisons are small, and when they are distributed in large volumes of body fluids, they become almost impossible to detect or measure by ordinary chemical means. However, it is highly desirable to trace minute amounts of the compounds in the bloodstream or in the organs of the body in order to determine whether they are concentrated in any organs or cells and to establish how long they remain and how they are excreted. This was made possible by the availability for scientific investigation of radioactive isotopes (chemical elements having almost exactly the same chemical properties as the normal, but capable of being detected by Geiger counters or similar instruments). Since 1945, pharmacologists have been tracing the passage of some compounds through the body by incorporating radioactive atoms into the compounds they wish to study. The small amounts of radioactivity are not harmful to the animals; in fact, in some carefully controlled studies such determinations have been made on human volunteers. The tracer compounds are usually synthesized chemically, but where this is difficult or impossible, they have been prepared by exposing plant or animal sources to radioactive materials in such a way that radioactive atoms are incorporated into the desired compounds as the living plant or animal manufactures them; the radioactive substances are then isolated and purified to be used in experiments.

In general, pharmacologic investigations are directed toward describing completely the interaction between the body and the drug. This includes describing fully the sequence of physiological changes that occur and describing what happens to the drug itself. It includes also explanations for the observed changes, at least in terms of physiology, and preferably in terms of chemistry or physics. Chemical explanations of mechanisms of action have been established for a number of chemical substances. These explanations have much more than academic interest; they tend to increase our knowledge of physiology and other biological sciences; they make it possible to use drugs more effectively; and by showing what characteristics are necessary for therapeutic action they stimulate the search for more effective new agents, without the undesirable side effects possessed by many available drugs. Such information is also sought for poisonous compounds used in the home (bleaches, insecticides, etc.), in industry or in agriculture (pesticides) in order to minimize health hazards (see *Pharmacology in Public Health*, below).

Pharmacology in Medical Education and Research.—Since pharmacology is a part of the curriculums of medicine, dentistry, veterinary medicine and pharmacy, departments of pharmacology are usually associated with educational institutions in these fields; the programs usually include training and study at the graduate level as well as the required courses of instruction. Such departments, especially in medical schools, are traditionally devoted to the study of basic problems in pharmacology and to the application of basic principles to the solution of specific medical problems. Research in pharmacology is conducted also in many hospitals and foundations, either publicly or privately supported.

Pharmacology in the Drug Industry.—Important basic research is carried out in the research laboratories of pharmaceutical and chemical companies. After 1930, this area of pharmacological research expanded rapidly, particularly in the United States. The utilization of the financial resources of industry, together with the contributions of universities, hospitals and foundations, resulted in the solution of many complicated problems in a surprisingly short time. Many new therapeutic agents were developed (*e.g.*, sulfa drugs, antibiotics, cortisone, "tranquilizing" drugs and many others), and a great body of fundamental knowledge was accumulated.

The work of pharmacologists in industry deals also with the exhaustive tests that must be made before promising new drugs can be introduced into medical use. Detailed observations of effects on all systems and organs of experimental animals are necessary before the physician can accurately predict effects of the drug on his patients, but their principal purpose is to disclose any potential toxicity to man. It must be emphasized that, except under unusual circumstances, the pharmacologist does not test the effects of drugs in patients; this is done only after complete tests on animals and is usually conducted by physicians to determine the clinical effectiveness of new drugs.

Constant testing is also required for the routine control and standardization of drug products. Those which contain only pure active ingredients can be tested by chemical means, but a few still remain that consist of relatively crude mixtures of plant or animal products (digitalis and pituitary, for example). These can be standardized (adjusted to standard strength) only after the pharmacological potency of each batch is determined by comparing its effect on some species of animal with the effect of a standard sample of drug. This process of testing is known as bioassay, and the entire process of standardization is known as biological standardization.

Pharmacology in Public Health.—The public welfare is obviously dependent on adequate pharmacological examinations of new products, but the development of new compounds and new processes throughout industry is also associated with potential health hazards for workers. The study of such hazards is termed industrial toxicology and the concepts and experimental methods are those of pharmacology, adapted for special conditions. Another application of pharmacology (or, more specifically, of toxicology) is in the study of the poisons used in agriculture to control plant pests and animal parasites. Here pharmacological or toxicological studies are undertaken to discover how the agents act to destroy pests; this makes it possible to use the agents more efficiently, and to develop more satisfactory new ones. Attention is also focused on the evaluation of potential health hazards and on the development of antidotes and methods of treatment to be used in cases of accidental poisoning. *See* also PHARMACY; PHARMACOPOEIA. (V. E.)

PHARMACOPOEIA, a book published by a government, or otherwise under official sanction, to provide, for a specific political area, standards of identity, quality and strength for those medicinals which represent the best practice and teaching of medicine. The primary function of a pharmacopoeia is to describe each drug on the approved list in such a way that whenever dispensed it meets the standards of quality and strength established for it. The provisions of the pharmacopoeia in force (*i.e.*, the one that is "official") are binding upon all who produce drugs and those who dispense them. The pharmacopoeia is a fundamental safeguard to public health.

The task of compiling most pharmacopoeias is carried out without compensation by experts in the professions of medicine, chemistry and pharmacy at the request of the agency undertaking the compilation, usually that responsible for matters of public welfare. Most programs are financed from government funds, but the *British Pharmacopœia* and the *United States Pharmacopeia* are written by private, nonprofit organizations with the sanction of their respective governments. In the case of these pharmacopoeias, the proceeds of their sale support the work of revision.

The oldest record in the form of a pharmacopoeia is a stone tablet of ancient Babylonia, believed to have been inscribed about 1700 B.C. The first true pharmacopoeia to appear in Europe was the Florentine *Nuovo Receptaris* (1498). The Danish Pharmacopoeia (established 1772) is the oldest in continued existence. The following countries established pharmacopoeias (the dates indicate the latest edition or [italics] supplement or reprinting): Argentina (1957), Austria (1960), Belgium (1930, *1953*), Brazil (1959), Chile (1941), China (1953), Czechoslovakia (1954, *1959*), Denmark (1948, *1954*), Egypt (1953), Finland (1956), France (1949, *1954*), Germany (1926, *1951*), Greece (1924), Hungary (1954, *1958*), India (1955), Italy (1940), Japan (1961), Mexico (1952), Netherlands (1958), Norway (1939, *1953*), Paraguay (1945), Poland (1954, *1962*), Portugal (1946), Rumania (1956), Spain (1954), Sweden (1946), Switzerland (1933, *1958*), Turkey (1948), U.S.S.R. (1961), United Kingdom (1963), United States (1960, *1962*), Venezuela (1942), Yugoslavia (1951).

Most countries not having a national pharmacopoeia adopted that of one or more other nations or in some cases adopted the international pharmacopoeia (*see* below).

The pharmacopoeial standards form the basis for enforcement of laws on the quality of drugs made available within the country concerned. Thus, the standards established have a vital bearing on the level of public health and the practice both of medicine and pharmacy. Actual enforcement of the standards is generally a function of an agency separate from that which creates them, but there are exceptions to this, notably in Canada, where the same department both establishes and enforces the standards. Enforcement involves collection and analysis of drug samples purporting to be of pharmacopoeial quality; when the analytical findings do not substantiate the label claim, legal action may be taken. This form of control varies greatly from one country to another. Where the central government is strong, the control is generally on a uniform national scale, as in the Americas and most of Europe. Where the local government is strong, as in the case of the cantons of Switzerland, enforcement is mainly on a local scale. These inter- and intra-national differences result in variations in the strength and quality of drugs, which cause confusion for both travelers and medical practitioners and are not in the best interests of public health. Travelers benefit especially from uniform drug standards. For example, a diabetic who travels must depend largely upon local sources for the insulin that makes the difference for him between good health and dangerous illness. Insulin is prepared from the pancreatic glands of cattle and its potency must be standardized by assays on rabbits or mice. Furthermore, it deteriorates if not kept cold. However, thanks to the acceptance of uniform pharmacopoeial standards, good insulin is available almost everywhere.

International Pharmacopoeia.—Efforts to eliminate international differences in drug standards date to 1865, but the first practical move was made in 1902 by the Belgian government in sponsoring an international conference in Brussels. This resulted in the Brussels agreement of 1906, which proposed uniform nomenclature and standards of strength for many important drugs, particularly those which were being dispensed in the form of tinctures and infusions. A second conference in 1925 went still further toward establishing uniformity in pharmacopoeial standards among nations. These agreements were limited in scope, since they applied to only a few of the drugs in use.

The problem became more acute with the increase in international travel and in international trade in medicinal products after 1925, and received the attention of the Health Organization of the League of Nations, which created a Technical Commission of

Pharmacopoeial Experts. The original seven-member group undertook to prepare an international pharmacopoeia, but this was interrupted when the League went out of existence. However, the work was resumed almost immediately upon creation of the World Health organization, a specialized agency of the United Nations which is the successor to the Health Organization of the League. The newly formed Expert Committee on the Unification of Pharmacopoeias (which later became the Expert Committee on the International Pharmacopoeia and Pharmaceutical Preparations) succeeded in compiling the first volume of the *Pharmacopoea Internationalis* for publication in 1951. A second, complementary volume appeared in 1955, and a supplement was added in 1958. The WHO published the texts in English, French and Spanish, but translations into German and Japanese were undertaken privately under WHO authority. The WHO planned to revise the standards periodically toward the end of providing model specifications for all of the important drugs.

The *Pharmacopoea Internationalis* was put forward by the WHO only as a recommendation aimed to minimize or eliminate entirely variations among national pharmacopoeial standards. Some nations among those without their own pharmacopoeia, for example, Ethiopia and Israel, made the international pharmacopoeia official for use within their borders.

The four Scandinavian countries and Iceland provided a notable example of international co-operation toward uniformity in drug standards. Jointly, they formed the Scandinavian Pharmacopoeial council, which laid the foundation for publication of a single pharmacopoeia in four languages (Danish, Finnish, Norwegian and Swedish) that supersedes the existing national pharmacopoeias of those countries as the binding authority on the identity, quality and strength of drugs.

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PHARMACUS, the title given in ancient Greek cult to a kind of human scapegoat used in certain state rituals. It is first mentioned by the 6th-century Ionian poet Hipponax in describing a ritual at Colophon in Lydia and is known also in Abdera (Thrace) and Massilia (modern Marseilles). In Athens a man and woman were selected as scapegoats each year. At the festival of the Thargelia (*q.v.*) in May or June, they were feasted, led round the town, beaten with green twigs, and driven out. The accounts sometimes suggest that they were killed with stones instead of being simply driven out of the country. The custom was meant to rid the place annually of ill luck.

See M. P. Nilsson, *Geschichte der griechischen Religion*, 2nd ed., vol. I, pp. 107–110 (1955). (H. W. PA.)

PHARMACY is the science and art concerned with the collection, preparation and standardization of drugs. Its scope includes the cultivation of plants that are used as drugs and the synthesis of chemical compounds of medicinal value. It further includes the analysis and standardization of medicinal agents. The pharmacist is responsible for the manufacture of the dosage forms of drugs, such as tablets, capsules and sterile solutions for injection. As a dispensing pharmacist, he compounds physicians' prescriptions for drugs. Pharmacology (*q.v.*) is the science that embraces all knowledge of drugs with special reference to their mechanism of action in the treatment of disease. Obviously this broad science has many subdivisions, such as toxicology (the study of poisons) and therapeutics (the use of drugs in the treatment of disease). Pharmacy, according to the foregoing description, is one of the subdivisions or specialties of pharmacology.

Historical Development.—The beginnings of pharmacy are of extremely ancient origin. When early man expressed a juice from a succulent leaf to apply to a wound he was practising this ancient art. In the book of Exodus, Moses was directed by the Lord to prepare "an ointment compound after the art of the apothecary." In the Greek legend, Asclepius, the god of the healing art, delegated to the beautiful Hygieia the duty of compounding his remedies. She was his apothecary or pharmacist. The physician-priests of Egypt were divided into two classes, those who visited the sick and those who remained in the temple and prepared the remedies for the patients.

In ancient Greece the art of healing recognized a separation between the duties of the physician and those of the pharmacist, and this separation prevailed also among the Roman practitioners. During the middle ages in Europe the separation of the two groups became less distinct. Many physicians undertook the preparation of their own medicines. The Moorish influence in Europe brought about the practice of separate duties for the pharmacist and physician again. The trend of specialization is exemplified by a law enacted by the city council of Bruges, Belg., in 1683, forbidding physicians to prepare their own remedies.

The distinct role of the pharmacist as separate from that of the physician is evidenced by the establishment of the office of apothecary general in the army of France during the middle of the 18th century. In America, Benjamin Franklin took an important step in keeping the two professions separated when he appointed an apothecary to the Pennsylvania hospital.

Education.—The history of pharmaceutical education has followed in the wake of medical education. As the training of the physician underwent the change from the apprenticeship system to formal educational courses, so did the training of the pharmacist. The first college of pharmacy was founded in the United States in 1821 and is now known as the Philadelphia College of Pharmacy and Science. Other institutes and colleges were established in the U. S., Great Britain and continental Europe. Later many universities organized schools and colleges of pharmacy within their courses of instruction. Colleges of pharmacy as independent organizations or as schools of universities operate in most countries of the world.

The course of instruction leading to the degree in pharmacy (bachelor of science in pharmacy) extends over four or five academic years. Many institutions, however, offer graduate courses in pharmacy and cognate sciences leading to the degrees of master of science and doctor of philosophy. These advanced courses are especially intended for those who are preparing for careers in research, manufacturing or teaching in the field of pharmacy.

It is clear that since the medication of the sick with drugs encompasses a wide field of knowledge in the biological and physical sciences, an understanding of these sciences is necessary for an adequate pharmaceutical training. The basic four-year curriculum in the colleges of pharmacy of the United States embraces physics, chemistry, biology, bacteriology, physiology, pharmacology and many other specialized courses such as dispensing pharmacy. In addition, subjects of a general educational character such as languages and mathematics are included. As the pharmacist is engaged in a business as well as a profession, special training is provided in merchandising, accountancy and pharmaceutical jurisprudence. After 1960 one year of college work in addition to high school was required for entrance to colleges of pharmacy in the United States.

Legislation.—Before he is permitted to practise pharmacy, an applicant must be qualified by graduation from a recognized college of pharmacy, meet specific requirements for experience and pass an examination conducted by a board of pharmacy appointed by the government. The passing of this board examination confers upon the person the legal right to practise pharmacy. In the United States he is then designated a registered pharmacist.

The pharmacy laws include the regulations for the practice of pharmacy, the sale of poisons, the dispensing of narcotics and the sale and labeling of dangerous drugs. The pharmacist sells and dispenses drugs within the provisions of the food and drug laws of the country in which he practises. These laws recognize the national pharmacopoeia as the standard for drugs (*see* PHARMACOPOEIA). The pharmacopoeias of the different nations are compiled and published according to the respective legal national procedures. The World Health Organization of the United Na-

tions published the first volume of the *Pharmacopoea Internationalis* in 1951. Its purpose is to standardize, as far as possible, the medication with drugs throughout the world. Furthermore, the *Pharmacopoea Internationalis* provides standards for drugs for smaller nations that have no national pharmacopoeia.

Organizations.—There are numerous national and international organizations of pharmacists. In Britain the Pharmaceutical Society of Great Britain, established in 1841, is typical of the pharmaceutical organizations. In the United States the American Pharmaceutical association, established in 1852, is a society that embraces all pharmaceutical interests. Some of the other organizations in the United States are the American Drug Manufacturers' association, the Federal Wholesale Druggists' association and the National Association of Retail Druggists. Among the international societies is the Fédération Internationale Pharmaceutique, founded in 1912 and supported by 35 national societies, for the advancement of the professional and scientific interests of pharmacy. The Pan American Congress of Biochemistry and Pharmacy includes the pharmaceutical societies in the various countries in the western hemisphere.

There are also other international societies in which history, teaching and the military aspects of pharmacy are given special emphasis.

Research.—Pharmaceutical research is conducted mainly in the schools of pharmacy and in the laboratories of the pharmaceutical manufacturing houses. It embraces the organic chemical synthesis of new chemical agents for use as drugs and is also concerned with the isolation and purification of plant constituents that might be useful as drugs. Research in pharmacy also includes methods for assay and standardization of medicinal agents. These phases of research in pharmacy are primarily an application of the science of chemistry to drug products, but the pharmacist also engages in research that is peculiar to the profession. This research involves formulation of dosage forms of medicaments, a study of their palatibility, methods of standardization and their stability. The researches of pharmacy are usually published in journals, such as the *Journal of Pharmacy and Pharmacology* (London), the *Journals* of the American Pharmaceutical association (Scientific Edition and Practical Edition) (Washington), the *American Journal of Pharmacy* (Philadelphia) and the *Pharmaceutica Acta Helvetiae* (Zürich). *See* also APOTHECARY; PHARMACOLOGY; PHARMACOPOEIA.

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PHARNABAZUS (5th–4th century B.C.), Persian soldier and statesman, was hereditary satrap of Dascylitis under Darius II and Artaxerxes II. In the war with Athens, which began in 413 B.C., he supported Spartan operations in the Hellespont. When war broke out with Sparta in 400 B.C. he persuaded Artaxerxes to organize a naval counterstroke and with the help of Conon and Evagoras of Salamis raised a fleet in Cyprus. While the naval offensive was in preparation, he was hard pressed in Phrygia by the Spartan king Agesilaus, but in 394 the Persian navy, jointly commanded by himself and Conon, completely destroyed the Spartan fleet off Cnidus and gained the mastery of the Aegean. In 393 Pharnabazus accompanied the fleet to the Greek coast and gave support to the Greek enemies of Sparta; he provided funds and allowed Conon to use his crews for the rebuilding of the "long walls" at Athens. When in 388 the revival of Athenian imperialist ambitions led Artaxerxes to conclude peace and enter into an alliance with Sparta, Pharnabazus, as the chief opponent of Sparta, was recalled with honour from his command. In 385 he was one of the generals in the unsuccessful attack on Egypt. In 373, after years of preparation, he led a second expedition against Egypt but failed to take Memphis and was eventually forced by the inundation to abandon the campaign. His failure was partly due to his distrust of Iphicrates, leader of the Greek mercenaries. When Pharnabazus died is not known. (J. M. M.-R.)

PHARSALUS, BATTLE OF (48 B.C.), the decisive victory of Julius Caesar (*q.v.*) over Pompey. When Caesar disengaged himself from Dyrrachium and marched to Thessaly, Pompey followed. The two armies made contact somewhere near the modern town of Farsala in the *nomos* of Larissa, Greece, at a site which cannot be established with certainty. Pompey camped on higher ground which would favour his chances if a battle ensued. After some days Caesar, who had failed to provoke Pompey to fight, decided to move off, but as he was starting he saw that the Pompeian army was drawn up for battle; he decided to stay and fight (Aug. 9 by the uncorrected Roman calendar, in fact June 6). Whereas Caesar had 80 cohorts or 22,000 men, Pompey had 110 cohorts which Caesar (probably with exaggeration) assessed at 45,000 men. Further, Pompey trusted his cavalry and its commander, Labienus. He massed the main force of his cavalry on his left wing, hoping to outflank and envelop Caesar's right. Realizing the danger, Caesar hoped to thwart the attack by detaching eight cohorts from his third line (which he intended to hold back as a reserve) and placing them obliquely behind the cavalry on his right wing. His main infantry line was drawn up in the usual three lines of cohorts. Pompey ordered his men to await the enemy's attack, but Caesar's veteran army did not fall into the trap of arriving exhausted. Without orders they halted halfway in their advance, then after recovering their breath they charged and hurled their *pila*. Pompey's cavalry drove back Caesar's cavalry, only to find themselves faced by Caesar's fourth line of eight cohorts, who used their *pila* as stabbing spears instead of as javelins, against the horses and the men's legs and faces. Pompey's cavalry turned and fled. While the eight cohorts outflanked Pompey's infantry, then locked in battle, Caesar threw in his reserve third line. Pompey's legions broke; he himself fled to Larissa. About 24,000 Pompeians surrendered; the rest were dead or in flight. When Caesar, whose casualties were less than 250, surveyed the stricken field and the dead optimates, he cried, "They would have it so" (*"Hoc voluerunt"*). The battle is described in book vii of the *Bellum civile* of Lucan.

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PHARYNX: *see* THROAT; THROAT, DISEASES OF.

PHASE EQUILIBRIA. Most substances are capable of existing in at least three forms or states of aggregation, namely the solid state, the liquid state and the vapour state. Water is a familiar example. These forms, differing in internal structure and in physical properties such as density, mobility, refractive index and heat content, constitute various phases of the substance. If a substance exhibits more than one crystalline form, as does sulfur, each of its polymorphic varieties is a distinct solid phase of the substance. The number of possible phases in a system containing more than one substance is greater, including solutions in both the liquid and solid states and other phases that are, in general, chemical compounds resulting from the chemical combination and interaction of the components.

The materials of nature and of technology are either homogeneous (*i.e.*, consisting of a single phase) or heterogeneous (*i.e.*, polyphasic) systems. Ice is a single phase; a sample of water consisting of some liquid with its vapour is in two phases; a piece of granite generally contains three phases, being essentially a conglomerate of pieces of quartz, mica and feldspar; brass is a single phase, *i.e.*, a solid solution of zinc in copper; and ordinary cast iron is an intimate mixture of at least two solid phases. Each phase, although it may be present in separate pieces, is considered to be one homogeneous kind of matter. The phase is distinct in structure, though not always in chemical composition, from the other phases of the heterogeneous sample and is mechanically separable from them.

The conditions for the coexistence at equilibrium of various

combinations of the possible phases of a system and for their formation and transformations, as controlled by variations in pressure, temperature and composition, constitute the subject of phase equilibria. The principles of phase equilibria find application in the study of structure and constitution of alloys, in practical problems of metallurgy, in the ceramics and glass industries, in the geological interpretation of minerals, in the study and utilization of salt deposits, and in general in problems of physical and chemical separations such as distillation, crystallization and extraction. The most useful and general principle underlying the treatment and representation of all phase equilibria is known as the phase rule, which was deduced by Josiah Willard Gibbs (*q.v.*) in his papers on thermodynamics (1873–78). The realization of the practical importance and universal applicability of the law is due principally to H. W. Bakhuis Roozeboom, whose treatise, *Die heterogenen Gleichgewichte vom Standpunkte der Phasenlehre* (1901–18), became the classical reference in the field.

The phase rule relates the number of components (α), the number of phases (β) and the number of degrees of freedom (*i.e.*, the variance [F]) in a system in interphase equilibrium. The system is subject only to changes in pressure, temperature and composition (proportions of its components). The equilibrium between liquid and vapour for pure water (one component) has a variance of one, *i.e.*, the system is univariant inasmuch as the vapour pressure is a unique function of the temperature, and these are the only intensive variables. (An intensive variable is one, such as pressure and temperature, that is not a function of the magnitude of the phase. Pressure and temperature are intensive variables, mass and volume are not; they are said to be extensive. *See* THERMODYNAMICS.) Arbitrary specification of one fixes the other. A liquid-vapour equilibrium for a binary solution (that is, one containing two components, such as acetone and water) is bivariant; it has two degrees of freedom. Of the four variable quantities—pressure, temperature, liquid composition, vapour composition—one may, within the range allowed by the system, arbitrarily choose the values of any two without disturbing the number or nature of the phases in equilibrium.

In other words, it is necessary and sufficient to specify two of the four quantities in order to fix the other two, and hence in order to specify the system completely with respect to its intensive variables. If this system is cooled until pure ice appears as a third phase the variance is reduced to one, for the specification of any one of the several variables already mentioned suffices to determine the system completely. At equilibrium these intensive variables are independent of the masses, actual and relative, of the phases involved. The freezing point of ice, for example, does not depend on the amount of ice being melted. Likewise, the solubility of a salt (*i.e.*, its concentration in its saturated solution) is independent of the amount of solid salt present in excess.

The number of components in a system is usually evident from the mode of preparation of the system, as for an alloy or an alcohol-water solution. It is not, however, simply the number of chemical species in a system. For example, water, a single substance, may exist in various states of molecular aggregation in its various phases; it may exist in part in the form of ions and it may dissociate at high temperature into hydrogen and oxygen. But as long as all these species are in equilibrium with each other in each phase, and provided that the total composition of each phase is analytically H_2O so that it is not necessary to state the proportions of two or more substances making up the system, only a single component is involved. The number of components is the smallest number of independently variable substances required to account for the composition of all the phases of the system. In the heterogeneous equilibrium between solid $CaCO_3$ and its dissociation products, solid CaO and CO_2 gas, there are three distinct species but only two components since CaO and CO_2 together give the composition of $CaCO_3$. But one may also choose $CaCO_3$ as one of the components if the quantity of the other (either CaO or CO_2) is allowed to have negative values in expressing composition. Similarly the four substances in the equilibrium $BaSO_4 + Na_2CO_3 \rightleftharpoons BaCO_3 + Na_2SO_4$ involve only three components, since any three can be used to express the composition of the fourth; thus $BaCO_3 = BaSO_4 + Na_2CO_3 - Na_2SO_4$. The choice of the nature of the components may be one of convenience, but their number, defined as the sufficient minimum, is fixed.

The phase rule states that for a system in equilibrium

$$F = \alpha - \beta + 2$$

The maximum number of phases possible at equilibrium is therefore $\alpha + 2$. This maximum number occurs only when the system is invariant, *i.e.*, when $F = 0$. The conditions of pressure, temperature and phase compositions are then uniquely fixed by the nature of the system itself. The pressure, for example, may be arbitrarily varied only if the equilibrium is at least univariant with the number of phases not greater than $\alpha + 1$. In the formation of certain mineral deposits, moreover, it must be assumed that the total process has taken place over a range of both pressure and temperature; the number of coexisting phases in the accompanying bivariant equilibria then cannot exceed the number of components. Such restrictions, however, apply only to systems in true heterogeneous equilibrium. Because of the very number of phases present, consequently, many materials (for example, certain metamorphic mineral assemblages, certain salt deposits produced by evaporation of sea water and some alloys undergoing various sequences of thermal and mechanical treatment in their preparation and use) would thus seem to be beyond treatment by the phase rule because they are obviously not in equilibrium. Nevertheless it is only by reference to principles of phase equilibria combined with kinetics of chemical reactions and phase transformations, as they must apply to the possible relations in these materials, backward and forward in time through changes of pressure and temperature, that one can interpret their formation or origin and predict their future behaviour in their inevitable course toward equilibrium.

The phase rule, moreover, is also limited in its application to the behaviour of systems assumed to be subject only to variations in pressure, temperature and proportions of components, and free from influences of electrical and magnetic fields, of gravitational effects and of surface energy effects. The effect of gravity, which can practically never be eliminated, is altogether negligible for almost all applications of the phase rule. Surface effects, on the other hand, are extremely important in systems containing finely divided colloidal substances or other materials possessing large surfaces, such as adsorbents and catalysts. The interphase relations in these cases are not covered by the ordinary phase rule, which applies to equilibrium of bulk phases.

One-Component Systems.—Since pressure and temperature are the only variables to be considered, the phase diagram of a single substance is represented with two co-ordinates, as in fig. 1.

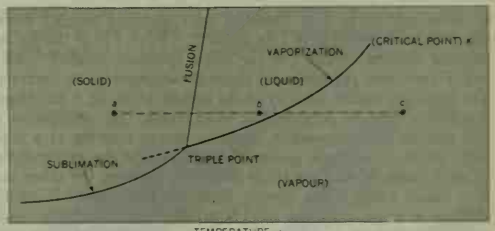

FIG. 1.—PHASE EQUILIBRIA FOR THE SOLID, LIQUID AND VAPOUR STATES OF A SUBSTANCE

Each of the three areas shows the range of pressure and temperature in which the substance exists as a single phase, in bivariant equilibrium. Both pressure and temperature of a sample of the vapour, for example, may be varied without change of phase, and both must be specified in order to fix the properties of the vapour; these properties depend solely on these variables. A line between two areas represents the univariant conditions of pressure and temperature for the equilibrium coexistence of two phases; these are phase boundaries or phase transition curves, specifically the sublimation curve for solid-vapour, the fusion curve for solid-liquid and the vaporization curve for liquid-vapour equilibrium.

These three curves intersect at the triple point, which shows the single values of the pressure and the temperature for the coexistence of the three phases.

For the co-ordinates at point *a* the substance is entirely solid. As the temperature is raised at constant pressure, the properties of the phase, such as heat content, refractive index and density, change gradually but the phase remains a single phase until the fusion curve is reached. Here the temperature remains constant as heat is absorbed and as solid melts to liquid. The system does not leave the transition curve until the solid is consumed. The sample is then entirely liquid as shown, for example, at point *b*, until the temperature of the vaporization curve is reached. Now vapour begins to form with absorption of heat, and the temperature remains constant until all of the liquid has disappeared and only vapour remains. The temperature may now increase further to a point such as *c*. The boiling of a pure liquid in the open, under constant atmospheric pressure, is thus seen to be a source of constant temperature (about 100° C. for water at 1 atm.). The two-phase equilibrium thus persists at constant temperature through isobaric introduction of heat, which is compensated by phase transitions leading to volume changes. Similarly, isothermal expansion of the system liquid-vapour merely causes some liquid to vaporize, with change in total heat content, while the pressure, depending solely on temperature, remains constant until the liquid is consumed. The triple point is characterized by unique values of pressure and temperature and hence of all the specific properties of each of the three phases. Neither a change in volume nor the addition or removal of heat can cause a change in any of the intensive variables because the applied stresses are completely compensated, at equilibrium, by changes in the relative amounts of the phases until one of them is consumed, leaving a univariant two-phase system.

The ice-liquid-vapour triple point for pure (and isolated) water is at 4.58 mm. and +0.0100° C. In the open air at 1 atm. pressure, however, the constant temperature obtained from the equilibrium of ice and liquid water is, by definition, zero on the Celsius or centigrade scale. The difference in the temperature results from the effect of the increased pressure in lowering the melting point of ice and a further slight effect of air dissolved in the liquid.

With increasing temperature at constant pressure, transitions occur from phases of lower to phases of higher heat content. With increasing pressure at constant temperature, transitions occur to phases of higher density. The slope of a transition curve at any point is given by the Clapeyron-Clausius equation:

$$\left(\frac{dP}{dT}\right)_{1\to 2} = \frac{\Delta H_{1\to 2}}{T(V_2 - V_1)}$$

in which ΔH is the heat absorbed (per specified weight) during the transition from phase 1 to phase 2; $(V_2 - V_1)$ is the accompanying volume change (of the same specified weight); and P and T represent pressure and absolute temperature respectively. The equation applies not only to the transitions in fig. 1 but also to transitions between polymorphic solid forms. In consequence of this relation the intersection of three curves meeting at a triple point involves no angle greater than 180°, and the extrapolation of each curve beyond the triple point lies between the other two. The fusion curve rising steeply from the triple point is usually positive in slope, since the solid is usually denser than the liquid, as illustrated in fig. 1. In the unusual case of water and a few other substances, the liquid is denser than the solid and the slope is negative.

For the relative slopes of the sublimation and vaporization curves at the triple point (with the same pressure and temperature for all three phases), the volume change is large and practically equal for both transitions, but the sublimation curve is steeper since the heat of sublimation exceeds the heat of vaporization by the heat of fusion. The dashed extension of the vaporization curve of fig. 1 represents the liquid-vapour system supercooled below the freezing point without crystallization, as is possible, at least temporarily, in the absence of dust, *i.e.*, of nuclei for crystal formation, and in the absence of mechanical disturbance. Although continuing to fall, the vapour pressure of the supercooled liquid is higher than that of the solid (on the sublimation curve) at corresponding temperatures. The supercooled liquid is said to be metastable with respect to the solid; the liquid eventually, especially if disturbed, transforms to the stable solid phase.

The actual physical and chemical properties are not directly indicated on the phase diagram, but they are nevertheless completely determined by the information in the diagram—pressure, temperature and phase compositions. The density of a pure vapour, for example, depends only upon its pressure and temperature.

In a closed vessel containing pure water in the forms of liquid and vapour at 25° C. the liquid is very much denser than its saturated vapour. With increasing temperature the vapour pressure rises, the liquid becomes less dense while the equilibrium vapour becomes denser and the two coexisting phases approach each other in all properties. They finally become identical, merging as one "fluid" phase at the critical point of the substance. This is shown as point *K* in fig. 1, marking the end of the vaporization curve; beyond this point the distinction between liquid and vapour has vanished. The critical constants for water are 218.3 atm. and 374.2° C. Its density at the critical point is 0.32 g. per cubic centimeter.

When a substance exists in more than one crystalline form, the number of phase areas in the equilibrium diagram increases. So also does the number of transition curves and triple points. In the case of water the polymorphism of ice is manifested only under high pressure. The temperature of equilibrium between ordinary ice (ice I) and liquid water falls with increasing pressure until, at triple point *a* of fig. 2 at 2,045 atm. and −22° C., a different crystalline variety of ice appears (ice III). Five distinct high-pressure forms of ice have been identified (II, III, V, VI, VII) with fields of stability as shown in fig. 2. Ice VII, requiring 21,700 atm. for its formation, is in equilibrium with liquid only at 81.6° C. (triple point *b*) and above. High-pressure polymorphism is exhibited frequently by both elements and compounds.

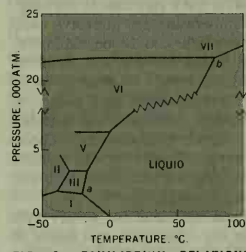

FIG. 2.—EQUILIBRIUM RELATIONS FOR THE HIGH-PRESSURE FORMS OF ICE

Of the two crystalline forms of carbon—graphite and diamond—the first is stable under ordinary conditions. Diamond is a high-pressure form corresponding somewhat to ice III in fig. 2. Once formed, naturally or artificially, under appropriate values of pressure and temperature, the diamond structure persists indefinitely at ordinary conditions because the rate of transformation to stable graphite is immeasurably slow. Boron nitride (BN), which is closely related to carbon in electronic structure, shows a polymorphism parallel to that of carbon; *i.e.*, it displays a hexagonal form with a layered structure like graphite and a very hard cubic form, obtainable at high pressure, similar to diamond.

The crystalline polymorphism of sulfur is observed, in contrast to the high-pressure relations of fig. 2, in the presence of the vapour phase, either pure or in open air. (Polymorphism of an element is usually called allotropy.) Rhombic sulfur, which is stable at low temperature, transforms at 95.5° C. to monoclinic sulfur, the form stable to the melting point. Each form has its own sublimation curve and the two curves intersect at the transition point (triple point *a* in fig. 3), where the two solids can coexist at equilib-

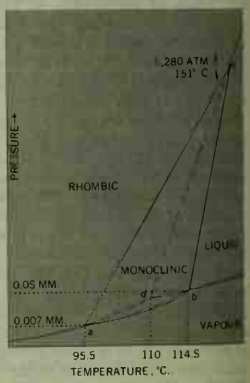

FIG. 3.—EQUILIBRIUM DIAGRAM FOR SULFUR (NOT TO SCALE)

rium in presence of vapour. Such polymorphism, with a transition point under the vapour pressure of the system, is known as enantiotropy. The triple point *b* represents stable equilibrium of liquid + vapour + monoclinic sulfur; the range of stability of this solid under increasing pressure is limited, and at the triple point *c* (1,280 atm. and 151° C.) the rhombic form comes to be in stable equilibrium with liquid. If rhombic sulfur, in open air, is heated very rapidly through 95.5° C., the monoclinic form may not appear and the metastable triple point *d*, for rhombic sulfur + liquid + vapour, may be reached. The two forms have the same vapour pressure only at the transition point, where they are in equilibrium. Above this temperature rhombic sulfur, metastable relative to monoclinic, is higher in vapour pressure and therefore in free energy and chemical activity.

When heated, monoclinic sulfur begins to melt only at a temperature (119° C.) higher than that of point *b*. The initial melting point gradually falls, during melting, toward the final equilibrium value of 114.5° C. as the liquid, consisting internally of two or more interchangeable forms in dynamic allotropy, approaches equilibrium proportions of these forms. The slowness of the approach to equilibrium gives the element a pseudobinary character in its liquid-solid transitions.

The enantiotropic polymorphism of silica involves a number of successive crystalline forms: α-quartz to 573°, β-quartz to 867°, β_2-tridymite to 1,470° and β-cristobalite to 1,723° C., the melting point; in addition, α- and β_1-tridymite and α-cristobalite appear as metastable forms at lower temperatures. Transformations between these phases are sluggish; the liquid, moreover, is easily supercooled to the noncrystalline vitreous condition (silica glass). This tendency to form glass persists in mixtures of silica with various metal oxides.

In monotropy, as contrasted to enantiotropy, one (or more) of the crystalline varieties is always unstable with respect to some stable form. Thus white (or yellow) phosphorus, regularly formed from the vapour of the element, is monotropic with respect to the red (or violet) modification. The vapour pressure of white phosphorus, either as solid or as liquid, is higher at any temperature than that of red phosphorus, and the white form eventually changes, at a rate depending on conditions, entirely to the red. Many organic compounds exhibit monotropy; menthol has four forms, three of them monotropic with respect to the highest melting one.

Some complex organic compounds exhibit stepwise transitions between crystalline and liquid (isotropic) states. The intervening phases, known as liquid crystals or mesomorphic states, may show either enantiotropic or monotropic relations, or both, and their transitions may be represented on the usual phase diagram. The phenomenon was first discovered for cholesteryl benzoate (1888).

Two-Component Systems.—The phase equilibria of a binary system require three dimensions for complete representation, with composition, either weight percentage or mole fraction, plotted perpendicularly to the axes of pressure and temperature. Such complete, three-dimensional phase diagrams are not considered here. Usually, only limited aspects of the phase equilibria are studied for most systems; hence the observations usually may be represented on a plane diagram showing only two of the three variables. Equilibria involving condensed phases—solids and liquids—are investigated principally as temperature-composition relations, either at constant pressure (isobaric) or with the pressure effect ignored when it is relatively small. Relations of pressure and composition and of pressure and temperature, on the other hand, are important for equilibria involving vapour.

Consider first the liquid-vapour relations for a binary solution varying continuously in composition from pure A to pure B, the two liquid components. If the vapour pressure falls continuously from P_A, that of component A, to P_B, that of component B, the isothermal pressure-composition diagram would be, schematically, fig. 4. The diagram consists of three fields, defined by curves representing compositions of coexisting liquid and vapour. These curves, called liquidus and vaporus respectively, meet at the compositions of the pure components. For compositions and pressures above the liquidus the system is entirely liquid, below the vaporus it is entirely vapour. Between the curves liquid and vapour coexist. Thus liquid *l* is in equilibrium with vapour *v*, and its vapour pressure at the temperature of the diagram is P_l.

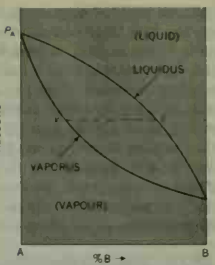

FIG. 4.—EQUILIBRIUM OF BINARY LIQUID AND VAPOUR AT CONSTANT TEMPERATURE

The temperature-composition relations of binary liquid and vapour at constant pressure constitute a boiling point diagram. The system of fig. 4 corresponds to the diagram of fig. 5(a) with the boiling points of all mixtures falling between those of the components. Positions of liquidus and vaporus are now reversed. Liquid of composition *x* begins to boil at T_x, giving off vapour of composition *y*. If this vapour, rich in A, is continually removed, as in open air boiling or in distillation, the residual liquid becomes richer in B and the boiling point rises, along the liquidus curve, toward that of pure B as a limit. Thus the mixture may be fractionated by distillation; the more volatile, lower-boiling component A accumulates in the vapour and hence in the condensate, while B accumulates in the residual liquid phase.

Fig. 5(b) and 5(c) represent systems with a binary maximum (or minimum) in boiling point. (These systems would show a minimum or maximum, respectively, in their isothermal vapour pressure curves.) Separation by fractional distillation in these cases cannot be carried beyond the maximum or the minimum. Liquids on the left of the maximum in fig. 5(b) give a vapour richer in A, and pure A may ultimately be obtained from vapour fractions but the residue cannot pass the composition of the maximum. The same residue composition is reached by the boiling of liquids on the right of the maximum. The liquid at the maximum boils without further fractionation, and without further change in boiling point, to a vapour of the same composition. This constant-boiling liquid, like that at the minimum of fig. 5(c), is called azeotropic, and the system is said to exhibit maximum (or minimum) azeotropy.

Examples for fig. 5(a), 5(b) and 5(c) respectively are the systems acetone-water, water-sulfuric acid, and alcohol-water.

If the components are completely miscible in the solid state, so that the binary system forms a continuous solid solution upon freezing, the relations between solid and liquid phases in freezing or melting may be schematically represented by the curves of fig. 5. The two-phase region of fig. 5(a) would now represent the equilibrium between a liquid solution (higher-temperature phase) as at point *y*, and a solid solution (lower-temperature phase) as at point *x*, with the freezing point falling continuously from that

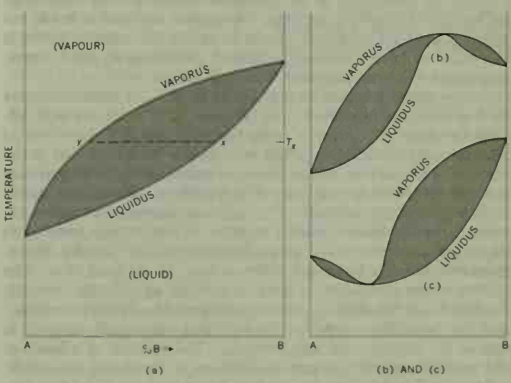

FIG. 5.—BINARY LIQUID-VAPOUR RELATIONS AT CONSTANT PRESSURE (BOILING POINT DIAGRAMS)

of pure B to that of pure A. When any binary liquid is cooled, then, the first trace of solid to form would be richer in B than the liquid, which is in turn enriched in A. If complete equilibrium could be maintained, with sufficiently slow cooling permitting the necessary diffusion through the solid, the phase compositions should continually adjust themselves, and upon complete solidification the solid should consist of a single phase that is uniform throughout in structure and in composition. Since this condition is hardly ever attained, each part of the final solid possesses a varying structure and composition, with the core being richer in B and the surface layer richer in A than the original liquid. The final properties of an alloy, for example, thus come to depend not only on total composition but also on conditions of preparation.

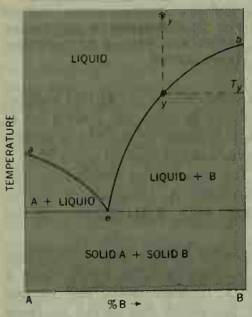

FIG. 6.—PHASE DIAGRAM OF BINARY SYSTEM WITH PURE COMPONENTS AS SOLID PHASES

Continuous solid solution as represented by the curves of fig. 5 is restricted, with few exceptions, to pairs of components isomorphous in the crystalline state and not differing greatly in lattice dimensions. Many examples are known both with continuous fall or continuous rise in freezing point, and with a minimum melting point, as in fig. 5(c). A maximum as in fig. 5(b) is rare.

If the freezing of the binary liquid produces the separate components as pure solid phases, the phase diagram is of the type shown in fig. 6. It consists of two intersecting branches, each falling from the freezing point of a component; curve *ae* represents liquid solution in equilibrium with solid A and curve *be* liquid in equilibrium with solid B. Curve *be* shows the lowering of the melting point of B by component A; it also represents the variation with temperature of the solubility of B in the binary liquid. Solid B begins to precipitate from liquid *y* when the liquid is cooled to temperature T_y, at which point the liquid has become saturated with B. At this temperature, solid B may be dissolved in pure liquid A until its concentration reaches the value *y*, where the liquid is saturated, and further addition leaves solid B in excess. The variation of the mole fraction of B, or (x_B), with the absolute temperature (T) on the curve *be* is given by the equation

$$\frac{dx_B}{dT} = \frac{x_B \Delta H_B}{RT^2}$$

in which R is the gas constant and ΔH_B the heat of solution of B. Near the melting point of pure B, the quantity ΔH_B is the heat of fusion of the solid, and when this is known the equation permits the estimation of the purity of a sample from the change in temperature during melting. A similar expression holds for component A on curve *ae*. Point *e*, called the eutectic point, is the liquid of lowest freezing point and, pertaining to both curves, represents solution saturated with both solids.

As the liquid *y* begins to precipitate B at T_y, it becomes richer in A and its freezing point falls further. The residual liquid follows the curve *be* toward *e* while the quantity of B deposited as primary crystallization product continually increases. At *e* the residual solution freezes at a constant temperature to an intimate mixture of pure A and pure B crystals in proportions corresponding to point *e* itself. This eutectic mixture (so called because it is the lowest-melting mixture of the binary system) is deposited as a secondary crystallization product usually distinguishable visually from the primary pure B (or pure A). The system water-potassium nitrate illustrates fig. 6; the eutectic ($-2.8°$ C., 10.9% KNO_3) is now the intersection of the "ice curve" and the "solubility curve" of the salt, and the eutectic mixture is one of ice crystals and salt crystals. The number of phases at the eutectic, including vapour in addition to liquid and two solids, is four, so that this is an invariant point of the binary system, corresponding to the triple point of a one-component system.

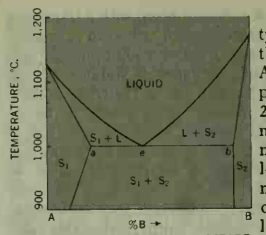

FIG. 7.—SYSTEM LEAD TUNGSTATE (= A)-LEAD SULFATE (= B). S_1 = SOLID SOLUTION OF B IN A: S_2 = SOLID SOLUTION OF A IN B: L = LIQUID

Binary systems of the eutectic type are often useful because of the low melting points obtainable. Although pure cadmium and pure bismuth melt at 321° and 271° C. respectively, suitable mixtures can be used as molten metal baths at temperatures as low as 144° C. Ice may be melted by addition of a salt because of the tendency to form the low-melting eutectic of the system. In some cases the ice-salt mixture may be used to produce low temperature, or as a freezing mixture, because of the endothermic nature of the simultaneous melting (or dissolving) of the solids to form the low-melting liquid. It is thus possible to reach temperatures as low as $-21.3°$ C. from snow and sodium chloride and $-54.9°$ C. from snow and calcium chloride hexahydrate.

If the components dissolve in each other in the solid state to a limited extent, there are still two separate solid phases in the system, a solid ranging in composition from pure A to a limiting concentration of B and one ranging from pure B to a limiting concentration of A. With two solids, the freezing point diagram again consists of two intersecting branches, with the intersection either at a minimum (eutectic type) or at an intermediate temperature (peritectic type). The system lead tungstate-lead sulfate (fig. 7) is of the eutectic type; points *a* and *b* are the limiting solid solutions at the eutectic, which is like that in fig. 6 except that the two solids (*a*, *b*) are not pure components. Fig. 8 shows the peritectic type in the system platinum-silver (Pt-Ag). Curve *ap* represents liquid saturated with platinum-rich solid solution on curve *ac*, and curve *pb* represents liquid saturated with silver-rich solid solution on curve *db*; liquid *p* is in equilibrium with two limiting solid solutions, *c* and *d*.

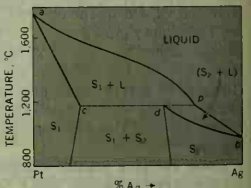

FIG. 8.—SYSTEM PLATINUM-SILVER. S_1 = SOLID SOLUTION OF AG IN PT: S_2 = SOLID SOLUTION OF PT IN AG: L = LIQUID

The limited mutual solubility (or miscibility) of liquids is usually more easily studied than that of solids. While some pairs of liquids, *i.e.*, as alcohol and water, dissolve in each other in all proportions so that they always give a single liquid phase, other pairs form two liquid layers that differ in composition. Unless the mutual solubility is zero, as is practically the case for mercury and water, neither layer is pure. Thus small amounts of ether dissolve in water, but the continued addition of ether leads to formation of a second, lighter layer that at equilibrium is itself a dilute solution of water in ether. Raising the temperature usually increases mutual solubility. The two coexisting layers, or conjugate liquids, then approach each other in concentration, and a temperature may be reached when the two layers become identical and merge with each other, with disappearance of the interface. The system phenol-water has such a consolute point of upper critical solution temperature at 66° C. In the system nicotine-water, the existence of two liquid layers is

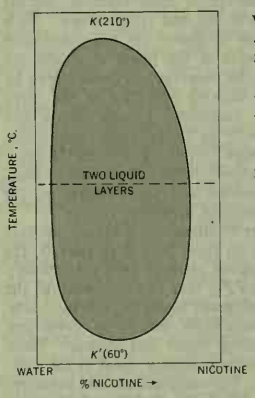

FIG. 9.—SYSTEM WATER-NICOTINE

limited both by an upper and by a lower consolute point (K and K' of fig. 9). Between these temperatures, mixtures having compositions falling within the closed curve separate into two layers, the compositions of conjugate layers being given by points on the curve joined by an isothermal line (horizontal on fig. 9). A mixture having a composition outside the closed curve exists as a single liquid solution. A lower consolute point is relatively rare, and the cooling of the conjugate liquids usually leads eventually to precipitation of one of the solids of the system. Thus the two phenol-water liquid layers come to be in equilibrium with a solid hemihydrate of phenol at 1.7° C.; with vapour present this constitutes a four-phase invariant point of the system.

If the two liquids remain partially miscible up to the boiling point, the boiling point curve of the system, unlike those in fig. 5, consists of two branches. Their intersection then represents the boiling point of the conjugate liquids, which may be either the maximum boiling point of the binary system or some temperature intermediate between those of the components.

The binary liquid, in certain concentration ranges, may produce on freezing a solid compound of the components. Two typical relations for such a system are shown in fig. 10, in which the compound (C) is assumed to have the composition 1A:1B. With three solid phases (A, C and B), the phase diagram consists of three curves, the middle one representing solutions in equilibrium with the solid compound and hence yielding the compound upon freezing. In fig. 10(a) this curve has a temperature maximum at the composition of the compound, and solid C is obtained on cooling solutions of compositions on either side of that of the compound itself, namely from e_1 to e_2. The (generally rounded) maximum of the curve is the melting point of the compound, which is said here to melt congruently to a liquid of its own composition. The two halves of the diagram are like simple eutectic systems (fig. 6) side by side, with eutectic e_1 for solids A and C, and e_2 for C and B. In fig. 10(b), on the other hand, only liquids with composition between p and e (containing excess of B relative to the compound C) give as first crystallization product solid C. The compound in this case decomposes, or melts incongruently, when heated to the temperature T_p (a peritectic point), yielding solid A and liquid p. Although the congruently melting compound on fig. 10(a) is stable as a solid phase up to its melting point (T_c), such compounds in general decompose to some extent in the liquid state, and the greater the extent of dissociation in the melt the flatter is the freezing point curve through the maximum.

The system calcium-magnesium (Ca-Mg) illustrates fig. 10-(a), with the intermetallic compound $CaMg_2$ melting congruently at 718° C. Fig. 10(b) is illustrated by the system aluminum oxide (Al_2O_3 = A) – silica (SiO_2 = B), with the compound $3Al_2O_3 \cdot 2SiO_2$ (= C) melting incongruently at 1,810° C. If the two components form a number of congruently melting compounds varying stepwise in composition between A and B, the phase diagram consists of a succession of curves, each with a maximum marking the melting point and the composition of a compound.

A system may involve both types of compounds and its

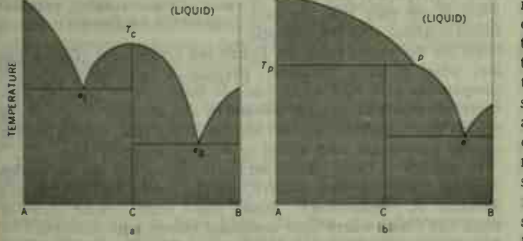

FIG. 10.—FREEZING POINT DIAGRAMS INVOLVING BINARY COMPOUNDS. (a) COMPOUND (C) WITH CONGRUENT MELTING POINT (T_c). (b) COMPOUND (C) WITH INCONGRUENT MELTING POINT (T_p)

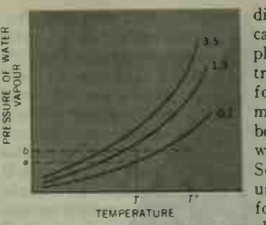

FIG. 11.—DISSOCIATION PRESSURES FOR HYDRATES OF CUPRIC SULFATE, $CuSO_4$ (NOT TO SCALE)

diagram may be further complicated sometimes by polymorphism of these solids. Sulfur trioxide (SO_3) and water (H_2O) form six or seven congruently melting compounds (sulfuric acid being one of them) and several with incongruent melting points. Sodium fluoride (NaF) and uranium tetrafluoride (UF_4) form two compounds of each class besides two that decompose with rising temperature before attaining equilibrium with liquid. In many binary alloys, intermediate solids appear that may be both solid solutions and intermetallic compounds. The first solid solution, or alpha phase, of the system Cu-Zn, extending from pure copper to almost 40% zinc, includes the composition of ordinary brass (30%–33% Zn).

When a binary compound is formed directly and reversibly from a solid and a vapour, as in the reaction of copper sulfate ($CuSO_4$) with water vapour to form the hydrate $CuSO_4 \cdot H_2O$, the vapour pressure of the three-phase univariant equilibrium varies with the temperature. In fig. 11 are plots of pressure against temperature for the following reactions, each for two solids and vapour:

Curve 0,1: $CuSO_4 + H_2O \rightleftarrows CuSO_4 \cdot H_2O$
Curve 1,3: $CuSO_4 \cdot H_2O + 2H_2O \rightleftarrows CuSO_4 \cdot 3H_2O$
Curve 3,5: $CuSO_4 \cdot 3H_2O + 2H_2O \rightleftarrows CuSO_4 \cdot 5H_2O$

At temperature T' the solids $CuSO_4$ and $CuSO_4 \cdot H_2O$ can coexist at equilibrium only under a partial pressure of water vapour, P_{H_2O}, equal to a. If, at this temperature, P_{H_2O} is maintained below a the hydrate dissociates. If P_{H_2O} is raised to the value b all the salt becomes hydrated, but if the monohydrate is now heated to T'' it decomposes. If a sufficient quantity of the anhydrous salt is present the final partial pressure of water in a closed space at T' cannot exceed the equilibrium value a. Thus, for example, magnesium perchlorate, forming a hydrate of extremely low dissociation pressure, is a powerful drying agent for moist gases.

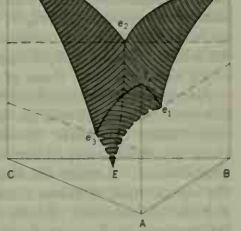

FIG. 12.—FREEZING POINT RELATIONS FOR A TERNARY SYSTEM WITH PURE COMPONENTS AS SOLID PHASES

Three-Component and Multicomponent Systems of Higher Orders.—The phase equilibria of a ternary system (*i.e.*, a system of three components) involve four independent variables, *i.e.*, the independent percentages of two of the components in addition to pressure and temperature. A three-dimensional diagram can represent only three independent variables, and for freezing, or solubility, equilibria of condensed phases the usual relations studied are those of composition and temperature. With composition plotted on an equilateral triangle as the base, and temperature as the vertical axis, the diagram takes the form of a triangular prism, in which pressure is either constant or is assumed to have negligible effect. Fig. 12 shows the type of relation resulting if the components form a single continuous liquid phase and if the only solids appearing on freezing are the separate, pure components (A, B, C). Each of the three surfaces (each of which may be regarded as either a freezing point surface or a solubility surface) gives the temperature at which liquids with compositions falling on that surface first yield a particular solid on cooling: solid C for the surface T_c-e_2-E-e_3, for example. This surface therefore represents ternary liquid solutions in equilibrium with solid C. Points e_1, e_2, e_3 are the eutectics of the separate binary systems. Each represents the temperature and composition of a

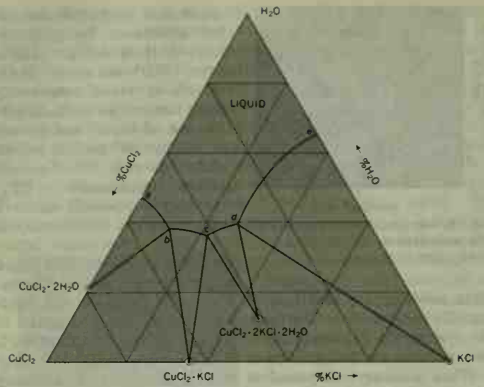

FIG. 13.—PHASE DIAGRAM OF SYSTEM $CuCl_2$-KCL-H_2O AT 75° C. PERCENTAGE OF EACH COMPONENT IS MEASURED FROM OPPOSITE SIDE

binary liquid in equilibrium with two solids (*cf.*, fig. 6). Point *E*, the liquid of lowest freezing point and in equilibrium with all three solids, is the ternary eutectic. When only pure (or almost pure) components appear as solids from a multicomponent solution each additional component causes a further decrease in the minimum (eutectic) melting point. The eutectic of the ternary alloy bismuth-cadmium-tin is at 102.5° C., and the quaternary eutectic, with lead added, is at 70° C.

A horizontal, isothermal section of fig. 12 represents the phase equilibria, specifically solubility relations, of the ternary system at a given temperature. Fig. 13 is the solubility diagram for the system copper chloride-potassium chloride-water ($CuCl_2$-KCl-H_2O) at 75° C. Compositions in the region labeled "Liquid" represent unsaturated solutions. The four curves from *a* to *e*, delimiting this region, represent, successively, the solubility, in ternary solutions, of each of the four solid phases of the system at this temperature: curve *ab* represents compositions of solutions saturated with $CuCl_2 \cdot 2H_2O$; *bc* with the double salt $CuCl_2 \cdot KCl$; *cd* with the hydrated double salt $CuCl_2 \cdot 2KCl \cdot 2H_2O$; and *de* with KCl. Points *b*, *c*, *d*, denote compositions of solutions saturated with two salts, those of the adjacent curves.

A system of four components, such as an alloy of four metals or the system of water and the salts sodium chloride, sodium sulfate and sodium carbonate, involves five independent variables, for there are three independent concentrations besides pressure and temperature. A three-dimensional figure is required to represent the composition relations alone at fixed pressure and temperature. For the aqueous salt system, for example, this figure would be a tetrahedron with water as an apex, and each side touching this apex would be the solubility isotherm, like fig. 13, of a ternary system of water and two salts. Surfaces and curves within the tetrahedron would then represent the simultaneous solubility relations in the quaternary solutions containing all three salts.

Difficulties both of experimentation and of graphical representation mount with each additional component. Nevertheless, at least partial studies of some high-order multicomponent systems have been made. Perhaps the most notable example is the work of J. H. van't Hoff on the complex system of sea water, treated essentially as a six-component system of the chlorides and sulfates of sodium, potassium, magnesium and calcium in water. Significant aspects of the phase equilibria were established at a number of temperatures. This work was of practical importance in connection with the utilization of the Stassfurt (*q.v.*) salt deposits and of theoretical interest as a basis for the interpretation of the geological history of their formation.

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(J. E. RI.)

PHEASANT, any of about 50 species of game birds of the Old World, belonging to the family Phasianidae (which also includes the new and old world quail and partridges). The males are brightly coloured, generally with long tails; the females are inconspicuously coloured. A few, like the tragopans (*Tragopan*) and impeyans or monals (*Lophophorus*) are short tailed; they are intermediate between the pheasants and the partridges.

The typical pheasant (*Phasianus colchicus*) was according to legend introduced into Europe by the Argonauts from the banks of the Phasis in Asia Minor and was later supposedly brought to England by the Romans. As a wild species it occurs in many parts of Eurasia in a number of local races, of which the Japanese green pheasant is especially distinct. The Chinese ring-necked variety was introduced into Oregon in 1881 and others were brought to the eastern United States from England. Pheasants now occur across the northern United States and southern Canada, where in many places they are the most important game bird. They are also raised for sport in shooting preserves in the United States and Britain (*see* GAME BIRDS). Pheasants nest in late April and early May, lay 7 to 18 olive-buff eggs in a nest on the ground hidden by a tussock of grass or a small bush. The male has brilliant plumage and red wattles; the female is protectively coloured in mottled brown. The wings are short, the tail long. In the breeding season sets of erectile feathers on each side of the head give the cock a horned appearance. The birds are polygamous, the male maintaining a harem. They feed on grain, seeds, shoots and insects. Both sexes fly and run well.

PETE CZURA

MALE RING-NECKED PHEASANT (PHASIANUS COLCHICUS)

The ornaments of pheasants are strikingly displayed in courtship, the peacock (*q.v.*) being the most notable example (*see* COURTSHIP, ANIMAL). The splendid Argus pheasant (*Argusianus*) and the ocellated pheasant (*Reinardia*) are related to the peacock. The rare Congo peacock (*Afropavo*), discovered in 1926, is the only true pheasant found in Africa. All the domestic fowls are descended from the Indian red jungle fowl (*Gallus gallus*), which is also a pheasant. Because of their beauty and the comparative ease with which some of them can be raised in captivity, pheasants are in great demand by aviculturists. Some of the species live in such dense cover and are so shy that, were it not for captive individuals, man would never set eyes upon them.

In addition to those mentioned above, favourites are the golden pheasant (*Chrysolophus pictus*) and the lovely Lady Amherst's pheasant (*C. amherstiae*). Many come from remote areas of India and China where their continued existence is threatened by destruction of the habitat and by hunters who snare them for food.

See W. Beebe, *Monograph of the Pheasants* (1918–22); J. Delacour, *Pheasants of the World* (1951).
(DN. A.)

PHEIDIAS: *see* PHIDIAS.

PHEIDON (probably 7th century B.C.), a powerful king of early Argos, in Greece. The Dorians of Argos considered that they inherited the traditional supremacy of Mycenae, Agamemnon's capital, and in the legend of the Dorian division of the Peloponnese most of the northeastern cities (Sicyon, Phlius, Epidaurus and others, but not Corinth) were reckoned to belong to the "lot" of Temenus, the Argive founder. A tradition of uncertain value asserts that Temenus' successors were weak kings till Pheidon, the tenth, who reunited the "lot of Temenus": Herodotus attests that he seized Olympia and held the festival himself, and that he established the standard system of measures in the Peloponnese.

Herodotus, naming Pheidon's son Leocedes among the suitors of Agariste, daughter of Cleisthenes of Sicyon, dates Pheidon by implication *c.* 600 B.C., but at this time the tyrannies of Corinth and Sicyon were at the height of their power and there is no room for a period of Argive ascendancy. Some later writers assigned him to the 8th century, but there are also grounds for doubting this. The evidence on his seizure of Olympia is confused, Pausanias dating it to 748 while others say that the Eleans held the presidency without a break till 672 or 668. There are still advocates of the 8th-century date, but most modern writers prefer the early 7th century. We may then attribute to him the defeat of Sparta at Hysiae, on the pass leading up from the southern Argolid into Arcadia, which Pausanias dates to 669.

The most striking evidence of his power is his ability to march across the Peloponnese and seize Olympia. A system of measures called Pheidonian certainly existed later in the Peloponnese and its colonies, and also in Athens before Solon, but Ephorus' statement that Pheidon was the first to coin silver money must rest on a misunderstanding: the beginning of coinage in mainland Greece is now dated too late in the 7th century for Pheidon. Aristotle says that he exceeded the traditional bounds of kingship and became tyrant; since he was legitimately king, the meaning must be that he asserted the royal power more effectively than was usual in this aristocratic period. The Argive recovery did not last long against the combination of Sparta and Elis, and the northeastern cities were soon independent under their own tyrants.

See P. N. Ure, *The Origin of Tyranny*, ch. vi (1922); A. Andrewes, *The Greek Tyrants*, ch. iii (1956). (A. As.)

PHELPS, WILLIAM LYON (1865–1943), U.S. teacher and author, did much to popularize the teaching of contemporary literature. Born on Jan. 2, 1865, in New Haven, Conn., he attended Yale University (B.A. 1887, M.A. 1891) and Harvard University (Ph.D., 1891). He taught at Harvard for a year, and then returned to Yale where he was for 41 years a member of the English department and Lampson professor from 1901 until his retirement in 1933. For years his students voted him Yale's most inspiring professor and thronged to his classes on contemporary drama, in the teaching of which he was a pioneer, and on Tennyson and Browning. In 1895 he taught the first U.S. college course in the modern novel, doing much to introduce Russian novelists to U.S. readers. A popular lecturer and critic, his literary essays in *Scribner's Magazine* and other periodicals and his syndicated newspaper column, "A Daily Thought," brought him an audience estimated in the millions.

As a critic he helped make the popular reputation of Thornton Wilder. An object of the scorn of H. L. Mencken, he endorsed Mencken's *Prejudices*. He died on Aug. 21, 1943, in New Haven.

His numerous books were devoted chiefly to English literature. His *Autobiography with Letters* was published in 1939.

See also F. H. Barber's *Fellow of Infinite Jest* (1949).

PHÉLYPEAUX, the family whose long tenure of offices of state in France made it one of the so-called ministerial dynasties of the 17th–18th centuries.

PAUL PHÉLYPEAUX, SIEUR DE PONTCHARTRAIN (1569–1621), the son of a councilor in the presidial court at Blois, began a career in the king's service in 1583 and was appointed one of the four secretaries of state in April 1610. He died at Castelsarrasin, in Languedoc, in October 1621, during the campaign against the Huguenots. His memoirs (published 1720) deal with the affairs of the regency of his patroness, Marie de Médicis.

As Paul's son LOUIS I, SIEUR DE PONTCHARTRAIN (1613–85; *see* below) was an infant in 1621, the secretaryship of state was taken over by Paul's elder brother, RAYMOND, SIEUR D'HERBAULT (1560–1629), who in 1626 became the first secretary of state to be assigned the sole administration of all foreign affairs and who also had the department of Huguenot affairs, as well as control of a number of provinces. Herbault's son LOUIS I, SIEUR DE LA VRILLIÈRE (1598–1681), secured the secretaryship in 1629, with the Huguenot department and more provinces, but without foreign affairs. La Vrillière was succeeded by his son BALTHAZAR, MARQUIS DE CHÂTEAUNEUF (*c.* 1638–1700), during whose lifetime the Huguenot department lost much of its scope because of the revocation of the Edict of Nantes (1685). Châteauneuf's son LOUIS II, MARQUIS DE LA VRILLIÈRE (1672–1725), who obtained the Huguenot department in 1700, was the only secretary of state to be retained in effective function during the system of councils (1715–18) under the regency of the duc d'Orléans, when he was moreover secretary general of the council of regency. He secured the reversion of his old secretaryship, with the Huguenot department, for his son LOUIS, COMTE DE SAINT-FLORENTIN (1705–77), in 1723. Saint-Florentin, completely obsequious to King Louis XV, further obtained the department of the king's household (with the affairs of the clergy) in 1749, the rank of minister of state in 1751, the title of duc de La Vrillière in 1770, and temporary management of foreign affairs in 1770–71. Hated for his ruthlessness toward *parlements*, heretics, and freethinkers, he was at last dismissed by Louis XVI in 1775.

Louis I de Pontchartrain (*see* above) became president of the Chambre des Comptes in Paris in 1650; but by refusing his assent to the condemnation of Nicolas Fouquet (*q.v.*) in the 1660s, he forfeited all hope of compensation for his father's secretaryship of state. His son LOUIS II, COMTE DE PONTCHARTRAIN (1643–1727), who was quite unexpectedly appointed premier president of the Breton Parlement in 1677, restored the Pontchartrain fortunes, becoming intendant of the French finances (1687–89), controller general of the finances (1689–99), minister of state (1690–1714), secretary of state with the marine department and the king's household (1690–99), and finally chancellor of France (1699–1714). His son JÉRÔME, COMTE DE PONTCHARTRAIN (1674–1747), was designated for the secretaryship in 1693 and took the departments over in 1699. Tactless and incompetent, he was forced to resign his office to his young son JEAN FRÉDÉRIC, COMTE DE MAUREPAS (*q.v.*) in 1715.

PHENACETIN, a drug also called acetophenetidin, is an effective analgesic and antipyretic for headaches, colds, muscular pains, and rheumatic conditions. It is one of the three ingredients used in APC tablets, the others being aspirin and caffeine.

Phenacetin crystallizes from water in colourless plates that melt at 135° C. It is soluble in about 70 parts of hot water and in about 1,400 parts of cold water. It is prepared by acetylating paraphenetidine or by heating paraacetylaminophenol and potassium ethyl sulfate with alcoholic soda to 150° C. Paraphenetidine is prepared by treating the sodium salt of paranitrophenol with ethyl iodide and reducing the nitrophenetole to paraphenetidine or aminophenetole. The yield may be doubled by diazotizing paraphenetidine, coupling with phenol, ethylating, and reducing.

The formula for phenacetin is $C_{10}H_{13}NO_2$ and its chemical name is paraethyoxyacetanilide.

PHENACITE, a rare mineral consisting of beryllium orthosilicate, occasionally used as a gem stone. In general appearance it is not unlike quartz, for which indeed it had been mistaken, and was for this reason named from the Greek meaning a deceiver.

For gem purposes the stone is cut in the brilliant form but it is not in general use; fine examples are seldom seen outside of private or museum gem collections. The indices of refraction are higher than those of quartz, beryl, or topaz; a faceted phenacite is consequently rather brilliant and may sometimes be mistaken for diamond.

Phenacite has long been known from the emerald and chrysoberyl mine on the Takovaya stream, near Sverdlovsk in the Urals, where large crystals occur in mica schist. It is also found with topaz and microline in the granite of the Ilmen mountains in the

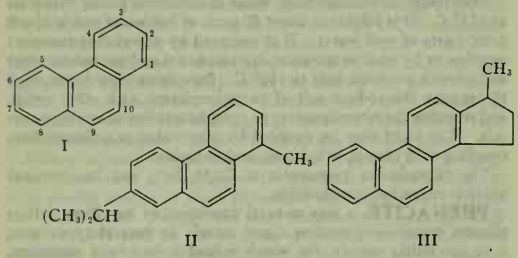
southern Urals and of the Pikes Peak region in Colorado. Large crystals of prismatic habit have been found in a feldspar quarry at Kragero, Nor., and clear lenticular crystals are abundant at San Miguel de Piricicaba in Minas Gerais, Braz.

The formula of phenacite is Be_2SiO_4. It occurs as isolated crystals, which are rhombohedral with parallel-faced hemihedrism and are either lenticular or prismatic in habit. There is no cleavage, the fracture is conchoidal, and the crystals are sometimes perfectly colourless and transparent, but more often grayish or yellowish and only translucent. The hardness is high, being 7.5–8; the specific gravity is 2.98. (Cl. F.)

PHENACODUS, a genus of hoofed mammals, now extinct, of the family Phenacodontidae (order Condylarthra). The two best-known species are represented by complete skeletons found in the Bighorn Basin of Wyoming in 1881. *Phenacodus*, appearing in the Early Eocene of Europe and North America, attained the size of a pig or a fox. The teeth were short crowned, with low rounded cusps, the dentition unreduced, the premolars smaller than the molars and of simple pattern. The feet were five toed but the first and fifth digits were considerably reduced; the small flattened hoofs resembled those of the tapir. The arrangement of the wrist-bones was serial, the upper row directly overlying the lower ones, as in the hyrax and the elephant, instead of alternating as in other hoofed animals. The anklebone in the hind foot had a distinct neck and convex rounded head like that of carnivores. This character distinguishes the Condylarthra from the higher ungulates, as the primitive construction of their teeth distinguishes them from the variously specialized ungulate tooth patterns. The brain was small and of inferior structure. (W. D. M.)

PHENANTHRENE, an aromatic hydrocarbon of little importance in itself but of great value and interest because its structural skeleton occurs as a part of many natural products, including the steroids. Phenanthrene was discovered in 1872 by Rudolf Fittig and Eugen Ostermayer. It has the same composition ($C_{14}H_{10}$) as anthracene and is found with it in coal tar distillates boiling between 300° and 400° C. Phenanthrene crystallizes as colourless leaflets; its melting point is 101° C and its boiling point is 332° C. The commercial product is contaminated with anthracene, fluorene, carbazole, and other substances. It may be purified by treatment with maleic anhydride to remove anthracene, followed by azeotropic distillation with ethylene glycol to remove fluorene, and then treatment with sodium to remove traces of sulfur compounds.

Phenanthrene is oxidized by chromic acid to the 9,10-phenanthrenequinone and diphenic acid (2,2′-biphenyldicarboxylic acid). This and a variety of synthetic methods of preparation establish its structure (I).



Phenanthrene also has been obtained from a Rumanian petroleum distillate, and 1,8-dimethyl- and 1,2,8-trimethylphenanthrene have been isolated from high-boiling fractions of a Kuwait petroleum. The last-named is a major product of dehydrogenation of tetracyclic triterpenoids and of many diterpenoids. Retene (1-methyl-7-isopropylphenanthrene), structure II, is found in fossilized pinewood and in the highest boiling fractions of pinewood tar. It is formed by dehydrogenation of abietic acid.

The completely or partly hydrogenated phenanthrene nucleus is present in opium alkaloids (notably morphine), resin acids, sterols, bile acids, sex hormones, adrenal cortical hormones, heart poisons, saponins, and the steroid alkaloids. The key to the elucidation of the structures of the various groups of steroids was the establishment by synthesis of the structure of Diels's hydrocarbon, formed from members of this group by selenium dehydrogenation, as 3′-methyl-1,2-cyclopentenophenanthrene (structure III).

Phenanthrene forms addition compounds on the 9,10 bond. Hydrogenation gives as the initial product 9,10-dihydrophenanthrene; the unstable 9,10-dichloride and 9,10-dibromide may also be prepared. A large variety of substitution products has been obtained. Nitration for example, gives all five possible mononitro derivatives.

See L. F. and Mary Fieser, *The Chemistry of Natural Products Related to Phenanthrene*, 3rd ed. (1949), *Steroids* (1959). (J. W. Ck.)

PHENIX CITY, a city of eastern Alabama, U.S., in Russell County, on the Chattahoochee River, is opposite Columbus, Ga., of which it is a residential and industrial suburb. Manufactured products include lumber, caskets, and embalming supplies.

In 1923 the legislature extended the corporate limits of Phenix City to include the town of Girard but it did not alter the county boundaries. In 1927, a branch courthouse was established, in that part of Phenix City which had formerly been Girard, to maintain jurisdiction over the northern division of Russell County. The county boundaries were finally altered in 1932, to include all of Phenix City in Russell. The legislature in 1943 provided for the transfer of all records from the old county seat, at Seale, to Phenix City. For comparative population figures *see* table in ALABAMA: *Population.* (P. A. B.)

PHENOLOGY, literally the study of phenomena or happenings, is applied to the recording and study of the dates of recurrent natural events (such as the flowering of a plant, or the first or last appearance of a migrant bird) in relation to seasonal climatic changes. Phenology thus combines ecology with meteorology.

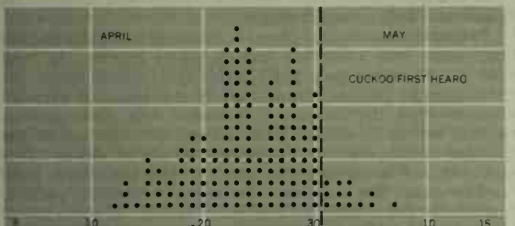
The weather factor that has the greatest influence on recurrent events in temperate climates is almost always temperature; in tropical areas it may be rainfall, humidity, or some other factor. The length of day, which fluctuates throughout the year but is always the same on the same date in every year, often determines the average date of natural events, but not the variation from year to year in a single locality. With resident species these local events are influenced by previous weather conditions in the area; with migrant animals dates of arrival are affected more by conditions at the start of and during their flights. The accompanying figure shows the Marsham records (*see* below) for the first appearance of two migrant birds, the cuckoo and the swallow, in eastern England as examples of the range of date of single annually recurring events over a period of nearly 200 years in the same locality. These data indicate that the swallow generally appears a few days earlier than the cuckoo, and is considerably more variable in its arrival date.

In addition to comparisons of the same event in different years in one locality, phenology is also concerned with studies of the times of the same event in different localities in the same year (when differences of geographic position, soil, slope, shelter, etc., are involved), and of the sequence of different events in one locality during the annual cycle of climate and biological changes. Phenological observations are of importance to farmers and gardeners, and to beekeepers who want to know when nectar-secreting flowers are at their peak production. The best date for spraying for insect pests, particularly of fruit trees in the spring, is determined by the state of development of the leaf and flower buds, which varies from year to year; and the study and application of this is a branch of phenology. In the Netherlands the Ministry of Agriculture informs farmers, a short time in advance, of the best date to start potato harvesting in relation to the state of the crop and the prevalence of certain fungus diseases. Phenological records also have medical applications: they are used to assess the flowering seasons of plants whose pollens cause hay fever.

Although the word "phenology" was first used about 1862, in England the study began as early as 1736, with Robert Marsham's observations of the seasonally recurring events involving plants, insects, and birds in his village in Norfolk, Eng. The Marsham records were continued by Robert's descendants until 1950, except for a break of 25 years. Before 1770 the naturalist Gilbert White

recorded the dates of the first appearances of 20 species of migratory birds at Selbourne, Hampshire, Eng. In 1875 the Royal Meteorological Society of London organized observations of certain plants, birds, and insects, publishing an annual report up to and including 1947. A brief history of phenology in the United Kingdom was given by J. E. Clark in 1936.

In the United States an early phenological study was J. Bigelow's "Facts Serving to Show the Comparative Forwardness of the Spring Season in Different Parts of the U.S.A." (1817; see *Bibliography*). In 1918, A. D. Hopkins, in an article called "Bioclimatic Laws," proposed a method for determining the range of date of occurrence of a seasonal event. His study of agricultural and forest conditions, particularly in the Midwestern U.S., suggested that if the date of a spring event was known at one locality, then the probable date of its occurrence at other localities in the same year would be four days later for each degree of latitude to the north, for each five degrees longitude to the east, and for each 400 ft. rise in altitude. Autumnal events would be approximately the same intervals earlier. Hopkins used his laws (with some empirical corrections) to advise farmers on the best date for certain agricultural operations, in relation to known dates at a particular experimental station. For example, he suggested the best date to sow winter wheat, which, if planted too early, was attacked by fruit fly and if planted too late would suffer from frost. His laws were of value in the comparatively simple weather conditions of the Midwest, where the spring isotherms move northeast at approximately the rates he indicated, but they do not hold for other areas where climatic changes are much more complicated. For example, in the British Isles some spring events happen earlier in the north than in the south. This is due to the unusual climatic conditions, including the influence of the Atlantic Ocean and the Gulf Stream, which result in a mean January temperature in the



PHENOLOGICAL RECORD SHOWING THE FIRST YEARLY APPEARANCES OF THE CUCKOO AND SWALLOW IN EASTERN ENGLAND

north of Scotland and the west of Ireland as high as that in the south of France. In general, spring events in Britain are earlier in the west than in the east.

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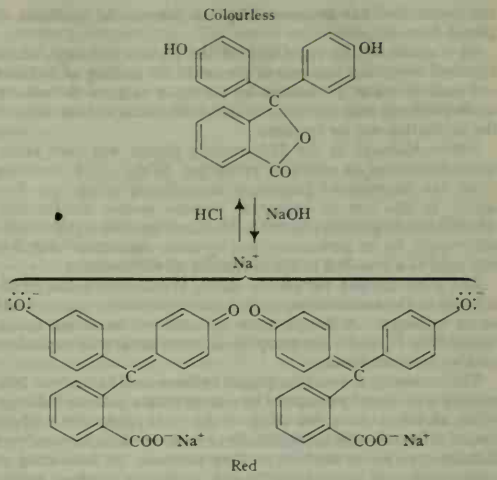
PHENOLPHTHALEIN, an organic chemical compound of the aromatic series that has two uses: (1) as an indicator for acids and bases in volumetric analysis; (2) as a cathartic drug. The phthaleins are prepared by condensing phenols (*q.v.*), with



phthalic anhydride (*q.v.*), phenol itself giving rise to phenolphthalein together with a small quantity of fluorane.

Phenolphthalein is obtained when phenol and phthalic anhydride are heated with concentrated sulfuric acid. It precipitates as colourless crystals (mp 250°–253° C) and is nearly insoluble in water, but the crystals dissolve in dilute alkaline solutions (pH 8.3 or higher) with the appearance of a red-violet colour that is due to the formation of the red disodium salt. If an excess of alkali is added, the solution becomes colourless as the colourless trisodium salt is formed. Crystals may be reprecipitated from these solutions by the addition of an acid. The use of phenolphthalein as an indicator is based on this remarkable colour change. (*See* also INDICATOR, CHEMICAL.)

Phenolphthalein is used extensively as a cathartic under many proprietary drug names. It dissolves in the bile and intestinal fluid, which are slightly alkaline, and, since it irritates the intestine, causes intestinal peristalsis and evacuation. *See* also CATHARTIC.

PHENOLS, a large class of organic substances of which phenol (hydroxybenzene) is the parent compound. They are characterized by the presence of at least one hydroxyl group attached to the benzene ring. Members of the group, in addition to phenol, include the cresols (*q.v.*; or methyl phenols), the xylenols (dimethyl phenols), the dihydroxybenzenes (pyrocatechol, resorcinol [*q.v.*], and hydroquinone), trihydroxybenzene (pyrogallol; *q.v.*), the aminophenols, the halophenols, the nitrophenols (*e.g.*, picric acid; *q.v.*), and the alkylated phenols (*e.g.*, thymol, or 5-methyl-2-isopropyl-1-phenol). Important phenol derivatives include vanillin and anisole.

Phenol, or carbolic acid, was discovered in 1834 by F. F. Runge, who separated it in crude form from coal tar and called it *Karbolsäure*. In 1841 A. Laurent produced the pure substance, again from coal tar, and named it *hydrate de phényle* or *acide phénique*. The term "phenol," which was later used, was introduced by C. F. Gerhardt. He prepared the substance in 1843 by the dry distillation of salicylic acid in the presence of lime. In 1867 A. Wurtz and F. A. Kekulé von Stradonitz discovered the synthesis from benzene, a process still of commercial importance involving the fusion of a strong alkali with the alkali salt of benzenesulfonic acid.

Phenol is found in coal tar, in wood tar, and in many other products derived from the pyrolysis of animal and vegetable matter. In small quantities it is also present in Galician and Caucasian petroleum. It is a product of animal metabolism and, bound to other substances, it occurs in the urine of many mammals.

The commercial manufacture of phenol began in 1860. Originally this substance was obtained solely from coal tar. In the early years of the 20th century, and particularly during World War I, the demand exceeded the supplies available from coal tar,

and production was augmented by the commercial synthesis of phenol from benzene.

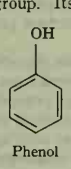
As a result of the rapid rise of the plastics industry, which absorbed increasing amounts of phenol in the making of Bakelite and epoxide resins, production by synthesis outgrew the volume recovered from coal tar, until by mid-20th century about 90% of the production was by synthesis.

Uses.—Although in the 19th century phenol was used extensively because of its antiseptic properties, its use in the operating room was discontinued because of its irritating action (*see* POISON). It also lost its important position among disinfectants, where it was largely supplanted by its homologues of higher molecular weight, by its derivatives, and by other chemicals. But it is still used as a standard in the evaluation of disinfectants.

The great demand for phenol during World War I can be attributed to the extensive use of its trinitro derivative (picric acid) as an explosive. Although made by some of the Allies during World War II, it did not compare in importance with explosives such as trinitrotoluene.

The increasing demand for phenol in the second half of the 20th century was caused principally by the expanding plastics industry, which absorbed about two-thirds of the total production. There phenol is treated with formaldehyde to make the infinite variety of Bakelite-type resins used for molding purposes, for laminating of paper, cloth, and wood, for adhesives, protective coatings, paints, and many other uses. For the epoxide-type resins, phenol is reacted with acetone to form bisphenol A (4,4′-isopropylidenediphenol), which in turn is condensed with epichlorohydrin. Roughly one-fourth of the output went to the chemical and pharmaceutical industries for conversion into such derivatives as salicylates, chlorophenols, alkyl phenols, phenyl phosphates, nitrophenols and phenolsulfonic acids. The production of salicylic acid was one of the best-known outlets for phenol. From it many medicinals (*e.g.,* aspirin), flavours, and dyes were prepared. The chlorophenols are important as bactericides, fungicides, selective herbicides (2,4-dichlorophenoxyacetic acid, or 2,4-D), and starting materials in the production of pharmaceuticals and photographic chemicals. The alkyl phenols are useful as oxidation inhibitors (*e.g.,* di-*tert*-butyl-*meta*-cresol), starting materials for drying-oil-soluble varnish resins (*e.g.,* para-*tert*-butylphenol), and as reagents in the manufacture of synthetic detergents. Triphenyl phosphate is a plasticizer used in cellulose acetate film, and phenolsulfonic acids find application principally in the production of synthetic tanning agents. The remaining production was used as selective solvents in the refining of lubricating oils, the extraction of aromatic fractions (toluene) from petroleum distillates, and for many other purposes. (*See* also ADHESIVES; ANTIOXIDANTS; PLASTICS: *Thermosetting Resins;* RESINS: *Synthetic Resins.*)

Properties.—Phenol is closely related to benzene, differing only in that one of the six hydrogen atoms in the benzene ring is replaced by a hydroxyl (OH) group. Its formula is $C_6H_5{\cdot}OH$. Thus



Phenol

it stands in the same relation to benzene as methyl alcohol, $CH_3{\cdot}OH$, does to methane, CH_4. (*See* also CHEMISTRY: *Hydroxy Compounds.*)

Although it has some properties that resemble those of the aliphatic alcohols, in particular of the tertiary alcohols, phenol cannot be classified as an alcohol. It is characterized by its acidic nature and its readiness to form salts with strong bases. Phenol is the prototype of the hydroxylated members of the benzene series.

Phenol has a molecular weight of 94.11. At atmospheric pressure it boils at 182° C. It solidifies at 41° C into colourless needles. At 25° C its density is 1.072 and its refractive index at 41° C is 1.5425. It has a characteristic pungent odour and in dilute water solution a sweetish taste. In more concentrated form it is poisonous and produces burns on the skin. At room temperature phenol is sparingly soluble in water. If more than 8% by weight of phenol is present, two phases appear in the solution, a bottom layer consisting of phenol with some dissolved water and a top layer of water containing about 8% phenol. As the temperature is elevated, the mutual solubility increases, until above 66° C phenol and water become soluble in all proportions. Phenol is readily soluble in alcohol, ether, chloroform, carbon disulfide, glacial acetic acid and the hydrocarbons of the aromatic series. It is less soluble in the liquid hydrocarbons of the aliphatic series. Because of its acidic nature, it dissolves readily in solutions of alkalies with the formation of alkali-metal salts. These salts are readily decomposed by the addition of acids. Similarly to ordinary alcohols, phenol can be esterified with carboxylic acids, although the reaction does not proceed with the same ease and often requires the action of the chloride or anhydride of the carboxylic acid or an alkali-metal salt of phenol. It can be converted into an ether by treating its sodium or potassium salt with an alkyl halide, such as methyl iodide, or by treating it under elevated temperature and pressure with acetylenes in the presence of alkaline catalysts.

As a typical derivative of benzene, phenol can be sulfonated, nitrated, and halogenated. The presence of the hydroxyl group enhances the reactivity of the benzene ring, so that milder conditions are indicated to control the reactions. Halogenations proceed quantitatively to the trihalide stage, a fact that is useful in the analysis for phenol. Substitutions take place principally in positions ortho and para to the hydroxyl group. Hydrogen, in the presence of active catalysts, will add to phenol to form cyclohexanol or, under more drastic conditions, cyclohexane. Of great commercial importance is the readiness with which phenol reacts with aldehydes, in particular formaldehyde, to form condensation products of high molecular weight.

Preparation.—Natural phenol is recovered at coal tar distillation plants from a distillate fraction boiling between 160° and 230° C. To extract the phenol together with its homologues—the various cresol (methyl phenols) and xylenol (dimethyl phenols) isomers—from this fraction, it is washed with dilute aqueous sodium hydroxide solution. To "spring" the acids out of the aqueous solution the extract is purified and treated with an acidic material, such as carbonic acid, which is often available in stack or kiln gases. The acids thus liberated are withdrawn, purified, and finally fractionally distilled under vacuum to yield phenol in various grades of purity followed by the cresol and xylenol cuts.

Synthetic phenol is produced from benzene mainly by three general procedures which may be classified according to the main process steps as follows:

1. Sulfonation process, which consists in the treatment of benzene with sulfuric acid and subsequent fusion of the resulting benzenesulfonic acid with sodium hydroxide to form sodium phenoxide, which is dissolved in acids to liberate phenol.

2. Chlorination process, which consists in the treatment of benzene with chlorine and subsequent hydrolysis of the resulting chlorobenzene with steam or with aqueous alkaline solutions to form phenol or alkali phenoxide solutions, the latter being treated with acids to liberate phenol.

3. Cumene process, which consists in the reaction of benzene with propylene to form cumene (monoisopropylbenzene); oxidation of the cumene with air to make cumene hydroperoxide; and, finally, cleavage of this hydroperoxide to produce phenol and acetone.

In the sulfonation process benzene is caused to react with an equivalent amount of concentrated sulfuric acid to form monobenzenesulfonic acid according to the equation

$$C_6H_6 + H_2SO_4 \rightarrow C_6H_5SO_3H + H_2O$$

Since the reaction slows down as the reactant sulfuric acid becomes diluted with the water of reaction, the process is often carried out by passing benzene vapour through a sulfuric acid bath, maintained at a temperature above 100° C, in such a way that only a portion of the benzene reacts while the rest escapes as vapour together with the water formed in the reaction. The vapours are condensed, the water is separated, and the benzene is returned to the sulfonation bath. At the end of the cycle there is obtained in

the bath benzenesulfonic acid which is essentially free of sulfuric acid and which can be used directly in the fusion step without the laborious intermediate steps necessary if appreciable quantities of free sulfuric acid remain dissolved in the sulfonation product. The second, so-called fusion, step in the process proceeds according to the reaction

$$C_6H_5{\cdot}SO_3H + 3NaOH \rightarrow C_6H_5{\cdot}ONa + Na_2SO_3 + 2H_2O$$

In practice this operation is carried out in cast-iron vessels. Caustic soda in excess of the theoretical requirement is first charged and heated to about 300° C. Then the benzenesulfonic acid or its sodium salt is pumped into the molten mass. After about six hours the reaction mixture is plunged into aqueous-process liquors in which sodium sulfite crystallizes out because of its low solubility in strongly alkaline solutions. The solution is filtered, and the filtrate, containing sodium phenoxide and residual free caustic soda, is treated with sulfuric acid to liberate the phenol and to convert the soda into sodium sulfate. A final distillation of the phenol removes water and furnishes the marketable product.

In the chlorination process, benzene is treated with chlorine to form monochlorobenzene according to the equation

$$C_6H_6 + Cl_2 \rightarrow C_6H_5{\cdot}Cl + HCl$$

The reaction is carried out in cylindrical vessels. Iron is added to the charge as a catalyst. To repress the formation of the more highly substituted polychlorobenzenes, an excess of benzene is maintained in the reaction zone. The resulting crude chlorination product is treated with a dilute caustic soda solution to free it of by-product hydrogen chloride.

After settling, the product is subjected to fractional distillation to separate from it the nonconverted benzene and to purify the monochlorobenzene. The more highly chlorinated products remain in the still bottoms. The conversion of monochlorobenzene into phenol is commercially accomplished by any one of the following reactions:

(1) $C_6H_5{\cdot}Cl + H_2O \rightarrow C_6H_5{\cdot}OH + HCl$
(2) $C_6H_5{\cdot}Cl + 2NaOH \rightarrow C_6H_5{\cdot}ONa + NaCl + H_2O$
(3) $C_6H_5{\cdot}Cl + Na_2CO_3 + H_2O \rightarrow C_6H_5OH + NaCl + NaHCO_3$

Reaction 1, in the presence of a catalyst, proceeds in the vapour phase at about 500° C and atmospheric pressure. Reaction 2 is carried out in the liquid phase at high pressure and temperature in corrosion-resistant autoclaves. The resulting sodium phenoxide solution is treated with the by-product hydrogen chloride from the chlorination step to liberate the phenol. Reaction 3 is utilized in the Dow Chemical Co. process in which chlorobenzene and soda ash solution are pumped through long copper coils at a pressure of 3,000 lb. per sq.in. and at about 320° C. After the mixture is cooled, the pressure is released and free phenol separates from the bicarbonate solution. Diphenyl ether appears as the product of a side reaction. Fortunately, its formation can be suppressed by returning some of it to the mixture entering the hydrolysis step. For final purification the phenol is subjected to a fractional distillation under vacuum.

Since the vapour-phase hydrolysis (reaction 1) furnishes hydrogen chloride, economies could be realized if this by-product were utilized as a source of chlorine in the chlorination of benzene. This has been accomplished by the Raschig process, which combines the principle of the Deacon process—the preparation of chlorine from hydrogen chloride and oxygen—with the chlorination of benzene and the subsequent vapour-phase hydrolysis of chlorobenzene. The process uses air as the source for oxygen and is operated on a large scale. The individual reactions can be summarized by the equation

$$C_6H_6 + \tfrac{1}{2}O_2 \rightarrow C_6H_5{\cdot}OH$$

In the cumene process (used commercially since 1950), benzene is treated with gaseous propylene in the presence of an acidic catalyst such as aluminum chloride or phosphoric acid on a clay support. After neutralization the resulting reaction mixture is distilled to separate monoisopropylbenzene (called cumene) from polyisopropylbenzene and unconverted benzene. The cumene is then subjected to air oxidation until about one-third is converted to cumene hydroperoxide. The excess cumene is removed from the oxidation mixture by distillation at reduced pressure and recycled. The residue contains the concentrated cumene hydroperoxide and is contacted with a strong acid whereupon it decomposes into phenol and acetone. These reactions are shown by the equations:

$$C_6H_6 + C_3H_6 \rightarrow C_6H_5CH(CH_3)_2$$
$$C_6H_5CH(CH_3)_2 + O_2 \rightarrow C_6H_5C(CH_3)_2OOH$$
$$C_6H_5C(CH_3)_2OOH \rightarrow C_6H_5OH + (CH_3)_2CO$$

The final products, phenol and acetone, are separated by fractional distillation.

See also references under "Phenols" in the Index. (E. W. V.)

PHENOMENALISM (from the Greek *phainomenon*, "appearance", *see* PHENOMENON), a philosophical theory of perception and the external world. Its essential tenet is that propositions about material objects are reducible to propositions about actual and possible sensations, or sense data, or appearances. According to the phenomenalists, a material object is not a mysterious something "behind" the appearances which we experience in sensation. If it were, the material world would be unknowable; indeed, the term "matter" itself would be unintelligible unless it could somehow be defined by reference to sense experiences. In a phenomenalistic analysis of material-object propositions, it is of course essential to mention possible sensations and not merely actual ones. The wall which someone sees just in front of him is hard and rough, though he is not at the moment touching it. But it is still true that, if he were to stretch out his hand, he would experience tactual sensations of hardness and roughness. These tactual sensations are possible, though not at the moment actual. Moreover, material objects continue to exist at times when they are not being observed at all. For instance, there is a fire burning in the next room, though no one at present sees or feels it. But it is still true that, if there were an observer in the next room, he would experience bright, flickery, yellowish colour-patches, and he would feel warmth. Moreover, the precise character of the visual sensations which he would experience and, likewise, the degree of warmth which he would feel would vary with the point of view which he occupied in the room. In speaking about a material object, then, we must be referring to a very large group or system of many different possibilities of sensation. Whether actualized or not, these possibilities continue during a certain period of time. When the object is observed, some of these possibilities are actualized, though not all of them. So long as it is unobserved, none of them are actualized. In this way, the phenomenalist claims, we can give an "empirical cash-value" to the concept of matter, by analyzing it in terms of sensations.

It must be emphasized that the term "possible sensation," as phenomenalists use it, is a kind of shorthand for a hypothetical ("if . . . , then . . .") proposition. When it is said that a visual sensation of such and such a kind is possible, though not actual, the meaning is that a colour sensation of that kind would occur if there were an observer at such and such a place where there is in fact no observer.

Some of the classical difficulties of phenomenalism arise directly from the central part which these hypothetical propositions play in the phenomenalist analysis. The phenomenalist claims to analyze all material-object expressions in terms of actual and possible sense experiences. But it is difficult for him to avoid using material-object expressions in his if-clauses, and this would make his analysis circular. In the example just given, "an observer" (*i.e.*, an animate human organism) is a material-object expression, and so is "in the next room." No doubt we might attempt to analyze each of these material-object expressions in terms of other possible sense experiences. "The next room," for instance, might be resolved into the visual and other sensations which an observer would have if he opened the door or looked through the window. Expressions referring to an observer might be analyzed in terms of the sensations which another observer would have if he were to look in a certain direction. But now the same difficulty arises again about these new if-clauses. A second and even

more important objection is this: it is very difficult to believe that categorical propositions about material objects (*e.g.*, "there is a fire in the next room") can be analyzed without remainder into sets of hypotheticals; *i.e.*, that a statement about what there actually is can be reduced to a set of statements about what there would be if certain (nonexistent) conditions were to be fulfilled.

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PHENOMENOLOGY is, in the 20th century, mainly the name for a philosophical movement whose primary objective is the direct investigation and description of phenomena as consciously experienced, without theories about their causal explanation and as free as possible from unexamined preconceptions and presuppositions. The word itself is much older, going back at least to the 18th century, when Johann Heinrich Lambert (*q.v.*), in his *Neues Organon* (1764), applied it to that part of his theory of knowledge which distinguishes truth from illusion and error. In the 19th century it became associated chiefly with Hegel's *Phänomenologie des Geistes* (1807), which undertook to trace the development of the human spirit from mere sense-experience to "absolute knowledge." The so-called Phenomenological Movement did not get under way until the first decade of the 20th century. But even this new phenomenology includes so many varieties that a fair picture requires a brief sketch of its development.

ORIGIN AND DEVELOPMENT

Husserl's Early Phenomenology.—Phenomenology was not founded: it grew. Its fountainhead was Edmund Husserl (*q.v.*). Yet even for Husserl the idea of phenomenology as a new method destined to supply a new foundation for both philosophy and science developed only gradually and kept changing to the very end of his career. Trained as a mathematician, Husserl was attracted to philosophy by Franz Brentano (*q.v.*), whose descriptive psychology seemed to offer a solid basis for a scientific philosophy. The failure of Husserl's first work, *Philosophie der Arithmetik* (1891), to secure an adequate foundation for mathematics, in combination with the strictures of Gottlob Frege (*q.v.*), resulted in Husserl's systematic examination and repudiation of "psychologism," the attempt to use empirical psychology as the ultimate basis for logic. Nevertheless, the "pure logic," which Husserl now outlined at the end of the "Prolegomena" for his *Logische Untersuchungen* (1900), still required, in his thinking, a parallel study of the acts in which the ideal structures of such a logic were given. So the second volume of this epoch-making work consisted largely of "phenomenological analyses," exploring these acts in their essential structures, in contrast to the merely empirical investigation of their factual modifications studied by psychology.

The most important of these painstaking studies dealt with Brentano's concept of intentionality, the main feature by which he had tried to distinguish psychological from physical "phenomena" (taking this term in the wide sense given it by the Newtonian and positivist tradition). But while for Brentano the "intentional relation" meant merely the reference of our perceiving, judging, or loving acts to their perceived, judged, or loved objects, Husserl found in these acts a much richer structure. Thus in our perceiving of this printed page he would distinguish not only the seeing and the seen but also the perspective aspects through which this page appears and its modes of clarity, and he would study the ways in which consciousness relates and synthesizes the various appearances as they refer to the identical object, the page. Husserl also distinguished between "empty" intentional references and those fulfilled with intuitive content (*Anschauung*), which alone could justify such intentions epistemologically. Besides, these intuitive acts were no longer confined to sense-experience. Even the correlates of such logical connectives as "and," "or," and "if" could be given in a nonsensuous or "categorial" intuition, an extension which opened the way for the recognition of the intuitive givenness of such phenomena as relations, essences, values, and other phenomena, both real and ideal.

Only in the years after the publication of these studies did Husserl develop the idea of phenomenology as a universal foundation of philosophy, capable of converting it into a "rigorous science," a science consisting in the descriptive exploration of the essential structures of the directly given, free on the one hand from the unexamined assumptions of a "naturalism" restricted to the empirical natural sciences, and on the other hand from the relativism implied in the historicism of the *Geisteswissenschaften*. This new scientific philosophy was, however, not meant to supply the cheap comforts of a complete *Weltanschauung* or a speculative metaphysics.

Husserl's Pure or Transcendental Phenomenology.—The development of a rigorous or "pure" phenomenology as the science of the essential structures of consciousness by means of correlated studies of the intentional act (*noesis*) and its objective referent (*noema*) involved for Husserl a systematic effort to purify the phenomena of all merely factual ingredients, as studied by the empirical sciences, and of all constructive interpretations. To this end he developed his technique of the "reductions," among which the phenomenological or "transcendental" reduction was the decisive one. Beginning with the suspension of belief in the reality of what seems to be immediately given, like the present printed page, and neither denying nor even doubting its existence, the reductive procedure (*epoché*) aimed at isolating first the field of pure phenomena given with absolute certainty. This field would include each reader's own ego, his acts of reading, and the page as read with all the complexities of its modes of givenness. This immanent region of absolute subjectivity thus coincided for Husserl largely with Descartes' sphere of the indubitable ego, its cogitating acts, and the objects of cogitation insofar as cogitated. Adopting Kantian terminology, Husserl also called this immanent region the transcendental consciousness, as distinguished from its transcendent counterpart, the objects of the real world, such as the page meant as part of the real world beyond consciousness. As to this transcendent world, the reduction was to uncover the otherwise hidden ways by which it was constituted in our consciousness, either passively, as it happens in the perceptual experience of this physical page, or actively, as it takes place in predicative judgments or in the constitution of the sense of the sentences as read on this page. Such "constitutive phenomenology" provided Husserl with the main evidence for his peculiar "transcendental idealism" (to be distinguished from Berkeley's idealism with its basis in the empirical mind), according to which the transcendent objects owe not only their being known but also their very being to the constituting acts of transcendental consciousness. Although even other transcendental egos were supposed to be constituted in each one's own consciousness, Husserl believed that he could avoid solipsism by the introduction of peculiar acts of "appresentation," which attested the equal rights of other transcendental egos. The outcome was a "metaphysical" framework for which Husserl adopted the Leibnizian term "monadology."

In his later philosophizing, consisting largely in the production of a vast number of research manuscripts, Husserl tried to refine especially his studies of the consciousness of time, to which he attributed fundamental importance for the understanding of the structures of all consciousness. But he also sought to open new avenues into his transcendental phenomenology. The one which proved most fruitful was the study of the immediate life world (*Lebenswelt*) of the individual with the ego at its centre, as distinguished from the uncentred objective world of modern science, which, however, was supposed to have sprung from it. This life world was to provide guides for the study of transcendental consciousness.

The Phenomenology of Essences.—A different type of phenomenology, the phenomenology of essences, developed from a tangential continuation of the phenomenology of the *Logische Untersuchungen*. Its supporters were Husserl's students in Göttingen and a group of young philosophers in Munich, originally students of Theodor Lipps (1851–1914), who had turned away from the latter's psychologism and discovered in Husserl powerful support. The Phenomenological Movement, which now began to take

shape, found its most tangible expression in the issuance of the *Jahrbuch für Philosophie und phänomenologische Forschung* (1913–30), a phenomenological yearbook under Husserl as main editor, whose preface defined phenomenology in terms of a return to intuition (*Anschauung*) and to the essential insights (*Wesenseinsichten*) derived from it as the ultimate foundation of all philosophy.

The 11 volumes of the *Jahrbuch* contained, in addition to Husserl's own works, the most important production of the movement in the broader sense. Of the co-editors, Alexander Pfänder (1870–1941) contributed chiefly to the development of phenomenological psychology and pure logic, but developed also the outlines of a complete phenomenological philosophy. Moritz Geiger (1880–1937) applied the new approach particularly to aesthetics, Adolf Reinach (1883–1917) to the philosophy of law. But the most original and dynamic of Husserl's early associates was Max Scheler (*q.v.*), who had joined the Munich group and who did his major phenomenological work in ethics, where he applied it particularly to the problems of value and oughtness. The Polish philosopher Roman Ingarden (1893–) did major work in structural ontology and analyzed the structures of various works of art in its light, while Hedwig Conrad-Martius (1889–) worked intensively in the ontology of nature. Wilhelm Schapp, Jean Hering, Edith Stein, and others have made comparable contributions to various other fields of philosophy. None of these early phenomenologists followed Husserl's road to transcendental idealism, while some tried to develop a phenomenology along realistic lines.

Heidegger's Hermeneutic Phenomenology.—Phenomenology took a new turn in 1916, when Husserl moved to Freiburg im Breisgau, where he was assisted chiefly by Ludwig Landgrebe (1902–) and Eugen Fink (1905–), who, however, emancipated themselves after Husserl's death. But the main event was the adoption of phenomenology by Martin Heidegger (*q.v.*), who had been trained in scholastic philosophy and in the Neo-Kantianism of Heinrich Rickert. Approaching what was for him the supreme question, that of the meaning of beingness (*Sein des Seienden*) through an analysis of the being which we ourselves are (*Dasein*), Heidegger saw in phenomenology the most promising way to uncover the categories of human existence (*existentialia*) for a "fundamental ontology." However, since neither Husserl's phenomenology of transcendental reduction nor the phenomenology of essences proved adequate to this task, he developed a new "hermeneutic phenomenology" designed to interpret the ontological meanings of such human conditions as being-in-the-world, anxiety, and care, with results as startling as they were original.

References to phenomenology nearly disappeared from Heidegger's publications after he had abandoned the completion of his magnum opus, *Sein und Zeit* (1927), for a variety of reasons, which involved not only his estrangement from Husserl, who was disappointed in Heidegger as his academic successor for not continuing his own transcendentalism, but also the failure of the approach to being via human existence to yield the final answer to his basic question. Still, even in his later works Heidegger claimed the "essential help of phenomenological seeing," much as his methods of philosophizing were otherwise changed.

Phenomenological Existentialism in France.—Phenomenology underwent further changes when it was adopted by French philosophy in the form of phenomenological existentialism, a merger which had not yet taken place in Germany, where Karl Jaspers had opposed his philosophy of existence, with its existential appeal to the individual, to phenomenology, with its claims to scientific rigour. Its first French practitioner, Gabriel Marcel (1889–), inspired primarily by Scheler, spoke of phenomenology in the context of his metaphysical meditations on human existence, using it as an aid in exploring concrete situations and such experiences as hope, which had been neglected by scientific psychology and more objectivist philosophies. Jean Paul Sartre (*q.v.*) found in Husserl's phenomenology the effective method for his descriptive explorations of the imagination and the emotions. He moved, however, closer to Heidegger's version in his "essay on phenomenological ontology," *L'Être et le néant* (1943). But even then Sartre defined existence in terms of Husserl's consciousness, rather than Heidegger's *Dasein*, though he rejected Husserl's transcendental idealism as an account of being, the essentially opaque counterpart of consciousness.

Phenomenology became even more central in the philosophy of Maurice Merleau-Ponty (1908–61), whose *Phénoménologie de la perception* (1945) was the most original achievement of French phenomenology of its time. Starting from Husserl's late phenomenology of the life world, Merleau-Ponty anchored the phenomena of perception in the phenomenology of the lived body, in which the perceiving subject was incarnated, as the mediating link to the phenomenal world. Such a phenomenology of human "presence" in the world was also to offer an alternative to the rigid disjunction between idealism and realism, in which consciousness and the world could be reciprocally related. Phenomenology thus became a way of showing the essential involvement of human existence in the world, starting with everyday perception. Important uses of phenomenology can also be found in Paul Ricoeur's *Philosophie de la volonté* (1950–) and Mikel Dufrenne's *Phénoménologie de l'expérience esthétique* (1953).

Dissemination and Influence.—Phenomenology also spread to countries other than France, but there its contributions were less original and substantial, and its modifications less pronounced. However, in Belgium, seat of the Husserl Archives in Louvain since the salvage of Husserl's papers from the Nazis, in the Netherlands, Switzerland, Italy, Spain, and the Latin-American countries, where José Ortega y Gasset introduced it, phenomenology became a major philosophical trend. It was less successful in the Anglo-American world, particularly in England, where it was soon eclipsed by the more congenial philosophy of Ludwig Wittgenstein, although the efforts of such philosophers as J. N. Findlay produced signs of renewed interest. Even in the United States, where Marvin Farber gained a hearing for it in the late 1930s, it never became fully naturalized, though John Wild's phenomenology of the life world gave it new impetus. It also influenced greatly such established international philosophies as Neo-Thomism (Albert Dondeyne).

Of greater significance is the role of phenomenology outside philosophy proper in stimulating or reinforcing phenomenological tendencies in such fields as mathematics (Oskar Becker, Moritz Geiger, Hermann Weyl) and the biological sciences (F. J. J. Buytendijk). Much stronger was its impact on psychology, where Franz Brentano and Carl Stumpf had prepared the ground and where William James, the Würzburg school, and the Gestalt psychologists had worked on parallel lines: apart from the philosophical phenomenologists interested in psychology, David Katz, Johannes Linschoten, and C. G. Graumann may serve as examples. But phenomenology has probably made its strongest contribution to psychopathology, where Karl Jaspers stressed the importance of phenomenological exploration of the patient's subjective experience, and was followed by Ludwig Binswanger, Eugène Minkowski, Viktor von Gebsattel, Erwin Straus, and others. The phenomenological strand is also very pronounced in American existential psychiatry, as promoted chiefly by Rollo May. Phenomenology has also affected sociology (Felix Kaufmann, Alfred Schutz), history (Raymond Aron), and the study of religion (Max Scheler, Rudolf Otto, Friedrich Heiler, Gerardus van der Leeuw, Paul Tillich).

CHARACTERISTICS

Considering the variety of phenomenologies which have thus issued directly or indirectly from Husserl's inspiration, it is not easy to find a common denominator for such a movement beyond its common source. But similar situations occur in other philosophical and nonphilosophical movements. Although, seen from Husserl's last perspective, all departures from his own could not but appear as heresies, a more generous view will show that all those who consider themselves as phenomenologists subscribe, for instance, to his watchword "To the Things" (*Zu den Sachen*), meaning by it a fresh approach to the concretely experienced phenomena, as free as possible from conceptual presuppositions, and an attempt to describe them as faithfully as possible. Besides,

most adherents to phenomenology will hold that it is possible to obtain insights into the essential structures and the essential relationships of these phenomena on the basis of the careful study of concrete examples supplied by experience or imagination and by systematic variation of these examples in the imagination. Some phenomenologists also stress the need of studying the ways in which the phenomena appear in our intentional consciousness. Beyond this merely static aspect of appearance some also want to investigate its genetic aspect, exploring, for instance, how the phenomenon intended, say, a book, constitutes itself in the typical unfolding of our experience. Husserl himself believed that such studies required a previous suspension of belief in the reality of these phenomena, while others consider it not indispensable but helpful. Finally, it should be mentioned that in existential phenomenology the meeting of certain phenomena such as anxiety is explored by a special "hermeneutic" interpretation, whose methodology needs further clarification.

It may also be helpful to bring out the distinctive "essence" of phenomenology by confronting it with some of its philosophical neighbours. In contrast to positivism and traditional empiricism, from which Brentano had started out and with which phenomenology shares the unconditional respect for the positive data of experience ("We are the true positivists," Husserl claimed in his *Ideen*), phenomenology does not restrict these data to the range of sense-experience, but admits on equal terms such nonsensuous data as relations, categorial entities, values, etc., as long as they present themselves intuitively. Consequently phenomenology does not reject universals and recognizes, in addition to the analytic *a priori* and the synthetic *a posteriori*, knowledge of synthetic *a priori* relationships based on insight into essential relationships within the empirically given.

In contrast to phenomenalism (*q.v.*), an epistemological position with which it is often confused, phenomenology, which is not primarily an epistemological theory, accepts neither the rigid division between appearance and reality, let alone a thing-in-itself, nor the narrower view that phenomena are all there is (sensations or permanent possibilities of sensations). These are questions on which phenomenology as such keeps an open mind, pointing out, however, that phenomenalism overlooks the complexities of the intentional structure of our consciousness of the phenomena.

In contrast to a rationalism which stresses conceptual reasoning at the expense of experience, phenomenology insists on the intuitive foundation and verification for all formal concepts, and especially for all *a priori* claims; in this sense it is a philosophy "from below," not "from above."

In contrast to an analytic philosophy which substitutes simplified constructions for the immediately given in its complexity and applies "Ockham's razor," phenomenology resists all transforming reinterpretations of the given, analyzing it for what it is in itself and on its own terms.

In contrast to linguistic analysis, with which however phenomenology shares its respect for the distinctions of the phenomena reflected in the shades of ordinary language as at least one possible starting point for phenomenological analyses, phenomenology does not think that the study of ordinary language is a sufficient basis for studying the phenomena in all their complexity, which ordinary language cannot and need not try to exhaust.

In contrast to an existential philosophy which believes that existence is unfit for phenomenological analysis and description, since it tries to objectify the unobjectifiable, phenomenology holds that it can and must deal with these phenomena, however cautiously, as well as with other intricate phenomena outside human existence.

In the third quarter of the 20th century it remained to be seen whether phenomenology could make solid contributions to philosophical knowledge. To this end it needed to develop rigorous standards, which had not always been observed by some of its most brilliant practitioners, such as Max Scheler, and which were apt to be violated in a philosophy whose ultimate appeal had to be made to intuitive verification. With this proviso, phenomenology may well be qualified, not only to become a bridge for better international communication in philosophy but also to shed new light on philosophical problems old and new, to reclaim for philosophy parts of our everyday life world which have been abandoned by science as too private and too subjective, and finally to give access to layers of our experience unprobed in our everyday living, thus providing deeper foundations for both science and life.

BIBLIOGRAPHY.—The *Logische Untersuchungen*, not yet available in English translation, are ably reported on in J. N. Findlay's article "Phenomenology" in the preceding editions of the *Encyclopædia Britannica* and more fully paraphrased in Marvin Farber's *The Foundation of Phenomenology* (1943). The first book of *Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie* is available in W. Boyce Gibson's not always reliable translation (1931; reissued 1952), the *Cartesianische Meditationen* in the faithful English rendering of Dorion Cairns (1960). The *Husserliana* edition of the Husserl Archives (1950 ff.) in its early volumes emphasized previously unpublished materials but will eventually include all of Husserl's works. Husserl's article "Phenomenology" in the 1929 edition of *Encyclopædia Britannica* (retained until 1956) appears in the light of the German original (*Husserliana* IX) as an over-condensation by the translator which cannot claim to be an authentic text.

References to the major works of the phenomenological movement in the original and translation and to the secondary literature, especially in English, can be found in H. Spiegelberg, *The Phenomenological Movement*, 2nd ed. (1965); *see* also works cited in the article HUSSERL, EDMUND. Most of the original German studies on phenomenology appeared in the *Jahrbuch für Philosophie und phänomenologische Forschung* (1913–30). The very different U.S. quarterly *Philosophy and Phenomenological Research*, ed. by Marvin Farber, occasionally publishes articles related to phenomenology. (HE. SP.)

PHENOMENON (Greek *phainomenon*, from *phainesthai*, "to be shown," "to seem," "to appear"), any object, fact, or occurrence perceived or observed. The Greek verb *phainesthai* can be used with or without the implication that the thing perceived is other than what it appears to be. Thus in Aristotle's ethics "the apparent good" is what seems good to a man, whether or not it really is good. In general, phenomena are the objects of the senses, sights, and sounds, contrasted with the real objects apprehended by the intellect. In later Greek philosophy phenomena are the observed facts contrasted with the theories devised to explain them. A theory is said to "save the phenomena" if it is consistent with the facts.

This last use became common in the early part of the 17th century when scientists used phenomena for the observed facts that they sought to explain (*e.g.*, astronomical phenomena, the phenomena of gravitation, phenomena of magnetism), a use still current. In modern philosophy the word is sometimes used for what is immediately apprehended by the senses before any judgment takes place; but it has never become a technical term, most philosophers preferring more artificial words such as sense-datum (hence such terms as phenomenalism and phenomenology, *qq.v.*). In English versions of Kant the word is often used to translate *Erscheinung* ("appearance"), Kant's word for the immediate object of sensory intuition, the bare datum which becomes an object only when interpreted through the categories of substance and cause. Kant himself uses it for the object interpreted through the categories as opposed to the noumenon (*q.v.*), or thing-in-itself, to which the categories do not apply. (P. H. N.-S.)

PHERECYDES OF SYROS (fl. *c.* 550 B.C.), Greek mythographer and cosmogonist, who is traditionally associated with the Seven Wise Men of Greece, especially with Thales. He was the son of Babys and is to be distinguished from the genealogist Pherecydes of Athens, who lived about a century later. The earliest known reference to Pherecydes of Syros is in the 5th-century poet Ion of Chios. The belief that he was responsible for a *heliotropion* (a means of marking the "turning-point" of the sun at the solstice) on the island of Syros made some connect him with a line in the *Odyssey* (xv, 404) and place him earlier than Homer; but tradition made him the teacher of Pythagoras. The same miracles were ascribed to both, and this may be the reason why Cicero (*Tusculan Disputations*, i, 16, 38) and Augustine (*Contra Academicos* iii, 17; *Epistle* cxxxvii, 12) say that he first taught the immortality of the soul. He was also credited with the doctrine of metempsychosis.

Aristotle (*Metaphysics* 1091 b 8) characterized Pherecydes' work as a mixture of myth and philosophy. His book the *Heptamychos*

(L. Preller's correction *Pentemychos* is probably unnecessary), of which only a few fragments remain, described the origin of the world and the loves and battles of the gods. Despite its mythical form, it has features reminiscent of 6th-century Ionian speculation; for instance, the god Time creates three elements, fire, air and water, which Zeus-Eros unites to form a cosmic system. Allegory is prominent, as in the names of the gods and in a fragment describing a robe embroidered by Zas (Zeus) for his bride Chthonie (Earth) with representations of earth and ocean. Its philosophical tendency and its prose form distinguish the work from most of the rich cosmogonical literature of the 7th and 6th centuries B.C. (*e.g.*, the theogonies of Hesiod and of the pseudo-Orpheus); some critics have seen the influence of Anaximander in both features.

See O. Kern, *De Orphei, Epimenidis Pherecydis theogoniis* (1888); H. Diels and W. Kranz, *Die Fragmente der Vorsokratiker*, 3 vol., 7th ed. (1954). (W. K. C. G.)

PHETBURI, a province of peninsular Thailand lying between the Gulf of Thailand and southern Burma. The eastern part, especially astride the middle course of the Phetburi River, contains areas of productive alluvial soils which produce rice, coconuts, and palm sugar. Irrigation, however, is necessary. The topography of the western part is mountainous and heavily forested. Area 2,454 sq.mi. (6,359 sq.km.); pop. (1960) 237,853.

Phetburi (pop. [1960] 24,654), the capital, is near the mouth of the Phetburi River, 93 mi. (150 km.) SW of Bangkok by rail.

In ancient times before the sea route through the Straits of Malacca and around the Malay Peninsula was developed, Phetburi was the eastern terminus of an overland trade route from India and Europe to continental southeastern Asia. Ruins of ancient Brahman and Buddhist temples and caves are found in the environs; also a palace built by King Mongkut and one built by his son King Chulalongkorn. (T. F. B.)

PHIDIAS (Pheidias) (active from about 475 to 430 B.C., or later), an Athenian, the son of Charmides and pupil of Hegias, may be regarded as the greatest of Greek sculptors. Among his early works, the most important were a bronze group at Delphi (perhaps *c.* 465), erected as a memorial after the battle of Marathon; a gold and ivory statue of Athena in Achaea; and the famous bronze Athena on the Athenian Acropolis, also a thank offering after Marathon, but not set up until *c.* 456 (*cf., Hesperia,* xv, pp. 106 ff.; 1946).

When Pericles rose to power (449) and initiated a great building program in Athens, Phidias was put in charge of all artistic undertakings (*see* Plutarch, *Perikles*). Phidias himself made the gold and ivory statue of Athena, about 40 ft. high including its base, that stood inside the Parthenon and was dedicated in 438.

According to Pausanias' *Description of Greece* (I. 24, 6), the goddess stood erect, wearing a tunic, aegis and helmet, a winged victory on her extended right hand, a spear in her lowered left; by her side were a shield and a serpent; base, shield and helmet were adorned with figures. From this description a number of copies have been identified, notably the Varvakeion and Lenormant statuettes in Athens, the Strangford shield in London and the reliefs found in the sea off the Piraeus.

Though Phidias himself could not have executed the sculptures of the Parthenon—the 92 metopes, the frieze about 170 yards long and the two pediments—it seems probable that he was responsible for their design. Much of the sculptural decoration has survived (now mostly in London, Athens and Paris; a few pieces in the Vatican). Since they are Greek originals, these remains show the style of Phidias better than a host of Roman copies. (*See* Parthenon.)

Phidias' foremost work, in the estimation of the ancients, was the gold and ivory statue of Zeus, about seven times life-size, that he made for the temple at Olympia. It was considered the greatest religious statue of Greece, and Quintilian (*Institutionum Oratoriarum,* XII, 10, 9) says that "its beauty can be said to have added something to traditional religion." All that now remain are the description by Pausanias, small reproductions on Roman coins and terra-cotta moulds used for the drapery. Zeus was shown seated on a throne, holding a Nike in his right hand and a sceptre in his left. All parts of the statue, even the sandals, were richly decorated.

After long discussion among modern archaeologists, it is now agreed that Phidias made the Athena Parthenos earlier than the Olympian Zeus; for the moulds from Olympia, which were found in a dump adjoining what was described by Pausanias as Phidias' workshop, and which had evidently been used for hammering into them the gold for the draperies of Zeus and Nike, indicate a style in the 430s rather than the 450s.

Besides his two masterpieces, ancient writers mention a number of other statues by Phidias, all now lost. The most credible identifications are: The Lemnian Athena, set up on the Acropolis and famous for its beauty, which is perhaps reproduced in a head in Bologna and a statue in Dresden; the Apollo Parnopius, also erected on the Acropolis, perhaps reproduced in the Cassel Apollo; the Anadumenus of Olympia, perhaps reproduced in the Farnese Diadumenus of the British museum; and the Amazon—made in competition with Polyclitus, Cresilas, Cydon and Phradmon (*cf.,* Pliny, *N.H.,* xxxiv, 53)—probably reproduced in a number of copies, all headless, of which the best-preserved is that found in Hadrian's villa, near Rome.

From these works one can gain some idea of Phidias' style. Quiet stances, serene expressions and a certain majesty of conception characterize his single figures; even when movement is represented in some of his reliefs, a monumental quality is imparted. Though the construction of the human body is perfectly understood, its rendering is restrained and harmonized. In other words, Phidias may be called the initiator of the idealistic, classical style that distinguishes Greek art in the later 5th and the 4th century B.C., after the experimental epoch of Myron and his associates, and before the advent of the realistic Hellenistic age. And this idealistic quality—expressed in restrained modeling and in elevation of spirit—is still considered typical of Greek art.

Phidias was also a painter, an engraver and a worker in embossed metalware. His chief pupils were Alcamenes, Agoracritus and Colotes.

See also Olympia: *The Remains.*

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PHIGALIA (Phialia), an ancient Greek city on the Neda River in southwest Arcadia. It stood on a high plateau between deep ravines, along which were defensive walls and towers in part still standing. The modern village of Figalia (formerly Pavlitsa) is at the southwestern corner of the ancient site. This remote fortress left only an inconsiderable record in the general history of Greece, but Pausanias, writing in the 2nd century A.D., noted some religious peculiarities, occult practices, and strange gods such as probably existed elsewhere in Arcadia. He describes the horse-headed Black Demeter, whose sanctuary was a cave, and the fish-tailed Artemis Eurynome.

The distinction of Phigalia in ancient as in modern times comes from its Temple of Apollo Epikourios ("the Helper") at Bassae, 4 mi. NW of the city on a high and desolate terrace of Mt. Cotilius. Pausanias says that it was the finest temple in the Peloponnese after that of Artemis at Tegea. It is now the best-preserved temple in Greece after the Parthenon and the Temple of Hephaestus (the so-called Theseum) at Athens. Pausanias also says that it was dedicated to Apollo by the Phigalians in gratitude for his protection during a plague and that its builder was the Athenian Ictinus, the architect of the Parthenon. The Peloponnesian states were then at war with Athens, but Ictinus could have worked in Arcadia during the short Peace of Nicias (421–418 B.C.), and this date agrees with the style of the architectural sculpture. The plan and structure of the temple were in many respects unique (*see* Greek Architecture: *The Culmination at Athens [450–400 B.C.]*).

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SOUTH FRIEZE OF THE TEMPLE OF APOLLO AT BASSAE, NEAR PHIGALIA, SHOWING THE COMBAT OF THE GREEKS AND AMAZONS; 5TH CENTURY B.C. IN THE BRITISH MUSEUM

The site was first explored in 1812 by the young English architect C. R. Cockerell and a party of traveling companions. Thirty-five of the original 38 exterior columns were then standing, with most of their architraves, but the interior columns had fallen with their frieze, which was buried under fragments of roof and walls. The frieze, which was found complete or nearly so, was removed, shipped to Zante, there put up to auction, and bought by the British Museum.

The material of the temple is the local limestone, but the frieze is a coarse marble. It consists of 23 slabs two feet high making a total length of 101 ft. Two conventional subjects are represented in high relief, the Battles of Lapiths and Centaurs and of Greeks and Amazons. The style is both dynamic and affected: violent and realistic motion in the figures, and fanciful exploitation of taut or flying draperies. It is the first appearance of the mannered style which is refined in the Victory of Paeonius at Olympia and later in the Amazon frieze of the Mausoleum at Halicarnassus. The execution of the Bassae frieze is inferior to the design. It was evidently cut by several provincial masons working from large detailed drawings. If the architect was Athenian, it may be assumed that the drawings came from Athens, and the assumption is supported by the relation of the style to Attic vase paintings and by the fact that the subjects represented were Attic versions of the myths. The protagonist in both battles seems to be Theseus, who is certainly the central figure of the Amazonomachy, marked by his club and lionskin. This scene is therefore the Amazons' attack on Athens, which was said to have ended in a formal peace. That happy issue may be indicated in the frieze by some friendly advances made by combatants of both sides toward their opponents. Such touches of humanity, and the pain and pity shown by facial expression, were a novel element in Greek art and here perhaps unique in sculpture.

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(E. J. F.)

PHILADELPHIA: *see* AMMAN, Jordan.

PHILADELPHIA, the largest city of Pennsylvania, U.S., known primarily, perhaps, for its high place in U.S. history, but also one of the principal cities of the northeastern United States. In the first part of the 20th century it showed one of the most rapid rates of population growth among the major U.S. cities; its industrial growth was proportionately high and it became a leader in devising redevelopment programs to deal with the urban problems characteristic of the 20th century. The city, which is coextensive with Philadelphia county, is at the confluence of the Delaware and Schuylkill rivers about 83 mi. (134 km.) S.W. of the centre of New York city and about 126 mi. (203 km.) N.E. of the centre of Washington, D.C.

The 1950 population of the city proper was 2,071,605, a 14.6% increase over the 1940 population. Like most other large U.S. cities, Philadelphia lost population in the following decade; the 1960 census figure was 2,002,512, a decrease of 3.3%. For comparative figures for selected years, *see* table in PENNSYLVANIA: *Population*. The 1960 population of the standard metropolitan statistical area, which includes Bucks, Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania and Burlington, Camden and Gloucester counties in New Jersey, was 4,342,897, an 18.3% increase over 1950. Within the standard metropolitan statistical area are the cities of Chester and Norristown (*qq.v.*) in Pennsylvania and Camden (*q.v.*) in New Jersey. The suburbs reach out far to the north and south virtually to meet those of New York city and Baltimore, for Philadelphia is a part of the almost unbroken urbanized region which has come to extend along the Atlantic coast from Maine to Virginia.

Philadelphia's eminence resulted to a large extent from its geography. Its central and oldest section lies on a peninsula between the Delaware and Schuylkill rivers. Although it is 88 nautical miles (75 statute miles) from the Atlantic ocean, the broad Delaware river and bay ensured ready access to the sea and made the city one of the leading U.S. seaports. Furthermore, Philadelphia occupies the place where the principal roads from New York city southward run close to the Delaware just after crossing it; an Indian trail followed this route even before the coming of the white men. Thus the city is important to inland as well as to nautical communication. The valleys of the Schuylkill and of other tributaries to the Delaware, finally, have always given Philadelphia avenues to the rich agricultural, mining and industrial areas of eastern Pennsylvania.

From the peninsula between the Delaware and the Schuylkill, where the centre of the city lies, Philadelphia stretches north and south along the Delaware to a total river frontage of 23.7 mi. (38.1 km.). Inland its extension varies from 5 to 15 mi. (8 to 24 km.). The topography of the city is largely of a sort more characteristic of New Jersey than of the Pennsylvania hills to the west, since much of it occupies the Atlantic coastal plain. The southern extremity, the Tinicum lowland, is protected by dikes, for in places it is more than 5 ft. (1½ m.) below high tide. The greatest part of the coastal plain rises gradually from the Delaware to a height of about 150 ft. (46 m.) above sea level at the fall line. There, in the western extremities of the city, communities such as Roxborough and Chestnut Hill climb hills of the Piedmont plateau, reaching an elevation of about 400 ft. (122 m.).

History.—Of the important Atlantic coastal cities, Philadelphia was the last to be established, in part because navigation of Delaware bay and the Delaware river presented severe problems to early mariners. The entrance to the bay was a dangerous open roadstead, which until the building of the immense Delaware breakwater in the early 19th century continued to claim hundreds of ships. The channel of the bay and river were uncommonly intricate, so that even after numerous improvements, Delaware pilots are often known as the most skilful on the Atlantic coast.

Giovanni da Verrazano may have seen Delaware bay in 1524 and Henry Hudson is known to have reached its mouth in 1609. Thereafter various explorers traveled up the bay and the river until sufficient interest was stimulated to lead to settlement attempts by the Dutch and the English in the 1630s. The first permanent white settlements in what is now Philadelphia were planted in the 1640s by the Swedes, whose interest in the region had been aroused by certain dissidents from the Dutch West India company who believed their company had not been sufficiently energetic in exploiting the Delaware country. In 1655 New Sweden surrendered to a Dutch expedition from New Amsterdam, but from the brief Swedish colonial effort came a population of

about 2,000 Swedes and Finns who inhabited the Delaware area by the 1680s, including the community in what is now South Philadelphia which was later to build Old Swedes' church.

The reign of the Dutch also proved brief, ending when New Netherland surrendered to the English in 1664. Thereafter the early history of the city of Philadelphia is inseparable from that of the state. (*See* also PENNSYLVANIA: *History.*) On March 4, 1681, William Penn received from Charles II, out of friendship with the king and the duke of York and in payment of a debt of £16,000 owed by the king to Penn's father, his charter for a colony to lie north of Maryland and west of the Delaware. As a Quaker leader, Penn planned in his colony a "Holy Experiment," where men of his own religious sect and of other persuasions might find freedom of the mind. Soon he sent out surveyors who were to plat a city along the river, which Penn envisioned as the capital and metropolis of his colony. He instructed the surveyors to choose a high, dry and healthy site, one where ships might well ride, and if possible one where a navigable creek flowing into the Delaware would lend further encouragement to commerce. When the surveyors reached Pennsylvania, they found such a site at the peninsula formed by the flow of the Schuylkill into the Delaware. The Lenni-Lenape Indians of the area called this place Kué-quenâku or, as the white men more commonly rendered it, Coaquannock, meaning "grove of tall pines." Penn, however, had already selected his own name, one with both classical and biblical associations and with a meaning appropriate to his purpose: Philadelphia. Passages in the Book of Revelation refer to the city of Philadelphia in Lydia in Asia Minor. That city was worthy of remembrance as the seat of one of the seven early Christian churches, and its name signified brotherly love.

Penn enjoined his surveyors and other agents so to plan Philadelphia that it should be "a greene countrie towne which will never be burnt, and always wholesome." Each house, Penn instructed, ought to be placed in the middle of its plot, with garden, orchards and fields around it. The streets were to be laid out in a straight and regular pattern, reserving spaces for markets and squares—instructions scrupulously obeyed by Thomas Holme, Penn's surveyor general. Holme's town plan formed a perfect checkerboard, to which the streets of central Philadelphia have generally continued to adhere.

William Penn himself sailed to his colony and city late in 1682, arriving in the ship "Welcome" inside the Delaware capes on Oct. 24 and proceeding thence, probably by barge from Chester, to Philadelphia. He remained only until the political and business problems of his colony called him back to England in Aug. 1684, but during his brief stay he was able to witness a remarkable growth of his city and colony. His policy of religious freedom together with his astute advertising of the potential wealth of Pennsylvania began to attract a large and multinational immigration which was to make Pennsylvania the prototype of the American melting pot. Swedes and Finns were already present; Englishmen and Welshmen, especially Quakers, came in large numbers; and the interest awakened by Penn's travels in Holland and Germany brought from those areas German Pietists, religiously akin to the Quakers, who were the vanguard of the great German migration to colonial Pennsylvania. Whatever part of Pennsylvania was their destination, most immigrants landed in Philadelphia and many of them stayed there. By the time Penn departed in 1684 there were 357 houses in Philadelphia, many of them "brave brick houses." By the next year, there were said to be 600 houses, and in that year the population of the colony, centring on Philadelphia, was estimated at more than 7,000. When Penn returned to his colony in 1699, for another two-year stay, he found that population growth already had erased his "greene countrie towne." His governors had felt compelled to divide and subdivide the city lots, and many of the owners had done likewise. The rich continued to enjoy lawns and trees but the middle class was coming to live in row houses facing each other across narrow streets, while the workingmen and their families occupied still more constricted quarters, often pressed into the narrow alleys behind the principal streets. As the 18th century began, Philadelphia was becoming the crowded city of narrow red brick houses which it was to be through the revolutionary period. Remains of this period can be seen in such places as Elfreth's alley.

The Metropolis of Colonial America.—By the time of Penn's second visit the economic pattern of 18th-century Philadelphia was becoming plain. Like all the cities of colonial North America, Philadelphia built its economic life upon a commerce aimed at bringing to the new world the manufactured goods of the old world. Philadelphia was well supplied with commercial resources which, as the 18th century progressed, enabled it to become the wealthiest and most populous city of British North America.

For the export trade Philadelphia could draw upon the produce of the fertile farmlands stretching from the Delaware to the Susquehanna and beyond, a region which through the early 18th century filled up with skilful and industrious German farmers and then, farther west, with Scotch-Irish settlers. Wheat, corn, hemp, flax, beef, pork and timber products reached Philadelphia from the Pennsylvania hinterland. By the second third of the 18th century iron furnaces and forges up the Schuylkill and farther west were adding another product to Philadelphia commerce. From the neighbouring provinces of New Jersey and Maryland, from the Delaware counties and in time even from the Shenandoah valley of Virginia came still more agricultural products.

Much of Philadelphia's export trade sailed to the West Indies, where foodstuffs went to the plantations in exchange for sugar, molasses or rum. Directly or indirectly the sugar trade in turn gave Philadelphia merchants staples which they sold in England and there bought manufactured goods. A brisk wine trade developed with the Madeiras. In time of war with France, *i.e.*, continually through Philadelphia's colonial history, many of the West India traders were not above turning to privateering; even certain Quaker merchants seem to have formed connections with privateers. Whether righteous or not, this activity also brought swift increments of wealth. In 1696 the governor of the province reported that "Philadelphia in fourteen years is become equal to the City of New York in trade and riches." Customs receipts increased from £1,500 in 1699 to £8,000 in 1702. By the middle years of the 18th century, Philadelphia was surpassing even Boston in volume of commerce.

Often overlooked, but of equal importance with Philadelphia's West India commerce and more important than its trade with

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ELFRETH'S ALLEY, SAID TO BE THE OLDEST RESIDENTIAL STREET IN CONTINUOUS USE IN THE U.S.

Europe, was its coastwise commerce. By the 1730s Pennsylvania had become the granary for the tobacco and rice colonies of the south as well as for the West Indies. In addition and more important, Philadelphia had developed an exceedingly profitable business with New England, which produced neither wheat nor bar iron sufficient to its needs; therefore these products sailed from Philadelphia to the colonies to the north in exchange for merchandise, coins and bills of exchange. In 1752, 103 vessels cleared Philadelphia for New England. The favourable balance of this trade in the mid-18th century amounted to over £52,000 annually.

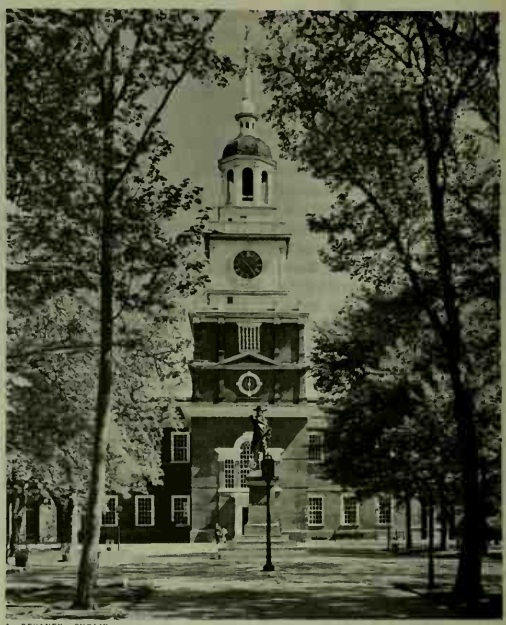
Philadelphia manufactories began to develop both as a result of the city's commercial growth and as a cause of further growth. After 1725 the Delaware valley became a shipbuilding centre; in 1726 the Delaware yards turned out only 7 ships but during the next decade and a half they built 380 vessels. The yards were soon the most extensive in the colonies. The demands of the port stimulated cooperage establishments. Flour mills appeared in the city and in 1690 the first American paper mill began to operate along Wissahickon creek. By 1718 the cordwainers (workers in leather) were numerous enough to incorporate as a craft. Fourteen rum distilleries, three steel furnaces and an anchor forge, four carriage and wagon shops, an establishment for the manufacture of fire engines and a glass works soon appeared. A distinct merchant class developed but there also emerged a growing lower class of mechanics and artisans.

With urban growth came civic improvements. In the mid-18th century Philadelphia ceased to be a wilderness outpost and became a community whose appearance rivaled that of European cities of comparable population. Public street lighting was instituted in 1752 and in the 1760s the streets began to be paved, while 500 public pumps were set up to supply the citizens with water. Public buildings of substantial size began to appear, many of which had grace as well as size and were among the architectural achievements of colonial America. Most notable was the state house, now known as Independence Hall, the construction of which began in 1732. Attorney General Andrew Hamilton had drawn up plans for a civic centre and shared with master carpenter Edmund Woolley the designing of the building itself; in it they gave Philadelphia an imposing structure of balanced masses in the 18th-century style.

During the 18th century the population of Philadelphia spilled beyond the original northern and southern boundaries, Vine street and South street, to form the suburbs of Southwark, the Northern Liberties, Passyunk and Moyamensing. The total population of the city and suburbs grew from 13,000 in 1740 to 22,000 in 1760 and to 40,000 by 1775. By that time Philadelphia was the largest city in the colonies (by about 15,000 persons) and in size probably ranked second only to London among empire cities.

By the 1770s Philadelphia was a centre of learning and culture as well as of trade and industry, not only by American standards but by European as well. Its growth in these directions had once been slow; in the beginning, of course, its settlers were too busy wresting a livelihood from the wilderness to bother with things of the mind, and even as late as the 1720s visitors were impressed with the way in which business swallowed up all other concerns. But a new era was coming. Historians often regard 1726 as marking the beginning of the change, for in that year Benjamin Franklin returned to the city from his first visit to England, still an obscure printer but destined to become the civic leader of Philadelphia and to guide his city into new paths of intellectual achievement. Among his contributions to the cultural life of colonial Philadelphia were his organization of certain alert and ambitious young mechanics of the city into the mutual improvement society which became the Junto; his assistance in the development of the Library Company of Philadelphia, the first subscription library in America, out of the Junto; and his leadership in the foundation of the American Philosophical society and in the establishment and growth of the Philadelphia academy, out of which the University of Pennsylvania was to arise.

But important as he was, Franklin was merely first among equals in a general cultural awakening. The way for Franklin had been prepared (albeit by a man who did not like him) by James Logan, William Penn's secretary, the collector of a private library of more than 2,000 volumes. Among Franklin's Philadelphia contemporaries were the botanist John Bartram, correspondent of Linnaeus; the noted physician John Morgan, first American author on medical education and medical history; Ebenezer Kinnersley, who rivaled Franklin as a pioneer investigator of electricity; and the astronomer David Rittenhouse, a leader in the observations of the transit of Venus across the sun in 1769 which were of great importance in determining the parallax of the sun. In the arts and letters, Benjamin West ventured his first artistic efforts in Philadelphia; Thomas Godfrey, Jr., wrote the first American tragic drama; and the literary circle which formed around Provost William Smith of the College of Philadelphia is worth mentioning if only to call attention to Smith, a man whose personal efforts did much to make Philadelphia an intellectual centre.



A. DEVANEY—PUBLIX

INDEPENDENCE HALL, THE OLD STATE HOUSE ERECTED IN 1732, WITH STATUE OF JOHN BARRY, NAVAL HERO OF THE REVOLUTIONARY WAR

Colonial and Republican Capital.—Its general prominence, together with its central location, led to the selection of Philadelphia as the meeting place of the first continental congress in 1774 and the city embarked on its turbulent revolutionary career. The first continental congress met in Carpenters' hall, and there drew up the continental association and the Declaration of Rights and Grievances, steps which led the colonies almost directly into war against the mother country. In 1775 the second continental congress met in the state house, acknowledged the fighting around Boston by organizing the continental army under the command of George Washington and, by thus embarking on rebellion, took the course which led to the adoption of the Declaration of Independence the following year. The role of Philadelphia as the headquarters of the revolutionary government made it the objective of the British general Sir William Howe's campaign of 1777; after Howe defeated Washington's forces south of the city the congress fled and Philadelphia was occupied by the British through the winter of 1777–78. The continental army camped outside the city at Valley Forge, and fighting occasionally flared up at such places as Germantown and Barren Hill on the outskirts. In the

spring of 1778, a change of generals and of war plans led the British army to evacuate the city and to return across New Jersey to New York, opening the way for the reconvening of the congress in Philadelphia.

The British occupation underlined the fact that the American Revolution made Philadelphia a city much divided within itself. Certain leading families were obviously not unhappy to welcome the British, and many Philadelphians participated gladly in the gay social season which the British officers improvised. Many Philadelphians, like many other Americans throughout the colonies, could not easily abandon the loyalty which as British subjects they had always felt to the crown. Mixed with their emotions of loyalty, furthermore, was the resentment which many members of the upper classes had come to feel toward a Revolution, which in Philadelphia had become peculiarly the cause of the lower classes, the mechanics and artisans. By the opening of the Revolution, Philadelphia society had become distinctly stratified. The growth of commerce had been highly profitable to some Philadelphians and had opened wide economic divisions within the population, so that social and economic leadership was held tightly by a comparatively small group of merchants, professional men and proprietary agents. Political leadership resided in the same hands, since the franchise was limited to men who possessed a freehold estate or personal property to the value of £50. By 1776 only about 1 in 50 of the male inhabitants could cast a ballot. The political power of the upper class further enhanced its economic power, for the city government frustrated competition from below through its regulations of markets, auctioneers and peddlers. When the Revolution broke out, the aristocrats, naturally conservative, hesitated to endorse the movement. But the mechanics, artisans and labourers took advantage of that hesitation to discredit the aristocrats as an unpatriotic class and thus to make the independence movement also a movement for increased democracy. They joined with equally discontented farmers from the back country of Pennsylvania to establish the radical Pennsylvania constitution of 1776, which allowed every adult male taxpayer to vote and hold office in the state government. It was against this background of a rising of the lower classes that much of the Philadelphia aristocracy welcomed the British occupation in 1777.

The end of the occupation brought back to Philadelphia both the continental congress and the ambitious local democratic party, but the withdrawal of the British and the eventual American victory in the Revolution did not open the way for the unmitigated triumph of either group. The continental congress was transformed into the congress of the Articles of Confederation, and during the 1780s that congress, meeting sometimes in Philadelphia but sometimes elsewhere, sank gradually into impotence. The success of the Pennsylvania and Philadelphia democrats in the state constitution of 1776 gradually gave way before a counter-revolution which culminated in the conservative state constitution of 1790. The economic power and social prestige of the Philadelphia aristocracy emerged from the war largely unimpaired, and these elements aimed at a substantial recapture of political power. In 1789 the state assembly passed an act of reincorporation of Philadelphia which was considerably more democratic than the colonial charter but nevertheless favourable to the merchant aristocracy. The vote was restricted to freeholders, who elected 30 common councilmen for three-year terms and 15 aldermen for seven-year terms. The aldermen chose the mayor from among their own number. Significantly, the first mayor under the new government, Samuel Powel, had also been the last mayor under the colonial charter.

As for national affairs the Constitutional Convention laboured in the Philadelphia state house during the summer of 1787 with the Philadelphians Benjamin Franklin and James Wilson among its most influential members. The congress of the new government first met in New York city, but in 1790 it voted to establish the seat of the new government at Philadelphia for ten years before moving to the permanent capital on the Potomac river.

The decade 1790–1800, when Philadelphia was once again the U.S. capital, constitutes something of a golden age in Philadelphia history. Political, economic and cultural leadership of the new nation were all concentrated in Philadelphia. Congress and the U.S. supreme court sat in new buildings flanking the state house. Presidents Washington and John Adams maintained a republican court, centring on the president's mansion on Market street near Sixth, whence Washington proceeded through the streets in a cream-coloured French coach, ornamented with cupids and flowers. The leaders of the new nation combined with the aristocracy of the city to give Philadelphia a social life distinguished for its conversation as well as for its gaiety and glitter.

The Philadelphia economy had by this time readjusted from the dislocations of the Revolution and was growing at least as rapidly as before the war. The shipyards were prospering, building vessels of such quality that even Boston, New York city and Baltimore papers advertised ships "built of the best white oak and finished off in the neatest manner on the Philadelphia plan." The U.S. navy yard had been established, building during the 1790s the frigate "United States," on the plan provided by the Philadelphia designer Joshua Humphreys for six sister ships, including the "Constitution." The merchant ships built in Philadelphia yards and sent out by Philadelphia merchants ventured into new quarters of the globe. Thomas Willing was instrumental in organizing the Philadelphia, Boston and New York city venture which in 1784 sent the first American trading ship to China, and thereafter until the middle of the 19th century the city was responsible for one-third of the China trade of the United States. Philadelphia traders, at last outside the British navigation system, found new ports in Europe; coastwise trade also continued to expand. In 1793 the total value of Philadelphia exports was $6,958,736, exceeding those of all New England by $1,717,572 and of New York city by $2,934,370. Behind Philadelphia trade still stood the wealth of the hinterland, which in 1790, for example, sent 150,000 bu. of wheat to the metropolis from the upper Susquehanna country alone.

The Philadelphia golden age of the 1790s was not without a few scars. During the early years of the decade mechanics and artisans aroused by the French Revolution became increasingly noisy in their discontent with the conservative turn of U.S. political events, to the point where some alarmed property owners began to fear new violence. Conservatives and Democrats alike suspended political agitation, however, in the face of the great yellow fever epidemic of 1793, in which perished between 4,000 and 5,000 people, one-tenth of the city's total population.

Meanwhile Philadelphia moved to leadership of the new nation in still another area, finance. Prerevolutionary America had possessed no banks in the modern sense of the term, but from the establishment of the first such institution, the Bank of North America, in 1781, the growth of an American banking system was rapid. The Bank of North America was chartered by the Confederation congress largely at the urging of Robert Morris, its principal purpose being the financing of the Revolution. Its location in the city assured Philadelphia's position as the first financial centre of the United States. State-chartered banks quickly followed in various places and the charter of the Bank of North America was suspended briefly during the 1780s; but the priority of Philadelphia in banking plus its general economic leadership gave the city continued financial pre-eminence. For this reason as well as because Philadelphia was the national capital, the first Bank of the United States was established there in 1791 and remained even after Philadelphia ceased to be the political capital. After the charter of that bank expired in 1811, state-chartered banks reassumed first place in a financial world of which Philadelphia remained the centre. Stephen Girard of Philadelphia emerged as the principal financier of the War of 1812 and when congress chartered a second Bank of the United States in 1816 it was located in Philadelphia. Through the second bank and the activities of Girard, Philadelphia retained financial leadership until the 1830s, despite the fact that by that time economic supremacy in other matters had passed to New York city.

The 19th Century.—By Andrew Jackson's presidency the golden age of Philadelphia had long since ended. The U.S. capital moved to Washington in 1800 and the capital of Pennsylvania already

had departed from Philadelphia in 1799. The removal of the federal capital cast something of a shadow upon Philadelphia's cultural leadership, presently superseded by that of Boston and New York city. Philadelphia culture in the 19th century was to be distinguished by the presence of such notables as the Peales, Gilbert Stuart, Thomas Sully, Henry Inman and Thomas Eakins in painting, William Rush in sculpture, William Strickland and Thomas U. Walter in architecture, and Walt Whitman as well as lesser lights such as Bayard Taylor and S. Weir Mitchell in literature. But the relative position of the city was far below what it had been; except possibly in painting, there was no longer in Philadelphia a community of national cultural leaders, but simply a collection of various individual luminaries.

Commercial ascendancy passed from Philadelphia partly because its port could not match New York city harbour. The approach to Philadelphia by water was far more difficult, the space for berthing of ships was limited and the port was on occasion impeded by ice in winter (the Delaware is fresh water at Philadelphia). The riches of the Philadelphia hinterland as compared with the narrow Hudson valley had more than offset the deficiencies of Philadelphia harbour during the colonial and early republican periods, but in the early 19th century there was opened to New York city a hinterland far richer and vaster than Philadelphia's: the old northwest, the Great Lakes and Ohio river country. Between Philadelphia and this region rose the barrier of the Appalachian mountains; between New York city and the northwest stretched the open avenue of the Hudson and Mohawk valleys. The completion of the Erie canal in 1825 added immeasurably to the already great convenience of that avenue. Promptly after the opening of the canal, the census of 1830 revealed that for the first time the population of New York city exceeded that of Philadelphia. Even earlier, in 1820, Philadelphia's exports had been only about $6,000,000 to New York city's $12,000,000, while Philadelphia imports had stood at $9,000,000 as against $23,000,000 for New York city.

Philadelphia did not yield its population and economic leadership without a contest. The city sought an answer to the Erie canal, a route of its own into the great valley beyond the mountains. Its effort to solve the problem was extraordinary, for the city promoted and helped to finance the completion of the amazing state-owned "Pennsylvania system" west to Pittsburgh. Beginning in 1834, passengers could travel from Philadelphia to Pittsburgh in 4 days, freight in 12–14 days, over a 394-mi. route combining railroads, canals and inclined planes.

Extraordinary, even heroic, as it was, the Pennsylvania system did not serve to recapture Philadelphia's advantage over New York city; the Erie canal was a more convenient freight-handling system. But even a westward transportation system equal to New York city's could not compensate for the inferiority of the Philadelphia port. This fact emerged clearly after the Pennsylvania railroad was completed to Pittsburgh in 1854; it became one of the great railroads of the world but New York city continued increasingly to outdistance Philadelphia in population, wealth and general economic importance.

With its national pre-eminence lost, Philadelphia embarked on a less spectacular career as a regional urban centre, but the city did not cease to be a major one; it remained second in size among U.S. cities until Chicago finally surpassed it in 1890. The agricultural wealth of the immediate hinterland remained and as the 19th century proceeded this area increasingly supplied industrial wealth as well. Philadelphia looked relatively less to its harbour and more to its inland resources to sustain itself. It developed its own manufactures. The textile industry was among the first to rise in the United States as in other nations in the early stages of industrialization, and in that industry Philadelphia was a leader. By 1825 there were 33 cotton and woolen factories in the city and its vicinity, 20 of them alone working 28,750 spindles. Iron foundries and glass works also secured an early prominence. After 1831 Baldwin locomotives and, still later, Stetson hats carried the name of Philadelphia through the 19th-century world. Philadelphia shoes, especially women's shoes, won note throughout the United States. The city became the principal distributing centre for the anthracite coal fields of northeastern Pennsylvania, which after about 1820 began their era of prosperity. The relative loss of emphasis upon the sea did not bring the abandonment of the shipbuilding industry; the William Cramp and Sons Ship and Engine company, founded in 1830, became the principal builders of the U.S. naval vessels during the 19th century and the builders of merchant ships, foreign and domestic, as well.

With industrial growth, the city's population increasingly spilled over the political limits, which had not changed since the first drawing of the town plan. These limits confined the city to an area of two square miles. Beyond that area, much of Philadelphia county was as densely populated as the city itself. There political subdivisions had sprung up haphazardly until the county included 29 such units, variously organized as cities, townships or boroughs; nearly all of them lay immediately adjacent to each other, constituting for all common-sense purposes a single city but frustrating each other through their political independence. In 1854 the Pennsylvania legislature at last acted to remedy this chaos, passing the Consolidation act, which annexed 28 of the 29 subdivisions into Philadelphia.

The city shared in one way or another in most of the principal national events of the 19th century. The influx of Irish and German immigrants to the United States during the mid-19th century called forth in reaction the first major American nativist movement. In Philadelphia, nativism culminated in a series of riots extending through the spring and summer of 1844, during which two Roman Catholic churches were destroyed by fire, seven civilians and two militiamen were killed and many more persons were injured. Earlier the slavery issue had led to antiabolitionist riots, and this issue continued to divide the city during the Civil War. Philadelphia Quakers had a long history of antislavery activity, but on the other hand prewar Philadelphia was a principal banking and mercantile centre for Southern agriculturalists and had many Southern business connections. Some Philadelphians supported the Union war effort only lukewarmly even after Ft. Sumter, but for the most part the city rallied with determination to the Union cause. Philadelphians followed the leadership of Jay Cooke in contributing to war finance, and their Unionism tended to become more pronounced after the Confederate invasion of Pennsylvania in 1863. The Union League of America was an expression of Philadelphia's support for the Union and membership in the league soon became a mark of status in the city.

Philadelphia was the site of the 1876 Centennial exposition commemorating the adoption of the Declaration of Independence. Financed largely by Philadelphia citizens, the exposition opened 180 buildings along the Schuylkill to more than 8,000,000 visitors. The emphasis of the exposition was upon industrial and commercial technology, in which the United States already ranked as a leading nation of the world.

Journalists remarked during the exposition that the political progress of the United States since independence had not matched material progress; the era was that of "Grantism." The same comment applied to Philadelphia. After the Civil War, the Republican party used its record as a war party, its program of friendship with business interests and an astute cultivation of every city precinct to win a stranglehold on Philadelphia politics. Philadelphia and Pennsylvania were in the hands of the machine led first by Sen. Matthew Stanley Quay and then by Sen. Boies Penrose. In the 20th century a local machine led by the brothers George A., Edwin H. and William S. Vare successfully challenged the statewide Penrose machine for control of Philadelphia, but with no change in the quality of city government. Lincoln Steffens not inaccurately described turn-of-the-century Philadelphia in a phrase that has become a byword, "corrupt and contented."

The city remained contented in its corruption partly because the old problem which had led to the Consolidation act of 1854 had emerged again: population had spilled beyond the city's political boundaries. Many civic leaders moved into the suburbs and out of city politics. They worked in the city but did not live in it and they found bad government tolerable. At the same time the Philadelphia machine, like its contemporaries elsewhere, drew many of its votes from the new immigrants who came crowding

into U.S. cities from southern and eastern Europe unprepared for the responsibilities of democratic citizenship. As in other U.S. cities, the new immigrants sought security by forming neighbourhoods along ethnic lines. The long history of many Philadelphia neighbourhoods as independent political entities made for an unusual degree of neighbourhood parochialism, and the forming of ethnic neighbourhoods intensified that tendency.

The 20th Century.—In the 20th century, especially after World War I, the immigrants and their children gradually became less docile voters. Other factors worked also to undermine the power of the city machine, not the least of which was the growth in the 1930s of federal social welfare programs under the New Deal. Providing social security of various sorts in return for votes had been one of the bulwarks of all urban political machines; the federal government removed such welfare measures from local politics. For these reasons and others, by the mid-20th century traditional machine dominance had much decayed.

Furthermore, the decline of machine politics was only one of a complex of changes stirring in Philadelphia in the middle of the 20th century. By that time the phrase "corrupt and contented" was no longer so accurate; a new sense of civic responsibility had arisen. The citizens always had been proud of their city but that pride was becoming difficult to sustain. Rapid but unplanned industrial and population growth had created slums that were among the worst in the world. A real property survey made in 1934 disclosed that of 506,420 dwellings in the city, 19,035 were unfit for occupancy, while another 28,768 were in need of major repairs. About 19,000 houses were without bathing facilities of any kind. Many of the slum dwellings were of the distinctive "bandbox" type, three stories high but only one room wide and deep. Such were depression conditions in the 1930s, but the years during and after World War II scarcely lightened the housing problem. A large influx of Negroes injected racial issues into already serious difficulties and many parts of Philadelphia became overcrowded Negro ghettoes. At the same time Philadelphia suffered from the common problem of all urban centres in the automobile age, an accelerated decay of the central city as population, industry and even commerce moved into the suburbs. The only virtue in all these developments was that they made it impossible for proud citizens to remain contented; they stimulated the new sense of civic responsibility.

Civic Redevelopment.—The Philadelphia Redevelopment authority, established under a state law of 1945, was constituted under a board appointed by the mayor. Its purpose was to eliminate blighted areas and, in co-operation with both public and private enterprise, replace them with socially and economically sound projects. The authority was to make use of federal, state and city funds. Within ten years, by 1955, 19 areas of the city, comprising about 11.5% of the total area and containing more than 20% of the population, had been scheduled for redevelopment. The continuing activities of the redevelopment authority included construction of middle- and low-income housing, the rehabilitation of certain old row houses, the development of new industrial sites, the conversion of blighted areas into improved and enlarged campuses for several of the city's universities, the provision of new parks and playgrounds and projects for automobile parking and street widening. In many of its activities the redevelopment authority co-operated with the Philadelphia Housing authority, a similar agency outside the regular structure of city government, whose purpose was to clear slum areas and to build on slum and open sites safe and sanitary dwellings for low-income families. Meanwhile, private enterprise rebuilt part of downtown Philadelphia into a planned commercial area, Penn Center.

Thus Philadelphia sought to renew its blighted areas and to assure its citizens of adequate housing, and it made substantial progress toward those goals. But social problems spawned during several centuries of unplanned growth could not be remedied in a decade or two; large blighted areas remained in the 1960s and new ones tended to appear as old ones were eliminated. Furthermore, new housing alone could not cope with the fact that much of the city's housing problem was also a problem in race relations. Viewing the growth of an already large Negro minority (about 25% of the population in 1960), city leaders considered experiments which would seek to prevent new housing developments from becoming Negro ghettoes.

Government.—Important to the progress of the various redevelopment programs of the mid-20th century was a newly reorganized city government. From its first incorporation under William Penn, Philadelphia was governed under various charters, all drawn up by the Pennsylvania legislature. After the Revolution, the charters tended to model the structure of municipal government upon the state and federal governments, with a bicameral legislature in the city council, an executive in the mayor and his elected and appointed assistants and a municipal judiciary. This system brought a multiplicity of offices and a diffusion of responsibilities grossly inappropriate to city government. Under the charter of 1885, for example, the bicameral city council grew to a total membership of 145, the largest municipal legislative body in the United States, so large that it tended to strangle its own usefulness. The charter of 1919 remedied this particular problem by creating a unicameral council whose membership ranged from 20 to 22. But the charter of 1919 still failed to meet the full needs of a modern city, especially in that the mayor remained too weak an executive to assure efficient or even honest administration.

Philadelphians came to conclude that what their city required was a charter drawn up by its own inhabitants, who understood their own needs. A fight for such a charter went on sporadically after 1922, when an amendment to the state constitution made possible municipal home rule. In 1951 the efforts of a local Com-

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PENN CENTER, HEART OF PHILADELPHIA'S REDEVELOPED BUSINESS DISTRICT

mittee of Fifteen combined with revelations of embezzlements by city officeholders to bring the movement for reform to a climax. In that year a special Philadelphia commission drew up a home rule charter, which was accepted by the voters; it went into effect early in 1952.

Under the 1952 charter, the administration is in the hands of a relatively strong mayor, elected for a four-year term. Executive responsibility is focused upon the mayor, who appoints and removes the principal administrative officers and controls expenditures. Furthermore, the mayor participates in the legislative function by recommending measures to the council, exerting his influence for their passage and exercising a power of veto which can be overridden only by a two-thirds vote of the membership of council. The mayor formulates the city budget, with the council simply voting lump-sum appropriations to each agency. The council consists of 17 members, 10 of them elected from geographic districts and 7 elected at large. While the council's administrative powers are severely limited in order to assure the responsibility of the mayor, its legislative powers are broad; it can legislate on many matters which before 1952 required state legislative action, notably in the fields of public health and municipal salaries.

Most municipal activities are in the hands of 14 departments, which are co-ordinated by the mayor's four principal appointees: (1) the managing director, who supervises the departments of police, fire, streets, water, public health, public welfare, recreation, licenses and inspection, records and public property; (2) the director of finance, who conducts, under the mayor, budgeting, accounting and purchasing, and supervises the departments of collections and procurement; (3) the city representative, who is the city's chief public relations officer and heads the department of commerce, through it holding responsibility for wharf and airport facilities; and (4) the city solicitor, who heads the law department which gives legal advice to city agencies and represents the city in litigation. In addition, there are various independent or semi-independent boards and commissions, such as the civil service commission.

The school district is a governmental unit completely separate from the city government. In addition to the city government and the school board, five "authorities" created for special purposes outside the regular governmental structure operate within the city. These are the Philadelphia Housing authority, the Philadelphia Redevelopment authority, the Philadelphia Parking authority, the Philadelphia Airports Improvement authority and the Delaware River Port authority, the latter an interstate body.

Philadelphia courts are part of the judicial system of Pennsylvania and thus are constitutionally separate from the city government. Their structure is that which is common to all Pennsylvania judicial districts, with the exception that Philadelphia also possesses a municipal court, with limited jurisdiction over specified civil and criminal actions, and 28 magistrates' courts, which have jurisdiction in minor civil and criminal cases and hold preliminary hearings in more serious criminal cases.

An amendment to the state constitution was passed in Nov. 1951, consolidating the Philadelphia city and county governments, with all county agencies becoming city agencies. Subsequently there was a gradual integration of the former county offices into the structure of city government.

The home rule charter and the progress of city-county consolidation did much to give Philadelphia effective government, but they also left many problems unsolved. For example, the problem which the Consolidation act sought to solve in 1854 emerged again in aggravated form. In 1960 there were 625 governmental units in metropolitan Philadelphia on the Pennsylvania side of the Delaware alone. The tendency of this multiplicity of governments was to complicate such issues as police protection, water supply and urban transportation. There was an obvious need for some measure of general metropolitan area government; but there were many obstacles, both constitutional and traditional, in its path.

Industry, Commerce and Transportation.—The leading industries are metals and metal products, textiles, food products and chemical and petroleum products. During the mid-20th century industrial expansion was especially noteworthy in the metals industry, with the establishment at Morrisville on the Delaware of a new plant of the United States Steel corporation intended for the processing of ore from Labrador-Ungava and Venezuela.

Railroads serving Philadelphia and its industries include the Pennsylvania, of which the city is the headquarters, the Reading and the Baltimore and Ohio. Truck and motorcar transportation proceeds from the city over a highway network dominated by the Pennsylvania turnpike to the west and the New Jersey turnpike to the northeast. The Philadelphia International airport brings to the city the services of transcontinental and trans-Atlantic air lines.

Although visitors are likely to remark that in no U.S. seaport is the presence of maritime activity less evident except in the immediate waterfront area, and although the harbour has long since ceased to be the major focus of Philadelphia commerce, the port continues active. The Delaware River Port authority supervises the second largest port in the United States, surpassed only by New York city, and the largest fresh-water port in the world.

The trend in banking in Philadelphia as elsewhere in the latter part of the 20th century was toward consolidation into larger institutions. In 1950 there were 39 commercial and savings banks in the city; in 1960 there were 27.

Education.—The Quakers who founded Philadelphia were not devoted to education with the ardour of the Puritan fathers of New England. They favoured schooling in the rudiments of learning and in practical subjects but were inclined to regard higher learning as a form of worldly ostentation. Therefore they early founded elementary and some secondary schools but they did not hurry to do more. William Penn and his council hired a schoolmaster in 1683 and in 1689 leading Quakers established the Friends' Public school, now the Penn Charter school, which was intended to be open to students of poor families without fee. Not until the mid-18th century, however, was an institution approaching collegiate rank inaugurated. In 1755 various antecedents coalesced to form the College of Philadelphia. By that time the original emphasis on modesty in learning as in living had lost ground among many Philadelphia Friends and in any case the intellectual leadership of the city had passed largely to Anglicans and disciples of the Enlightenment. Once established, the college rose rapidly to prominence among kindred institutions of British America. It was noteworthy among colonial colleges especially for the emphasis upon scientific studies and modern languages which its founders, including Provost William Smith, sought to place beside the traditional preoccupation with the classics. But it had to pass through further vicissitudes during the revolutionary era before it emerged as the University of Pennsylvania.

Meanwhile numerous private and church-related elementary schools and academies had made their appearance, with Germantown academy (1780) and Episcopal academy (1785) notable among the latter. During the late 18th century proposals for state-sponsored public education began to arise but it was not until 1818 that Pennsylvania took a substantial step in that direction by establishing in Philadelphia a school district where pupils might obtain education at public expense. By 1830 more than 34,000 children had received instruction, with girls between 5 and 13 and boys from 6 to 14 eligible for its free services. The Philadelphia school district now maintains public schools through senior high school. The Roman Catholic archdiocese maintains an extensive educational system, including elementary, special and high schools. There are over 40 other private schools.

The University of Pennsylvania, founded in 1740 (*see* PENNSYLVANIA: *Education*), and Temple university, founded in 1884, are the largest institutions of higher learning in Philadelphia. Other institutions in the city include Philadelphia College of Pharmacy and Science (1821); Philadelphia College of Textiles and Science (1884); Jefferson Medical College of Philadelphia (1825); Hahnemann Medical College and Hospital (1848); Women's Medical College of Philadelphia (1850); St. Joseph's, a Roman Catholic college for men (1851); Divinity School of the Protestant Episcopal Church (1862); Lutheran Theological seminary (1864); La Salle college, a Roman Catholic college for men (1863); Chestnut Hill college, Roman Catholic, for women

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(1871); Eastern Baptist Theological seminary, coeducational (1925); Drexel Institute of Technology, a private coeducational institution (1891); and Dropsie college, Jewish coeducational (1907). In the metropolitan area are Haverford (1833), Swarthmore (1869) and Bryn Mawr (1880), colleges Quaker in affiliation or origin, and Villanova, a Roman Catholic university (1842).

On the grounds of Temple university is an interfaith chapel dedicated as a memorial to the four U.S. army chaplains—George L. Fox and Clark V. Poling (Protestants), Alexander D. Goode (Jewish) and John P. Washington (Roman Catholic)—who died together in the sinking of the torpedoed troop transport "Dorchester" (Feb. 3, 1943) after each had given up his own life jacket to another passenger or crew member.

Cultural Activities.—During the 18th century, Philadelphia led the British colonies in the establishment of libraries open to the public. In 1731 Benjamin Franklin and his associates founded the Library Company of Philadelphia, the first subscription library in America. Three other such libraries had been founded when the first public library in the colonies, the Loganian library, based on James Logan's collections, was opened in 1760. By 1792 the Library company had absorbed the other collections. Meanwhile the American Philosophical society had also begun a noteworthy library and the Pennsylvania hospital had established the first medical library in the United States. The 19th century witnessed the founding of the Philadelphia Bar Association Law library (1802), the Philadelphia athenaeum (1814), the German society library (1817), the Mercantile library (1821) and the Philadelphia City institute (1852). In 1891 was chartered the Free Library of Philadelphia, the present municipal library. In 1943 this institution received custody of the Library company and the Loganian library, and in the following year of the Philadelphia City institute and the Mercantile library, thus establishing a unified system. Among the approximately 280 private and special libraries in Philadelphia, that of the University of Pennsylvania is outstanding. The libraries of the Historical Society of Pennsylvania and American Philosophical society are especially rich in documents relating to American history.

Philadelphia was also something of a pioneer among U.S. cities in the establishment of museums; soon after the Revolution Charles Willson Peale, the artist, opened his famous museum in Independence Hall, a hodgepodge collection of stuffed animals, a mastodon skeleton, curious gadgets and portraits of American patriots. Most of the portraits remain in Independence Hall.

Philadelphia has attempted to sustain the artistic tradition begun by Charles Willson Peale and, before him, Benjamin West. There are in the city about 40 art associations, schools, museums and collections, public and private. The Pennsylvania Academy of the Fine Arts, oldest art institution in the United States, dates officially from a charter of 1805, but unofficially from Peale's efforts to organize an art school beginning in 1791. Its schools remain among the most distinguished in the United States. Thomas Eakins was long an instructor, and among those he stimulated were the artists of the Henri group, or the Ash Can school (*see* HENRI, ROBERT). The permanent collection of the academy is rich in examples of the evolution of U.S. art.

The Philadelphia Museum of Art, a huge Greek temple standing on the leveled top of Fairmount, offers collections giving a broad view of the development of art throughout history. It has noteworthy "period" rooms, outstanding special collections such as the Arensburg collection of 20th-century painting and much U.S. and Philadelphia material. Associated with it is the Philadelphia Museum School of Art, founded in 1877–78.

In the promotion of science, the American Philosophical society continues in the path opened by Franklin and his fellow scientific leaders of 18th-century Philadelphia. The Academy of Natural Sciences (1812), the oldest such institution in the United States, has sponsored numerous explorations, including Adm. Robert E. Peary's voyage of 1892 which proved that Greenland is an island. It maintains a museum in its headquarters building. The Franklin institute (1824) emphasizes the promotion of applied science and also maintains a large public museum.

The theatre in colonial Philadelphia, as elsewhere in colonial America, had to surmount obstacles both in public attitudes and in law in order to establish itself. Itinerant performers drew crowds to the outskirts of the city as early as the 1720s, but the usual date given for the establishment of the Philadelphia theatre is 1754, when Lewis Hallam's company arrived from London. Within little more than a decade, in 1766, the Southwark theatre was erected, and the next year occurred the performance of Godfrey's *The Prince of Parthia*, the first American tragedy. Thereupon the Philadelphia theatre entered upon a century of imposing development. The completion of the first Chestnut Street theatre in 1793 was an architectural as well as a theatrical event. The Walnut street theatre, opened in 1809, remains as the oldest existing theatre in the United States. The Arch street theatre (1828) became the most famous of all Philadelphia theatres, associated with Joseph Jefferson and the Drews. Late in the 19th century, however, a theatrical decline set in, as the Philadelphia stage became increasingly a satellite of the New York city stage.

Music in Philadelphia began with the German immigrants; the first recorded recital was given by German mystics, the Hermits of the Wissahickon, who in 1703 played the viol, oboe, kettledrum and trumpet at an ordination service in Old Swedes' church. During the heyday of the colonial city a wider musical interest developed. An Italian music master helped encourage the art; the first public concert was given in 1757; and Francis Hopkinson emerged as the first American composer of any importance. Organized cultivation of music was a product of the 19th century, with the organization of the Harmonic society (1802), the Haydn society (1809), the Cecelia society (1824) and, most important, the Music Fund society (1820), which built its own hall in 1824 and established a school of music there. At this hall the principal performances took place until the opening in 1857 of the Academy of Music, home of the Philadelphia symphony orchestra.

Hospitals.—Philadelphia has been a medical-surgical centre since the 18th century. The Pennsylvania hospital (1751) was the first to be established in the British colonies and it early dis-

tinguished itself especially in the study of mental diseases. The medical school of the University of Pennsylvania (1765) is the oldest in the country. A Philadelphia medical society was organized in 1768 and the College of Physicians and Surgeons was established in 1787. There are more than 40 general hospitals and more than 30 special hospitals and dispensaries within the city.

Parks and Recreation.—The Philadelphia city park system of more than 7,500 ac. (3,035 ha.) includes large and small parks scattered through the city, athletic fields and play areas, maintained by the board of education, and Fairmount park, supervised by a special agency of the city government. It comprises almost 4,000 ac. (1,619 ha.) and extends 10 mi. (16 km.) along the Schuylkill river and Wissahickon creek, including within its boundaries the beautiful Wissahickon and Cresheim valleys, the Philadelphia Zoological gardens, oldest in the United States, Robin Hood Dell for summer concerts, 15 historic mansion houses, 2 surviving buildings of the Centennial exposition, more than 50 sculptural groups and figures and many miles of driveways, avenues, footpaths and bridle paths. Throughout the park system there are varied recreational facilities, including golf, baseball, football, swimming, boating and tennis. A special board of trustees administers Convention hall, which can be used as an indoor sports arena. Independence Hall is now a part of the Independence National Historic site, 18 ac. (7 ha.), administered by the National Park service since 1951. The Old Custom House, a fine example of Greek revival architecture and site of the second Bank of the United States, is also a part of the national park and monument system.

See also references under "Philadelphia" in the Index.

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PHILADELPHIANS, a sect of religious mystics, holding a kind of nature pantheism, who flourished in London in the latter part of the 17th century. In 1652 John Pordage (1607–81), rector of Bradfield, Berkshire, gathered together a few followers of Jakob Böhme (*q.v.*), the chief of whom was Jane Lead or Leade (1623–1704). Mrs. Leade had been from girlhood of a mystical temperament and experienced visions which she recorded in a diary entitled *A Fountain of Gardens*, beginning in 1670, in which year the Philadelphian Society for the Advancement of Piety and Divine Philosophy was definitely organized in Bradfield (it later moved to London). In 1693 some of Mrs. Leade's writings were translated into Dutch, and by this means and her acquaintance with Francis Lee, an Oxford scholar who studied medicine at Leiden and became her son-in-law, a connection was opened up with Germany and Holland. In 1703 the Philadelphians drew up their confession, but they made no further progress and after Mrs. Leade's death soon declined, the Dutch branch withdrawing and the English government forbidding the society to meet.

See J. Hastings *et al.* (eds.), *Encyclopaedia of Religion and Ethics*, vol. ix, pp. 836 ff. (1917).

PHILADELPHUS, a genus of deciduous shrubs including the popular garden forms commonly known as mock orange or syringa (the latter is also the generic name of the lilac). *Philadelphus*, comprising about 70 species, belongs to the saxifrage family (Saxifragaceae). The characteristic orange-blossom fragrance of many species is the chief reason for the name mock orange for these plants. They have opposite entire or toothed leaves, the pith being solid, the lateral buds hidden in the leaf axils. The flowers are solitary or arranged in terminal or lateral clusters, the parts in groups of four, the petals mostly white, in some varieties somewhat purplish at the base, and with numerous stamens. The fruit is a capsule with many small seeds.

These decorative and fragrant spring-flowering shrubs are much planted in temperate regions because they grow unusually well in dry soils, endure the trying conditions encountered in city gardens, and are subject to few insect pests and plant diseases. The growth habit is usually upright with arching branches, most of which originate at the base of the plant. Some species are not more than 4 ft. high, others may attain a height of 15 ft.

ROCHE

PHILADELPHUS VIRGINALIS, COMMONLY KNOWN AS MOCK ORANGE

Perhaps the oldest *Philadelphus* in cultivation is the very fragrant common mock orange (*P. coronarius*), a shrub up to 10 ft. high with clusters of creamy-white flowers; its varieties include kinds with golden flowers, double blossoms, and leaves bright yellow in youth. *P. microphyllus*, a smaller shrub, has solitary 1-inch-wide flowers with a pineapple scent. *P. lemoinei*, a hybrid of *P. coronarius* and *P. microphyllus*, has given rise to a number of horticultural varieties with large and fragrant flowers. *P. virginalis*, with semi-double or double blossoms, is useful for forcing. (E. D. Ml.)

PHILAE (Arabic Jazirat Filah), an island of the Nile measuring about 500 by 160 yd., situated at the head of the First Cataract about 2 mi. above the Aswan Dam. Philae is the Greek name; the Egyptian term was P-aaleq, and the Coptic Philak, meaning "the frontier," since it marks the boundary with Nubia. The earliest buildings are those of Nekhtharheb (Nectanebo II), last king of the 30th dynasty (359–341 B.C.), whose temple to Isis, partly destroyed by flooding, was rebuilt by the 2nd and 13th Ptolemies and enjoyed a great reputation and prosperity in Ptolemaic and Roman times. As a reputed burial place of Osiris it was sacred alike to the Egyptians and Ethiopians; and the island of Philae and its neighbour Bigeh (Bijah, ancient Sinan) were regarded as the sources of the Nile and the home of the Nile god. The worship of Osiris and Isis continued there for nearly 200 years after the Edict of Theodosius I in A.D. 378 suppressing the old religion. The priests of Isis obtained great powers unequaled elsewhere in Upper Egypt, probably because they held the gold mines at Wadi Alaki and controlled the terminus of the caravan route at Kubban.

Other temples on Philae include one dedicated to Arsnuphis, with a Coptic Church within; a temple to Imhotep, and one to Hathor; chapels to Osiris, Horus, and Nephthys; the kiosk built by Trajan and dedicated to Isis and Horus; and two Coptic churches. These structures were thoroughly explored and strengthened in the years 1895–96, before being partially flooded by the building of the Aswan Dam. They are now almost entirely submerged, owing to the raising of the dam, except for dry years and for some years in the dry season. (*See* Aswan.) At first it was thought that the flooding would have little effect on the granite temples, but the water damaged the salt-encrusted stones, and by the mid-20th century they were showing considerable signs of weathering and disintegration. (M. V. S.-W.)

PHILANTHROPY, literally "love of mankind," refers to benevolent efforts to promote human welfare and especially to help the handicapped, the sick, and the poor. The term, though it was used by Jeremy Taylor in a sermon about 1650, does not seem to have been commonly employed before the 18th century. It is used interchangeably with the older word "charity," but the latter may also have particular religious connotations (*see* Charity).

Usually, though not always, philanthropy applies to large-scale enterprises aiming at the prevention as well as the relief of human ills (*see* Foundations, Philanthropic). This article traces the origins of philanthropy in personal, religious, and social sanctions to care for members of the family, or kinship group, and to extend hospitality to strangers. It briefly surveys the influence of the teachings of Buddhism, Islam, Judaism, and Christianity and the history of philanthropic institutions up to the time of the 16th-century poor laws, which were a landmark in the

recognition of social (secular and legal) as well as moral and religious obligations to aid the unfortunate (*see* POOR LAW). (*See* also POVERTY.) For the development of modern public and private philanthropic programs *see* CHILD WELFARE; PENSIONS; SOCIAL SECURITY; SOCIAL SERVICE; SOCIAL WELFARE. International Programs are discussed under UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION; UNITED NATIONS RELIEF AND REHABILITATION ADMINISTRATION; INTERNATIONAL REFUGEE ORGANIZATION; WORLD HEALTH ORGANIZATION; and FOOD AND AGRICULTURAL ORGANIZATION.

Historically, philanthropy grew out of the obligations of the family, or kinship group, to care for its members and to extend hospitality to strangers. The self-maintaining clan-family (patriarchal extended family) encompassed successive generations and provided a special niche for the elderly, the sick and disabled, and the widowed and orphaned. In cities, however, this form of social organization was sometimes disrupted and other forms of aid became necessary: in Egypt the Pharaoh and his appointed agents gave shelter to the poor and distributed bread and clothing. It was believed that charity and good works would assist the soul in attaining salvation after death.

EARLY GREECE AND ROME

In ancient Greece and Rome the provision of food and shelter for the stranger involved precise rules and a code of conduct resembling the formal courtesies adopted by primitive peoples everywhere toward the tribal guest. Vagrants and beggars were under the patronage of the gods and on that account held to be deserving; later, as evidenced in the *Odyssey* and in Hesiod, they were regarded as nuisances. Begging was a recognized means of self-maintenance and the treatment of beggars a perennial problem.

In early Greek communities, as recorded by Hesiod (8th century B.C.) of Boeotia, customary laws of charity involved duty to one's guest and to one's family, especially to orphans and the aged, and also a reciprocal duty to one's neighbour. Four hundred years later a pupil of Aristotle reported that the Boeotians were well-to-do farmers, practising justice, good faith, and hospitality and giving freely of their substance to needy neighbours and strangers: "for meanness and covetousness are unknown to them." Early Greek examples of philanthropy directed toward communities rather than individuals include that of Cimon of Athens, who gave and laid out parks and gardens; and that of Xenophon, who created an endowed foundation in Scillus to provide food for all on days of festival. One function of feasts was the relief of the poor: beggars carried away extra food in their "wallets," as, later, Roman clients carried away portions of food in baskets (*sportula*) from their patrons' dinners. Throughout Greece inns or resting places for strangers were maintained at or near temples, also initially the centres of medical relief for wayfarers and the poor, and there were brotherhoods in which hospitality was a duty and that supported a kind of common relief fund. These practices continued until the Christian era.

In early Rome, public lands (*ager publicus*) were distributed by the state to citizens without property. As the patrician families acquired more and more of the land, other philanthropies had to be undertaken, and a kind of poor relief in the shape of cheap or free distribution of grain to all citizens was instituted: the *annona civica*. The right to relief was dependent on the right of citizenship; it was hereditary and passed from father to son. It was thus in the nature of a continuous endowed charity affecting the whole population, although later it became necessary to restrict the civic bounty to as few persons as possible.

The *sportula*, referred to previously, represented the home charity of the clan-family and the charity of the patron to his clients. During the empire particularly, leading citizens displayed munificence and benevolence in other ways. Thus in the 1st and 2nd centuries A.D., rich citizens gave freely for education, municipal games, etc., and some endowed religious or charitable institutions. Corporations of craftsmen (*collegia*, forerunners of guilds) were widespread. They embraced artisans and even slaves who contributed regular sums toward the costs of common worship, funerals, care for orphans and widows, and loans to the needy. But under the emperor Severus (A.D. 193) the *collegia* were brought under state control. This marked their decline as benefit societies and their transformation into purely industrial guilds controlled by the municipalities.

The first recorded charitable foundation linked with the Roman "poor" as a class was apparently the *alimentationes* for bringing up poor children, founded probably by Nerva or Trajan about the end of the 1st century A.D. Hospitals in Rome developed from a refuge for sick slaves that existed in republican times on an island in the Tiber. By the 1st century private hospitals or *valetudinaria* for slaves and poor freemen had come into being, and these were followed by the public hospitals of the later empire.

BUDDHISM AND ISLAM

All the great teachers and philosophers who have influenced the history of the East stressed that the well-to-do had duties toward the unfortunate. As a result there are many examples of public philanthropic works, especially provisions for the sick and infirm.

In ancient India philanthropy was promoted by the teachings of the Buddha. Buddhism, a profoundly ethical religion, naturally emphasizes compassion for suffering and the doing of good deeds as one of man's duties and a source of merit. A scriptural writing of Theravada Buddhism, the *Khuddaka Patha*, in a teaching reminiscent of the Sermon on the Mount, counsels, "By charity, goodness, restraint, and self-control man and woman alike can store up a well-hidden treasure—a treasure which cannot be given to others and which robbers cannot steal. A wise man should do good—that is the treasure which will not leave him." Mahayana Buddhism emphasizes the doctrine of the Bodhisattva, the compassionate saviour, and man is urged to follow his example. The *Tathagataguhya Sutra*, describing the qualities of the Bodhisattva, says: "He gives the best food to those who are hungry. He protects those who are afraid. He strives for the healing of those who are sick. He delights the poor with his riches. . . . He shares his riches with those afflicted by poverty. He bears the burdens of those who are tired and weary."

The Buddhist emperor Asoka (*c.* 274–232 B.C.), according to one of his inscriptions, provided medical facilities throughout his realm and caused wells to be dug and trees to be planted for the enjoyment of man and beast. The infirmaries of Buddhist monasteries sometimes took patients from outside, and in Ceylon Buddhist monks studied medicine and visited the sick. In China there were houses of refuge for sick people, isolation hospitals, sick-visiting, nursing, and support of the needy. Craft associations, or guilds, undertook much benevolent and charitable work. Typically, these paid attention not only to the material needs of the sick and infirm but also to their spiritual needs and to the religious proprieties; thus much importance was attached to the fitting burial of deceased members.

Philanthropic works have long been among the glories of Islam. Indeed, one of the five "pillars" or obligatory duties of Islam is the payment of the *zakat* tax (from the root verb *zaka*, "to be pure," which indicates its connotations), which is levied in varying percentages on specified types of property and is distributed to several categories of the needy. In addition to this obligatory alms, the voluntary payment of charities (*sadaqat*) is considered highly meritorious, a witness to the truth of the Muslim's religion. Numerous specific references in the Koran indicate the Prophet's concern for the giving of alms; *e.g.*, "Of their goods take alms, that so thou mightest purify and sanctify them" (ix, 103); "Those who rehearse the Book of God . . . spend (in charity) out of what We have provided for them, secretly and openly" (xxxv, 29).

The early caliphate maintained an elaborate system of assistance to the widows and orphans of its soldiers and colonists. As early as A.D. 707 the first great hospital was founded at Damascus, followed in the last years of the 8th century by one in Baghdad, founded by Harun al-Rashid. In 1283 the Mameluke sultan Qalawun opened the great hospital in Cairo. In it, patients were isolated for study and treatment; there were separate wards for patients suffering from dysentery, fevers, diseases of the eyes, and

bone injuries; and there were galleries for convalescents. A resident staff of men and women was supported by a full organization of storerooms, dispensaries (backed by a herb garden), kitchens, library, lecture rooms, and accommodations for "interns." Famous doctors—including some Christians and Jews—attended the patients and also made domiciliary visits, distributing food and medicines. Qalawun declared that this noble and magnificently endowed foundation was "for kings and servants, amirs and common soldiers, rich and poor, bond or free, men and women alike," and directed that all indigent patients should receive a sum of five pieces of gold on their discharge. Another form of Muslim philanthropy was the founding of universities, some of which, such as Al Azhar (970) in Cairo, are among the oldest in the world.

Medical education in Europe largely sprang from Moorish Spain: the *Altasrif* of the Spanish Muslim physician Abul Kasim includes some surgical notations and has been styled "the common fountain of modern medicine." Moorish foundations in Spain, North Africa, and the Middle East included lazar houses (leprosariums), which had originated in Armenia about A.D. 260.

JUDAISM AND CHRISTIANITY

Jewish ethical thought recognized from the beginning that the poor had rights and that the rich had duties. This was exemplified in injunctions such as that for the remission of debts every 7th, or sabbatical, year and every 50th, or jubilee, year; and in those governing the right of the poor to glean in the fields, and the distribution of largess at weddings and funerals. The Decalogue refers to sabbath rest for the stranger within the gates of Israel (Ex. 20:10); and the Levitical ordinances enjoin love of one's neighbour as oneself and good treatment of the stranger in memory of Israel's sojourn in the land of Egypt (Lev. 19:18 and 19:34).

Ideal and practice were continued in later Jewish history, partly because of the need for solidarity. From the period of the fall of the Jewish state, the charity overseer was part of the recognized institutional system of every community. Numerous voluntary associations existed for the care of the indigent and unfortunate. By the Byzantine period the Jewish charitable inn heralded the appearance of endowed charity: every ghetto had its lodging house for indigent strangers. Alms were collected not only for the poor of the city but on occasion "for the poor of the whole world," as the 12th-century rabbi Maimonides testifies, and it was laid down in the codes that a town without proper charity organization was not a proper place of residence for a self-respecting Jew. It was also expected that he would devote a tithe of his income to philanthropy.

Christian teaching from the beginning inculcated charitable activity as essential to the showing forth of that love that is the fulfilling of the law (Rom. 13:8–10); and many Christians at all periods have found the motive for their philanthropy in Christ's saying: "Truly, I say to you, as you did it to one of the least of these my brethren, you did it to me" (Matt. 25:40). Some, however, with a materialistic view of the rewards and punishments of the afterlife, have seen, in almsgiving especially, a means of "making God their debtor"; and this was particularly obvious in the medieval period.

Early Church Foundations.—In the early years of the Christian Church, the congregational fund was used to succour the poorer members and those who had suffered for their faith; to bury such as lacked means, and to care for their widows and orphans. Later, through administration of charitable funds by the deacons, the churches of Rome and other large towns became well endowed, especially from the time of an edict of the emperor Constantine (A.D. 321) which for the first time authorized the willing of property to the church. Although the edict was temporarily withdrawn (by Valentinian in 379) because of legacy-hunting by the clergy, by 529 it had become legal to give property for "churches, hostels, poorhouses, infant and orphan homes, homes for the aged, and for any such community." A share of an estate left to "Christ our Lord" was held to be payable to the nearest church "to become the alimony of the poor." Legacies "to the poor" of a district were payable to its church. Such gifts were treated as given to pious uses, as "alms," and were free from taxation. Thus grew up the system of endowed charities, for the most part in relation to the church or administered by its officers.

Medieval Philanthropy.—Out of these privileges emerged a system of philanthropy shaped by three factors: the position of the bishop, the eleemosynary nature of church funds, and the need for some responsible charitable organization within an expanding church. Originally all income of the church from alms and gifts was paid into one fund, intended primarily for the poor. Before the reign of Constantine very few church buildings had been erected and the church was in large measure a charitable society. When the need for funds for building was recognized, a fourfold division of offerings was made: (1) for the bishop; (2) for the clergy; (3) for the poor; and (4) for church buildings. (Traces of this arrangement survive in the organization of funds in the Church of England.) Thus a separate fund for almsgiving, supervised by the bishop, was created and up to the time of Charlemagne (*c.* 750–800) philanthropy was mainly parochial; measures to aid the poor consisted principally of assistance in the home. But during the wars and confusions of the 9th and 10th centuries, almsgiving tended to be more and more obscured by the rise of the feudal system, which changed the obligation of individuals to their church and to the poor of their parish into an obligation to their feudal masters, to whom they were bound by fealty. By the same process, the officially recognized clients of the church came to consist of the gradually decreasing number of free poor and those who were tenants of church land. Under these circumstances, the revenues of property and charity for the poor all too often enriched private or ecclesiastical purses. Sometimes, however, they passed to the newly founded monasteries, which became institutional centres of relief, providing through an almonry to the aged, infirm, lame, and blind (who were visited in their homes), and for travelers and the ever-present mendicants. Sometimes the almonry contained rooms for the sick. These were the forerunners of the hospitals, which by the 12th century were commonly created out of the rich foundation endowments of the monasteries (*e.g.*, a grant of land was made by Henry I of England to the abbey of Abingdon "to the use of the alms of the said abbey"). From the 11th century, the number of hospitals greatly increased. About 750 existed in England by 1540. The continent of Europe showed similar development and European explorers helped introduce hospitals to the New World (*e.g.*, the Hospital of Jesus of Nazareth, founded by Cortés in Mexico City in 1524). (*See* also HOSPITAL: *History of Hospitals.*)

Almshouses, too, were founded; for example, four in Canterbury, two of which were endowed by Lanfranc in 1084, one for poor, infirm, lame, and blind men and women, and one (outside the town) for the victims of leprosy; *i.e.*, all sufferers from disfiguring diseases. These institutions were attached to and administered by a priory and endowed with tithes. The hospital in its modern sense was but slowly created. Thus the earliest great hospitals of London, St. Bartholomew's (1123) and St. Thomas's (1200), were part almshouses and part shelters for poor, diseased, and disabled in-patients; they also cared for orphan children. St. Thomas's, founded by Peter, bishop of Winchester, had a master and brothers and lay sisters, and provided 40 beds for the sick, poor, or aged. (Guy's Hospital—the last general hospital to be endowed by a single person—was founded in 1724 to relieve the overcrowding at St. Thomas's.) There were many hospital orders (including the "Hospitaller" Knights of St. John of Jerusalem, who have operated hospitals for the poor from the 12th century to the present day), and the friars of the newly founded Franciscan order went about tending the sick and distressed wherever they might be found.

Often almshouses and schools were created out of a common endowment and in a single complex of buildings, as was the "hospital" and school of Archbishop Whitgift (1596). Both (though the school has been rebuilt) still survive as one foundation.

Religious institutions were not the only centres of organized philanthropy; municipal authorities, too, took an increasing share in promoting the welfare of their inhabitants. This happened first of course in the countries where town life was early important: in Italy, for example, in the 9th century. By the 13th

century many municipalities maintained *tables des pauvres* such as that at Ypres (Flanders; 12th century) for local residents and pilgrims. The merchant and craft guilds, which rose to importance in the later Middle Ages, also conducted secular charitable activities. Richer citizens willed lands and funds to their guilds or municipalities for the maintenance of almshouses, the education of children, and the support of widows and unmarried daughters —usually with preference for the families of other guild members or those born in the city. Endowments were made to finance apprenticeships and loans to young men starting in trade, and there were benefactions for the support of poor scholars at the universities.

A curious mixture of nonendowed public and private philanthropic action is found in the medieval method of dealing with disasters such as fires. Before the Reformation, these had usually been the occasion of church collections: but from that time royal letters patent, known as charity "briefs," authorized collections in specified parishes or districts or in all the parishes of a county. Any surpluses were applied to the building of hospitals, bridges, causeways, etc.; *e.g.*, to record a single instance, to repair the Cobb (pier) at Lyme Regis, Dorset. Boroughs also were left land and funds from which to maintain roads, fords, embankments, and bridges or, as in Scotland, for "the general good of the community."

Decline of Medieval System.—The system of monastic and church-door poor relief had begun to break down a long time before the Reformation. The methods of charity practised by the monasteries had been indiscriminate, property of the hospices had often been diverted from its intended use, and the hospitality of monasteries or hospices had frequently served the rich rather than the poor. Against this popes and church councils fulminated in vain. The Council of Vienne (1311), after condemning corrupt administrators of leprosariums, hospices, and hospitals, had forbidden the transformation of charitable foundations into clerical benefices. The edict was renewed by the Council of Trent. In many countries, consequently, attempts were made to transfer the administration of foundations to secular control. Thus in France from the time of Louis XII a series of ordinances sought to reorganize the administration of philanthropic institutions and to take them out of the control of religious bodies. The same tendencies were found in England, and the suppression of the monasteries under Henry VIII and Edward VI did not destroy a system of relief that had previously been working effectively, but rendered more apparent the amount of pauperism that existed.

These were the circumstances from which evolved the policy of public support through compulsory taxation to relieve at least extreme poverty through the enactment of poor laws. (*See* Poor Law and Poor Law: *United States.*)

See Charity Commissioners for England and Wales; Casual Ward; Guild; Hospital; Housing; Nursing; Trust; *see* also references under "Philanthropy" in the Index.

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PHILARET (1553?–1633), patriarch of Moscow who from 1619 ruled Russia in harmony with his son Tsar Michael, was known in his secular life as Fedor Nikitich Romanov, being the eldest son of the boyar Nikita Romanovich. During the reign of his cousin Fedor I (1584–98), he distinguished himself both as a soldier and as a diplomat. On the death of the childless tsar, he was the popular candidate for the vacant throne; but he acquiesced in the election of Boris Godunov (*q.v.*), who compelled him, three years later, to take monastic vows under the name of Philaret. Philaret was confined to the Antoniev Monastery, near Kholmogory, but when the first False Dimitri overthrew the Godunovs he released Philaret and made him metropolitan of Rostov (1606). In 1609 Philaret fell into the hands of the second False Dimitri, who named him, apparently against his will, patriarch of all Russia—though in fact his jurisdiction was limited. In September 1610 Philaret was sent by the Muscovite boyars to King Sigismund III of Poland to negotiate for the accession of the latter's son Wladyslaw to the throne of Russia. The king's intransigence caused these negotiations to break down, and Philaret was eventually arrested and sent to Poland, where he was kept in confinement (1611–19). After the election of his son Michael Romanov as tsar of Russia (1613) and a long-delayed exchange of prisoners, Philaret returned to Moscow and, on July 4 (new style; June 24, old style), 1619, was enthroned patriarch. Father and son then shared the sovereignty of the realm as co-regents.

Philaret replenished the treasury by a more rational system of assessing and collecting the taxes. His most important domestic measure was the chaining of the peasantry to the soil, a measure directed against the ever-increasing migration of the serfs to the steppes, where they became freebooters instead of taxpayers. The taxation of the tsar's *sluzhilye lyudi*, or military tenants, was a first step toward the proportional taxation of the privileged classes. Philaret moreover formed the nucleus of the Patriarchal Library and commanded that every archbishop should establish a seminary for the clergy, himself setting the example. He also reorganized the Muscovite Army with the help of foreign officers. His death, in Moscow, on Oct. 11 (N.S.; 1, O.S.), 1633, put an end to the attack on Poland that had been launched in 1632, since it deprived Russia's still weak executive of its strongest prop.

See R. N. Bain, *The First Romanovs* (1905).

PHILARET (Vasili Mikhailovich Drozdov) (1782–1867), metropolitan of Moscow, whose strong personality, broad learning, and acute perception of the needs and demands of contemporary church life made him one of the most important and influential prelates and theologians of the 19th-century Russian Orthodox Church. He was born at Kolomna near Moscow on Dec. 26 (old style), 1782, the son of a priest. He completed the usual training as priest in 1803 at the seminary of St. Sergius' Monastery of the Trinity, and immediately entered on a brilliant career as teacher in theological seminaries and academies, first in Moscow and from 1809 in St. Petersburg, his subjects including Greek, Hebrew, philosophy, poetry, biblical hermeneutics, biblical history, church history and Christian archaeology, canon law, and dogmatics. On the advice of his patron, the famous metropolitan of Moscow Platon Levshin, Drozdov became a monk (1808) and speedily rose in ecclesiastical rank and office. As rector of the St. Petersburg theological academy he was a member of many committees on the reform and improvement of theological studies in Russia. From 1817 vicar bishop of St. Petersburg and from 1819 archbishop of Tver (now Kalinin), he was a member of the Holy Synod until the end of his life, although from 1843 to 1855 he was in disgrace with the high procurator N. A. Protasov and could make his influence felt only indirectly. On July 2 (O.S.), 1821, he became archbishop of Moscow and on Aug. 22 (O.S.), 1826, metropolitan. Philaret died in Moscow on Nov. 19 (O.S.), 1867.

As metropolitan, Philaret was widely active in church politics, interesting himself particularly in reunion with members of the church in east Poland and in establishing a connection with the Old Believers. His *Mnenia i otzivi* (1905; "Views and Comments") dealt with all the theological, ecclesiastical, and political questions of his time, and their influence can hardly be overestimated. He worked eagerly for the introduction of a modern Russian translation of the Church Slavonic Bible and from 1814 to 1858 he fought a hard, and finally successful, battle on its behalf, associated as he was with the fate of the Russian Bible Society, of which he was a member until its dissolution. His most important literary work apart from his sermons is his catechism, which he first published in 1823 and of which he was obliged to publish three versions revised in accordance with the reigning theological opinions of the Holy Synod, that is of the tsarist government. It became the official 19th-century Russian Orthodox catechism.

See Philaret's *Catechism* (Eng. trans.) in P. Schaff, *The Creeds of Christendom*, 2nd ed., vol. ii (1877). *See* also D. Jugie, "Philarète Drozdov," in A. Vacant, *Dictionnaire de théologie catholique*, vol. xii (1933). (F. v. L.)

PHILATELY (STAMP COLLECTING) is the hobby of collecting and studying postage stamps. The first postage stamps for prepayment of letter postage were issued in England in 1840. Almost everything connected with them began at that date, including the vocabulary needed for the hobby of stamp collecting and even the name stamp itself. For the history of posts and postal systems, *see* POSTAL SERVICES.

The term philately was coined in 1865 by a Frenchman, M. Herpin, who invented it from the Greek *philos* "love," *a* "negative," *telein* "to tax"; since the postage stamp was evidence of a letter's coming free of charge to the recipient, the postage stamp rendered it untaxed. The term caught the popular fancy much more than the word timbromania (Fr. *timbre* "stamp") previously used, and became the accepted word to describe stamp collecting and the study of postage stamps.

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I. HISTORY

In 1835 Rowland Hill (*q.v.*) began to study the tax situation in England, there having been a surplus of revenue. He noted that while reduction of tax rates sometimes brought a reduction of net revenue, the reduction of the tax on coffee by one-half had produced a net increase in revenue of one-half. Furthermore, he determined that postal revenues were falling despite increased rates, while a reduction in postal rates in France had increased the net revenue.

Further inquiry revealed that since most letters went through post unpaid, to be collected on delivery, many of these were refused and had to be returned, often to be unclaimed or refused on return, thus necessitating records at every step of the two-way trip, as well as double portage for no revenue. Most illuminating of all was the discovery that the cost of transport per letter was frequently less for a long journey—from London to Glasgow, for example—than for a short one—such as London to Kent—for the long haul went with a greater number of letters than the short local trip. Hill therefore proposed a radical change: that letters be carried any distance within Great Britain and Ireland for a fixed rate, which he suggested be a penny for each one-half ounce, and that all postage be prepaid. Wrappers and envelopes with the stamp denoting prepayment were to be sold at all post offices, and for those who wished to use their own stationery he proposed "a bit of paper just large enough to bear the stamp" (he meant the imprint of the post office hand stamp), "and covered at the back with a glutinous wash, which might, by applying a little moisture, attach to the back of the letter, so as to avoid the necessity for redirecting it."

Hill's pamphlet, *Post Office Reform*, was issued in January 1837 for private circulation. Parliament investigated, and the postmaster general Lord Lichfield reported that of all the wild and visionary schemes he had ever heard or read of, it was the most extraordinary. A second edition of the book, for public circulation, had its effect. The public response was loud and strong, the treasury reduced rates to a uniform 4*d.* per ½ oz. basis, and in 1839 reduced it to Hill's proposed 1*d.* per ½ oz. regardless of distance, effective Jan. 10, 1840.

Hill was asked by the treasury to work out the details. In 1839 he entrusted the design of the envelope and wrapper to William Mulready (*q.v.*). To create the "bit of paper," he held a public competition, and more than 2,600 essays were entered. Meanwhile, Hill had heard of a new process of steel engraving, in which he became interested. When the prizes (four of £100 each) were awarded, the "label" with the glutinous wash on the back was finally produced by the new, revolutionary Perkins process for reproducing steel engravings.

Jacob Perkins, a native of Massachusetts, was an inventor of mechanical devices. In 1819, having invented the D-roller copperplate press, an engine lathe for engraving copper and steel plates, and the triple transfer process of reproducing steel engravings together with the machines to carry it out, he was persuaded to travel to England to interest the Bank of England in the process for producing its notes. The British minister to the United States extended the invitation, and though the Bank of England finally decided to proceed with a process then being installed, a grant, reported to be £5,000, was made to Perkins and his partners. Meanwhile, he secured the business of many other banks, for prior to 1844 almost every British bank issued its own notes.

In brief, the essence of the process is: a soft-steel die is engraved with the original intaglio of the proposed finished engraving. This master die is then hardened and a soft-steel roller is pressed against it in a transfer press and rolled back and forth until a transfer in relief is obtained on the roller. A second, third or fourth relief or even more, likewise can be obtained on the transfer roll, each of them in relief; *i.e.*, the lines that are cut into the original die and that will retain the ink to make the print of the engraving are in relief on the transfer roll. The roll is hardened, in turn. The last stage is to impress the transfer roll against the plate from which the printing is to be done, once more in the transfer press. The relief lines become intaglio lines on the printing plate, exact reproductions of the original die, reproduced as often as wished.

To the inventor's firm of Perkins, Bacon and Petch (later Perkins, Bacon and Co.), Sir Henry Cole, on behalf of Hill, suggested in December 1839 the possibility of securing the contract for the proposed labels.

For Hill's label, the background chosen was an engine-turned lathework that had been used often as a background of bank notes. To use this on the stamp, a die block was impressed with the proper amount of the geometric pattern from the transfer roll. (This same transfer roll was later used to make the background for the Cape of Good Hope triangular stamps of 1853, the St. Vincent one-crown stamps of 1880 and the New Zealand George V series of 1915. It is now in the possession of the Royal Philatelic Society.) The overall size and the space for the portrait of the queen were carefully marked. The pattern was transferred to a roll, and the space for the queen's head and the unused portion were burnished clean. The roll was then entered on a new die block. The portrait chosen was that engraved by W. Wyon of the royal mint for the medal struck commemorating the queen's first visit to the city of London in 1837. Henry Corbould made the drawing, and the engraving was made directly on the die by Charles and Frederick Heath. The first die was not used and a second was made. Above the head was a panel with the word "Postage," the upper corners were embellished with a cross pattée; below was a panel with "One Penny" or "Two Pence"; in the lower corners were initials. Hill was afraid of counterfeiting, and for this reason the initials were used.

Each plate (11 were used for the one-penny value and two for the two-pence the first year) contained 240 stamps; each horizontal row of 12 was therefore valued at as many shillings as the single stamp was worth pence. There were 20 rows, each full sheet being worth in pounds what each stamp was valued in pence. The lower right-hand corner of the stamps was lettered "A" for the first vertical row, "B" for the second and so up to "L" for the 12th; the lower left corner was similarly lettered "A" for the first horizontal row, "B" for the second and so to "T" for the 20th. It was thought that any counterfeiter would use only one or two combinations, and any very frequent recurrence of these would apprise the postal clerks of the attempt.

Neither the envelopes and wrappers nor the stamps were ready

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1. GREAT BRITAIN, "PENNY BLACK," 1840, THE FIRST ADHESIVE POSTAGE STAMP. 2. BRAZIL, "BULLS-EYE," 1843, THE FIRST STAMP ISSUED IN THE WESTERN HEMISPHERE. 3. ST. LOUIS, MO., "BEAR," POSTMASTER'S PROVISIONAL STAMP, ISSUED PRIVATELY IN 1845. 4. UNITED STATES, 5-CENT AND 10-CENT STAMPS, 1847, THE FIRST U.S. GENERAL ISSUES

in January. Hand stamps were used to mark the letters "paid" until May 6, 1840. On May 1, both stamps and envelopes, including wrappers, were ready—the one-penny black, the two-pence blue—and were put on sale. They were not valid for postage until May 6. It was Hill's thought that the envelopes and wrappers would be in demand, and adhesive stamps would be merely for the exceptional user. But in fact, it was the stamps that were in demand, and the printers worked night and day to keep the offices supplied, while the original supply of the envelopes and wrappers was never exhausted in the year they were available for postage.

In the latter part of 1885 James Chalmers, whose father had been a printer in Dundee, advanced the proposition that Hill had stolen the idea for the adhesive postage stamp from the elder Chalmers. Both the principals were dead, but an unpleasant controversy arose that was scotched by Chalmers' own evidence, which gave the date of his father's suggestion as after Hill's (quoted above) had been read into evidence before a parliamentary committee. However, from time to time, copies of Chalmers' vitriolic pamphlets come into the hands of newcomers to philately and provide another tempest in a teapot.

Although Hill's estimate of the loss of revenue was greatly surpassed by the facts, there was never any serious question of reverting to the old system. Prepaid postage, and with it the adhesive label that later became the postage stamp, had become accepted.

In 1843 the empire of Brazil issued three values of postage stamps, becoming the second government to use them. These stamps did not contain the portrait of the emperor, but large figures of value on a background of engine-turning, and are popularly known as bull's-eyes. In the same year two Swiss cantons, Zürich and Geneva, issued stamps. That of Geneva was a double stamp: a half paid the postage within one commune, the whole paid it within the canton.

The first adhesive stamp in the United States was issued in 1842 by the semiofficial City Despatch Post of New York City for local carrier delivery. In 1845 several postmasters in the United States issued stamps to facilitate prepayment of letters—New York City issued a 5-cent value; St. Louis issued 5- and 10-cent stamps (later adding 20-cent); and the postmaster at New Haven, Conn., issued a 5-cent envelope.

In the succeeding two years, more postmasters issued similar local labels all with the tacit consent of the postmaster general, since the postmasters were charged with each letter they forwarded "paid" and the issuing of the stamps was merely their own method of bookkeeping.

In 1847 the United States issued stamps of 5- and 10-cent value and the "postmaster's provisionals" were abandoned. Prepayment became obligatory in 1856.

In 1845 the Swiss canton of Basel issued a stamp. In 1847 the British colony of Mauritius issued two values made locally that have become two of the philatelist's most sought-after rarities. In 1848 the Bermuda postmaster issued a provisional similar in purpose to those issued by the U.S. offices between 1845 and 1847. France and Belgium issued their first stamps in 1849, as did Bavaria. In 1850 Austria, Hanover, Prussia, Saxony and Schleswig-Holstein in central Europe, Spain and the three British colonies of New South Wales, Victoria and British Guiana all issued stamps. So did the Swiss federation, replacing the cantonal issue of previous years, for these stamps were valid in all cantons.

The first British stamps bore no country name, being intended only for internal use. Subsequent issues of Great Britain have likewise been content to bear the legend "Postage" without any designation of the country of issue. The first Brazilian issue was also without a name. The Swiss stamps, seeking to avoid giving offense to German-, French- or Italian-speaking Swiss, were likewise without a country name; subsequent issues avoided argument by carrying the Latin name "Helvetia," or later "Confoederatio Helvetica."

After 1850 the remaining countries of the world began to issue stamps, more being added each year. Some countries began with local issues for the larger cities. Others plunged into national production. Following World Wars I and II numerous new countries and subdivisions issued stamps, while others ceased to exist as stamp-issuing entities.

II. STAMP MANUFACTURE

Although the first stamps, those of Great Britain, were made by intaglio printing, not all stamps are so made. Five basic processes of printing are used in making stamps: (1) the engraved or intaglio process, in which the lines to be reproduced are incised into the surface of the plate and inked, while the surface is wiped clean;

BY COURTESY OF OWNERS (1) LEEMAN, (4) BRITISH MUSEUM; PHOTOGRAPHS (1-4), LIFE, © TIME, INC.

1. SWITZERLAND (CANTON OF BASEL), THE BASEL "DOVE," 1845. 2. MAURITIUS, 1848. THE WORD "PENCE" WAS MISSPELLED "PENOE." 3. NEWFOUNDLAND, "HAWKER," 1919, THE FIRST STAMP ISSUED FOR AN ATLANTIC FLIGHT, MADE BY OVERPRINTING A REGULARLY ISSUED STAMP. 4. NEW SOUTH WALES, "SYDNEY VIEW," 1850, THE FIRST PICTORIAL STAMP

(2) typographed or letterpress, in which the lines to be printed are raised above the surface and inked; (3) lithographed or offset, in which the line to be reproduced is drawn on stone (or on a metal plate with a surface simulating that of stone) with an oily ink which attracts the oily ink used to reproduce it, which in turn is repelled by water on the rest of the stone; (4) embossed, in which the paper is raised by an incised die struck against a soft platen or "force"; and (5) photogravure (rotogravure), in which lines are photographed through a screen on a sensitive film covering the plate and then etched into it as in engraving. (*See* also GRAVURE; LITHOGRAPH; PHOTOENGRAVING; PRINTING.)

BY COURTESY OF HELEN K. ZIRKLE

1. BULGARIA, PARCEL POST, 1931–32. 2. FINLAND, SEMIPOSTAL STAMP, 1938, SURTAX FOR BENEFIT OF SOLDIERS OF THE FINNISH FRONT. 3. GERMANY, NEWSPAPER STAMP, 1939. 4. NETHERLANDS, POSTAGE DUE STAMP, 1947–53. 5. ITALY, SPECIAL DELIVERY, 1948. 6. INDIA, OFFICIAL OR SERVICE STAMP, 1950. FOR GOVERNMENT USE

1. Production.—The first stamps were made by private contractors under governmental supervision. Great Britain still contracts with private companies for supplies of stamps. The United States began by contracting for both postage and revenue stamps but, after the Civil War, the Treasury Department began printing its own tax stamps at the Bureau of Engraving and Printing. In 1885 this bureau bid on the postage stamps, but lost to a private concern, the American Bank Note Company. In 1894 the bureau was low bidder; thereafter it produced the postage stamps as well as the revenue stamps, banknotes, currency and bonds.

France also began with a private contractor, but after 28 years transferred the production of stamps to the national mint. Many countries have followed the lead of Great Britain and entrusted their stamps to private concerns—Perkins, Bacon and Co., which produced the first British stamps, also produced the original issues for many other countries. For Chile, for example, the company printed the first issue in sheets of the same dimension and layout as the first British issue, which made bookkeeping rather difficult for the Chileans, who use a decimal currency. Most countries with decimal coinage use sheets of 100.

2. Paper and Watermarks.—Philatelists are deeply conscious of the kind of paper used for stamps. Chief item in papermaking for stamps is the watermark (*q.v.*), a sign or symbol made in the paper as it is manufactured. On paper to be used in printing stamps, watermarks may be spaced so as to fall on each particular stamp, or to run through the sheet in a recurring pattern or to fall with one quarter on each stamp, a block making a full pattern. Typical watermarks are the small crown that appears on each of the 1840 stamps of Great Britain or the "crown and C A" (crown agents) on many colonial stamps; the "USPS" used by the United States between 1895 and 1915, a letter or part of one letter falling on each stamp; or the wavy lines used by Bavaria for early issues, which fell on each stamp and in the margins as well.

Basically, paper is wove or laid. Wove paper is made on a woven screen, and either presents no appearance other than general opacity when held to the light, or it dimly resembles a tiny network, as a woven screen greatly reduced. If the screen is strengthened with heavier wires evenly spaced in one direction, it becomes a laid paper, with these lay-lines showing. If these are exceptionally heavy, it is called batonné paper, and if the heavy batons are placed perpendicular to lay-lines it is laid batonné. A thin onionskin paper sometimes used for stamps is called *pelure* paper.

Paper in which coloured fibres are used, presenting a gray or mottled appearance, is termed granite paper. Silk paper has tiny threads of coloured silk worked into it, and silk-thread paper has one or two very noticeable silk threads laid lengthwise or across it, falling on each stamp. (*See* also PAPER MANUFACTURE.)

3. Gum.—The glue applied to the back of the stamp, which is moistened and thereby made to adhere to the envelope, wrapper, etc., is referred to as gum. Different kinds of gum may be distinguished by colour, opacity, streaks, etc. Stamps may be ungummed. Usually gum is applied to the sheet of stamps before the perforation process is performed.

4. Perforation.—The first stamps were printed on a sheet of paper with no provision for separation one from the other. This required use of a knife or scissors to secure individual stamps. Such stamps are known to collectors as imperforate. In 1847 an Irish engineer, Henry Archer, offered a machine to provide stamps with separations. A toothed wheel cut a series of scallops between the stamps, permitting easy tearing of the sheet. Experiments were made by the British Post Office, and in 1848 the machine was put in service. However, the wheel used to cut the scallops soon became blunted; it also damaged the work table. A new set of wheels with lancet-shaped knives fared little better. In 1849 Archer introduced a machine that punched tiny holes between the rows of stamps. Such sheets as were not ruined in experimenting were sold in the regular course of business by the post offices. In 1854 the machine was so far perfected that thereafter all British stamps were perforated.

Philatelists differentiate between these various methods of separating stamps. The first method, which cuts the paper between the stamps but does not remove any of it, is called rouletting; it is further differentiated by the pattern of the cutting: serpentine, scalloped (or *en arc*), saw-toothed (or *en scie*), straight-line (or *en ligne*), etc. When small portions of the paper are removed, it is termed perforated. These, with imperforate, make up the three main classes of separation of stamps.

Philatelists further differentiate stamps by their perforations. To many, though not all, collectors, a difference in the number of perforations creates a separate, collectible variety. To obviate differences caused by slight variations in the dimensions of stamps, philatelists measure the number of perforations in 20 mm. Thus, "perf. 12" means that there are 12 holes counted in 20 mm., and so on. Roulettes are similarly counted.

III. STAMP COLLECTING

No one can say with certainty when stamp collecting began, but clearly it was subsequent to May 1, 1840, when the first postage

stamps were put on sale. The earliest reference to it is in an advertisement in the *Times* of London in 1841:

A young lady, being desirous of covering her dressing-room with cancelled postage stamps, has been so far encouraged in her wish by private friends as to have succeeded in collecting 16,000. These, however, being insufficient, she will be greatly obliged if any good-natured person who may have these (otherwise useless) little articles at their disposal, would assist her in her whimsical project. Address to E. D., Mr. Butt's, Glover, Leadenhall Street; or Mr. Marshall's, Jeweller, Hackney.

That this mania for accumulating, if not collecting, was rather widespread within the year is evidenced by this paragraph in *Punch*, 1842:

A new mania has bitten the industriously idle ladies of England. To enable a wager to be gained, they have been indefatigable in their endeavours to collect penny stamps; in fact they betray more anxiety to treasure Queen's heads than Harry the Eighth did to get rid of them!

Accumulation led to collecting, in all probability, though there is no evidence of just how or where it started.

1. Catalogues.—From the practically simultaneous appearance of catalogues in the 1860s, it seems clear that collecting was spontaneous and not confined to any one region. Great Britain, France, Germany, Belgium and the United States apparently had active collectors prior to 1862. In the British magazine *Notes and Queries* of June 23, 1860, appears a letter from a schoolmaster recounting that one of his pupils had a collection of 300 or 400 different stamps, and that "Sir Rowland Hill had told him at that time there might be 500 varieties on the whole." He suggests that a list of stamps would be useful and asks if there is any shop in London where stamps are sold and that has a list available. The identical idea must have been surging in other lands. In 1861 Oscar Berger-Levrault, in Strasbourg, issued his list of stamps, *Timbres-Poste*, by lithography from manuscript. In Paris, Alfred Potiquet published a *Catalogue des timbres-poste crées dans les divers états du globe*. The acceptance of the lists must have been immediate, for Berger-Levrault issued a second edition later in the year. In January 1862, J. B. Moens of Brussels, Belg., issued his *Manuel du collectionneur*. In England, Frederick Booty, J. E. Gray and Mount Brown all issued catalogues in 1862. A pirated edition of the last, listing 1,200 varieties, was issued by A. C. Kline in Philadelphia. Brown issued two more editions of his catalogue, the third (1866) listing 2,400 varieties, inclusive of what is now termed postal stationery or envelopes, wrappers and letter sheets, as well as many local issues.

The standard modern catalogues exclude this latter material, and yet the total number of listings, including minor varieties, reaches more than 200,000.

E. Stanley Gibbons issued in 1863 a catalogue that continues to be one of the major catalogues of Great Britain. The standard in France is by Yvert and Tellier; in Germany it is Michel's catalogue, in Switzerland Zumstein's. The Scott catalogue (originating in 1863) and the Minkus catalogue (begun in 1954) are standard works for the United States. Each of the above catalogues stresses information about the country in which it is issued, either as part of the main volume or in a separate specialized edition which may include postal stationery. Also, because of the sheer bulk of printed matter needed to catalogue over 200,000 philatelic items, the major catalogues tend to be published in two or three volumes; shortened versions for beginners and general collectors are produced by both Gibbons and Scott.

Many stamps are issued for postal charges other than letter carrying (*see* below), and some of the major catalogues list these also. Revenue and telegraph stamps, issued to prepay telegrams in certain countries, also are collectible and may be listed in modern catalogues.

2. Albums.—The first stamp albums were issued in 1862. Justin Lallier originated both the French and the English editions, in Paris. He rapidly increased his albums, to accommodate new stamps as they were issued, and for several years held first place among collectors for the completeness and arrangement of his books. In the latter part of the decade (1867) he began to add information about stamp collecting and bibliographies.

3. Special Stamps.—Airmail stamps are issued especially for letters to be carried by air. Italy issued the first of these for the first government-sponsored experimental flight in 1917; the first regular issue was that of the United States the following year. Almost every country has issued them since, with the exception of Great Britain and its colonies, though in these countries certain values of the regular postal issues are of denominations primarily for airmail use. Special delivery, registry, insured and acknowledgment-of-receipt stamps are for payment of the special fees levied for these services. Late fee stamps are sometimes issued to pay the extra postage for letters mailed after the closing of special mails.

Official stamps are issued for the use of governmental departments. Formerly widely used, they are now largely supplanted by printed franks.

Semipostal stamps are sold at a premium over their letter-carrying value, the overage going to some officially recognized charity. Postage due stamps indicate the amount a letter lacks of full payment of the charges, which is collected on delivery. Newspaper and parcel post stamps are for the special duties indicated.

Commemorative stamps are regular postage stamps issued to honour some event, activity or person of national importance. The first stamps of this kind were issued by New South Wales in 1888, on the 100th anniversary of the founding of the colony. Argentina (1892) and the United States (1893) issued stamps commemorating the 400th anniversary of the discovery of America. In 1897 Great Britain and Canada signalized the diamond jubilee of Queen Victoria's coronation. Thereafter, the practice became common.

4. Specialization.—When Mount Brown's catalogue listed 2,400 stamps (1866), a modest collection of 2,000 varieties would contain more than 80% of all stamps. A similar proportion in the 1960s would necessitate 150,000 varieties. Because of the sheer bulk, not to mention the prohibitive expense, of such a general collection, most collectors turn to more or less limited fields. For example, they may collect only the stamps of one country, or of one continent or of one period. Others specialize in collections of certain kinds of stamps; some collect only one issue and study it thoroughly, others may collect only revenue stamps or postal stationery. Those interested purely in stamp designs may collect art or religion on stamps, or flowers, fish, bridges, etc.; this sort of collecting is called topical or thematic.

The collection of postal markings, both on stamped and pre-stamp covers, is a form of specialization; collecting of precanceled stamps is another. Meters (machines that print a postal frank on the envelope) have given rise to yet another specialized form. Telegraph stamps are also collected by some specialists.

Plating.—The collecting of one issue or even of one stamp of an early issue, may necessitate some of the deepest philatelic study. The early stamps, especially the engraved ones, were often retouched after transfer, so that each stamp on each plate has minute identifiable characteristics. For instance, it is possible to identify each of the 2,640 specimens of the Great Britain one-penny of 1840, and this is easy, compared with other issues, because the plate position is located by the check letters in the corners. It is also possible to identify most of the 2,600 varieties of the 3-cent U.S. stamps of 1851. This has led to "plating" or reconstruction of the original sheet, which in turn has led to many discoveries of the ways in which sheets were laid out and manufactured.

BY COURTESY OF HELEN K. ZIRKLE
FIRST U.S. CHRISTMAS SEAL, 1907

Christmas Seals.—Christmas seals were invented by a Danish postal clerk, Einar Holbøll, in 1903, as a source of revenue for an antituberculosis society. They were used on packets and letters sent at Christmas, and sold for a small sum, the money going to the society. The use spread to many other countries, where they are issued each year. While they have no franking power, they are widely used and often collected.

Government Philatelic Agencies.—Specialization in 20th-century stamps has been helped by establishment of governmental philatelic agencies to sell fine-quality stamps to collectors. The United States opened the first of these in 1921, and the success

was soon so apparent that similar agencies were established by many European countries. The U.S.S.R. made traffic in stamps a government monopoly and Germany followed suit when the Nazi Party came into power. In 1942 the U.S. placed revenue stamps on sale at a special agency for collectors.

The forms of specialization are limitless, and the ingenuity of collectors leads to the constant discovery of new and individual methods.

5. Famous Collections.—Many famous collections of the past have been dispersed and absorbed by others. One of the most famous of all times was the collection of Philippe la Renotiere von Ferrari, an Austrian subject resident in Paris. During World War I he fled to Switzerland, where he died in 1917. His property was seized by the French government, and his collection, which he had formed during 40 years, was sold at auction, realizing more than 26,000,000 fr. (£400,000 or $2,000,000 at the rates of exchange of the day).

Arthur Hind's collection, which included the Duveen collection of Mauritius and the Griebert collection of Spain and which was sold in 1933–34 after his death, brought a gross return of nearly $1,000,000. In addition, the unique 1-cent British Guiana magenta of 1856 was sold by private negotiation for a price reputed to be more than $50,000, the highest price ever recorded for a single stamp.

BY COURTESY OF FINBAR KENNY OF J. B. H. STOLOW, NEW YORK CITY

BRITISH GUIANA, "ONE-PENNY MAGENTA." THE MOST VALUABLE STAMP IN THE WORLD. IT WAS ISSUED IN 1856

The outstanding collection in Europe in the 1960s was the private collection of Queen Elizabeth II. Principally formed by King George V, who was a famed philatelist, it is especially rich in British and colonial issues.

Of the several famous collections in the United States, one of the most bizarre was formed by Col. E. H. R. Green; it stressed unusual materials, such as quantities of the "blue paper" issues of the U.S., the only position blocks of the 24-cent airmail with inverted centre (U.S., 1918) and a number of sheets of the imperforate 5-cent carmine error (U.S., 1915). Other noted collections were those of Sol Newbury (Chicago), Alfred Lichtenstein and Theodore Steinway (New York). Alfred H. Caspary's stamps were sold in the late 1950s in New York City for $2,895,146, the largest sum realized by any stamp collection to that time.

The Thomas K. Tapling collection, bequeathed to the British Museum, may well be the finest in public hands. The Smithsonian Institution collection at Washington, D.C., stresses U.S. stamps. The postal museums of many European capitals have outstanding collections, such as those at Berlin, at The Hague and at Stockholm; the last received the Hans Lagerlof (New York) collection.

IV. PHILATELIC SCHOLARSHIP

1. Societies.—Clubs or societies of collectors are to be found in most cities of the world, with national and international societies tending to bind them together. The American Philatelic Society, founded in 1886, had about 13,000 members in the 1960s; the Society of Philatelic Americans (1894) had about 6,000. The Royal Philatelic Society of London was founded in 1869 and became "royal" in 1906. The Junior Philatelic Society of London was founded in 1899. The Collectors Club of New York stands preeminently for philatelic research, as does the Royal Philatelic Society. Many countries have national philatelic organizations with research groups.

Because of the quantity of philatelic material, added to each year by the issuance of about 3,000 new stamps, with the resultant tendency to specialization, specialist societies have sprung up, notably since 1945. Many of these issue bulletins. Particularly noteworthy are the specialty clubs dealing with the philately of France and colonies, Germany, Italy and colonies, Korea, Lithuania, Luxembourg, Japan, Switzerland, airmails, postal history, postal stationery, U.S. bureau issues, and others too numerous to list.

2. Congresses.—The Philatelic Congress of Great Britain celebrated its 50th anniversary in 1959 and the American Philatelic Congress celebrated its 25th the same year. The "congress" idea fosters philatelic research by the publication of articles annually in book form, with annual conventions at which these articles are discussed and the material upon which they are based is studied. The first (Congress Internationale des Timbrophiles) congress was held in Paris, June 26, 1878. After 1945, there was an increase in the number of congresses held in various countries.

3. Exhibitions.—One of the most important activities of stamp clubs is the holding of exhibitions from time to time. National and regional societies hold annual exhibitions, offering valuable awards in competition. International exhibitions are held in the United States at approximately ten-year intervals. Other countries arrange to honour philatelic or national events at the appropriate date with similar world-wide celebrations.

4. Literature.—Perhaps no hobby has been so prolific of literature as philately. The standard catalogues (*see* above) issued annually are generally minor encyclopaedias of the hobby, but there are and usually have been journals in every language.

It is difficult to list accurately monthly or weekly publications, since many are short-lived. The first one of record that was specifically devoted to philately was the *British Monthly Intelligence;* appearing first in October 1862, it lasted only three issues. In December 1862 appeared the *British Monthly Advertiser,* which appeared in January 1863 as the *Stamp Collector's Review;* it lasted nearly two years. Moen's (Brussels) published the *Timbre-Poste* for many years, starting in 1863, in which year the German *Magazin für Briefmarken-Sammler* began. In 1874 John K. Tiffany published *The Philatelical Library,* a catalogue of philatelic literature in his extensive private library in St. Louis, Mo. This collection of books he afterward sold to the earl of Crawford, who combined it with his own extensive holdings and bequeathed all to the British Museum.

Among the journals founded in the 19th century and still extant are *Mekeel's Weekly Stamp News* (founded 1892) and the *American Philatelist* (published by the American Philatelic Society, founded 1887, but with two lapses since), in the U.S.; the *London Philatelist* (published by the Royal Philatelic Society); and *Echoes de la Timbrologie,* in France.

BY COURTESY OF CHARLESS HAHN AND H. R. HARMER INC., N.Y.; PHOTOGRAPH BY ADRIAN BOUTRELLE

UNITED STATES, AIRMAIL, 1918; ONLY ONE SHEET OF 100 STAMPS WITH CENTRE INVERTED (PLANE UPSIDE DOWN) REACHED THE PUBLIC

There have been many books on stamp collecting, especially in specialized fields. Since these appeal to a limited public, they are issued in small editions and few remain long in print.

5. Libraries.—In the United States the library of the Collectors Club of New York is outstanding. The Philatelic Library of Los Angeles, the Eugene Klein Collection in the Philadelphia Free Library and that of the Philatelic Research Society (Oakland, Calif.) also are noteworthy. Many public libraries have growing sections devoted to philately and are usually expected to have at least the standard catalogues. In England the library of the Royal Philatelic Society has been kept up-to-date consistently, and in other European countries where there are postal museums, libraries are apt to be an important adjunct. Probably the best private philatelic library is that of George T. Turner of Washington, D.C.

6. Some Philatelic Terms.—Philatelists, like other hobbyists, use words with special meanings pertinent to their collecting. Some have been coined, others are words from current usage twisted to specific connotations. Many words in the philatelic vocabulary have been internationalized from the French.

Bisect.—These are stamps that have been cut in half or into smaller bits to serve as postage; *e.g.,* the 3-cent of the 1869 U.S. issue was bisected (trisected would be a better term, but philatelists continue to use bisect) to permit the mailing of a number of forms that called for only two cents' postage. Such bisects are usually collected only when on the original envelope or mailing

piece, and then with a cancellation identifying them with the letter. Some bisects also have been overprinted with the new fractional value; in such case they bear their own proof of bona fide and do not need the supporting evidence of the letter.

Block.—A block consists of four or more stamps with the horizontal and vertical separations untouched. Thus, a block of four stamps can only be arranged two wide by two deep.

Booklets.—These are blocks of stamps, sometimes all of the same denomination, sometimes of different denominations, arranged between covers, usually with interleaving to prevent sticking. Size and value of booklets is determined by the country of issue.

BY COURTESY OF HELEN K. ZIRKLE

SWEDEN, PAIR OF VERTICALLY PERFORATED COIL STAMPS, 1954

Coil Stamps.—These are stamps issued in long strips—(usually 500) for use in mailing or vending machines. Some countries, notably Sweden, prefer coils for post office sale in place of sheets as they are easier to store. The stamps are usually imperforate on top and bottom (or the two sides) and perforate between the stamps. If imperforate top and bottom, they come from horizontal coils; if imperforate on the two sides, from vertical coils.

Cover.—A cover is the outer wrapping of a piece of mail: the envelope or outer side of a folded sealed letter or the wrapper of a packet. A stamp is "tied to cover" when the cancellation or other postal marking falls partly on the stamp and partly on the cover.

Double Impression.—This occurs where the sheet of paper was put through the press twice, the second imprint shifting slightly from the first one.

Double Transfer.—In engraved stamps this occurs where the impression on the printing plate, either through shifting in the transfer press or an attempt to re-enter and deepen the impression, has caused portions of the entry to have double lines.

Grill or Grille.—This is the impression of a knurled roller on a stamp to break the fibres of the paper so the canceling ink will soak in and prevent washing to reuse.

Hinge.—In arranging a collection, stamps are not pasted directly on the album page but secured there by hinges, small rectangles of paper gummed on one side and folded. The gum is a special kind that allows the hinge to be peeled off with minimum damage to the stamp and its original gum. One gummed section is fastened to the stamp, the fold at the top of the stamp; the other is fastened to the page. Thus the stamp may be lifted at will for study of the back.

Inverted Centres.—These occur only when two or more plates are used to make a stamp. Occasionally a sheet will be reversed when passing through the second press, and the centre will be inverted in relation to the frame; actually the centre may have been printed first, in which case it is an inverted frame.

Miniature Sheet.—This term has two meanings. (1) A form of collecting in which stamps from the corners, sides, top, bottom and at least one from the centre are put together to show every possible variety the sheet possesses—nine stamps from a U.S. sheet of 100 would give this effect. (2) More commonly the term is applied to little sheets of 25, 10 or fewer stamps issued as souvenirs of an occasion or a national event. These are also known as souvenir sheets.

Mint.—This is the condition of a stamp as it comes from the post office, with its original gum undamaged and without blemish on its face. A stamp that has lost its gum but is otherwise unblemished is spoken of as "unused—no gum," save in rare instances when there was originally no gum, in which case it is still mint.

Overprint or Surcharge.—Either of these terms is used to refer to a stamp that has been printed over, to change one or several of the original qualifications. The trend is to use the word overprint, to avoid connotations that have become attached to the word surcharge. Stamps are often overprinted to change the value, usually because there is a shortage of a needed denomination and a surplus of another. Stamps are also overprinted to change the country, as stamps of one nation used in the territory of another in war or after cession. Another overprint is applied to change the use of stamps; a revenue stamp, for example, may be overprinted for postal duty. Stamps that have been withdrawn have been overprinted to make them valid again.

Plate Numbers.—These are often put on the margins of plates, and thus are printed on the sheets, to identify the plate. Sometimes, as with many issues of Great Britain, they are worked into the design and appear on every stamp.

Postal Markings.—These are the cancellations, postmarks and other hand or machine stampings applied by the post office to the letter or piece of mail.

Precancel.—Precanceled stamps are a particular form of overprint, a cancellation applied before sale to the user. Only those with special permits are allowed to use precanceled stamps, and these must be employed according to strict regulations. They are intended to save unnecessary labour by the post office clerks, and are usually used for large mailings of identical pieces or for newspapers or periodicals.

Reissues.—These, not to be confused with reprints, are made by governments, hence are often called government reprints; frequently they are rarer and more valuable than the original issues.

Remainders.—Remainders are stamps left in the hands of governments after they have been demonetized. Sometimes these remainders are sold in bulk and accordingly depress the value of unused stamps.

Reprints.—These are stamps printed from the original plates after the stamps are no longer valid for postage. The only reason for doing this is to sell the stamps to collectors, and reprinted stamps are accordingly generally deprecated by philatelists. A few governments have been guilty of this practice, and some of them have been persuaded to turn the plates over to private parties. The most notable cases were those of certain Central and South American governments which, in the 1890s, entered contracts with the Hamilton Bank Note Company, of New York, by which the company furnished a complete series of stamps each year, and after the stamps had been demonetized, was permitted to sell the remainders and such other stamps as it wished to make from the plates. These issues, called Seebecks after the president of the company, have suffered accordingly. Certain African countries made similar contracts more recently.

BY COURTESY OF HELEN K. ZIRKLE

PRECANCELED U.S. STAMP

Misprints Reprinted.—In 1935 a Greek postage stamp was overprinted for use as a postal tax stamp and on a few the overprint was found inverted. Though the error occurred unintentionally, the Greek government had many more made to avoid speculation. This is an illustration of what a government may do although most are happy to have the philatelist enjoy the fruits of his discoveries (notably Canada when a small number of the St. Lawrence Seaway 5-cent of 1959 was discovered with inverted centre). On Oct. 23, 1962, a 4-cent bicoloured, two-process stamp was issued by the United States, in the usual quantity of 120,000,000 for commemorative stamps, to honour the late Dag Hammarskjöld, secretary-general of the United Nations. At least two panes of 100 of these stamps with the yellow colour inverted slipped past the inspectors inadvertently, one being found by a collector in New Jersey, the other in Ohio. When this reached the attention of the Postmaster General he ordered printed another 2,000,000 of them (later increased to a total of 10,000,000) on the theory that every collector should have one if he wished. Instead of pleasing philatelists this new policy angered them almost unanimously as it took from their hobby the element of fame and benefit from a possible discovery, always a stimulating factor.

Se-tenant Stamps.—These are two or more stamps unsevered from each other in which one or more of the stamps differ from the other. Sometimes two denominations of stamps are printed in one sheet; a pair of stamps of the different denominations would be described as a se-tenant pair.

Tete-Beche.—Occasionally plates have been made with one stamp entered upside down. Such a stamp is said to be tete-beche, and can only be identified when se-tenant with one or more of the normal stamps.

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Indexes and Handbooks: John Boynton Kaiser, "Bibliography: the Basis of Philatelic Research," *19th American Philatelic Congress Book* (1953); John Freehafer and Helen K. Zirkle, "Literature: Philatelic Handbooks, Including a List of Libraries in Which They May Be Found," *22nd American Philatelic Congress Book* (1956). *American Philatelist,* the American Philatelic Society's monthly, prints a quarterly index of current philatelic publications from all over the world. For the specialist, it is recommended that each find out what is available by writing to his nearest philatelic library, and that each study the complete file of publications issued by the specialty group in his chosen field. (M. HA.; H. K. Z.)

PHILEMON (*c.* 363–*c.* 264 B.C.), poet of the Athenian New Comedy, an elder contemporary and successful rival of Menander, whom posterity preferred to him. Born probably in Syracuse, by 328 he was producing plays in Athens, where he eventually became a citizen; he also worked in Alexandria for a time. About 60 titles from his 97 comedies are known; they survive in Greek fragments (perhaps including quotations from his son, Philemon the Younger), and in Latin adaptations by Plautus (*Mercator, Mostellaria, Trinummus* and possibly other plays). His characteristics include neatly contrived plots, vivid description and frequent moralizing in a style which lacks Menander's grace.

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PHILEMON, EPISTLE TO, one of the Epistles of St. Paul in the New Testament. Though coming in the canon next before the Epistle to the Hebrews, it clearly belongs with the Epistle to the Colossians and among the "captivity epistles" of St. Paul. Both Philemon and Colossians allude to Onesimus; both send greetings from Timothy, Epaphras, Mark, Aristarchus, Luke, and Demas; in both the writer is a prisoner. For the date, therefore, and the imprisonment in question, *see* COLOSSIANS, EPISTLE TO THE.

The primary purpose of this epistle is to persuade one Philemon to forgive and receive back his slave Onesimus, who had apparently (though this is not explicitly stated) absconded, perhaps with money or goods, for which the apostle undertakes to compensate Philemon. St. Paul would have liked to keep Onesimus with him, to wait upon him in his imprisonment as Philemon's representative, but he would do nothing without Philemon's consent, and, indeed, it was illegal to harbour a runaway slave. At the very least, however, he confidently asks Philemon to welcome him kindly: does not Philemon owe his very self to the apostle? This seems to mean that St. Paul had brought Philemon to Christ, a service he appears also to have done for the slave. The epistle includes a brief but weighty reference to the meaning of Christian love and faith, and shows that Paul was expecting release shortly. It is important for showing how Christianity, though accepting slavery as a matter of course, was revolutionizing the relation between master and slave; Onesimus, sent back to his owner, is expected to be beloved by him, both as a man and as a Christian. Considering the severe penalties that might have been inflicted, this is remarkable.

Philemon (with Apphia, his wife, and Archippus, perhaps their son) is, like Onesimus (Col. 4:9), a member of the group of Christians in the Lycus Valley (in Asia Minor) and probably resident at Colossae. The letter, not strictly a private one, is addressed to Philemon's house-church. The Epistle to Philemon appears in two 2nd-century canons, that of Marcion and the Muratorian, though its lack of doctrinal importance as well as its brevity (25 verses only) threw it afterward into some disfavour among certain circles of the church. *See* also BIBLE; PAUL, SAINT.

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PHILEMON AND BAUCIS, in Ovid's *Metamorphoses,* were a pious Phrygian couple who hospitably received Zeus and Hermes when their richer neighbours turned away the gods, who were disguised as wayfarers. As a reward, they were saved from a flood that drowned the rest of the country; their cottage was turned into a temple, and at their own request they became priest and priestess of it. Long after, they ended their lives at the same moment, being turned into trees. Similar stories are given in the *Märchen* ("fairy tales") of the Grimm brothers.

PHILES, MANUEL (13th/14th century), of Ephesus, was a Byzantine court poet in the manner of Theodore Prodromus. He lived in Constantinople under Michael VIII Palaeologus and Andronicus I and II, was acquainted with the chief persons of his day, and traveled widely. His poems, mostly in iambic trimeters, include verses on church festivals, works of art, and animals, as well as dialogues and occasional pieces. Their literary quality is not high, but they have historical and social interest.

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PHILETAS OF COS (*c.* 330–*c.* 275 B.C.), Greek poet and grammarian, is rightly regarded as the founder of the Alexandrian school of poetry. He was tutor to Ptolemy II and taught Zenodotus, Hermesianax and Theocritus. The titles of five of his poems or collections of poems have survived, the most important being apparently the *Demeter,* an elegy narrating Demeter's wanderings. Though he wrote at least one poem in hexameters Philetas' chief fame was as an elegist. His lady love was Bittis (or Battis) and Hermesianax states that the Coans put up a statue of him singing her charms. Among the Romans Propertius and Ovid mention him as their model. Philetas also compiled a lexicon of *Miscellaneous Glosses* (*Miscellanea*) comprising a collection of rare words from Homer, the Greek dialects and other sources.

See A. A. Day, *The Origins of Latin Love-Elegy,* pp. 14–19 (1938). (E. A. B.)

PHILIP, SAINT, THE APOSTLE, one of the Twelve, so mentioned in the apostle lists, always as the first of the second group of four names (Mark 3:18; Matt. 10:3; Luke 6:14; Acts 1:13). According to John 1:43–51 he came from Bethsaida, answered Christ's call, and was instrumental in Nathanael's call. He had a part in the multiplication of the loaves and fishes (John 6:5–7), and with Andrew acted as a go-between for the Greeks who wanted to see Jesus (John 12:21–22). In John 14:8–9 he asked Jesus to reveal the Father, and received the answer, "Have I been with you so long, and yet you do not know me, Philip? He who has seen me has seen the Father." Nothing more is known about him from the New Testament. In later legends he was often confused with Philip the "evangelist," one of the seven deacons of the early church (Acts 6:5). His apostolate was supposed to have been in the territory of Scythia. He died at Hierapolis, according to one tradition, of natural causes, but according to another, of crucifixion. In medieval art his symbol was loaves (dependent on John 6:7) or a tall cross. His feast day in the Western Church (together with that of St. James the Less) is now May 11. In the Eastern Church it is Nov. 14. *See* also APOSTLE. (J. A. FI.)

PHILIP, SAINT, THE EVANGELIST, is mentioned in Acts 6:5, as one of "the seven" chosen to superintend certain secular business of the Jerusalem church, in consequence of dissension between the Aramaic-speaking and Greek-speaking disciples. Luke in mentioning the common meals appears to want his readers to connect these officials with the later diaconate, but among the Hellenistic

Jews they seem to have been originally parallel to the Twelve among the Hebraists. Philip's was a ministry of the word. He went to Samaria and preached with much success, Simon Magus being one of his converts (Acts 8:9–13). He afterward instructed and baptized the Ethiopian eunuch on the road from Jerusalem to Gaza. His missionary journey ended at Caesarea (Acts 8), where he entertained Paul and his companions on their last journey to Jerusalem (Acts 21:8). His feast day is June 6. (W. K. L. C.)

PHILIP THE ARABIAN (MARCUS JULIUS PHILIPPUS), Roman emperor A.D. 244–249, came of a distinguished equestrian family of Arab descent. He was praetorian prefect when the emperor Gordian III was killed in a mutiny, with or without Philip's connivance. Philip succeeded him, ended the Persian war, and undertook a series of campaigns against the Goths and other tribes on the Danube, returning to Rome to celebrate in 248 the 1,000th anniversary of the foundation of the city. He faced a series of revolts by provincial army commanders, the last of whom, Decius, killed and succeeded him in the autumn of 249. His wife was named Otacilia Severa. Christian writers of the 4th and later centuries regarded him as a Christian, or at least as a patron of the Christians.

PHILIP I (1052–1108), king of France, was the elder son of Henry I of France by his second wife, Anne of Kiev. Crowned at Reims on May 23, 1059, he became the sole king on his father's death (Aug. 4, 1060). His minority, during which Baldwin V, count of Flanders, was regent for him, ended in 1066.

Philip was badly misjudged by contemporary chroniclers, who resented his spoliation of churches and disapproved of his personal life. He in fact increased the royal domain, maintained order in it, and held his own against his powerful vassals, especially by exploiting their quarrels among themselves. As the price of his neutrality in the struggle between the brothers Fulk le Réchin and Geoffrey the Bearded for the heritage of Anjou, Philip obtained Château-Landon and the Gâtinais from Fulk (*c.* 1068), thus securing a territorial link between the county of Sens and the other lands of the royal domain around Paris, Melun and Orléans. He likewise took advantage of the dynastic conflict in Flanders after Baldwin VI's death (1070). He was engaged from 1076 in intermittent hostilities against the kings of England: first against William I, who as duke of Normandy (*q.v.*) had more territory in France than the king his suzerain; then against William II, whose brother, Robert Curthose, was more acceptable to Philip as his vassal in Normandy.

About 1072 Philip had married Bertha, sister of Count Dirk V of Holland. By her he had two children who survived infancy: namely his son, Louis VI (*q.v.*) of France, who was associated with Philip as "king-designate" in the later years of the reign; and a daughter, Constance, married first, in 1097, to Hugh I of Champagne, secondly, in 1106 (after the annulment of her first marriage in 1104), to Bohemund I of Antioch. On May 15, 1092, however, at Tours, Philip abducted Fulk le Réchin's wife, Bertrada de Montfort (*c.* 1070–*c.* 1117). He next demanded the annulment of his marriage with Bertha and of Fulk's with Bertrada; some French bishops took a complaisant attitude; and before the end of October the king and Bertrada went through a form of marriage. Ivo (*q.v.*) of Chartres and other bishops strongly objected to these proceedings; and in 1094, when Philip, on Bertha's death, organized a council at Reims to ratify his designs, Pope Urban II's legate, Hugh of Die, convened a countercouncil at Autun and excommunicated Philip. Urban himself, who had hitherto only protested, excommunicated Philip at the Council of Clermont in 1095. Having promised to renounce Bertrada, Philip was absolved at the Council of Nîmes in 1096; but he soon resumed his relations with her, and in April 1097 his lands were put under an interdict. Absolved again (1098), he relapsed again and was excommunicated by legates of the new pope, Paschal II, at the Council of Poitiers (1100). Finally, in 1104, on his promising to abstain from carnal intercourse with Bertrada and to see her only in the presence of "nonsuspect" persons, Philip was reconciled with the church by the councils of Beaugency and of Paris; and thenceforward Paschal II turned a blind eye to his conduct with Bertrada, who continued to style herself queen. Philip's children by Bertrada were Philip, count of Mantes from 1104; Florus, married to the heiress of Nangis; and Cecilia, married first to Tancred, regent of Antioch, secondly to Pons, count of Tripoli.

Philip I died on July 29 or 30, 1108, probably at Melun.

See A. Fliche, *Le Règne de Philippe Ier, roi de France* (1912).

(M. PAC.)

PHILIP II AUGUSTUS (1165–1223), king of France, with his father, from 1179 and sole king from 1180, was born in Paris on Aug. 21, 1165, the son of Louis VII of France and Adela of Champagne. He was crowned at Reims on Nov. 1, 1179, so as to be associated as king with his father, who had fallen mortally ill. His uncles of the house of Champagne, namely Henry I, count of Champagne, Guillaume, archbishop of Reims, and Thibaut V, count of Blois and Chartres, hoped to control France through the youthful king. To escape from their tutelage, Philip on April 28, 1180, married Isabella, daughter of Baldwin V of Hainaut and niece, through her mother Margaret, of the count of Flanders, Philip of Alsace, who promised Arras, Saint-Omer, Aire and Hesdin —in other words the lands later known as Artois—for her dowry. The Flemings' dreams of power were in turn frustrated by the king who had even less intention of being dominated by Flanders than by Champagne. When the Plantagenet Henry II (*q.v.*) of England arrived in Normandy, perhaps with the intention of responding to an appeal by the house of Champagne, Philip II entered into negotiations with him and, at Gisors on June 28, 1180, renewed the understanding which Louis VII had reached with him in 1177. The house of Champagne was thus politically isolated, and Philip II was already making all decisions for himself and acting as he saw fit when his father died, on Sept. 18, 1180, leaving him sole king in name as well as in fact.

The disappointed count of Flanders soon allied himself with the Champagne faction, and there followed a serious revolt against the king. By the Peace of Boves, however, in July 1185 (confirmed by the Treaty of Gisors in May 1186), the king and the count of Flanders composed their differences, which had been chiefly over the succession to the heritage of Vermandois: the disputed territory was partitioned, Amienois and numerous other places passing to the king, the remainder, with the countship of Vermandois proper, being left provisionally to Philip of Alsace. The king was thenceforward free to turn against Henry II of England.

The Struggle Against the Plantagenets.—Henry's continental possessions, the so-called Angevin Empire—Normandy, Maine, Anjou, and Touraine, with Aquitaine in the hands of his son, the future Richard I (*q.v.*) of England, and with Brittany ruled by another son, Geoffrey (d. 1186)—were a constant menace to the French royal domain. There were also long-standing disputes over the Vexin (*see* NORMANDY), Berry, and Auvergne; Henry's promise that Richard should marry Philip's sister Alice remained unfulfilled; and a new quarrel arose in 1187 over the wardship of the new duke of Brittany, Geoffrey's posthumous son Arthur I.

Philip II launched an attack on Berry in summer 1187, but made the truce of Châteauroux with Henry in June. This truce, which left Issoudun in his hands and also granted him Fréteval in Vendômois, was for two years, but Philip found grounds for resuming hostilities in summer 1188. The estrangement between Henry and Richard was ably exploited by him: Richard did homage to him voluntarily at Bonmoulins in November 1188; and finally, by the Treaty of Azay-le-Rideau or of Colombières (July 4, 1189), Henry was forced to renew his own homage, to confirm the cession of Issoudun, with Graçay also, to Philip and to renounce his claim to suzerainty over Auvergne. Henry died two days later.

Richard, who succeeded Henry as king of England, had already undertaken to go on crusade against Saladin in the Holy Land. Philip now did likewise. Before his departure, he made the so-called Testament of 1190 for the government of his kingdom in his absence. On his way to Palestine he met Richard in Sicily, where they promptly found themselves at variance, though they made their Treaty of Messina (March 1191). Arriving in Palestine they conducted the siege of Acre, but Philip soon fell ill and made this his pretext for returning to France. In fact he was bent on settling the succession to Flanders (Philip of Alsace had just

died on the crusade) while Richard was still absent. By the end of 1191, Philip II was back in France.

In spite of promises made in the Holy Land, Philip at once prepared to attack the Plantagenet possessions in France. Informed of this, Richard also left the crusade, but he was taken prisoner on his way back by the duke of Austria, Leopold V of Babenberg. Philip brought everything into play to prolong his rival's captivity, but Richard was at last set free (1194) and went to war against Philip. The French king suffered a number of defeats (from that at Fréteval in July 1194 to that at Courcelles in September 1198) in a series of campaigns punctuated by negotiations. Luckily for Philip, Richard was killed in April 1199.

Richard's brother John (*q.v.*) was by no means so formidable a fighter. Moreover, his right to Richard's whole succession could be contested by Arthur of Brittany, whose father had been senior to John. To secure the succession, therefore, John came to terms with Philip: by the Treaty of Le Goulet (May 22, 1200), in return for Philip's recognition of him as Richard's heir, he ceded Évreux and the Vexin Normand to Philip; agreed that Issoudun and Graçay should be the dowry of his niece Blanche of Castile, who was to marry the future Louis VIII (Philip's son by Isabella of Hainaut); and renounced any claim to suzerainty over Berry and Auvergne. Shortly afterward, however, John entered into conflict with the house of Lusignan and other Poitevin barons, who appealed to Philip as overlord. Summoned to appear before the royal court as a vassal of the French crown, John did not present himself. Consequently Philip in April 1202 pronounced John's French fiefs forfeit and undertook to carry out the sentence himself. He invaded Normandy, overran the northeast and laid siege to Arques, while Arthur of Brittany campaigned against John's supporters in Poitou; but John, marching south from Maine, captured Arthur at Mirebeau (Aug. 1). Philip in fury abandoned the siege of Arques and marched southwestward to Tours, ravaging John's territory on his way before returning to Paris. Guillaume des Roches, the powerful seneschal of Anjou, who had lately taken John's side, came to terms with Philip in March 1203.

Resuming operations against Normandy, Philip occupied the towns around the great fortress of Château-Gaillard, to which he laid siege in September 1203, having overruled Pope Innocent III's attempts to mediate. John, who is supposed to have murdered Arthur of Brittany in April, retired to England in December, and Château-Gaillard fell to Philip in March 1204. Then Rouen, the Norman capital, surrendered in June, after 40 days' resistance.

After his conquest of Normandy, Philip subdued Maine, Touraine, Anjou, and most of Poitou with less difficulty (1204–05), though the castles of Loches and Chinon held out for a year. He sought to secure his conquests by lavishing privileges on the towns and on the religious houses, but otherwise left the local barons in power. Unrest, however, was endemic in Poitou, and in June 1206 John landed at La Rochelle. After a campaign in the south, he turned north toward the Loire. At Thouars in October 1206 he and Philip made a two-year truce, leaving John in possession of the reconquered Poitevin lands. Next year, however, Philip invaded Poitou again; and after a further campaign in 1208 only the south and part of the west of Poitou remained loyal to John (with Saintonge, some of the Aquitanian hinterland, and Gascony).

Philip next hoped to exploit the dispute between John and Pope Innocent III. When Innocent was threatening to declare John unfit to reign (1212), plans were made for a French landing in England and for the accession of Philip's son Louis to the English throne; but these plans had to be dropped when John made his submission to the pope (1213). John on the other hand threw himself into schemes for revenge and formed a coalition against France: the Holy Roman emperor Otto IV, the count of Flanders (Ferrand or Ferdinand of Portugal), and the count of Boulogne (Raynald or Renaud of Dammartin) were to invade the Capetian territory from the northeast while John attacked from the west, with the help of his Poitevin barons. John landed at La Rochelle in February 1214 and advanced into Anjou, but was put to flight by Louis at La Roche-aux-Moines on July 2; and his confederates were completely defeated by Philip in the decisive Battle of Bouvines (*q.v.*) on July 27. The Anglo-Angevin power in France and the coalition had been broken in one month. Meanwhile, in 1213, Philip had transferred Brittany to his cousin, Peter (*q.v.*) of Dreux.

When the English barons revolted against John (1215), Louis of France was invited by them to take the English throne. He landed in England in 1216, but the enterprise was ultimately unsuccessful, and the barons gradually rallied round the infant Henry III after John's death (*see* Louis VIII).

The Matrimonial Conflict with the Papacy.—Several years before he tried to take advantage of the papacy's quarrel with John, Philip Augustus had himself been in dispute with Rome. After the death (1190) of Isabella of Hainaut, he had married Ingeborg, sister of the Danish king Canute VI, on Aug. 14, 1193; but next day, for some private reason, he had resolved to separate from her. Having procured the annulment of his marriage by an assembly of bishops in November 1193, he took a Tirolese lady, Agnes, daughter of Bertold IV of Meran, as his wife in June 1196. Denmark meanwhile had complained to Rome about the repudiation of Ingeborg, and Pope Celestine III had countermanded it in 1195; but Celestine died (1198) before he could resort to coercion against Philip. The next pope, Innocent III, was sterner: in January 1200 he imposed an interdict on France. Philip therefore in September 1200 had to submit, pretending to be reconciled with Ingeborg. In fact he refused to cohabit with her and kept her in semicaptivity till 1213, when he accepted her beside him—not as his wife but at least as his queen. Agnes had died in 1201, after bearing two children to Philip: namely Marie, countess of Namur (1211) and duchess of Brabant (1213) by successive marriages; and Philip, called Hurepel, count of Clermont (-en-Beauvaisis).

The Northeastern Frontier and Languedoc.—It was not only at the Plantagenets' expense that Philip enlarged the royal domain. His claim to Artois through his first marriage and his gains by the settlement of 1185–86 have been mentioned above, and he subsequently proceeded, step by step, to acquire the rest of Vermandois and Valois. His regular insistence on his suzerainty over vacant fiefs and on his tutelage over minors and heiresses was particularly effective with regard to Flanders, since not only Philip of Alsace (d. 1191) but also Baldwin IX, who disappeared as a prisoner of the Bulgars (1205), left no male issue.

Though he did not personally take part in the "Albigensian crusade" against the Cathari in Languedoc, Philip Augustus allowed his vassals and knights to carry it out. Simon de Montfort's capture of Béziers and Carcassonne (1209) and his victory at Muret over Raymond VI of Toulouse and Peter II of Aragon (1213) prepared the way for the eventual annexation of eastern Languedoc to the royal domain six years after Philip's death and checked Aragonese ambitions in southern France.

Internal Affairs.—Throughout his reign Philip Augustus kept a close watch over the French nobility, which he brought effectively to heel. He maintained excellent relations with the French clergy, leaving the canons of the cathedral chapters free to elect their bishops and favouring the monastic orders. He knew too how to win the support of the towns, granting privileges and liberties to merchants and upholding the communal movement, which weakened the seigniorial authority of the nobles (*see* Commune [Medieval]). In return, the communes helped him financially and militarily: for instance, the militias of his Picard communes were present at Bouvines. Most of all, Philip gave his attention to Paris (*q.v.*), not only fortifying it with a great rampart but also having its streets and thoroughfares put in order. For the countryside, he multiplied the number of *villes neuves* ("new towns"), or enfranchised communities, on the already established pattern of the one at Lorris-en-Gâtinais.

The Capetian monarchy's hold on the huge royal domain and on the kingdom as a whole was considerably strengthened by Philip's institution of a new class of administrative officers, the royal *baillis* and the seneschals for the provinces, who were appointed by the king to supervise the conduct of the local *prévôts* ("provosts"), to give justice in his name, to collect the revenues of the domain for him, to call up the armed forces, etc.

Conclusion.—Philip II Augustus died at Mantes on July 14, 1223. His political ability and the indefatigable energy with which

he had accomplished an immense work on all fronts had made him in fact supreme in his kingdom, where the Capetian dynasty's authority was henceforth more or less incontestable. Knowing his own strength, he was the first of the Capetians not to have his eldest son crowned and associated with him during his lifetime.

See further FRANCE: *History; see* also references under "Philip II (of France)" in the Index.

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PHILIP III LE HARDI OR THE BOLD (1245–1285), king of France from 1270, was born on April 30, 1245, the second son of Louis IX of France and Margaret of Provence. Heir to the crown from the death of his brother Louis (1260), he was married in May 1262 to Isabella, daughter of James I of Aragon. Accompanying the crusade against Tunis, he was in Africa when Louis IX's death (Aug. 25, 1270) made him king. Having made a truce with the Muslims (Oct. 1270), he set off for France via Italy. On the journey Isabella of Aragon died at Cosenza, as the result of a miscarriage, in January 1271. Philip was anointed at Reims on Aug. 15, 1271.

Mathieu de Vendôme, abbot of Saint-Denis, whom Louis IX had left as regent in France, was maintained in control of the administration. The first important matter was the annexation to the French crown of the immense inheritance of Alphonse (*q.v.*) of Poitiers, and his wife, the heiress of Toulouse, who both died in Aug. 1271. This was accomplished, pending settlement of rival claims.

The king's personal entourage, meanwhile, was at first dominated by the chamberlain Pierre de La Broce, whose aggrandizement and accumulation of riches provoked envy. But in August 1274 Philip married his second wife, Mary, daughter of the duke of Brabant (Henry III); and she made herself the focus at court of a princely faction hostile to La Broce. When the prince Louis, Philip's eldest son by his first marriage, died suddenly in 1276, La Broce spread a report that he had been poisoned as a step toward clearing the way to the crown for Mary's children. For evidence, he concocted supernatural revelations allegedly made to some nuns in the Netherlands. The fraud was detected, and La Broce, whom Mary's friends also accused of treasonable relations with Castile, was arrested in January 1278, and hanged on June 30.

Revolts in Foix and Armagnac (1272) had been suppressed without much trouble; and Philip maintained correct relations with Edward I of England, notwithstanding crises that arose over their vassals in Limoges and in Béarn (1273–74) and Edward's claim to part of the Poitiers-Toulouse succession. More important were the affairs (1) of Champagne and Navarre and (2) of Castile.

Henry III, count of Champagne, who was also king of Navarre as Henry I, died in 1274, leaving his widow, Blanche of Artois, as regent for his infant daughter Joan. Though Joan had been promised first to an English prince, then to an Aragonese, Blanche in May 1275 concluded the Treaty of Orléans with Philip, betrothing Joan to one of Philip's sons and agreeing that Philip should govern Navarre till Joan's majority. In 1276 there was a serious revolt against the French regime in Navarre; but Joan's marriage (1284) to the future Philip IV of France led to the reunion of Champagne and the royal domain and to a personal union of the French and Navarrese crowns.

Blanche of France, Philip's sister, had two sons by her husband Ferdinand (Fernando de La Cerda), heir apparent to Alfonso X of Castile. (*See* ALFONSO.) When Alfonso, on Ferdinand's death (1275), overruled the rights of Blanche's sons and recognized their uncle Sancho as his heir instead, Philip went to war for his nephews. In the autumn of 1276 a great army was mustered round the king at Sauveterre, in Béarn; but it never crossed the Pyrenees, as diplomatic pressures and suggestions of treachery induced the king to abandon the project in December. Punctuated by truces, the state of war between France and Castile outlasted Philip's reign.

By the Treaty of Amiens (May 1279), Philip ceded Agenais to Edward I of England, undertook to investigate his rights to lands in Quercy and recognized his succession by right of his wife, Eleanor of Castile, to the countship of Ponthieu. This was a success for the queen mother, Margaret of Provence, who always supported a pro-English policy. Thereafter the party of Mary of Brabant steered French policy along a line favourable to Philip's uncle, Charles of Anjou, despite Margaret's persistent hostility toward him.

The War of the Sicilian Vespers (*q.v.*) broke out in 1282. Impelled by Mary's faction, Philip lent himself to the papacy's appeal for a crusade against Peter III of Aragon. Having accepted Pope Martin IV's offer of Aragon for his son Charles (*q.v.*) of Valois in Feb. 1284, Philip advanced with his army into Roussillon in May 1285 and crossed the Pyrenees into Catalonia in June. Harassed by guerrillas and exposed to malaria, the crusaders besieged Gerona, which held out till September. Then the destruction of their fleet off the coast by Ruggiero di Lauria made retreat inevitable. On Oct. 5, 1285, the king died of fever at Perpignan.

Philip III left two sons by Isabella of Aragon, namely Philip IV of France and Charles of Valois, and three children by Mary of Brabant, namely Louis, later count of Évreux (d. 1319), Margaret, married in 1299 to Edward I of England, and Blanche, married in 1300 to Rudolf III of Austria.

See C. V. Langlois, *Le Règne de Philippe III le Hardi* (1887).

PHILIP IV LE BEL OR THE FAIR (1268–1314), king of France from 1285, was born at Fontainebleau, the second son of King Philip III by Isabella of Aragon. The death of his elder brother Louis in 1276 made him heir apparent to the French crown; and on his marriage (Aug. 16, 1284) to Joan of Navarre and Champagne he immediately assumed the title of king of Navarre and count of Champagne. He became king of France on his father's death on Oct. 5, 1285.

Aragon, England, and Flanders.—Philip IV, who had disapproved of his father's disastrous "crusade" against Aragon (1284–85), set himself to make peace with the new Aragonese king, Alfonso III. But their quarrel was part of the wider discord unleashed in the War of the Sicilian Vespers (*q.v.*); and their treaty of Brignoles (February 1291) was repudiated by Alfonso's successor, James II. Peace, however, was finally concluded with the treaty of Anagni (June 1295).

ARCHIVES PHOTOGRAPHIQUES

PHILIP IV, ALSO CALLED "PHILIP THE FAIR." STATUE FROM HIS TOMB IN THE BASILICA OF SAINT-DENIS

Meanwhile, Philip's relations with Edward I of England had deteriorated. In 1293 there were skirmishes at sea between French and English or Gascon fleets, and Philip summoned Edward, his vassal for the duchy of Guienne, to answer at his court. On the excuse of Edward's nonappearance, Philip announced the confiscation of Guienne (May 1294) and sent an army to invade the duchy. By 1296 almost all Guienne was in French hands, and in 1297 Philip and Edward made a truce.

Philip was also attempting to increase his influence in Flanders, and to this end he supported the town oligarchies against the count of Flanders, Guy of Dampierre. In 1297 he demanded the cession of certain border towns. Guy's refusal and his alliance with Edward I led to a French invasion of Flanders, the royal army occupying the main cities. When Philip came to more definite terms with Edward and evacuated Guienne under the Treaty of Montreuil (1299), Guy was isolated; and in May 1300 he surrendered to Philip, who was thus left in virtual control of Flanders. The Flemish towns, however, resented the

French king's authority as much as the count's; and on May 18, 1302, the French in Bruges were massacred (the "Matins of Bruges"). An army sent to avenge them was defeated at Courtrai in July 1302, and Philip himself had to lead another army to Flanders. He defeated the Flemings at Mons-en-Pévèle (Aug. 18, 1304) and forced them to accept the oppressive Treaty of Athis-sur-Orge (June 23, 1305). Guy's son Robert of Béthune was recognized as count of Flanders, but his subjects were pledged to assist France—if need be, against him; some town walls were demolished, French troops occupied certain places, and heavy indemnities and services were exacted. Though Philip had won, Flemish opposition to Capetian rule remained strong.

The Eastern Frontier.—Philip IV also extended royal control elsewhere on his eastern frontier. Henry III of Bar, who had allied himself with Edward I and attacked Champagne (1296–97), was taken prisoner and released only in 1301 on his acknowledging Philip's suzerainty over certain lands west of the Meuse (*see* BAR, COUNTS AND DUKES OF). With regard to Lyons and the Lyonnais, Philip supported the townsmen against their archbishop from 1290, then accepted the archbishop as his vassal in 1307, and finally obtained complete sovereignty in 1312, notwithstanding the rights of the church or of the Holy Roman emperor's kingdom of Arles. In 1307 likewise, after long pressure, French control was recognized over the Vivarais, that is, the bishopric of Viviers and its dependencies along the right bank of the Rhône in northeastern Languedoc.

The Conflict with the Papacy.—Philip's most spectacular contest was with the Holy See. His relations with it had originally been cordial, but in 1296 a dispute broke out over the titles which Philip sought to levy from the clergy of France. The popes had hitherto allowed the clergy to contribute to the cost of crusades against Muslims, against heretics (such as the Cathari), or against the Aragonese in the matter of Sicily; and they could even be taxed "for the defense of the realm." Then the Cistercians, always heavily taxed, protested to Pope Boniface VIII. Boniface, a curt authoritarian who was convinced of the absolute sovereignty of the Holy See, thereupon issued the bull *Clericis laicos* (February 1296), forbidding clergy to pay subsidies to lay authorities without his express permission. Philip retaliated by prohibiting the export of gold or silver from the country, so that the papacy would not receive its customary dues. The pope's next bull, *Ineffabilis amor* (September 1296), was more conciliatory, and in 1297 he allowed the French clergy to contribute for the Flanders campaign.

In 1301 a more serious conflict began. Bernard Saisset, whose diocese of Pamiers had been carved from that of Toulouse by the pope's orders, was denounced to Philip by the bishop of Toulouse and was brought before the king's court at Senlis in October 1301. He admitted speaking against the king, and it is conceivable that he had, as was alleged, intrigued with the Aragonese; but further charges of heresy and simony seem to have been unwarranted. Boniface, to whom Philip sent a list of Saisset's alleged crimes, retorted in December with *Salvator mundi* and *Ausculta fili*, which withdrew all privileges from the king of France, and summoned French prelates to a council to be held at Rome in November 1302. Philip convened an assembly of barons, prelates, and town representatives in April 1302, at which it was decided to boycott Boniface's council; and a letter was sent to Boniface denouncing him as an intruder in the Holy See, as the former pope, Celestine V, who had abdicated, had died in confinement under Boniface. (*See* CELESTINE.) Boniface then issued the bull *Unam sanctam* (November 1302), defining his supreme authority, and prepared to excommunicate Philip. But, before the sentence was pronounced, Philip sent a small force to Italy, led by one of his counselors, Guillaume de Nogaret (*q.v.*). Nogaret's men and their accomplices surprised the pope at Anagni (Sept. 7, 1303), did him some violence, and held him prisoner till the local populace released him two days later.

Boniface died in Rome on Oct. 11, 1303. His successor, Benedict XI, reigned for less than a year; and Philip was able to enforce a conciliatory attitude on the next pope, Clement V, by the perpetual threat of pressing the question of Boniface's legitimacy of office. Clement annulled the bulls *Clericis laicos* and *Unam sanctam*, thus conceding outright victory to the secular power in its conflict with the church. Philip and his advisers had, indeed, no intention of allowing the church to meddle in secular affairs, though they of course recognized its jurisdiction in matters of conscience.

The Government of France.—Philip IV had collected around him a group of very able counselors, in particular the so-called "légistes," who were men trained in Roman law and therefore familiar with the idea of an all-powerful state. Servants of proved fidelity, they could also wield authority. Among them were Pierre Flote, keeper of the seals in the first part of the reign; Guillaume de Nogaret, keeper of the seals after 1307; the jurist Guillaume de Plaisians; and Enguerrand de Marigny, who administered the finances.

The national assemblies which Philip convened to strengthen his government were the forerunners of the French estates-general. After the assembly of 1302, called to range France with him against the pope, two more assemblies of nobles, prelates, and town representatives discussed ecclesiastical problems in 1304; and in 1308 the affair of the Templars was discussed at an assembly at Tours. The work of the *parlement* (*q.v.*) grew more specialized, and the chancellery became increasingly important as an office of government in Philip's reign. But Philip's influence was most clearly felt in the sphere of finance. He reformed the central fiscal administration and, in 1303, created the *chambre des comptes* (*camera compotorum:* chamber of accounts) as a sovereign court. Determined to increase his revenue, he enforced the regular collection of direct and indirect taxes, laying particular stress on the so-called *maltôte*, a tax begun by Louis IX by which the crown claimed one *denier* in the *livre* on every commercial transaction. He also revived the *fouage*, a land tax for war subsidies, not employed since Charlemagne's time. Philip's fiscal measures, however, provided insufficient revenue, and he resorted to debasement of the coinage. In 1295 and 1296 the quality of gold coins was debased and silver coins were reduced in size. A further debasement occurred in 1303, when the value of the royal *gros Parisis* fell by 50%; but this alarmed the merchants, and in 1306 a reverse policy of deflation was carried through. Then in 1311 the currency was again debased, before a better coinage was restored in 1313.

Philip exacted vast sums from Jews and Lombards. The Jews paid him 100,000 *livres* in 1292 and 215,000 *livres* in 1295, in 1299, in 1302, and in 1303; and in 1306 they were arrested and their assets appropriated. The Lombards were all imprisoned in 1291 and 1311, and were only released on the payment of heavy subsidies.

The Affair of the Templars.—His desperate need for money may have been the reason why, in October 1307, Philip arrested all the Templars (*q.v.*) in France; for they were immensely rich. An excuse lay ready to hand in the accusations of heresy and unnatural vice currently leveled against the Templars. Informed by Philip of the charges, Pope Clement V ordered an inquiry and decided that the Templars were to be interrogated by churchmen. Nevertheless, partly by threatening to revive the case against Boniface, Philip contrived to force the pope's hand; and some Templars, who had retracted their earlier confessions, were burned as relapsed heretics in May 1309. In April 1312 Clement suppressed the Order, and in May 1314 its leading dignitaries in France, including the grand master, Jacques de Molay, were burned by royal officials.

The King's Daughters-in-Law.—The end of Philip's reign saw one last sombre incident, a notorious scandal in the royal family. Philip's eldest son, the future Louis X of France, had been married to Margaret, daughter of Robert II, duke of Burgundy; and the younger sons, later Philip V and Charles IV, had been married respectively to Joan and to Blanche, daughters of Otto IV, count of Burgundy (Franche-Comté). Margaret, Joan, and Blanche were arrested on charges of adultery in May 1314, and Joan alone was acquitted by the *parlement*, the others being convicted and imprisoned.

Conclusion.—Philip died on Oct. 29, 1314, at Fontainebleau.

Few kings have been so variously judged. Some historians have treated him as insignificant, the pawn of his counselors and interested only in hunting. Recently, however, he has come to be regarded as a skilful statesman who forcefully continued the centralizing work of Philip II and Louis IX. Pragmatical, given to intrigue, taciturn and cynical, he yet showed more than conventional piety; his nickname "the Fair" is testimony of his outstanding good looks.

See also references under "Philip IV (of France)" in the Index.

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(M. PAC.)

PHILIP V LE LONG OR THE TALL (1293 or 1294–1322), king of France from 1316, was the second son of King Philip IV by Joan of Navarre and Champagne. He was married in January 1307 to Joan (d. 1330), elder daughter of Count Otto IV of Burgundy (Franche-Comté) by Mahaut of Artois. In December 1311 his father made him count of Poitiers. His wife was accused of adultery in 1314, but was acquitted, whereas his brothers' wives were found guilty.

While Philip was on a mission to the conclave at Lyons, his elder brother, King Louis X, died in the night of June 4–5, 1316, leaving (1) a four-year-old daughter, Joan (Jeanne), by his adulterous first wife and (2) a pregnant widow, Clémence of Hungary. In this unprecedented situation the regency of France was claimed by Charles of Valois, as the eldest male of the royal house, and by Eudes IV, duke of Burgundy, as the infant Joan's maternal uncle. Philip, however, reached Paris on July 12, won the support of the officers of the crown and of the bourgeois, and seized the royal palace. On July 16 an assembly of princes and magnates accepted him as regent till the majority of the unborn child: if that child should be a daughter, her claims, together with her half sister's and Philip's, were then to be adjusted. The Treaty of Vincennes (July 17) gave the custody of the infant Joan to Eudes, who in September was betrothed to Philip's eldest daughter, another Joan.

Clémence produced a son, John I (*q.v.*), but he died five days later (Nov. 19, 1316). Thereupon Philip declared himself king, regardless of his niece Joan's rights. The duke of Burgundy and Philip's own brother, the future Charles IV of France, refused to attend Philip's anointing at Reims (Jan. 9, 1317); but on Feb. 2 an assembly of barons, prelates, Parisian bourgeois, and doctors of the University of Paris recognized Philip as king. (*See* also SALIC LAW OF SUCCESSION.)

Philip and his brother Charles were reconciled when the death of Philip's only son (Feb. 18, 1317) made Charles the heir presumptive under the existing arrangement. The Burgundians and the infant Joan's partisans in Champagne, who had taken up arms, came to terms with Philip in March 1318. In Artois, where the rule of Mahaut was contested by her nephew Robert III, order was restored in July 1319. The count of Flanders, Robert of Béthune, to whom Philip in 1316 had offered to review the oppressive treaty of Athis-sur-Orge (1305), was on the brink of war from 1318, but did homage to Philip in April 1320. Edward II of England did a form of homage for his French fiefs at Amiens on June 20, 1320.

The assembly of February 1317 was hardly representative of the kingdom as a whole. Philip convened seven more assemblies, some regional, some more limited, but they assumed no political character and were mainly consulted on monetary questions or finance. The king tried to restore the royal power to what it had been before Louis X; he strengthened the local militias, under officers approved by the crown; and he was zealous for the redressing of grievances and for the efficient administration of justice. Yet he could do little against the Pastoureaux (*q.v.*) in 1320; and his ordinance of June 1321 against the lepers, who were alleged to be conspiring with the Moors for the ruin of Christendom, authorized an atrocious persecution.

Philip V died in the night of Jan. 2–3, 1322. Besides Joan (d. 1347), duchess of Burgundy by her marriage, he left two other daughters: Margaret (d. 1382), countess of Flanders by her marriage to Louis of Nevers; and Isabella (d. 1345), who was married to Guigues VIII, dauphin of Viennois.

See P. Lehugeur, *Histoire de Philippe le Long*, 2 vol. (1897–1931).

PHILIP VI (1293–1350), king of France from 1328, the first king of the Valois dynasty, was the elder son of Charles (*q.v.*) of Valois by Margaret of Naples-Sicily. Nephew of King Philip IV, he was first cousin to the brothers Louis X, Philip V, and Charles IV, the last Capetian kings of the direct line. Count of Le Mans (or of Maine) from 1315, he succeeded to the countships of Valois and of Anjou after his father's death, which took place in December 1325. He had been married in July 1313 to Joan, daughter of Duke Robert II of Burgundy.

Though Philip was Charles IV's closest kinsman by male descent, his right to the crown was contested by several claimants when Charles IV died (February 1328). In particular, there was support for Edward III of England, whose mother was the daughter of Philip IV. An assembly of magnates, however, not without bargaining, determined (1) that Philip should be regent till the end of the pregnancy of Charles IV's widow; and (2), as the widow produced a daughter on April 1, 1328, that Philip should be king. He was crowned at Reims on May 29, 1328. (*See* SALIC LAW OF SUCCESSION.)

On behalf of Louis of Nevers, count of Flanders, Philip led an army against the rebellious Flemings and defeated them in the Battle of Cassel (Aug. 23, 1328). Then a dispute arose in the king's immediate entourage. Robert of Artois, who had helped Philip to win the crown, claimed the countship of Artois against Joan of France (granddaughter of the countess Mahaut) and her husband Eudes IV, duke of Burgundy (Philip VI's brother-in-law). Philip had to institute judicial proceedings against Robert, who became his bitter enemy. Eventually Robert went to England (spring 1334) and began to incite Edward to claim the French crown.

Though Edward did homage to Philip for his French fiefs in 1329 and in 1331, Anglo-French relations deteriorated rapidly from 1334, partly because of Robert, partly because of the continuing French occupation of lands in Guienne, and partly because of France's support of the Scots. Philip in May 1337 declared Edward to have forfeited Guienne; and Edward in October 1337 assumed the title of king of France. Thus began the Hundred Years' War (*q.v.*).

Military operations were at first restricted; the English sacked or besieged towns in northern France; the French seized castles in Guienne. In 1340, however, France suffered a grave defeat in the naval battle of Sluys. In 1341 the war shifted to Brittany, where Charles of Blois, backed by Philip, and John of Montfort, backed by Edward, were contesting the ducal succession. Mediation by Pope Clement VI's envoys procured the Anglo-French truce of Malestroit (January 1343).

France's internal situation had worsened. Philip had been obliged, from 1335, to pack his council with nominees of the duke of Burgundy; and this Burgundian tutelage was almost insufferable to many of the king's subjects, especially in western France. A serious crisis resulted in 1343, and Philip had to act with severity against baronial revolts in Normandy and Brittany. The estates of the kingdom, summoned to Paris, took some measures to appease public opinion and to reduce the burden of administration. Men less subservient to Burgundy were taken into the council.

The truce of Malestroit, which had scarcely been observed in Brittany, lasted little more than two years. In summer 1345 the earl of Derby (Henry of Grosmont, soon to be duke of Lancaster) launched an offensive from Bordeaux and ravaged Périgord, Agenais, and Bazadais; and in 1346, while a French army in the south was trying in vain to take the little fortress of Aiguillon (northwest of Agen), Edward III landed in Normandy. After

threatening Paris, Edward turned northeastward into Ponthieu, where Philip, in pursuit of him, was heavily defeated in the Battle of Crécy.

This defeat, in which numbers of the French nobility perished, gave rise to another political crisis. To conciliate its opponents, the government undertook to reorganize the *chambre des comptes;* and control of the finances was entrusted to three abbots—those of Saint-Denis (Gille Rigaud), of Marmoutier (Simon Le Maire), and of Corbie (Hugues de Ver). Moreover, John, duke of Normandy, Philip's son and heir apparent, was excluded from public affairs, and a dynastic arrangement with Edward, to John's disadvantage, was contemplated. By May 1347, however, John had recovered his position, which thenceforward grew steadily stronger.

Meetings of estates had taken place in Paris (February 1346) and in Toulouse (February and May). After the fall of Calais to the English (August 1347), a new meeting was summoned to Paris for Nov. 30, 1347. This assembly, which seems to have been extremely hostile to the king's counselors, forced the king to promise the reestablishment of a sound currency and to accept the resignation (January 1348) of his chancellor, Guillaume Flote, who had been ten years in office. The council was again recast, with the admission of men who would promote the necessary reforms. Then the spread of the Black Death in 1348 and 1349 distracted men's minds from political questions.

Philip VI died on Aug. 22, 1350. His first wife, Joan of Burgundy, had died in December 1349, leaving two sons, the future John II (*q.v.*) and Philippe (1336–75; *see* Orléans, Ducs d'); other children had predeceased her. By a subsequent marriage to Blanche of Navarre (d. 1398), Philip had a posthumous daughter, Blanche.

Philip VI was a man of positive and methodical character who preferred the ways of diplomacy to war. Reigning at a difficult time, he had to bow before events stronger than his will and to witness an important development of the political power of the estates. Though he left a kingdom divided and weakened by war and plague, he yet had expanded its territory: he purchased Montpellier from James III of Majorca in 1349; and transactions with Humbert II of Viennois culminated in the sale of Dauphiné to Philip's grandson, the future Charles V, in 1349 likewise. Philip also continued the efforts of the 13th-century Capetians toward the progressive centralization of the administration in Paris. But Philip had no means of imposing on his kingdom the measures necessary for the maintenance of his monarchical power. To raise taxes for war he was obliged to make concessions to nobility, clergy, and bourgeoisie. The bourgeoisie, profiting from the king's power, proved grateful and loyal enough; it was chiefly among the clergy and nobility that the movement for reform took root.

See R. Cazelles, *La Société politique et la crise de la royauté sous Philippe de Valois* (1958). (R. Cs.)

PHILIP (*c.* 1177–1208), German king from 1198, also duke of Swabia from 1196, was the youngest son of the Holy Roman emperor Frederick I Barbarossa, of the Hohenstaufen dynasty, and Beatrix of Upper Burgundy (Franche-Comté). Destined for the church, he was appointed provost of the cathedral at Aachen and, in 1190 or 1191, elected bishop of Würzburg; but he soon renounced his ecclesiastical career. His brother, the emperor Henry VI, made him duke of Tuscany in 1195 and duke of Swabia in 1196; and in May 1197 he was married to Irene, daughter of the Byzantine emperor Isaac II Angelus and widow of Roger II of Sicily.

When Henry VI died in September 1197, his son, the future emperor Frederick II, was not yet three years old, and the German princes were unwilling to accept a child as king. So, while the Hohenstaufens' Welf rivals, namely the brothers Henry and Otto of Brunswick, were absent from Germany, Philip rather than Frederick was elected German king at Mühlhausen on March 8, 1198. Since the archbishop of Mainz was absent, however, the right of crowning the king belonged to Archbishop Adolf of Cologne; and he was leader of the anti-Hohenstaufen party, which in June proceeded to elect one of the Welf brothers as king. The Welf was crowned as Otto IV (*q.v.*) at Aachen, the proper place for the ceremony, by Adolf in July. Philip's coronation, by another prelate, did not take place till Sept. 8, 1198, at Mainz.

In the consequent warfare the Hohenstaufen cause at first prospered. However, Pope Innocent III, who claimed to be the arbiter of the conflict, in 1201 recognized Otto as king and excommunicated Philip. Then Otakar I of Bohemia deserted Philip's side, as Hermann of Thuringia had already done. Philip's fortunes thus waned till 1204, when they were restored by a series of defections from Otto's side, culminating in that of Adolf of Cologne himself. On Jan. 6, 1205, Adolf crowned Philip at Aachen.

The town of Cologne, which had stood for Otto despite its archbishop, submitted to Philip in January 1207, and Otto's cause seemed lost. Innocent, to whom Philip had long been making overtures, acknowledged him as king early in 1208. Philip was preparing a decisive stroke against Otto in Brunswick when he was murdered in Bamberg, on June 21, 1208, by Otto of Wittelsbach, count palatine for Bavaria, to whom he had refused to give one of his daughters in marriage. His eldest daughter, Beatrix (d. 1212), was betrothed to the Welf Otto in 1209 as a step toward reconciling the factions; the second, Kunegunda (d. 1248), married the Premyslid Vaclav I, king of Bohemia; the third, Maria (d. 1235), married Henry II of Brabant; and the fourth, Elizabeth, later known also as Beatrice (d. 1235), married Ferdinand III of Castile. A brave man, Philip was praised by contemporaries for his mildness and generosity. The diversion of the Fourth Crusade to Constantinople is sometimes thought to have been prompted by him in the interests of his brother-in-law, the Byzantine emperor Alexius IV.

As well as works cited under Otto IV, *see* O. Abel, *König Philipp der Hohenstaufe* (1852); A. Luchaire, *Innocent III,* vol. iii (1906).

PHILIP II (382–336 B.C.), son of Amyntas III, king of Macedonia, made his country predominant in Greece and laid the foundations for its expansion under his son Alexander III (*q.v.*) the Great. As regent to his nephew Amyntas on the death of his brother Perdiccas III in 359 (for the dynastic history, *see* Macedonia, Kingdom of: *The Argeads to 336 B.C.*), he suppressed various rivals by generalship and cunning diplomacy and defeated first the Paeonians, then the Illyrians who had overrun Lyncestis (around modern Bitola, Yugos.). Probably in 356 by popular consent he was hailed king in his own right. As a youth Philip had passed three years (367–365) as a hostage in Thebes; his admiring acquaintance with Epaminondas there may have inspired the reforms which now transformed the Macedonian army into a formidable weapon of expansion. Philip's first moves led him eastward into an area where Athens was deeply committed. In 357 he took Amphipolis, and from 356 onward the possession of Crenides (which he renamed Philippi) gave him control over the gold and silver deposits of Mt. Pangaeus, which were to produce 1,000 talents a year, thus furnishing the mainstay of his military budget and of a diplomacy in which bribery and corruption were to loom large. Meanwhile Philip's seizure of Potidaea in Chalcidice (356) and of Pydna (356) and Methone (354) on the Thermaic Gulf rounded off Macedonian power along the coast to the further detriment of Athens. But the Athenians, divided internally by rival policies, preoccupied with revolts of their allies, and outmaneuvered by Philip's unscrupulous diplomacy, took no effective action.

During the next nine years (354–346) Philip gained a firm foothold in central Greece, where the still dominant Thebans shortsightedly welcomed intervention against their enemies in the neighbouring state of Phocis. The seizure of Delphi and its temple treasures by the Phocians, who used them to hire a large mercenary army, led the Aleuadae of Larissa in Thessaly to appeal to Philip. After one setback in 353 he defeated the Phocian general Onomarchus at the Battle of the Crocus Field (*see* Greece: *History: Macedonian Period*), thus becoming virtually master of Thessaly; but a joint Greek army, containing contingents from Athens and Sparta, denied him access to Thermopylae. Philip countered with a new advance in the northeast, where he soon defeated Athens' Thracian allies and extended Macedonian influence to the

whole of Thrace between the Nestos River and the Black Sea. Next, between 351 and 348, he turned on the Chalcidian League, which had earlier connived at his seizure of Potidaea. Its chief city, Olynthus, now appealed for help to Athens, but despite Demosthenes' vigorous oratory the help sent was too little and came too late, and in 348 Olynthus fell. Philip meanwhile hamstrung Athenian resistance by stimulating a revolt against Athens in Euboea. Eventually in 346 the Athenians sent envoys to Pella and the so-called Peace of Philocrates was sworn. This left Philip free to complete the defeat of Phocis, and he emerged as the dominant figure in central Greece, with a seat on the amphictyonic council controlling Delphi (*see* AMPHICTYONY).

Between 345 and 340 Philip carried out a determined campaign to consolidate and extend his position in Greece. His education had been Greek and as an Argead he claimed descent from Heracles. The recognition implicit in his presidency of the Pythian Games (346) thus brought him great satisfaction. Hence he appears to have shrunk from a purely military solution of his problems, which could have been maintained only by garrisons and suppression, and to have preferred a subtle policy of diplomatic insinuation and the exploitation of internal differences among the parties in the Greek cities. At Athens the publicist Isocrates turned to him as the potential leader of a crusade against Persia, which would open up Asia Minor for Greek colonization; and such plans may already have been in Philip's mind, though hardly in the form in which Isocrates, concerned only for the Greeks, conceived them. Meanwhile Demosthenes devoted himself to whipping up an anti-Macedonian coalition, in which he saw the only hope of a secure, independent Athens.

Philip used the lull to extend his power to the west and to the south. In Epirus, to which he was already linked by his marriage in 357 to Olympias, a princess of the royal house, he now won full control by expelling the ruling king, Arybbas, and putting Olympias' younger brother Alexander on the throne (342). In 344/343 he became archon of Thessaly for life, and reorganized the whole state under his personal domination; Thessaly was to remain an appendage of the Macedonian monarchy until 197 B.C. Demosthenes' campaign now received a fillip from the king's advance eastward toward the Bosporus, through which Athens' vital grain trade passed. From 341 onward Demosthenes succeeded in organizing a coalition including Chalcis, Corinth, Megara, Achaea, some northwestern Greek states, and in the northeast Abydos, Perinthus, and Byzantium. But most of the Peloponnesian states held aloof, and the Thebans, grateful for help against Phocis, remained Philip's hesitant ally. Philip's attack on Byzantium in 340 was followed by an Athenian declaration of war; and a confused conflict with Amphissa within the amphictyony afforded a pretext to bring Philip south to take the command in a new Sacred War. Now at last Demosthenes succeeded in winning over the Thebans, alarmed too late at Philip's proximity; but in August 338 Philip won a decisive victory at Chaeronea (*q.v.*) in Boeotia, where his well-timed use of cavalry and infantry routed the uncoordinated forces of Thebes and Athens.

As master of Greece Philip had to settle Greek affairs. Thebes was harshly treated and a Macedonian garrison installed; but toward Athens Philip was lenient, for he retained a genuine respect for the Athenian cultural tradition and, perhaps more important, the Athenians' fleet still made them a formidable enemy. His motives at this point were almost certainly mixed and even contemporaries discussed them without reaching unanimity. But at least it appears that he had now decided to attack Persia, having already broken off relations in 341 after the arrest and execution of his friend and ally, Hermeias of Atarneus. An anti-Persian crusade would require a consolidated and collaborative Greece, and to this end Philip now applied himself in a statesmanlike fashion. All the cities except Sparta quickly submitted; and in 338/337 a panhellenic congress was called to Corinth, where a common peace was established and a confederacy of Greeks set up, with a representative council (*synedrion*) and Philip as "leader" (*hegemon*). This confederacy was allied to Macedonia and served as an instrument of Macedonian domination in Greece. It brought Greece a stability it had failed to find while independent; but this did not last long, for the majority of the Greeks rejected a unity imposed by force from without. At a second meeting of the confederacy in 337 Philip announced the war against Persia, and in spring 336 an advance force of 10,000 crossed over into the Troad. But the same summer, at a feast held at Aegae to celebrate the wedding of his daughter Cleopatra with Alexander of Epirus, Philip fell murdered by one of his courtiers, Pausanias; this man may have been suborned by Olympias, whom Philip had recently repudiated (he had married a Macedonian, Cleopatra, in 337), but proof is lacking.

The historian Theopompus said with some justice that Philip was the greatest man Europe had yet produced. He had built up Macedonia by centralizing power in the monarchy, by reducing the authority of the principalities in the fringe areas, and by introducing territorial divisions into the national army organization; he had also secured it a seaboard by annexing Chalcidice and the Thermaic towns and had given it vast economic resources by his acquisition of the mines of Pangaeus in Thrace. Philip shared with his son Alexander the quality of high personal courage, and on various occasions he sustained serious wounds, including the loss of an eye at Methone. He was wholly tireless and campaigned readily at all seasons of the year. As a general he lacked Alexander's adaptability and sheer genius, and he probably owed much to reliable subordinates like Parmenio. But he developed siegecraft significantly and trained the army with which Alexander was subsequently to conquer much of Asia. Following the traditions of his country, he was a man of considerable sensuality and a heavy drinker; but his interests ranged beyond these pleasures. He assembled a mixed body of Greek and Macedonian "companions" (*hetairoi*) around him; he had a real love of Hellenic culture, and to educate his son Alexander he brought the philosopher Aristotle to Pella. In diplomacy he outstripped most of his contemporaries and was quite unscrupulous in his methods; he used marriage alliances as an instrument of policy, and his widespread distribution of money acquired for him supporters in every city. Ultimately he may well have intended to reduce both Macedonia and Greece to elements in a personal autocracy; but his reign introduced an age of Macedonian preeminence which was to end only in 197 when the phalanx was broken by the Roman legions at Cynoscephalae.

See also references under "Philip II (of Macedonia)" in the Index.

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PHILIP V (238–179 B.C.), king of Macedonia, son of Demetrius II and his wife Phthia (Chryseis). On his father's death (229) Philip's half cousin Antigonus Doson adopted him, and when Antigonus died (summer, 221) Philip succeeded. He soon won renown in the war of the Greek alliance against Aetolia, Sparta, and Elis (220–217), and he asserted his personal control by executing several ministers for conspiracy in 218. After the Peace of Naupactus (217), incited by Demetrius of Pharos, he attacked the Roman client states in Illyria by sea and, after losing his fleet (214), by land. In 215 he made a treaty with Hannibal. The Romans countered this by an Aetolian alliance (211), and with the collaboration of Attalus of Pergamum soon gained an advantage in Greece; but Philip effectively aided his allies, and when the Romans withdrew in 207 he sacked Thermum and forced peace upon Aetolia (206). The Peace of Phoenice (205) ended the war in Philip's favour. He then turned to the east. He used a pirate, Dicaearchus, to obtain resources, plotted against Rhodes, and in 203/202 conspired with Antiochus III to plunder Ptolemy V's possessions. But the people of Rhodes and Pergamum defeated him by sea off Chios (201) and their exaggerated reports contributed to a Roman decision to make war. Philip meanwhile was attacking Athens and the Thracian Chersonese; but by September 200 a Roman army was in Illyria. Two campaigns in Macedonia (199) and Thessaly (198) shook Philip's position and detached his Achaean allies. In 197 at Cynoscephalae in Thessaly the Romans under T. Quinctius Flamininus defeated him, and by

the peace terms he was confined to Macedonia and had to surrender 1,000 talents indemnity and most of his fleet and deposit hostages, including his younger son Demetrius, at Rome.

From then until 189 Philip collaborated with Rome, sending aid against Nabis (195) and Antiochus and Aetolia (192–189), and winning back some places in Thessaly. He afforded the Scipios invaluable help in Macedonia and Thrace; consequently his outstanding tribute was remitted and his son restored (190). His last decade was devoted to consolidating his kingdom. He reorganized finance, transplanted populations, reopened mines, and issued central and local currencies. But his neighbours constantly accused him at Rome, and with success. Adverse decisions (185) seemed to foreshadow his destruction and accordingly he turned his attention to the Balkans, where he carried out three campaigns (184, 183, 181). Meanwhile Demetrius' pro-Roman policy precipitated a quarrel with the crown prince Perseus and Demetrius' execution as a traitor (180). In 179, while pursuing a scheme for directing the Bastarnae against the Dardanians, Philip died at Amphipolis.

Philip was a fine soldier and a popular king, at his best in adversity; but a lack of balance often led to political errors. He never neglected his northern frontiers, but his plans for expansion elsewhere, pursued without scruple, lacked consistent aim and encountered limited success. Hence his historical significance lies mainly as an episode in the expansion of Rome. *See* also MACEDONIA, KINGDOM OF: *The Antigonids, 277–168 B.C.*

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PHILIP I THE HANDSOME (1478–1506), the first Habsburg king of Castile, was born at Bruges, in Flanders, on July 22, 1478, the son of the future Holy Roman emperor Maximilian I and Mary of Burgundy. At his mother's death, in 1482, he succeeded to her Burgundian (Netherlands) dominions, with Maximilian acting as regent for him during his minority. In 1496, at Lille, he was married to Joan (the Mad), daughter of Ferdinand V of Aragon and Isabella I of Castile. Recognized as prospective heir to the Spanish kingdoms in 1502, Philip was soon at variance with his father-in-law, who was unwilling to give up his own claims to the government of Castile. On Isabella's death (1504), Joan succeeded to the crown of Castile; and early in 1506 Philip sailed for Spain, to claim his wife's inheritance. His ships, however, had to take temporary shelter in Weymouth, and Henry VII of England forced him to sign the so-called *Intercursus Malus*, a trade agreement disadvantageous to the Netherlands. In Castile, Philip was supported by the majority of the nobles against Ferdinand, but he died suddenly at Burgos, on Sept. 25, 1506. His son, the future emperor Charles V, succeeded him in the Netherlands and, after Ferdinand's death in 1516, also in Spain.

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PHILIP II (1527–1598), king of Spain from 1556, in whose reign Spain and the Spanish Empire attained their greatest power and widest geographical extent, was born at Valladolid on May 21, 1527, the son of the emperor Charles V and Isabella of Portugal. From time to time, the emperor wrote Philip secret memoranda, impressing on him the high duties to which God had called him and warning him against trusting any of his advisers too much. Philip, a very dutiful son, took this advice to heart. From 1543 Charles conferred on his son the regency of Spain whenever he himself was abroad. From 1548 until 1551, Philip traveled in Italy, Germany, and the Netherlands; but his great reserve and his inability to speak fluently any language except Castilian made him unpopular with the German and Flemish nobility.

Philip contracted four marriages. The first was with his cousin, María of Portugal, in 1543. She died in 1545 giving birth to the ill-fated Don Carlos (*q.v.*). In 1554, Philip married Mary I of England and became joint sovereign of England, until Mary's death, without issue, in 1558. Philip's third marriage, with Elizabeth of Valois, daughter of Henry II of France, in 1559, was the result of the Peace of Câteau-Cambrésis (1559), which for a generation ended the open wars between Spain and France. Elizabeth bore Philip two daughters, Isabella Clara Eugenia (1566–1633) and Catherine Micaela (1567–97). Elizabeth died in 1568 and, in 1570, Philip married another cousin, Anna of Austria, daughter of the emperor Maximilian II. She died in 1580, her only surviving son being the later Philip III.

King of Spain.—Philip had received the duchy of Milan from Charles V in 1540 and the Kingdoms of Naples and Sicily in 1554 on the occasion of his marriage to Mary of England. On Oct. 25, 1555, Charles resigned the Netherlands in Philip's favour, and on Jan. 16, 1556, the kingdoms of Spain and the Spanish overseas empire. Shortly afterward Philip also received the Franche-Comté. The Habsburg dominions in Germany and the Imperial title went to his uncle Ferdinand I. At this time Philip was in the Netherlands. After his army's victory over the French at St. Quentin (1557), at the sight of the battlefield he exclaimed, "How could my father like this?" From then onward he always preferred to achieve his aims by peaceful methods rather than by war, although he did not shrink from it when he judged it necessary.

After his return to Spain from the Netherlands in 1559 Philip never again left the Iberian Peninsula. From Madrid he ruled his empire through his personal control of official appointments and all forms of patronage. Philip's subjects outside Castile, thus, never saw him and they gradually turned not only against his ministers but against himself. This happened particularly in the Netherlands, in Granada, and in Aragon.

MANSELL—ALINARI

PHILIP II, KING OF SPAIN. DETAIL FROM A PORTRAIT BY TITIAN IN THE CORSINI GALLERY, ROME

System of Government.—By sheer hard work Philip tried to overcome the defects of this system. His methods have become famous. All work was done on paper, on the basis of *consultas*, that is, memoranda, reports, and advice presented him by his ministers. In Madrid, or in the gloomy magnificence of his monastic palace of El Escorial which he built (1563–84) on the slopes of the Sierra de Guadarrama, the king worked alone in his small office, giving his decisions or, as often, deferring them. Nothing is known of his order of work, but all his contemporaries agreed that his methods dangerously, and sometimes fatally, slowed down a system of government already notorious for its dilatoriness. Painstaking and conscientious, Philip's craving for ever more information hid an inability to distinguish between the important and the trivial and a temperamental unwillingness to make decisions.

This was coupled with an almost pathological suspicion of his most able and faithful servants. Margaret of Austria, duchess of Parma, the duke of Alba, Don John of Austria, Antonio Pérez, and finally Alessandro Farnese (*qq.v.*), to name only the most distinguished, suffered disgrace. "His smile and his dagger were very close," wrote his official court historian, Cabrera de Córdoba. It was no exaggeration; for, in the case of Juan de Escovedo, the secretary of Don John of Austria, Philip even consented to murder (*see* PÉREZ, ANTONIO). As a result, Philip's court became notorious for the bitterness of its faction fights. The atmosphere of the Spanish court did much to poison the whole Spanish system of government and this played no small part in causing the rebellions of the Netherlanders (1568–1609; *see* NETHERLANDS, THE: *History*), of the Moriscos of Granada (1568–70), and of the Aragonese (1591–92; *see* SPAIN: *History: The House of Austria.*)

Yet the "black legend" which, in Protestant countries, represented Philip II as a monster of bigotry, ambition, lust, and cruelty is certainly false. Philip's spare and elegant appearance is known

from the famous portraits by Titian and by Anthonis Mor (Sir Anthony More). A lover of books and pictures, an affectionate father to his daughters, he lived an austere and dedicated life. "You may assure His Holiness," Philip wrote to his ambassador in Rome, in 1566, "that rather than suffer the least damage to religion and the service of God, I would lose all my states and an hundred lives, if I had them; for I do not propose nor desire to be the ruler of heretics." This remark may be regarded as the motto of his reign. To accomplish the task set him by God of preserving his subjects in the true Catholic religion, Philip felt in duty bound to use his royal powers, if need be, to the point of the most ruthless political tyranny, as he did in the Netherlands. Even the popes found it sometimes difficult to distinguish between Philip's views as to what was the service of God and what the service of the Spanish monarchy.

Foreign Policy.—For the first 20 years of his reign, Philip sought to preserve peace with his neighbours in western Europe. He was fighting a major naval war with the Ottoman Empire in the Mediterranean and, from 1568, he was faced with rebellion and war in the Netherlands. From the late 1570s, his policy gradually changed. The death (August 1578) without heirs of his nephew, King Sebastian of Portugal, opened up the prospect of Philip's succession to Portugal. He had to conquer (1580) by force what he regarded as his just, hereditary rights, but the rest of Europe was alarmed at this growth in Spanish power. Both England and France gave increasing support to the rebellious provinces of the Netherlands. Gradually, in the 1580s, Philip became convinced that the Catholic religion in western Europe, and his own authority in the Netherlands, could be saved only by open intervention against England and France. To this end he fitted out the Armada (*q.v.*) which, with the help of the Spanish army in the Netherlands, was intended to conquer England (1588). He sent money and troops to support the League, the ultra-Catholic party in France, against Henry of Navarre and the Huguenots. He even claimed the throne of France for his daughter, Isabella Clara Eugenia, after the murder of Henry III in 1589. Again, even his Catholic allies found it difficult to distinguish between Philip's championship of the Catholic Church and of the interests of the Spanish monarchy.

All these plans failed. Henry of Navarre became a Catholic (1593) and Philip had to accept (Peace of Vervins, 1598) his succession as Henry IV of France. England and the northern Netherlands remained Protestant and unconquered. Yet Philip's reign as a whole was not a failure. He had defeated the great Ottoman offensive in the Mediterranean at the Battle of Lepanto (1571). In the Iberian Peninsula he had completed the work of unification begun by the "Catholic Kings," Ferdinand and Isabella. Most important of all, in his own eyes, he had won great victories for the Catholic Church. If England, Scotland, and the northern Netherlands were lost, the southern Netherlands (the modern Belgium) had been preserved. In Spain and Italy he had prevented the spread of heresy and his intervention in France was one of the factors which forced Henry IV to become a Catholic. When Philip II died at El Escorial on Sept. 13, 1598, Spain was still at the height of her power and it took almost another half century before it became finally clear that the Counter-Reformation would make no further major conquests.

See also references under "Philip II (of Spain)" in the Index.

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PHILIP III (1578–1621), king of Spain from 1598, was born in Madrid on April 14, 1578, the son of Philip II by his fourth consort, Anna of Austria. Succeeding his father on Sept. 13, 1598, he married the Austrian archduchess Margaret at Valencia in April 1599. A representative of the so-called "Baroque pacifist generation," he sought peace in western Europe: as his father had finally made the Peace of Vervins with France, Philip III concluded the Treaty of London with England (1604) and the Twelve Years' truce with the United Provinces of the Netherlands (1609). In this policy he had the ready collaboration of his chief minister, the duque de Lerma (*q.v.*), till 1618, when Lerma was supplanted by his son Cristóbal, duque de Uceda. Peace in the west enabled the government to deal with the internal problem of the Moriscos (*q.v.*); but the expulsion of the Moriscos had a serious effect on the country's economy.

In Italy affairs were complicated (1) by the activities of the duke of Savoy, Charles Emmanuel I, which led to war over Montferrat (*q.v.*); and (2) by the attempts of Venice to undermine the Spanish position in the peninsula. The so-called "conspiracy of Venice" (1618) is a matter of controversy among historians: some see it as a real effort by Philip's viceroy of Naples, Pedro Téllez Girón, duque de Osuna, and his agents to subvert the Venetian republic; others see it as an invention of the Venetians to discredit Spain. The policy of peace for western Europe was in any case brought to an end by the outbreak of the Thirty Years' War in 1618, whereupon Philip gave his unconditional support to the Holy Roman emperor Ferdinand II and the Catholic German princes. The occupation of the Valtellina (1620), carried out on Philip's orders by his governor of Milan, the duque de Feria (Gómez Suárez de Figueroa), was intended to ensure communications between Italy and the Habsburg territories north of the Alps.

Philip signed a treaty with the shah of Persia, Abbas I, against the Turks (1602) and gave some encouragement to anti-Turkish movements in the Balkans. Against Morocco he made contact with the kings of Cuco, in the Atlas Mountains.

Having resided at Valladolid for the first years of his reign, Philip eventually fixed his court at Madrid. After a visit to Portugal (1619), he fell ill. He died at Madrid on March 31, 1621. For his children who survived infancy *see* HABSBURG: *Table III.*

See Matías de Novoa, *Historia de Felipe III*, in the *Colección de documentos inéditos . . .*, vol. 60 (1875); C. Pérez Bustamante, *Semblanza de un monarca y perfiles de una privanza* (1948); Ubieto-Reglà-Jouer, *Introducción a la historia de España* (1963). (J. Re.)

PHILIP IV (1605–1665), king of Spain from 1621, was born at Valladolid on April 8, 1605, the eldest son of Philip III of Spain and Margaret of Austria. He succeeded his father on March 31, 1621.

For the first 22 years of his reign, Philip's *valido* or chief minister was the conde-duque de Olivares (*q.v.*), who took the spread of the Thirty Years' War (*q.v.*) as an opportunity, not only for resuming hostilities against the Dutch at the end of the Twelve Years' truce of 1609 (1621), but also for an ambitious attempt to restore Spanish hegemony in Europe, in close alliance with the imperial branch of the Habsburg dynasty. The Spanish armies won some conspicuous victories, for instance the capture of Breda from the Dutch (1626) and the defeat of the Swedes and Weimarians at Nördlingen (1634); but France declared open war in 1635, and Spain's early successes were offset, from 1640, by the separatist rebellions of Catalonia and of Portugal, which provided the French with footholds in the Iberian Peninsula itself. There was also an abortive conspiracy by the Andalusian nobility in 1641.

Olivares was dismissed in 1643 and his place was then taken by Don Luis de Haro, who remained in power till his death. The course of events went worse for Spain, however: the French won great victories at Rocroi (1643) and at Lens (1648); there were insurrections in Palermo and in Naples (1647–48); a treasonable plot to detach Aragon from Philip's dominions came to light; and finally the Treaty of Münster (January 1648), whereby Spain recognized the independence of the United Provinces of the Netherlands, was followed by the Peace of Westphalia (October), whereby the imperial Habsburgs and their German allies came to terms with France, leaving Spain to fight on alone. The scheme of Olivares for a revival of Charles V's empire was brought to nothing. After 11 more years of war Spain had to accept the Treaty of the Pyrenees (1659), ceding to France several places in the southern Netherlands and on the Pyrenean frontier, Roussillon and part of Cerdagne in return for France's renunciation of Catalonia, which in any case had been almost entirely recovered by Philip's forces since Don John of Austria's entry into Barcelona in 1652. Con-

tinued attempts to reconquer Portugal were unsuccessful.

Soured by defeat, Spain sank into pessimism, isolationism, and retrospection. The so-called "problem of Spain" became the subject of argument between those who remained faithful to the Habsburg tradition and those who demanded a complete change of policy.

From the death of Don Luis de Haro (1661) to the close of the reign Philip had no *valido,* though he still received the advice of the nun, María de Ágreda (*q.v.*), whose long correspondence with him dealt both with spiritual matters and with affairs of state. He was twice married: first, in 1615, to the Bourbon princess Elizabeth (Sp. Isabel; d. 1644), daughter of Henry IV of France; secondly, in 1649, to the Austrian archduchess Maria Anna (Mariana; d. 1696), daughter of the Holy Roman emperor Ferdinand III. For the children of these marriages *see* HABSBURG: *Table III.* Philip also had numerous mistresses and several illegitimate children, the most famous of the latter being the second Don John (*q.v.*) of Austria, son of the actress Maria Calderón. A poet and a lover of the arts, Philip was the friend and patron of the painter Velázquez, whose works are the most glorious monument of the reign. Philip IV died in Madrid on Sept. 17, 1665.

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PHILIP V (1683–1746), king of Spain from 1700 except for a brief period from January to August 1724, was the founder of the Bourbon dynasty in Spain. During his reign Spain regained much of its former influence in international affairs. He was born at Versailles on Dec. 19, 1683, the second son of the dauphin Louis (son of Louis XIV) and of Marie Anne, daughter of Ferdinand, elector of Bavaria. Philip's whole career was coloured by the fact that he was a grandson of Louis XIV and a great grandson of Philip IV, king of Spain. With his elder brother Louis, duc de Bourgogne, he was educated in France by François Fénelon, as a result of whose influence Philip always remained strongly averse to the immorality which had been prominent at the court of France in the youth of Louis XIV. He was also at all times scrupulously religious and had an abnormally tender conscience. The people who had the most influence on him were his two wives and his confessors.

Philip held the title of duc d'Anjou until 1700. In that year he emerged as a person of political importance when Charles II, the last Habsburg king of Spain, died without issue and in his will left Philip all his possessions: Spain, Spanish America, the Spanish Netherlands, and certain parts of Italy. Louis XIV's acceptance of this will, together with his refusal to exclude Philip from the line of succession to the French throne, provoked the War of the Spanish Succession (*q.v.*). Philip proceeded to Spain in 1701 as Philip V and aided by his heroic and very young wife María Luisa of Savoy, who bore him four sons, he earned a good military reputation and won the loyalty of the majority of the Spanish people. The Treaty of Utrecht (1713) deprived Philip of the Spanish Netherlands and of the Italian possessions of the Spanish Habsburgs, but left him the throne of Spain and Spanish America.

The death of María Luisa on Feb. 14, 1714, created a delicate problem. It was clear that whoever married the king would exercise very considerable influence on the policies of Spain. During the first 13 years of his reign France had a dominant influence on the Spanish court. The French ambassador had a place on the inmost council of state and the queen had been largely influenced by her chief lady of the bedchamber, the French princesse des Ursins. Though she was 72 years of age at the time of the death of María Luisa, her influence over Philip was so great that there were rumours that he would marry her. In fact Philip chose the young Princess Isabella (*q.v.*) Farnese, the niece and stepdaughter of the duke of Parma. Under the tuition of Giulio Alberoni (*q.v.*), the Parmesan envoy at Madrid, this inexperienced princess banished the princesse des Ursins at their first meeting (Dec. 23, 1714), before Isabella had even met her husband.

It was characteristic of Philip V that he did nothing to restore the fallen favourite. He was peculiarly cold blooded in his personal relationships. He showed no enduring friendship for the Spanish nobles who had supported his cause in the last years of Charles II, and he had no real friendship for his ministers. His only really intimate friend was his master of horse, the duque del Arco, who had saved his life while hunting. For a time the new queen shared her influence over the king with his confessor but, though Philip remained all his life extremely religious, the queen gradually came to exercise the greater influence over him. Isabella bore Philip four sons and three daughters, but since in 1714 Philip had three sons surviving from his first marriage there was little chance that Isabella's children would inherit the Spanish throne. For the rest of the reign, therefore, Spanish policy was directed partly by the dynastic ambitions of Isabella to obtain territories in Italy for her sons (*see* SPAIN: *History*). Isabella's eldest son, Charles (afterward Charles III of Spain) successively received the duchy of Parma (1732) and the kingdom of Naples (1734), and his brother Philip acquired Parma in 1748.

Insofar as Philip had a foreign policy independent of the ambitions of his wife, it was determined by his unswerving determination to safeguard his claim as a Bourbon prince to the throne of France. His father had died in 1711 and his elder brother in 1712 so that the only person who stood between Philip and Versailles was his nephew Louis XV, a sickly child who seemed most unlikely to grow to manhood or ever produce an heir. In January 1724 Philip abdicated from the Spanish throne. His decision may have been partly inspired by his desire to secure the throne of France, but his eldest son Luis, who succeeded him, died in August 1724 and Philip was then prevailed upon by Isabella and by the French ambassador, the comte de Tessé, to resume the Spanish crown. At home Philip's reign was characterized by an increase in centralization and considerable financial reforms which were largely the work of the French advisers, particularly Jean Orry, who had been sent by Louis XIV to help the king at the beginning of his reign. The reforms were inspired by the example of Louis XIV, but they were the work of such men as Orry, Alberoni, and José Patiño and owed little or nothing to Philip V.

Apart from his almost morbid devotion to religion, Philip's two chief interests were hunting and music. In later life he came to appreciate the singing of the famous Carlo Farinelli. Philip insisted on Farinelli's singing the same few songs night after night and would himself shout them in a tuneless voice. Even as early as 1722, when the duc de Saint-Simon visited Spain, Philip showed signs of having deteriorated seriously from the handsome young prince who had been nicknamed by his subjects *El Animoso.* Already his gait was shambling, his clothes old and shabby and during an audience he stood with his mouth open. For months during the 1730s Philip suffered from some kind of melancholia. He feared he was being poisoned; would wear only a chemise belonging to his wife; would not have his hair or beard cut; and sometimes lay in bed for long periods without speaking. News of the possibility of a military expedition or a rumour that the king of France was ill would revive him from these states of insanity, but during the latter part of his reign his wife largely controlled public business. Philip died at Madrid on July 9, 1746.

See also references under "Philip V" in the Index.

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PHILIP (*c.* 20 B.C.–A.D. 34), the tetrarch, son of Herod (*q.v.*) the Great by a Jerusalem Jewess, Cleopatra, was brought up at Rome. By his father's final will, as ratified by Augustus, Philip became tetrarch of the northeastern appanages of Herod's realm; Ituraea and Trachonitis (Luke iii, 1), in southern Lebanon and modern Syria, to the east of the Sea of Galilee. He was a model ruler, of whom almost nothing is known, and ruled for 37 years (3 B.C.–A.D. 34). He went on official tours with a modest staff, taking with him a portable judgment seat to administer justice on the spot. He enlarged the temple precinct of Paneas, above the source of the Jordan, and called his new city Caesarea Philippi. He was married to a niece, Salome, daughter of Herodias. It is she, not her blameless husband, who is remembered to this day as

having been the immediate cause of the execution of John the Baptist (Matt. xiv, 3–11; Mark vi, 22–28).

See S. Perowne, *The Later Herods* (1958). (S. H. P.)

PHILIP THE BOLD (1342–1404), duke of Burgundy from 1364, was born on Jan. 17, 1342, the fourth and youngest son of John II, king of France. He fought at his father's side at Poitiers (1356) and shared his subsequent captivity in England. He was granted the duchy of Touraine in October 1360 and was appointed king's lieutenant in Champagne and Burgundy in June 1363. His father's grant of the duchy of Burgundy to him (September 1363) did not become effective till June 1364, when his brother, the new king Charles V, confirmed it. Philip had renounced Touraine, but retained his appointment as king's lieutenant till 1367.

Philip and Charles V supported each other's policies. Philip helped Charles to suppress marauding bands in Burgundy and later took part in the campaigns against the English. His marriage (June 1369) to Margaret of Flanders, widow of the former duke of Burgundy, Philip of Rouvre (d. 1361), was arranged by Charles to prevent Margaret's marrying an English prince.

Philip supported his father-in-law, Louis of Male, count of Flanders, against the rebellious Flemings (*see* below); and when Louis died (January 1384) Philip and his wife inherited Flanders, Artois, Rethel, Nevers, Franche-Comté, and some lands in Champagne. Having won the submission of the Flemings in 1385, Philip in 1386 arranged to separate the administration of his northern territories from that of his southern, setting up both at Lille and at Dijon a *chambre de conseil* (chamber of government) and a *chambre des comptes* (exchequer). In order to induce his wife's aunt, the childless Joan (Johanna), duchess of Brabant, to adopt as her heir his second son, Anthony of Rethel, he had to oppose the claims to Brabant of the house of Luxembourg, to which Joan's husband had belonged. For this purpose he allied himself with the counts of Holland of the house of Bavaria (Wittelsbach): in 1385 his eldest son John (*see* JOHN the Fearless, duke of Burgundy) was married to Margaret of Bavaria, while Margaret's brother, the future William VI of Holland, was married to Philip's daughter Margaret. For John and Margaret he bought the countship of Charolais in 1390; and his transactions with Joan of Brabant finally secured the duchy of Limburg for Anthony in 1396 and the eventual succession to Brabant on Joan's death in 1406. (*See* NETHERLANDS, THE: *History*.)

Meanwhile Philip and his brothers had shared the government of France and the spoils of power there during the minority (1380–88) of their nephew, King Charles VI. In furtherance of his own aims Philip had taken the king and the royal army to Flanders in support of Louis of Male in 1382, when they won the great Battle of Roosebeke and laid siege to Ghent. He had also arranged the king's marriage (July 1385) to Isabella of Bavaria and involved him (August 1388) in an arduous and inglorious campaign on behalf of Joan of Brabant against William of Gelre. In November 1388 Charles terminated the regency of his uncles; but in 1392, when Charles became insane, Philip regained his preeminence in France. He could thus impose his own policies on the French government: alliance with England (1396); and the withdrawal (1398) of support for the Avignon pope Benedict XIII, since Philip's Flemish subjects adhered to the Roman, Boniface IX. On various pretexts, moreover, he extracted large sums of money from the royal treasury, thus coming into conflict with Charles VI's brother Louis, duc d'Orléans (*q.v.*), who favoured a different policy and wanted any diversion of royal funds to be to his own benefit.

Philip was a patron of the arts. He collected illuminated books and manuscripts and commissioned from Christine de Pisan the *Livre des fais et bonnes moeurs du sage roy Charles V* and from Gace de La Bigne his poem on hunting. He ordered jewelry from the goldsmiths and precious cloth from the merchants (especially from Dino Rapondi of Lucca) and encouraged painters, for instance Jean Malouel. To shelter his tomb, at Dijon, he built the Chartreuse de Champmol, which was adorned by the sculptures of Jean de Marville and of Claus Sluter (*q.v.*). He fell heavily into debt, however, chiefly through financing his son John's crusade against the Ottoman Turks (1396) and then paying John's ransom of 200,000 gold ducats. Consequently his widow renounced her right of succession and the obligations that it entailed after Philip's death, which took place at Halle, in Brabant, on April 27, 1404.

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PHILIP THE GOOD (1396–1467), duke of Burgundy from 1419, was born at Dijon on July 31, 1396, the son of John (*q.v.*) the Fearless and Margaret of Bavaria. He bore the title comte de Charolais during his father's lifetime and was governing Flanders when John was assassinated (Sept. 10, 1419). Succeeding to the duchy and to his father's other titles, Philip decided, not without hesitation, to recognize Henry V of England as heir to the French crown (*see* HUNDRED YEARS' WAR), so as to compel the queen of France, Isabella of Bavaria, to disinherit the dauphin (later Charles VII of France), whom he held to be answerable for the murder of John the Fearless. He campaigned against the dauphin's troops in Picardy (receiving knighthood at the Battle of St. Riquier) and on the frontiers of Burgundy. Even so, John, duke of Bedford, regent of France for the new English king Henry VI, had to marry Philip's sister Anne (1423) and to grant Auxerre, Mâcon, and Bar-sur-Seine to him (1424) in order to retain his loyalty; and when Philip withdrew his troops from the siege of Orléans (1429), Bedford had to promise Champagne and Brie to him as well before he would take up arms against Joan of Arc (1430).

After his campaign of 1433 against Charles VII's troops in Burgundy, Philip consented to act as mediator between English and French at the Congress of Arras (summer 1435). When his mediation proved fruitless, he concluded his own Treaty of Arras with the French (Sept. 21, 1435). By this he acknowledged Charles VII as king of France, accepting his disavowal of the murder of John the Fearless, but exacting from him not only confirmation of the grants made by Bedford in 1424 but also new concessions in Burgundy and chiefly in Picardy: namely the countship of Ponthieu, Montdidier, Roye, Péronne, and the "Somme towns," that is, all the strongholds, lands, and lordships of the royal domain on the Somme River and beyond it in the direction of the Low Countries, with the proviso that the French king might buy these Somme towns back for 400,000 gold crowns.

At war against the English, Philip helped the French armies to recover Paris (1436) and conducted an unsuccessful siege of Calais; but in 1440 he signed a truce with the English. By paying the ransom for Charles, duc d'Orléans, he put an end to the long-standing enmity between the houses of Burgundy and of Orléans.

Meanwhile Philip had been augmenting his territorial power in the Netherlands. He purchased the rights to the countship of Namur in 1421 and came into possession of it in 1429; he obtained the administration of Holland, Zeeland, and Hainaut from the countess Jacoba (*q.v.*) in 1428, after some years of conflict; he inherited Brabant and Limburg in 1430; and after transactions with Elizabeth of Görlitz he was able to occupy Luxembourg in 1443. It only remained for him to subdue the Flemish communes, and by his victory in the Battle of Gavere (1453) he forced Ghent to submit. The ecclesiastical principalities of the Netherlands had to accept his nominees as bishops; *e.g.*, David, one of his numerous bastards, bishop of Utrecht from 1455. Whereas the Holy Roman emperor Sigismund had objected, in vain, to Philip's aggrandizement, the future emperor Frederick III suggested in 1447 that Philip's possessions should be erected into a kingdom. Philip, however, rejected Frederick's terms.

With the help of Nicolas Rolin, his chancellor from 1422 to 1457, Philip reorganized the administration of his territories. He also founded the Order of the Golden Fleece on the occasion of his marriage, in 1430, to his third wife, Isabella of Portugal. His first marriage (1409) had been to Charles VI's daughter Michelle of France (d. 1422), his second (1424) to Bonne of Artois (d. 1425).

Philip's great project, from 1432, was a crusade against the Turks. From 1441 to 1445 he maintained a fleet in the Mediterranean and in the Black Sea. After the fall of Constantinople (1453) he took the cross himself at his splendid "Banquet of the Pheasant," in Lille, on Feb. 17, 1454. He made contacts with the princes of eastern Europe who were already in league against the Turks

and tried to induce France and Germany to collaborate. Finally he organized an expedition and dispatched its first contingent in 1464, but it went no farther than Marseilles.

By this time Philip's relations with France were strained again. In 1456, when the dauphin Louis (*see* LOUIS XI, king of France) appeared at his court as a refugee, Philip granted him asylum, and Charles VII never forgave this. On Charles VII's death (1461) Philip escorted Louis back to France as king; but Louis then began to build up a faction of his own among members of Philip's entourage. One of these, Antoine de Croy, persuaded the duke to allow Louis to redeem the Somme towns (August 1463), in accordance with the treaty of 1435. Then Philip's son Charles (*see* CHARLES the Bold, duke of Burgundy), who had been on bad terms with his father since 1457, got rid of Croy by a *coup d'état* (February–March 1465); and in April 1465 Philip handed the government over to Charles, with the title of lieutenant general. Philip died at Bruges, in Flanders, on June 15, 1467.

Philip was renowned as a patron of artists—painters, miniaturists, sculptors, musicians, and writers. His court was magnificent; and jousts and banquets attracted knights from every part of Europe. His lands enjoyed great prosperity under him. *See* also references under "Philip the Good" in the Index.

See *Algemene Geschiedenis der Nederlanden*, vol. iii (1951); P. Bonenfant, *Philippe le Bon*, 3rd ed. (1955). (J. B. R.)

PHILIP THE MAGNANIMOUS (1504–1567), landgrave of Hesse from 1509, an outstanding figure among the German-Protestant princes of the Reformation, was born at Marburg on Nov. 13, 1504, the son of the shrewd and energetic landgrave William II. As he was only five years old when his father died (1509), his mother, Anna of Mecklenburg, became regent for him. Her passionate and forceful character led to conflict between the government and the estates of Hesse till in 1518 the Holy Roman emperor Maximilian I pronounced Philip to be of age to rule.

Philip never forgot the bitter experience of his youth, when, in the struggle against Franz von Sickingen (*q.v.*), a part of the Hessian nobility, out of self-interest, went over to the enemy's side. For himself he retained his parents' valued counselors, mostly of bourgeois stock, who worked for the political rehabilitation of his shattered territory and imbued him with their own single-minded devotion to its welfare. Throughout his reign he thought always in terms of the territorial state; and this consideration made him the defender of the Middle German principalities in the Peasants' War (1525) and subsequently determined his relations with the imperial House of Habsburg. He ruled in a spirit of enlightened absolutism.

In 1524, when Luther's doctrine had already won some adherents at his court and elsewhere in his dominions, Philip personally went over to the Reformation; but he began to apply it to his territory only when the imperial Diet of Speyer had apparently made such action legal (1526). He then convened a "synod"—half Hessian church council and half an assembly of the estates—at Homberg and had the religious question publicly debated. His theologians, among whom the former Franciscan, Lambert of Avignon, was especially influential, consequently drew up the *Reformatio ecclesiarum Hassiae*, which included many elements of South German and Swiss Zwinglian thought; but since Luther and Melanchthon rejected this scheme, Philip in 1527 adopted instead a program modeled on that of the Reformation in electoral Saxony. Together with the secularization of monastic property, the Hessian Reformation was characterized by the systematic way in which the new ecclesiastical order was implanted: for instance, the first Protestant university was established at Marburg in 1527.

Though he henceforth determined the religion of his territory, Philip, unlike many other German princes, yet respected freedom of conscience insofar as he allowed his subjects to emigrate. When Anabaptism spread over Germany, he saw in it a genuine crisis in the relationship between the faithful and their church. While numerous princes dealt harshly with the Anabaptists, he had some success in converting the dissidents by methods of gentle persuasion, in which he had the valuable support of Martin Bucer from Strasbourg; and the rite of confirmation, introduced in Hesse (December 1538) with a view to solving the Anabaptist problem, set the pattern for all other Protestant churches. Philip's humane treatment both of the peasants after their defeat in 1525 and of the outlawed Anabaptists contrasts very favourably with the conduct of most other German princes.

Philip's change of religion compromised his political position. It was for that reason that he and the elector of Saxony, John the Steadfast, in 1526 formed the defensive alliance known as the Gotha-Torgau League, which in 1531 grew into the League of Schmalkalden. For 20 years this Hessian-Saxon alliance formed the axis of the Protestant concert and decisively influenced the course of German history; and during this period the versatile and infectiously energetic Philip was the leader of political Protestantism. Yet the Pack affair of 1528 (*see* PACK, OTTO VON) exposed in him a credulity which detracted from his statesmanship, while the disadvantages of mixing religious motives with princely interests also became apparent. Politically he recognized the danger of splitting the Reformation between North German Lutherans and South German Zwinglians; and so, without regard for the dogmatic points at issue, he tried in vain to reconcile Luther and Zwingli at the Colloquy of Marburg (*q.v.*) in 1529. The far-reaching hopes that he and Zwingli entertained of a European alliance against the Catholic emperor Charles V came to nothing. Philip brought his fame to its zenith through the successful campaign of 1534 by which he restored the exiled Ulrich of Württemberg to his duchy and opened Württemberg to Protestantism.

Philip forfeited his leading role in Protestantism and brought the Reformers into disrepute by entering, in 1540, into a secondary marriage with Margarete von der Saale, though his lawful wife, Christine of Saxony, whom he had married in 1523, was still alive. Since the emperor Charles V was already determined to solve the religious question by force of arms, hostilities could not long be postponed; and despite a temporary *rapprochement* between the rivals, the Schmalkaldic War broke out in 1546. After an inglorious campaign by the league in southern Germany, Philip's ally, the elector John Frederick I of Saxony, was taken prisoner at Mühlberg (1547), and Philip then made his submission to the emperor. To his bitter dismay, he too was taken into captivity. His attempt to win freedom by accepting Charles V's Augsburg Interim was thwarted by his subjects' refusal to accept it; but the shallowness of Philip's religious insight and his readiness to abandon his spiritual commitments were made clear. Not until 1552 were Philip and John Frederick set free, when the alliance of Philip's son-in-law Maurice (*q.v.*) of Saxony, Philip's eldest son the landgrave William IV, and other German princes with Henry II of France had forced Charles to make the Peace of Passau.

Restored to Hesse, Philip tried thereafter to maintain the peace of Germany. Prematurely aged and saddened by the quarrel between his two families of descendants, he devoted his efforts to rebuilding the prosperity of Hesse again. If he took any further part in high politics, it was to promote the unity of Protestantism and to help those of the faith who were persecuted in France and in the Netherlands. By the time of his death, which took place at Kassel on March 31, 1567, he was already known to his contemporaries as Philip the Magnanimous (*der Grossmütige*).

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PHILIP (Indian name METACOMET) (*c.* 1639–1676), sachem of the Wampanoag Indians and leader of the worst Indian war in New England's history, was the son of Massasoit and the brother of Alexander (Wamsutta). Both Alexander, who succeeded his father (Massasoit) in 1661, and Philip, who became sachem after Alexander's death in 1662, pledged to keep the peace established by Massasoit with the English, but the pledge became more difficult to fulfill as the differences between the Indians and the English became a struggle for survival between two mutually antagonistic civilizations. The proud, ambitious Philip was embittered by the

humiliations to which he, his brother, and his people were subjected, and there is circumstantial evidence that he had a plot under way in 1674–75 to clear the English from Indian lands. In June 1675, when three of Philip's warriors were executed for the murder of an informer, John Sassamon, Philip could no longer hold his young braves in check, and war came before any well-planned or coordinated campaign had been worked out. The fact that this war was, in proportion to population, one of the most costly in lives ever fought in North America was more the result of colonial inefficiency than Indian genius in battle. Philip was not the great leader he was once assumed to be. King Philip's War bears his name because he started it and became a symbol of the struggle, but he was never in command and actually had no major part in the battles after the summer of 1675. He was killed Aug. 12, 1676.

See D. E. Leach, *Flintlock and Tomahawk: New England in King Philip's War* (1958). (RA. MU.)

PHILIP, JOHN (1775–1851), Scottish missionary, who successfully defended the rights of the Hottentots against exploitation by the settlers in South Africa, was born at Kirkcaldy, Fife, on April 14, 1775, and was minister to the Great George Street Congregational Church, Aberdeen, 1804–18. During this period he became a director of the London Missionary Society, which in 1818 appointed him a member of a commission sent to investigate its affairs in South Africa. What he saw there of the disabilities and sufferings of the Hottentots, many of whom were virtually slaves to the British and Dutch settlers, determined him to seek justice for them.

By correspondence with influential friends, among them William Wilberforce, by his own speeches during his visit to Great Britain in 1826 and by his book *Researches in South Africa* (1828), Philip did much to rouse opinion about the Hottentot question. He secured the enactment (1829) by the British government of Ordinance 50 embodying the principle that "the same freedom and protection be given to all the natives of South Africa as are enjoyed by all other persons residing at the Cape."

Philip's activities on behalf of the natives brought him great unpopularity in Cape Colony, especially among those who, when earlier compeled by law to emancipate their slaves, had retained a few Hottentots and believed in their right to control and direct them. Even after his death at Hankey on Aug. 27, 1851, his name was execrated by many white people in South Africa, but historians have vindicated his memory. *See* also CAPE OF GOOD HOPE: *History*.

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PHILIPON, CHARLES (1806–1862), French journalist, caricaturist and lithographer who raised caricature from the level of a print-seller's venture to that of a regular feature in journalism. Born at Lyons, April 19, 1806, he settled in Paris in 1823, took to lithography and began to draw caricatures for a living. He was an excellent draftsman with a fertile and irrepressible sense of satire. Moreover, he had vigorous political opinions, an enterprising spirit and boundless energy. Among the projects that overflowed from his active mind was an ambition to found a paper. This was realized in 1830 when he published a journal of political satire, *La Caricature*. Its career was brief and turbulent; after an avalanche of legal actions, it was suppressed in 1834. Meanwhile, in 1832, Philipon had produced a daily paper (with a new drawing every day) called *Le Charivari* which, ten years later, was to become godfather to *Punch* or *The London Charivari*. In 1838 *La Caricature* made a cautious reappearance under the title of *La Caricature Provisoire* but its success was such that, before long, the adjective *Provisoire* was discarded. His next publication of importance, *Le Journal pour Rire* (later *Le Journal Amusant*) appeared in 1849 in the form of large newspaper sheets filled with woodcuts. Besides these journals, Philipon issued many occasional publications, such as *Le Musée Philipon*, *Le Robert Macaire*, *Les Physiologies* and numerous political brochures.

As an artist, his best-known invention was a drawing which depicted the gradual transformation of Louis Philippe into the shape of a pear. *La Poire* became the common symbol of the king and all Philipon's artists used it in their caricatures. They were a notable group: he was able to attract and inspire the best talents in France. Honoré Daumier and Gustave Doré were the most famous but, there were also Paul Gavarni, Grandville (J. I. I. Gérard), Henri Monnier, Auguste Raffet and Charles Joseph Traviès de Villers. For one man, his achievement was considerable; his effect on caricature in France and other countries was decisive, as was his influence on the development of lithography as an artistic and commercial medium.

Philipon died in Paris, Jan. 25, 1862.

See Champfleury (Jules Fleury), *Histoire de la Caricature Moderne* (1865); Edwin de Turck Bechtel, *Freedom of the Press and L'Association Mensuelle: Philipon Versus Louis Philippe* (1952). (F. W. W.-S.)

PHILIPPA OF HAINAUT (*c.* 1314–1369), queen consort of the English king Edward III, was the daughter of William I the Good, count of Hainaut and (as William III) count of Holland, by his wife Jeanne de Valois, granddaughter of Philip III of France. Philippa's marriage was arranged in 1326 by Edward's mother, Queen Isabella, who was in Hainaut with her son gathering forces for the rebellion against Edward II. Philippa was married by proxy at Valenciennes in Oct. 1327; she crossed to England in December, joined Edward at York, and was remarried there on Jan. 24, 1328. She was crowned at Westminster a few weeks later. She accompanied Edward on his Scottish campaign in 1333 and was with him in Flanders, at the beginning of the Hundred Years' War, from 1338 to 1340. In 1348 she joined him at the siege of Calais.

Philippa was constantly in debt, but this was not necessarily due to culpable extravagance. At her marriage only 1,000 marks (£666 13*s.* 4*d.*) out of a promised dower of £3,000 were assigned for her expenses. In 1330, however, she was granted several estates and in Dec. 1330 she received, among other payments, £1,000 from the customs at Hull. But in 1333 Edward had to disburse £2,000 toward her debts and in Feb. 1363 the revenues from all her lands were reserved for six years until her debts should be paid. Her household was then merged with that of the king.

Philippa, described by contemporaries as a "full noble and good woman," was loved for her gentleness and compassion. When a stand collapsed at a tournament in Cheapside (London) in 1331, injuring some of her retinue, she saved the carpenters from punishment. There is no serious reason to doubt the famous story of her intercession for the lives of the burghers of Calais, although it is not mentioned by all the chroniclers. Unlike certain earlier foreign queens, Philippa did not swamp the English court with her compatriots. The most notable Hainauters of whom she was patron were Sir Walter de Manny, who arrived in her retinue and by 1372 held land in 16 English counties, and Jean Froissart, who acted as her secretary from 1361 until her death. She supported the Flemish weavers who settled at Norwich, visiting them in 1340, 1342, and 1344. Queen's college, Oxford, founded by her chaplain, Robert of Eglesfield, was named after her, as were the castle and town of Queenborough in Sheppey (Kent), built by William of Wykeham.

Philippa bore her husband seven sons and five daughters (*see* EDWARD III). She died at Windsor on Aug. 15, 1369.

See A. Strickland, *Lives of the Queens of England*, rev. ed. (1878).

PHILIPPE, CHARLES LOUIS (1874–1909), French writer of novels which describe from personal experience the sufferings of the poor. Born at Cérilly (Allier), on Aug. 4, 1874, the son of a shoemaker, he was ambitious to become an army officer, but was refused entry to the École Polytechnique in 1894 because of his puny physique and finally found employment in the Paris municipal service as a shop inspector. He died in Paris of typhoid on Dec. 21, 1909.

His novels either describe the dregs of Parisian society or are set in his native province. Of the first group, the most notable is *Bubu de Montparnasse* (1901; English translation 1952), which tells the story of a young prostitute's relationship with her procurer, and with a young intellectual who tries to save her. The novels of rural poverty include *La Mère et l'enfant* (1900), in which he tenderly recalls his own childhood; *Le Père perdrix* (1902; title page 1903), the story of an old blacksmith, reduced by illness

to indigence, and of a young engineer who loses his job because of his independence of outlook; and the unfinished *Charles Blanchard* (1913), a moving evocation of the unhappy childhood of his father.

Philippe's novels are distinguished by acute pity for the social outcast, and by his power to depict tenderly, yet with realistic precision, the sufferings of the poor in their struggle against cold and hunger. Although his style can be cloying, at its best it conveys emotional intensity by its simplicity and sincerity.

See J. de Fourchambault, *C.-L. Philippe: le bon sujet* (1943).
(Ja. La.)

PHILIPPEVILLE (Skikda since Algerian independence), a town and Mediterranean seaport of northeastern Algeria in Constantine *départements*, lies on the Gulf of Stora, about 55 mi. NNE of Constantine by rail and road. Pop. (1960) 80,281. Formerly the population was predominantly European, partly of Italian and Maltese origin, but during the Algerian War there was an influx of Muslim refugees and subsequently an exodus of Europeans.

Founded by the French in 1838 to serve as the port of Constantine, Philippeville is rectilinear in plan and occupies the site of ancient Rusicade, which was the port of Cirta, as Constantine was called until the 4th century. It lies near the mouth of the Safsaf River, escaping the humidity of the alluvial plain by its situation on a saddle between two hills. The road and the railway to Constantine follow the course of the former Roman road. The Safsaf Valley is rich in vines, citrus fruit trees, and early vegetables; Philippeville exports its products as well as those of the upper plains of the Constantine region (chiefly cereals and the products of sheep raising), dates from the oases of the Biskra region, and iron pyrites from the surrounding district. It imports combustibles and construction materials, and also a wide variety of manufactures and sugar and coffee, which are redistributed through Constantine to the whole of eastern Algeria. There is considerable passenger traffic through the port, which, with the village of Stora, is a centre for sardine fishing and canning.
(J.-J. Ds.)

PHILIPPI (modern Greek Filippoi in the *nomos* of Drama), a city of ancient Macedonia, on a steep hill near the Gangites (modern Angitis) River, overlooking an extensive coastal plain on the highway between Neapolis (Kavalla) and Thessalonica (Salonika). Originally a Thasian settlement called Crenides ("fountains"), it was fortified by Philip II of Macedonia in 356 B.C., to control the neighbouring gold mines.

In 42 B.C. Philippi was the site of the decisive battle in which Mark Antony and Octavian (later the emperor Augustus) defeated Brutus and Cassius. The latter, whose forces roughly equaled those of their opponents, lay astride the Via Egnatia to the west of Philippi, their position being partly protected by a marsh. Antony made a successful attack on the camp of Cassius, who, not knowing that Brutus' forces had successfully assailed Octavian's camp, committed suicide. About three weeks later, on Oct. 23, Brutus against his better judgment fought a second action in which he was routed; despairing of restoring the republican cause, he too took his own life.

After the battle a colony for Roman veterans was started at Philippi, and this was later reinforced by Augustus (according to Dio Cassius in 30 B.C. for supporters of Antony who had been dispossessed of their lands in Italy; former members of the praetorian cohorts also shared in the settlement). The first colony (ignored by ancient writers) is attested by coins with the legend *A(ntonii) I(ussu)* ("by order of Antony") *C(olonia) V(ictrix) P(hilippensium)*. Philippi was visited on his second and third missionary journeys by St. Paul, whose Epistle to the Philippians was written to the Christian converts there. The site has many ruins, especially of the imperial epoch, including the huge monument of the Roman soldier Gaius Vibius (known locally as "the manger of Bucephalus").

See S. Casson, *Macedonia, Thrace and Illyria*, part i (1926); P. Collart, *Philippes* (1937). (H. H. So.)

PHILIPPIANS, EPISTLE TO THE, a book of the New Testament, written by St. Paul to thank the church at Philippi, in Macedonia, for the financial assistance it had sent him when he was in prison, apparently facing the prospect of execution but still not without hope of release (1:19–26; 2:24). Its authenticity, doubted in the 19th century, is now almost universally accepted.

The Philippians seem to have been conscious of their position as the first European congregation of Paul, who crossed from Asia Minor into Macedonia after a special revelation (Acts 16:6–12). Paul himself looks back on the conversion of the Philippians as "the beginning of the gospel" (4:15). The Philippians alone among his churches continued to send him money (4:16; II Cor. 11:8–9), and they promised support for his collection among the gentile churches for the mother church of Jerusalem (II Cor. 8:1 ff.). For a long time they had sent nothing, but hearing of Paul's imprisonment they sent relief by the hand of one Epaphroditus, who, discovering his needy state and the insufficiency of the amount sent, laboured to earn more and in so doing fell ill. On recovery Epaphroditus became the bearer of Paul's letter of thanks to the church; the "bishops and deacons" singled out in the address (1:1) were perhaps responsible for the church chest. The Epistle is an intensely personal document, perhaps the most attractive of Paul's writings. At the same time there are undercurrents of passionate debate. His thanks are combined with admonition, and there are reverberations of harsh controversy centring in Paul himself. The Epistle's tranquillity is far from effortless, and the sunlight shines through lowering storm clouds. That Paul's rejoicing is achieved under strain is shown by the left-handed praise for the evangelistic labours of his rivals (1:15–17).

Contents.—The book may be outlined as follows:

1:1–11	Paul thanks the Philippians for their support in his imprisonment
1:12–18	This imprisonment, however, has been providentially overruled
1:19–26	Soon he hopes to visit the Philippians
1:27–2:18	let them keep unity by humility and love
2:19–30	they should be ready to welcome Timothy and Epaphroditus
3	they should beware of agitators
4	let them continue in glad dependence on God in mutual harmony

Literary Unity.—The problem of literary unity is raised by the sudden attack (3:2 ff.) on some who teach that gentile Christians need to be circumcised to attain perfection. The identity of these teachers is problematic; they may be members of the orthodox synagogue, or Jewish Christians, or Judaizing "gnostics" of uncertain morality (*cf.* 3:19). The change of mood at 3:2 has led to the conjecture that at this point there has been inserted into the letter to Philippi a fragment of another Pauline letter of unknown date and destination. Those who hold this view, however, disagree about the point where the insertion ends (3:19; 4:1, 4, 20 have all had advocates, 4:1 being supported by a majority). The probability of the conjecture is bound up with the view taken of the similar phenomena of sudden changes of mood in I and II Corinthians, which have also led to speculation that these Epistles (especially II Corinthians) consist of diverse fragments casually united perhaps by an unknown person who in about the year 95 is supposed to have published the Pauline corpus. Admittedly, the case for regarding either of the Corinthian Epistles as other than a literary unity falls far short of demonstration, and the case for so regarding Philippians is much weaker.

Place of Writing.—Traditionally the place is generally understood to be Rome, where Paul is known to have been imprisoned and executed. This hypothesis receives powerful support from the references to "the whole praetorian guard" (or "the whole praetorium") in 1:13 and to Christians in "Caesar's household" in 4:22. These phrases, however, do not compel the conclusion that the Epistle was written in Rome, and some 20th-century scholars have dated the letter many years earlier and ascribed it either to the imprisonment at Caesarea in "Herod's praetorium" (Acts 23:23–35) or to a hypothetical imprisonment at Ephesus for which there is no evidence. In favour of Ephesus it is argued, on the one hand, that the hypothesis makes it easier to regard as authentic some parts of the Pastoral Epistles to Timothy and Titus, and on the other hand that Epaphroditus' journey from Philippi to Rome would require seven weeks, whereas he could have reached Ephesus in ten days. (It is a point against the Caesarean hypothesis that

the overland journey to Caesarea would have taken much longer than that to Rome; in the summer a sea voyage of about a month would be necessary.) If Paul's prison was not at Rome, 1:13 may refer to a detachment of the praetorian guard in the provinces. Asia was a senatorial province, but "Caesar's household" might mean the staff who managed imperial estates there. Moreover, Phil. 1:1 and 2:19 ff. show that Timothy is with Paul; Timothy's presence at Ephesus is attested in Acts 19:22, but that he was ever in Rome is mere conjecture. Accordingly, the Ephesian hypothesis can be made plausible. However, the traditional view that the Epistle was written in Rome cannot be called implausible, and it remains the more probable opinion.

Influence.—Theologically, the most influential passages in the Epistle are: (1) The Christological hymn of the humiliation of the Son of God and his exaltation on the ground of his obedience (2:5–11; this has been regarded, without sufficient evidence, as a pre-Pauline hymn). The doctrine of the person of Christ here is remarkable for its use of language closely parallel to that used by Hellenistic writers about divine heroes such as Heracles, who, though the son of Zeus and Alcmene, was elevated to divine honours on account of his virtue. The passage influenced the theology of Theodore of Mopsuestia and the anti-Apollinarian school of Antioch in the 4th and 5th centuries. In modern times the statement that the Son "emptied himself" has given the impetus to "kenotic" Christology; *i.e.*, the doctrine that in the incarnation the Son of God set aside his distinctively divine attributes of omniscience, omnipotence and omnipresence. (2) The exhortation (2:12–13) "Work out your own salvation . . . for God is at work in you," which has been appealed to on both sides in the controversy concerning grace and free will. (3) The mystical ideal of never-ceasing advance in the apprehension of Christ, which is also apprehension by Christ (3:8–16). The passage is perhaps the most important single statement in Paul's Epistles of his doctrine of sanctification. *See* also BIBLE; PAUL, SAINT.

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(HY. C.)

PHILIPPICUS BARDANES (VARDAN) (d. after 713), Byzantine emperor from 711 to 713, was the son of the patrician Nicephorus of Pergamum. His Armenian name may be derived from his mother. He was banished to Cephallenia by Tiberius III Apsimar, but recalled by Justinian II who sent him to destroy Cherson (Tauric Chersonese, in the Crimea), which was in revolt. He revolted against Justinian, making common cause with Cherson, and was proclaimed emperor under the name of Philippicus. He sailed to Constantinople, gained the throne, and had Justinian and his family killed. Philippicus was a Monothelite, and though he roused the opposition of the orthodox and of Rome he was not without supporters. His extravagance ill-fitted him to organize the imperial defenses against the Bulgars, who plundered up to the city walls, or against the Arabs on the eastern frontier. Military opposition brought about his downfall in 713, when he was deposed and blinded. His chief secretary, Artemius, mainly at the instigation of the senate and people, was hurriedly crowned as Anastasius II.

See J. B. Bury, *Later Roman Empire,* vol. 2 (1889); E. W. Brooks in *Cambridge Medieval History,* vol. 2, ch. 13 (1913).

(J. M. HY.)

PHILIPPINES, REPUBLIC OF THE (REPÚBLICA DE FILIPINAS, REPUBLIKA NG PILIPINAS), an archipelago named after Philip II of Spain, of approximately 7,100 islands, about 500 mi. off the southeast coast of Asia, lying between lat. 4° 23′ and 21° 25′ N. and long. 116° and 126° 30′ E. It is bounded on the west and north by the stormy China sea, on the east by the Pacific ocean and on the south by the Celebes sea and the coastal waters of Borneo. The islands extend north and south about 1,152 mi. (1,855 km.) and east and west about 688 mi. (1,108 km.), their shape, if bounded by straight lines, being about that of an isosceles triangle and their area 115,707 sq.mi. (299,682 sq.km.). The northernmost island, Y'Ami, is 65 mi. S.E. of Formosa, while the southernmost, Saluag, is 30 mi. E. of Borneo. Only 462 of the islands have an area of 1 sq.mi. or more. Eleven have areas of more than 1,000 sq.mi.—Luzon, the most northerly of the large islands, 40,420 sq.mi.; Mindanao, the most southerly, 36,537 sq.mi.; Samar, 5,050 sq.mi.; Negros, 4,905 sq.mi.; Palawan, 4,550 sq.mi.; Panay, 4,446 sq.mi.; Mindoro, 3,759 sq.mi.; Leyte, 2,785 sq.mi.; Cebu, 1,703 sq.mi.; Bohol, 1,575 sq.mi.; and Masbate, 1,262 sq.mi.

In addition to the large islands and those with distinct names are various groups, among which may be noted the Babuyanes and Batanes, north of Luzon; the Visayas (or Bisayas), between Luzon and Mindanao; the Cagayan and the Calamian groups, respectively east and north of Palawan; and the Sulu archipelago of 448 islands, the chief of which is Jolo.

Additional information on the Philippines can be found in the articles on the individual islands, provinces and major cities.

This article is divided into the following sections:

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I. PHYSICAL GEOGRAPHY

1. Physical Features.—The irregular configuration of the archipelago, the coast line of more than 21,500 mi. (34,800 km.), the great extent of mountainous country with the mountains lying close to the sea in many places, the narrow and interrupted coastal plains, the generally northward trend of the river systems and the lakes comprise the salient physical features of the Philippines. The islands have volcanic, coral and all principal rock formations. The mountain ranges for the most part run in the general direction of the main axes of the islands. The Cordillera Central of Luzon, running north to the Pacific ocean from the northern boundary of the central plain, is the most prominent chain. It consists of two, and in places three, parallel ranges, each of which averages 5,900 ft. (1,800 m.) in height. The narrow Ilocos or Malaya range, lying close along the narrow west coast, rises in places to more than 5,000 ft. The Sierra Madre, fringing the northeast coast, rises to more than 5,000 ft. and is seldom less than 3,500 ft. high; it is largely volcanic. This range and the Cordillera Central coalesce in Nueva Vizcaya forming the Caraballo mountains. North of the latter and between the two ranges is the fertile

Cagayan valley, about 50 mi. wide. In the southwestern part of northern Luzon are the rugged Zambales mountains, which consist of more or less isolated old volcanic stocks.

The central plain of northern Luzon is about 150 by 50 mi. and only about 100 ft. above sea level except near its centre. The greater part of southern Luzon is occupied by isolated volcanoes and irregular masses of hills and mountains. The highest peak is Mayon (7,943 ft.) near Legaspi in Albay province.

Through Palawan (about 15 mi. wide) extends a range with an average height of 4,000 to 5,000 ft. Each of the Visayan islands, except Samar and Bohol, is traversed longitudinally by a single range with occasional spurs. Several peaks in Panay reach an altitude of 6,000 ft. or more. In Negros is Mt. Canlaon, a volcano of 8,035 ft., and other peaks reach an altitude of more than 6,000 ft.

There are several important ranges in Mindanao, the Diuata range along the eastern coast being the most prominent. West of this lies the fertile Agusan valley, 40 or 50 mi. wide. Farther west and southwest is the valley of the Río Grande de Mindanao, the largest river system in the island, and between the lower course of this river system and the southern coast lies a range trending northwest and southeast. On the southern border of the basin of Río Grande de Mindanao river is Mt. Apo (9,691 ft.), the highest peak in the Philippines. Around Lake Lanao are a number of volcanic peaks. A low cordillera extends into Zamboanga province.

PHYSICAL FEATURES OF THE PHILIPPINES

Many of the mountains are covered with dense forests in which are many valuable hardwood timbers. In northern Luzon the principal mountain tree is the pine. In many places where the forests have been burned away their place has been taken by cogon or other coarse grasses. The plains lying amid the mountains—*e.g.*, the central plain of Luzon, the Bikol plain of southeastern Luzon, the Cagayan plain of northern Luzon, the central plain of Panay and the Agusan and Cotabato valleys in Mindanao—have the densest populations of the islands except in Cebu, where the people live mostly on the coastal plain, as the interior is high and rugged. The most important rivers are the Cagayan, Agno, Pampanga, Pasig and Bikol in Luzon and the Río Grande de Mindanao and Agusan in Mindanao. The Cagayan, flowing northward through northern Luzon and draining about one-fourth of the island, is the largest river. This river and the Río Grande de Mindanao and the Agusan are each more than 200 mi. (322 km.) long. The Pasig, flowing through Manila, is commercially important. The largest lake in the archipelago is Laguna de Bay, located south of Manila.

2. Geology.—Mountain building is still in progress, and evidence of the recent vertical movement of various portions of mountain mass can be measured. The archipelago is the crumpled edge of the Asian continental platform. The structure is a complex one, however, for in addition to faulting and folding, volcanic actions of diverse kinds have taken place. Prior to the Tertiary period there seems to have been a period of intense deformation, when some of the schists were formed. Toward the end of the Miocene period, the Vigo and Batan formations were generally folded, in some places being intensively crumpled and faulted. Another less pronounced period of folding occurred in the Pliocene or early Pleistocene period. The islands were subjected to a great uplift during the Pliocene, Pleistocene and Recent periods. A striking similarity exists between the formation in the Philippines and the western coast of America. Practically all rock types are found in the islands, as well as areas of coral limestone.

3. Volcanoes.—The volcanoes are the most conspicuous feature of the landscape, but there is relatively little volcanic activity. All gradations of volcanoes can be seen, from the almost perfect cone of Mayon to old, worn-down volcanic stocks whose present form gives little indication of their origin. The several distinct volcanic areas are that of southwestern Luzon (the provinces of Rizal, Cavite, Laguna, Batangas and a portion of northwestern Quezon); that of southeastern Luzon; the mountain region in Camarines Norte; Negros; Mindanao; Jolo; and a few others. Seismic disturbances are common.

4. Climate.—The archipelago has a decided variety of climate. The general direction of winds is from north to east, October to January; east to southeast, February to April; and southwest, the rest of the year. Typhoons often strike the islands from the east to the southeast, then curve to the north, sometimes crossing the land to the China sea, sometimes only touching the eastern shores. Eighty-five per cent of them affect the islands from Samar to the north while only 15% are felt south of Samar. Often the greatest loss of life and destruction of property are caused not by high-velocity winds but by the concomitant or subsequent torrential rains, which cause floods.

Temperature differences are slight on the lowlands but altitudinal variations are marked. Rainfall variations are important in dividing the archipelago into climatic regions, and many local rainfall patterns exist. The most common rainfall pattern is that having two pronounced seasons, dry in winter and spring, rainy in summer and autumn, with local variation in the length of the dry season and in the total rainfall. This is found in western Luzon and the western Visayas. A second kind of pattern has a marked winter maximum of rain and irregular but short dry seasons during the summer and autumn, with local variations. This is found in eastern Luzon, the eastern Visayas and northern and eastern Mindanao. Southern and western Mindanao have no pronounced seasonal maximum of rain but do have short irregular dry seasons, with local variations.

5. Vegetation.—About 10,000 species of flowering plants and

ferns have been found. The flora is essentially Malaysian, but continental (Himalayan) elements occur in the mountains of northern Luzon, while a few Australian types are found at various altitudes. There is a small percentage of native genera and a high percentage of native species (about 60%). The dominant forest species are usually native. Among the grasses of the grasslands are lalang (cogon) and other coarse grasses. The vegetation of the coastal regions (including the mangrove swamps) is practically identical with that of similar areas throughout the Malay archipelago. Considerably more than half the land area of the islands is covered with forest. Members of the *Lauan* family, known as Philippine mahogany, often comprise a high percentage of the forest. There are many other valuable hardwoods as well as many softwoods. About 1,000 different woods have a commercial value, among which may be noted apitong, camagon, ipil, lauan, *mayapis*, molave, narra, *tangile*, tindalo and yacal. Some timber trees attain a huge size which makes them especially adaptable for tables and other large pieces of furniture. There are many useful kinds of palms, including the coconut palm, from which is obtained food, clothing, fibre for export, coconut oil, copra, building material and other products. Useful bamboos and rattans abound. About 900 species of orchids occur; some of them very rare. Several hundred fibres are known, among them the abacá, from which manila rope is made. The forests also yield gums (including rubber), various fruits, nuts, spices and drugs, oils and other useful substances.

EWING GALLOWAY

CROSS SECTION OF PHILIPPINE VEGETATION ON PANAY

6. Animal Life.—Mammals are scarce, with the exception of shrews, rats, mice and bats. The anteaters are represented by the pangolin. Red or brown deer (*Rusa*) are found in Basilan, Mindanao, Leyte, Samar and the Calamian Islands. The mouse deer or chevrotain (*Tragulus nigricans*) is found in Balabac and Palawan. The timarau (*Bubalus mindorensis*), a small buffalo, is peculiar to Mindoro. Carnivores are represented by mongooses (*Mungos palawanus* and *M. parvus*), the binturong (*Arctictis binturong*), an otter (*Aonyx cinerea*), civet cats (*Viverra* and *Paradoxurus*) and a small wildcat (*Felix minuta*) which is also found in Java. At least 56 species of bats are known, many being peculiar to the Philippines. The flying lemur (*Cynocephalus volans*) and tarsier (*Tarsius*) range from Basilan to southern Luzon. Large fruit bats live in colonies and are sometimes hunted for their flesh and fur. Only one genus of monkey (*Pithecus*) has been found, but it is represented by five species. Five new genera of small mammals (*Celaenomys, Chrotomys, Rhynchomys, Batomys* and *Carpomys*) representing 15 species have been discovered on a small plateau on the top of Mt. Data in northern Luzon, at an altitude of more than 8,000 ft. There are about 760 species of birds which show rather strong relationship to those of Borneo. Reptiles and batrachians also abound.

The marine fauna is one of the most abundant known, more than 1,000 species having been found, at least three-fourths of which are used as food. Sharks and rays are caught for their fins. The fresh-water fish fauna is relatively unimportant. Terrestrial and marine mollusks are abundant, the Philippines having the richest molluscan fauna of any equal area in the world, and many of the shells are of great beauty. Many of the mollusks are edible and of considerable local importance. Pearl oysters abound and the pearls of the Sulu archipelago have an international reputation. The shells of *Placuna placenta* have been used as a substitute for window glass. Land mollusks are found in great variety and are remarkable for their beauty. The best sponges of the southern islands are equal to those of the Mediterranean. Coral beds are numerous. (R. E. He.)

II. THE PEOPLE

The population of the Philippines is composed of a considerable number of cultural and linguistic groups, the result of varied historical relationships and of local specialization. Ancestors of the present-day population came from southeast Asia, either by way of the island chains to the south or directly across the China sea. Chinese from the coastal cities of south China came to trade and remained in Luzon and the Bisayas; Arab and Indian traders added their blood to the Muslim population in the southern islands; later came rulers from Spain and the U.S. At the time of Magellan (1521) the estimated population of the Philippines was about 500,000; since then it has increased over fortyfold. During this period there has been a blending of diverse racial strains, though linguistic differentiation continued until well into the 20th century. Increased mobility and the long period of Spanish and U.S. control, however, brought about considerable cultural uniformity except in the Muslim and pagan areas.

1. Racial Types.—The peoples of the Philippines belong to the Malay race which is a subdivision of the great Mongoloid stock of eastern Asia (*see* Races of Mankind). They were preceded in the archipelago by the Negritos (*q.v.*), small Negroes related to those of the Andaman Islands and Malaya, who entered via land bridges at the height of the last glaciation, and survive today in the Bataan peninsula and other marginal areas. Discovery in 1958 of extinct fauna in apparent association with hand axes in the Cagayan valley make it probable that earlier types of man related to the Java series may have inhabited the area.

The Malay race is sometimes divided into an earlier Indonesian or proto-Malay element, with a more Caucasoid appearance, and a later, more Mongoloid Malay type characteristic of the coastal regions; but these distinctions are not clear-cut in the Philippines. The composition of the "Filipino blend," as it was called by archaeologist H. Otley Beyer, shows a number of earlier migrations, but the origins of the bulk of the population are to be sought in southeast Asia and Indonesia, where there are obvious resemblances in physical type.

2. Languages.—All of the Philippine populations, including the Negritos, speak languages belonging to the widespread Malayo-

PAUL ALMASY

FAMILY GROUP IN THE IFUGAO DISTRICT OF NORTHERN LUZON

Polynesian stock which includes most of the peoples of Oceania. Language offers an important clue to the history of Philippine groups, and according to Paul Benedict, the region of Hainan island is the probable "jumping-off" place for Malayo-Polynesian peoples for their journeys into Oceania.

About 75 linguistic groups are found in the Philippines, and today language is an important identifying feature of Filipino ethnic groups. Three or four of these groups are major languages which are gradually absorbing their smaller neighbours. Tagalog (*q.v.*), the most important of these linguistic groups, is second in size, but its strategic position in central Luzon led to its adoption in 1946 as the basis for the national language. Bisayan or Visayan, the largest major language group, occupies the central islands but is split into three subdivisions. In northern Luzon, Ilokano has become the dominant language.

Spanish was never widely used among the masses and declined sharply after World War II. English was the most widely used language at mid-20th century, being spoken by about 40% of the population, but Tagalog was also being taught in the schools and was increasing at a faster rate.

3. Religion.—The great bulk of the Philippine population is Roman Catholic, reflecting the long period of Spanish control. Islam was introduced prior to the Spanish conquest by Muslim traders from the south, but its spread was checked by the advent of the Spaniards until its resurgence in the 20th century. The aboriginal pagan religions are still to be found in the Mountain Province and Mindanao, though many of these groups have come under Christian or Muslim influence.

During the revolt against Spain the Philippine Independent church split off from Roman Catholicism under the leadership of Gregorio Aglipay. The Aglipayans, less than 10% of the population, have kept many aspects of Roman Catholic ritual but have modified doctrine, introduced the vernacular, and added national heroes to the roster of saints. The Aglipayans later divided into two groups, one of which affiliated with the Episcopal Church.

Protestantism entered the Philippines with the U.S. occupation. In 1925 there were about 22 independent national churches, and by the second half of the 20th century the number had more than doubled. With 2% to 3% of the population as members, most of these Protestant denominations are affiliated with the Philippine Federation of Christian Churches. An independent group, the Iglesia ni Kristo, grew rapidly in the post-World War II period.

4. Customs and Culture.—Filipino culture has roots far back in the past of the Malayan world, and has been profoundly influenced by Spanish culture and by U.S. training for independence. The major ethno-linguistic regional groups show a general cultural uniformity. Outside of the cities rice (or corn) agriculture and fishing furnish the basic subsistence; the family and the "kinship circle" are the centre of social life, and the annual cycle of ceremonies and fiestas of folk catholicism give colour and meaning to daily life.

In the Muslim areas in the south, there is a stronger development of political authority and territorial units, and the religious customs follow the Islamic pattern, but the other bases of life are similar to those in the Christian areas. Aboriginal cultures surviving in marginal regions show greater variability and retain some aspects of the pre-Spanish period. (F. R. E.)

III. HISTORY

The Philippine archipelago first became known to Europeans on March 16, 1521, through Ferdinand Magellan (*q.v.*). But there are authentic Chinese accounts of trading voyages as early as the 10th and 13th centuries, and the contact probably went back much further. A Hindu influence undoubtedly came by way of the Malay peninsula, Java and other islands nearby, and probably reached back to the early centuries of the Christian era. The Hindus influenced the life of the people intimately. Many Sanskrit words in the languages and dialects of the people of the Philippines and the forms of the letters used at the time of their discovery by the Spanish indicate this.

A. The Philippines Under Spain

The second, third and fourth Spanish expeditions were those of García Jofre de Loaisa, Alvaro de Saavedra and Ruy López de Villalobos. The next expedition, that of Miguel López de Legazpi (1564–72), was dispatched, like its predecessor, from New Spain, but it was far more carefully planned. Leaving Puerto de Navidad in New Spain on Nov. 20, 1564, Legazpi reached Cebu in April 1565, where the first permanent settlement was made early in May. But Legazpi, with inadequate forces and resources, meeting prolonged hostility from the Portuguese who also were present in the region, at last (1569) moved his main forces to the island of Panay, hoping thereby to have better protection. In 1571 Legazpi made Manila the administrative centre. Thereafter the conquest of Luzon proceeded rapidly, at first principally under Juan de Salcedo, the precocious young grandson of Legazpi. All the archipelago except the Moro islands of Mindanao, the Sulu archipelago and Palawan were in fairly peaceful possession of the Spaniards before 1600. In June 1572 the city of Manila was formally established. In 1574 Manila was attacked by the Chinese Limahong, but he was forced to retire from the island and from the entire group. Several of the provisional governors were churchmen who played into the hands of the ecclesiastics or catered to their own order.

1. Conquest.—The Spaniards were accepted easily, even hospitably in many cases, and the native populations coming into closest contact with them began almost immediately to take on a veneer of European culture. The conquest was especially easy along the coast and in the low interiors where the Spaniards first went. The principal opposition at Manila in 1570 came from Muslims, but that faith was not yet strongly entrenched in Luzon. The situation was quite different in Mindanao and at various other points in the south. The Spaniards were instinctive enemies of Islam, and it was they who gave the Philippine Muslims the name Moro (*q.v.*) by which they are still known. In 1574 the Moros of the Río Grande de Mindanao offered submission. In 1578–79 Francisco de Sande (governor, 1575–80) conducted a fairly successful expedition against the Moros, but the Spaniards were unable to gain any lasting advantage. Until 1837 piratical raids were almost continuous. The Moros ravaged the coasts far and wide, even threatening Manila itself. They often joined the Dutch after the latter began to be interested in oriental waters. In 1848 on Balanguingui Island, Gov. Narciso Clavería y Zaldua won the most decisive victory ever gained over the Moros. In 1850 Gov. Antonio de Urbiztondo y Eguía destroyed the strongholds on Tonkil Island and the next year stormed and captured the town of Jolo. This ended the real power of the Moros.

During the interim between Magellan's discovery and the settlement of Manila, the Portuguese actively contested Spanish right to the archipelago. Their hostility ceased only with the union of Spain and Portugal (1580–1640). In 1577 Sir Francis Drake started on the voyage which brought him to the Philippines at Mindanao. Again, in 1587, Thomas Cavendish sailed to the Moluccas and thence back to California to intercept the rich galleon "Santa Ana." He then went to the Philippines, where he tried in vain to capture the shipyard at Iloilo.

The Dutch came next. Their primary object was trade rather than colonies. In 1596–97 Adm. Cornelius Houtman opened trade with the Netherlands, and during the years 1598–1600 the expedition under J. C. van Neck and W. van Warwijck traded in the Moluccas. In 1600 Oliver van Noordt reached Philippine waters, where he committed various depredations. Dutch vessels now traded for spices and other oriental wares in the Moluccas, harried the coasts and waters of the Philippines and attacked Portuguese, Spanish, Japanese and Chinese shipping. In 1610 Gov. Juan de Silva defeated and killed the Dutch admiral Francis de Wittert at Playa Hondo, near Manila, and captured part of his fleet. In 1640 the Dutch captured Malacca and in 1662 they permanently occupied the Moluccas. Their attacks in the Philippines gradually ceased.

On Sept. 22, 1762, a British expedition reached Manila, found the Spanish but ill prepared and on Oct. 5 captured the city. By the treaty of Paris in 1763 Manila was restored to Spain.

With Legazpi had come five Augustinians; in 1577 came the Franciscans, in 1580 the Jesuits, in 1587 the Dominicans and in 1605 the Augustinian Recollects. It was the intention of Spain to replace the friars by secular parish priests whenever any mission assumed the character of a parish. But the friars, desirous of retaining their holdings and power, fought secularization and it was never carried out in its entirety. The friars became the storm centre of the gradually increasing Filipino demand for change; the insurrection of 1896 was directed principally against them, and during the later insurrection against the United States they suffered many indignities.

The last Manila galleon left the Philippines in 1811 and returned in 1815. Thereupon the trade was taken over by private persons, exports to the value of 750,000 pesos were allowed and three other ports besides Acapulco were opened to it, namely San Blas, Guayaquil and Callao. In 1766, however, the crown had allowed direct trade between Spain and Manila by one national vessel annually. In 1785 the Royal Company of the Philippines began to trade between Manila and Cádiz; the company ceased to exist in 1830.

In 1809 an English commercial house was permitted to establish itself in Manila, and in 1814 a like privilege was extended to all foreigners. As a rule, however, Spaniards were still jealous of foreigners, and reactionary decrees in 1828 and 1840 forbade them to sell goods at retail or to do any business in the provinces. The vacillating Spanish policy is seen again in the opening of seven ports to foreign trade in 1830 and their closing the next year. In 1837 Manila was reopened to foreign trade, and Iloilo and Cebu were reopened in 1855 and 1863. In 1842 there were 39 Spanish shipping and commercial concerns in Manila and about a dozen foreign houses. Various governments maintained consuls, among them Great Britain and the United States.

2. Philippine Nationalism.—During the first half of the 19th century, there were only from 2,000 to 5,000 Spaniards in the archipelago. Spanish was spoken by some of the natives, principally in Manila and a few other important centres, but the friars had made comparatively little effort to inculcate a knowledge of Castilian. There was no homogeneity among the several native peoples, very largely because of the different languages. Partly because of these conditions, insular representation in the Spanish *Cortes* carried little meaning or a mistaken one to the mass of the population. After the building of the Suez canal, in 1869, ambitious Filipino youths went to Spain and other countries for study. The first daily newspaper was *La Esperanza* (1847). *La Solidaridad* was founded in 1888 in Barcelona by Graciano López Jaena in the interest of Filipino propaganda, and throughout its course it urged reforms in both religion and government. One of its foremost contributors was the precocious Chinese mestizo, José Rizal y Mercado. The Filipinos had ample grounds for complaint, especially after 1872. That year about 200 native soldiers at the Cavite arsenal revolted, killed their officers and shouted for independence. Plans for a similar demonstration in Manila failed. The insurrection was quickly suppressed, and led to wholesale arrests, life imprisonment and the execution, among others, of three Filipino secular priests, whose connection with the uprising was not satisfactorily explained.

Meanwhile the gradually expanding idea of Filipino nationality began to manifest itself. The campaign of Rizal, Marcelo del Pilar, López Jaena and Apolinario Mabini, leaders in the Young Filipino party, was a protest against both the domination of the friars and economic and administrative caciquism. These aspirations met a sympathetic reception from several governors, but other Spaniards, especially the friars, were diametrically opposed; and much of the old easy and cordial intercourse between the two peoples was changed. Rizal threw himself into the propaganda with eagerness. In 1891 he founded at Hong Kong an organization called the Liga Filipina, and in 1892 formed a branch at Manila. He was arrested in 1896 at Barcelona, returned to the Philippines, given a farcical trial and executed on Dec. 30, 1896. At about the time of Rizal's establishment of the Liga Filipina there was also founded an organization called the Supreme Worshipful Association of the Sons of the People, which is generally called the Katipunan. The organization was altogether Tagalog and is said to have numbered anywhere from 100,000 to 400,000 members. On Aug. 26, 1896, the actual insurrection broke out. "The cry of Balintawak" is the name given to the first hostilities by the Filipinos. The centre of the revolt was in Cavite province, where Emilio Aguinaldo first came into prominence. Spain sent over reinforcements until there was an army of 28,000 besides a few loyal regiments of native soldiers. A stiff campaign of 52 days brought the defeat of the insurgents, but upon the execution of Rizal the insurrection broke out again and spread to the provinces of Pangasinan, Zambales and Ilocos. Fernando Primo de Rivera opened negotiations with Aguinaldo and concluded with the insurgents the pact of Biac-na-Bató. Accordingly, Aguinaldo left for Hong Kong on Dec. 27, 1897. With the blowing up of the "Maine" on Feb. 15, 1898, actual hostilities broke out between Spain and the United States. (*See* SPANISH-AMERICAN WAR.)

Aguinaldo returned to the Philippines May 19, 1898, and announced renewal of the struggle with Spain. The Filipinos, who declared their independence of Spain on June 12, 1898, proclaimed a provisional republic with Aguinaldo as president, and on Sept. 9, 1898, moved their capital to Malolos, with Apolinario Mabini, the "mouthpiece of the revolution," as Aguinaldo's chief adviser. A revolutionary assembly met on Sept. 15 and on Sept. 29 ratified Filipino independence. In November and December revolutionary tribunals were organized in the Visayas. The Philippines, along with Puerto Rico and Guam, were ceded by Spain to the U.S. by the Treaty of Paris, Dec. 10, 1898.

B. The Philippines Under the United States

1. The Insurrection.—Relations between the Americans and the Filipinos were unfriendly and grew steadily worse. On Jan. 23, 1899, the Malolos constitution, by virtue of which the Philippines were declared a republic and which had been approved by the assembly on Nov. 29 and by Aguinaldo on Dec. 23, was proclaimed. Aguinaldo, who had been president of the provisional government, was elected president.

On the night of Feb. 4 the inevitable conflict between the Americans and Filipinos surrounding Manila was precipitated. Morning found the Filipinos, who had fought bravely, even recklessly, defeated at all points. While the fighting was in progress, Aguinaldo issued a proclamation of war against the United States. On Feb. 6 the U.S. senate ratified the treaty with Spain, and reinforcements were immediately sent to the Philippines. Antonio Luna, the best-trained military man among the Filipinos, was given charge of military operations, but seems to have been greatly hampered by the jealousy and distrust of Aguinaldo, which he

fully returned. Luna was murdered, and on March 31, 1899, Malolos was captured by the U.S. forces. The Filipino government fled northward. In Nov. 1899 the Filipinos resorted to guerrilla warfare, with all its devastating features. The capture of Aguinaldo by Gen. Frederick Funston in March 1901 virtually ended the real insurrection, although the last surrender was that of Gen. Miguel Malvar in Samar on April 16, 1902. The major operations of the insurrection were conducted in Luzon, and throughout the army was assisted materially by the Makabebe scouts, who remained loyal to the U.S. Meanwhile, on April 7, 1900, Pres. William McKinley instructed the second (Taft) commission to "bear in mind that the government which they are establishing is designed not for our satisfaction nor for the expression of our theoretical views, but for the happiness, peace and prosperity of the people of the Philippine Islands." Nothing was said about independence, although the instructions were later often cited in support thereof.

2. Taft.—Gov. William Howard Taft initiated negotiations with Pope Leo XIII for the purchase of friar lands (about 400,000 ac.) which were finally bought Dec. 23, 1903, at a price of approximately $7,250,000. Taft pledged the credit of the Philippine government for the amount, and bonds were issued therefor. A considerable portion of the lands, of high agricultural quality, were later sold to Filipinos. The pope also replaced the Spanish archbishop and bishops with U.S. prelates.

In 1904 Taft was called home to become secretary of war, but he continued to govern the Philippines from Washington, D.C. In 1905 he took a party of senators and representatives to the islands, at the expense of the Philippine government, and on Oct. 16, 1907, on the eve of his presidential campaign, he opened the first Philippine legislature at Manila, although there was still fighting in the Visayas and the act of 1902 required a state of "complete peace" before convening the legislature. Among other acts, that body voted to continue both Spanish and English as official languages until 1913, when Spanish was to be dropped. That, however, was never accomplished, and it was not until 1940 that Tagalog was added as another official language. On Aug. 6, 1909, congress passed the Payne bill, granting important trade concessions to the Philippines, and in 1913 the Underwood act provided for complete free trade between the islands and the United States. This concession continued until Jan. 1, 1941.

3. The Governors General.—Taft was succeeded as governor by Luke E. Wright of Tennessee, who had been a member of the Philippine commission and became the first American to bear the title of governor general. Serving from 1904 to 1906, he was very popular with Americans; but his firm and conservative policy failed to suit the more radical Filipinos and he was transferred to Tokyo as minister. Henry C. Ide of Vermont was the next incumbent of the office. He too was a member of the Philippine commission and had seen service in Samoa during the partition of that group. He was a wise and able administrator but was permitted to remain as governor general for a few months only. He was succeeded by James F. Smith of California, who had come to the islands as a colonel of volunteers and later served on the supreme court and the Philippine commission. It was understood that he was much opposed to accepting the governorship but that Taft insisted on having a Catholic for the office. Smith served from 1906 until 1909. On Nov. 11 of that year, W. C. Forbes of Massachusetts was inaugurated as governor general, serving until Aug. 1913, when he was removed. Some of his acts occasioned bitter controversy (such as his deportation, without trial, of a large and prosperous group of Chinese merchants who had been long established in Manila), and his administration was a stormy one. Francis B. Harrison of New York succeeded and served from 1913 to 1921, the longest term of any U.S. governor general.

The Wood-Forbes mission, sent by Pres. Warren G. Harding in the first year of his administration, reported that the grant of immediate independence would be premature and urged that the U.S. government not be left in a position of responsibility without authority. Leonard Wood, a major general in the regular army and the former military governor of Cuba and later of the Philippine Moro province, seemed unusually well equipped for the governor generalship to which President Harding appointed him, effective Oct. 6, 1921. But by that time the Filipino leaders, having had a taste of power under Wood's predecessor, were in no mood to submit to authority if actually exercised. He administered the government through undersecretaries until 1927, when he died in Boston, Mass. Meanwhile, Pres. Calvin Coolidge had sent Carmi Thompson of Ohio "to investigate and report" on the Philippines. He made the trip with considerable publicity and likewise reported against the grant of independence, but recommended certain reforms.

Henry L. Stimson of New York was the next governor general. As secretary of war in the Taft administration he had acquired considerable familiarity with Philippine affairs, and he had just returned from a successful mission to untangle a difficult situation in a middle American state. Proceeding with tact and caution, he gradually won over the Filipino leaders, obtained some reforms and was about to secure others, when he was called home in 1929 by Pres.-Elect Herbert Hoover to become secretary of state.

In May 1930, Dwight F. Davis of Missouri, who had also been secretary of war, was appointed. His administration was uneventful, as was that of Theodore Roosevelt, Jr., who succeeded him in 1932. Pres. Franklin D. Roosevelt appointed Frank Murphy of Michigan, a strong advocate of independence, who took office as governor general June 15, 1933, and served until Nov. 15, 1935, when he became the first high commissioner in the Philippines. Leaving that post in 1936, Murphy was succeeded by Paul V. McNutt of Indiana, who served until 1939. He realized the value of the islands as a source of supply for tropical products and for their mineral wealth, and evidently felt that the grant of independence was a mistake for both countries. But it was now too late to effect any change in the general policy. Francis B. Sayre of Massachusetts, who was appointed to succeed him, arrived in Manila Oct. 21, 1939. He had been on the faculty of Harvard university and later an assistant secretary of state. His prescribed task was to prepare for independence.

4. Campaign for Independence.—As early as 1929, the campaign of the Filipinos for that goal had been gaining momentum, with new allies, in the United States, among producers of sugar, tobacco, fats and other products and the labour unions which feared the competition of Filipino immigrants. A bill supported by these interests and providing for independence finally passed both houses of congress, was vetoed by President Hoover, passed again over the veto in Jan. 1933, but failed of ratification by the Philippine legislature because of opposition by Manuel Quezon, who, his opponents declared, wished to divert credit from those who had secured passage of the bill in his absence from Washington. This would have been an opportune time to re-examine the whole question, for the Filipinos had been given their long-sought chance and had rejected it. But the U.S. interests were determined to push the measure through. Quezon hurried to the United States to win President Roosevelt's support for a new bill, differing but little from its predecessor, but omitting the important provision reserving absolutely, as in Cuba, sites for naval bases, etc.

The new bill, known as the Tydings-McDuffie act—public law 127—passed both houses of congress, received presidential approval March 24, 1934, and was ratified by the Philippine legislature on May 1. It established a Philippine commonwealth, provided for independence in 1946 and for a graduated tax on Philippine exports to the United States (to be collected by said government for a sinking fund for bonded indebtedness) of 5% of the corresponding U.S. duty for the first year, beginning Jan. 1, 1941, and increasing by 5% each subsequent year. This was amended by the act of 1939 (public law 200), exempting cigars, scrap and filler tobacco, coconut oil and pearl or shell buttons, which were all subjected to free quotas, reducible by 5% each year. Hemp and copra were already on the free list. The U.S. immigration laws were applied, and the annual Filipino quota was limited to 50.

Pursuant to the act, a constitutional convention assembled in Manila July 30, 1934, and remained in session until Feb. 8, 1935, when a draft constitution was approved. It was certified by President Roosevelt on March 23 and ratified on May 14 of the same year by popular vote. It was on the whole a creditable document;

but two of its unique features—a single six-year term for the presidency and a unicameral legislature—were eliminated by amendments adopted in 1939 and approved by President Roosevelt Dec. 2, 1940. Quezon, elected first president of the commonwealth in Sept. 1935, was re-elected for a four-year term Nov. 4, 1941, but with the understanding—not legally enforceable—that he would give way to Vice-Pres. Sergio Osmeña after two years. The Philippine army, trained under Douglas MacArthur, son of the last American military governor, was called into the U.S. service on July 26, 1941, in time to help meet the Japanese invasion, Dec. 8 (Philippine time). (*See* WORLD WAR II.)

With the Japanese invasion, Quezon, Osmeña and the commonwealth cabinet left the Philippines to conduct a government in exile in Washington. Osmeña became president upon the death of Quezon in Aug. 1944 and returned to the Philippines when U.S. forces made their first Philippine landings on Leyte Island Oct. 20, 1944. General MacArthur proclaimed the liberation of the Philippines in July 1945. In general elections held in April 1946, Osmeña was defeated by Manuel Roxas y Acuna, who served as the last president of the commonwealth and within a few months became first president of the Republic of the Philippines.

C. The Philippines After Independence

On July 4, 1946, the commonwealth ended and the Republic of the Philippines came into existence as a sovereign independent state. In contrast with the transition which had been envisaged at the time of the Tydings-McDuffie act of 1934, the Philippines had suffered invasion, a three-year Japanese occupation and the added war damage of liberation. An estimated 1,000,000 lives had been lost as a result of the war. The damage to major industries was estimated as follows: shipping 85%, transportation 70%, mining 80%, sugar production 65% and coconut oil production 95%. Losses in production of rice, hemp, lumber and tobacco and in the fishing industry were estimated at $117,000,000. Damage to dwellings, port facilities and communications was extensive. Manila was one of the world's most devastated capitals. In addition to a shattered economy, the Roxas government was confronted with political controversy and an incipient Communist-led rebellion.

Immediately prior to independence the United States had acted to assist the Philippine government in restoring the economy. On April 30, 1946, Pres. Harry S. Truman signed the Philippine Rehabilitation (war damage) act and the Philippine Trade act of 1946. The Rehabilitation act authorized the appropriation of $620,000,000 to meet war damage claims and for Philippine government reconstruction programs and authorized 12 United States government agencies to engage in rehabilitation programs in the Philippines. The Trade act extended the period of duty-free trade until 1954 with an increase of 5% of the full tariff rate to be applied thereafter. The act provided that no change would be made in U.S. import quotas of Philippine sugar and cordage for a period of 28 years. A military assistance pact authorizing the establishment of U.S. bases was signed March 14, 1947. This was followed by a mutual defense treaty signed Aug. 30, 1951.

Pres. Elpidio Quirino became chief executive upon the death of Roxas on April 15, 1948. Within one year the deficit in the general fund was reduced from 153,000,000 pesos to less than 1,000,000 pesos.

During the Quirino administration the Hukbalahap movement became a threat to the republic. This movement had developed during the Japanese occupation as a guerrilla army to fight Japan. After the defeat of Japan the Huks, as they were called, turned against landowners and, in the interest of gaining reforms, committed acts of violence and terror principally in central Luzon and in Panay. At the end of 1949 the Huks renounced reform by constitutional means, became identified with the Communist party and advocated the forceful overthrow of the government. In 1951 Secretary of Defense Ramón Magsaysay began a program of combined military pressure and granting of homesteads on the island of Mindanao to surrendered Huks. By Dec. 1955 the Huk rebellion had died out.

Magsaysay was elected president of the republic as candidate of the Nationalist party in the elections of Nov. 1953. He was elected on a platform promising real reform in government. During Magsaysay's first year in office, he succeeded in dominating the professional politicians of his Nationalist party. Early in May 1954 the president relinquished the post of minister of defense, feeling that the problems of internal security were under control. The chief Hukbalahap leader, Louis Taruc, surrendered to the government during that month. Major progress in opening new land settlements outside crowded Luzon had taken the edge off agrarian unrest, though the basic issues of land reform had not yet been carried out in Luzon itself. President Magsaysay had at least temporarily stopped trends of opportunism among his political opponents by committing the Philippines to participation in the free world's collective security programs against Communism, and to the maintenance of the strong traditional ties to the U.S.

The main problem facing the Magsaysay administration in the mid-1950s was unemployment, a result in part of stagnation in the Philippine economy. Magsaysay, who died in a plane crash in March 1957, was succeeded by Vice-Pres. Carlos P. García. García, a member of the Nationalist party, was then elected president on Nov. 12, 1957.

In preparation for the 1961 presidential elections the Progressive and Liberal parties merged to form a united front against the Nationalists. They nominated Diosdado Macapagal, vice-president under García, as their presidential candidate, while the Nationalists chose García to run for re-election. On Nov. 14, 1961, Macapagal defeated García for the presidency; the Liberals also won the vice-presidency but the Nationalists retained control of both houses of congress.

Following independence the United States and the Philippines joined in treaty arrangements for the defense of the islands. Under the terms of a military bases agreement concluded in March 1947, the use of designated military, naval and air bases was granted to the United States for a period of 99 years. In Aug. 1951 a mutual defense treaty was signed between the two countries. In Sept. 1954, at a conference in Manila, the Philippines joined with seven other nations (Pakistan, Thailand, Australia, New Zealand, France, the United Kingdom and the United States) in forming the Southeast Asia Treaty Organization (SEATO), which committed the members to act against aggression, colonialism and internal subversion in the treaty area.

On May 15, 1958, a new U.S.-Philippine defense agreement was announced which established a mutual defense board and resolved the question of U.S. military bases. A memorandum signed Oct. 12, 1959, shortened the 99-year lease originally signed in 1947, to 25 years.

IV. POPULATION

The population of the Philippines in 1960 was 27,087,685, an increase of almost 8,000,000 since 1948 (19,234,182), or an average annual increase rate of more than 3%. The 1964 estimate indicated a total population of 31,764,000.

Of the total population in 1960, only 14.3% lived in towns and cities with populations of over 5,000, and almost one-third of these were concentrated in the city of Manila. Manila alone had a population of 1,138,611 in 1960. Other cities, Quezon City (397,990), Cebu City (251,146), Davao (225,712), Basilan (155,712), and Iloilo (151,266), also had considerable population concentrations. Although the populations of these and other urban centres increased greatly between 1948 and 1960, the larger percentage of the Philippine population continued to live in rural villages of fewer than 1,000 persons. Thus the Philippines can be characterized as a predominantly rural country. The average density of population in 1960 was 235.9 per square mile. The areas of greatest density were the city of Manila (81,329) and the provinces of Rizal (1,841), Laguna (1,015) and Cavite (759), while Palawan (29) and Mindoro Occidental (41) were the most sparsely populated.

V. ADMINISTRATION AND SOCIAL CONDITIONS

1. Government and Administration.—During the period of United States control, from 1898 until the Philippine republic attained sovereignty on July 4, 1946, the Philippine citizens in-

Area and Population by Province

Province (with capital city)	Area (in sq.mi.)	Pop. (1960 census)	Density per sq.mi.
Abra (Bangued)	1,471	115,193	78.3
Agusan (Butuan)	4,120	271,010	65.8
Aklan (Kalibo)	738	226,232	306.5
Albay (Legaspi)	996	514,980	517.0
Antique (San Jose)	1,035	238,405	230.3
Bataan (Balanga)	517	145,323	281.1
Batanes (Basco)	76	10,309	135.6
Batangas (Batangas)	1,191	681,414	572.1
Bohol (Tagbilaran)	1,575	592,194	376.0
Bukidnon (Malaybalay)	3,104	194,368	62.6
Bulacan (Malolos)	1,021	555,819	544.4
Cagayan (Tuguegarao)	3,470	445,289	128.3
Camarines Norte (Daet)	829	188,091	226.9
Camarines Sur (Naga)	2,060	819,565	397.8
Capiz (Roxas)	965	315,079	326.5
Catanduanes (Virac)	552	156,329	283.2
Cavite (Cavite)	498	378,138	758.8
Cebu (Cebu City)	1,880	1,332,847	709.0
Cotabato (Cotabato)	8,868	1,029,119	116.0
Davao (Davao)	7,529	893,023	118.6
Ilocos Norte (Laoag)	1,308	287,333	219.7
Ilocos Sur (Vigan)	1,037	338,058	325.9
Iloilo (Iloilo)	2,048	966,266	471.8
Isabela (Ilagan)	4,069	442,062	108.6
Laguna (Santa Cruz)	465	172,064	1,015.2
Lanao del Norte (Iligan)	1,313	270,603	206.1
Lanao del Sur (Marawi)	1,261	378,327	300.0
La Union (San Fernando)	530	293,330	553.5
Leyte (Tacloban)	3,084	1,172,972	380.3
Marinduque (Boac)	355	114,586	322.8
Masbate (Masbate)	1,571	335,971	213.9
Mindoro Occidental (Mamburao)	2,075	84,316	40.6
Mindoro Oriental (Calapan)	1,816	228,998	126.1
Misamis Occidental (Oroquieta)	802	248,371	309.7
Misamis Oriental (Cagayan de Oro)	1,512	388,615	257.0
Mountain Province (Bontoc)	5,458	435,839	79.9
Negros Occidental (Bacolod)	2,989	1,332,323	445.7
Negros Oriental (Dumaguete)	2,053	597,761	291.2
Nueva Ecija (Cabanatuan)	2,120	608,316	287.0
Nueva Vizcaya (Bayombong)	2,627	138,090	52.6
Palawan (Puerto Princesa)	5,693	162,669	28.6
Pampanga (San Fernando)	827	617,259	746.4
Pangasinan (Lingayen)	2,021	1,124,144	556.2
Quezon (Lucena)	4,616	653,426	141.6
Rizal (Pasig)	791	1,456,362	1,841.2
Romblon (Romblon)	512	131,658	257.1
Samar (Catbalogan)	5,309	867,994	163.5
Sorsogon (Sorsogon)	793	347,771	438.6
Sulu (Jolo)	1,087	326,898	300.7
Surigao (Surigao)	3,079	359,997	116.9
Tarlac (Tarlac)	1,175	426,647	363.1
Zambales (Iba)	1,408	213,412	151.6
Zamboanga del Norte (Dipolog)	2,285	281,429	123.2
Zamboanga del Sur (Pagadian)	4,232	742,404	175.4
Manila, city of	14	1,138,611	81,329.4
Total	114,830*	27,087,685	235.9

*Land area.

creasingly were granted and assumed the responsibilities of self-government. With the end of military government on July 4, 1901, a civil government was established under a governor (later called governor general). On July 1, 1902, the U.S. congress passed an enabling act providing for a popularly elected assembly which would constitute the lower house of a Philippine legislature. The Philippine commission, which consisted of seven members appointed by the president of the United States, would serve as the upper house. An election of members of the assembly was held on July 30, 1907. Under the provisions of the enabling act two resident commissioners were appointed to the United States with power to speak on legislation affecting the Philippines but with no vote. In 1909 the Philippine commission was expanded to include four Filipinos.

The Jones act of Aug. 29, 1916, provided for the replacement of the Philippine commission by an elected senate of 24 members and for a house of representatives of 91 (later 92) members. The act proclaimed a bill of rights.

The Philippine Commonwealth and Independence act (Tydings-McDuffie act) abolished the office of governor general and placed remaining United States authority in a high commissioner. The commonwealth government was established in Nov. 1935 with Manuel Quezon as its first president. While the islands were under Japanese occupation during World War II, the commonwealth government continued to operate in exile in the United States.

When the Republic of the Philippines became a sovereign and independent state, no substantial changes were made in the structure of government provided in the constitution of 1935 (as amended in 1940 and 1946). By the amendment of 1940, executive power was lodged in a president and vice-president, elected for terms of four years with eligibility for re-election.

The legislative power was vested in the congress of the Philippines, composed of the senate and the house of representatives. It was provided that the 24 members of the senate be elected at large by direct popular vote for six-year terms and the members of the house of representatives, representing 102 congressional districts, be elected for terms of four years.

Judicial power was vested in the justices of the supreme court (the highest tribunal), the court of appeals, courts of first instance, municipal courts of chartered cities and justices of the peace. All justices and judges were appointed by the president.

Each of the 53 provinces of the Philippines in 1958 (later increased to 55 provinces) was governed by a provincial board composed of the governor and two other board members, all elected. The 1,078 municipalities were administered by elected mayors and had municipal councils.

The governing body of each of the 30 chartered cities in 1958 was a municipal board composed of a mayor, vice-mayor and councilors. The members might be either appointed by the president or elected as provided by the charter. Quezon City, east of Manila, was designated as the national capital and by the late 1950s construction of several government buildings was under way, but most of the functions of national government remained in Manila. The 55 provinces, their areas and capital cities are shown in the population table.

2. Education.—The educational system of the Philippines is the most extensively developed in the orient. During most of the Spanish period, elementary education was undertaken only by the pastors and curates of parishes and was designed primarily to inculcate Christian values. A decree in 1863 established a compulsory educational system under civil control. Although this decree was never fully implemented, educational facilities and opportunities were expanded. A program of mass education was begun in 1901 under United States civil government; soldiers had acted as teachers for about two years prior to that time. The program sought to develop free political institutions through universal education. In 1901, 1,000 U.S. teachers were brought en masse to the Philippines. English was established as the medium of instruction and remained so. A system of scholarships was set up to train Filipinos in U.S. colleges and universities. The educational system thereafter continued to expand rapidly. The Philippine people eagerly adopted the U.S. concept of education. Education is highly valued as a factor in individual advancement and national development. The republic is perhaps unique in that the majority of the rural elementary schools have been built directly by the people through private initiative and planning. The educational system is highly centralized, with administrative control in Manila. Public education embraces all levels: elementary school, four years; intermediate school, three years; secondary school, four years; college and university. There are public schools for arts and trades, commerce, agriculture and fishing. Tuition is paid from the secondary level on, but many scholarships are available. The private educational system is vitally important, particularly at secondary, normal, collegiate and university levels. All private schools are supervised and accredited by the government.

Education is the second largest item in the national budget, amounting each year to nearly 20% of the total. The literacy rate of those persons 10 years old and over in the early 1960s stood at about 72%, the highest in southeast Asia.

3. Defense.—There is a program of mutual defense and cooperation with the U.S. and SEATO (*see* History above). The Philippine constabulary and local police maintain public order. The former is part of the armed forces whose chief of staff has over-all command of the land, sea and air forces.

VI. THE ECONOMY

A. Finance and Trade

1. National Finance.—The Philippines entered the period after World War II under financial difficulties. Large reconstruction costs were only partly compensated by U.S. financial aid and war damage compensation, and government deficits, as well as trade deficits, were normal, owing in good part to large-scale development programs.

The Philippine Central bank's foreign exchange reserves fell from 800,000,000 pesos at the end of 1948 to 450,000,000 pesos on Dec. 9, 1949. On that date controls were imposed, placing all foreign exchange under licencing. The economic and fiscal position of the Philippines continued to decline, and the Bell mission recommended in 1950 that, among other measures, taxes be increased and reforms be made in tax collection procedure. During 1951 tax machinery was improved and new taxes were imposed, including a tax of 17% on the sale of foreign exchange.

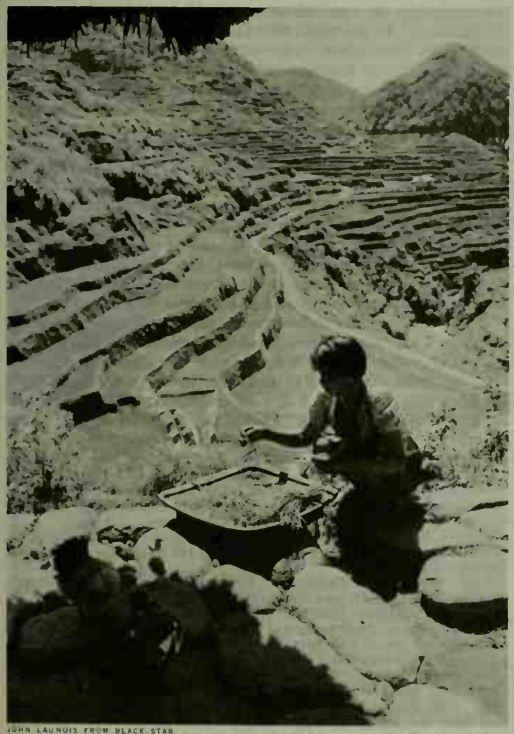
During 1949 and 1950 import controls had been established as a measure to stimulate Philippine production and to conserve foreign exchange. This resulted in a decline in the yield of some internal taxes but it improved the general financial position. A partial relaxation of import controls in 1951 contributed to a government surplus in 1952. The degree of import control varied after 1952. Throughout the 1950s national government expenditures slightly exceeded revenue for each fiscal year.

The international reserve had reached a high point of 782,500,000 pesos on April 30, 1951, after the low level in 1949, but it declined slowly after that.

In addition to the Central bank, there are more than 15 commercial banks with more than 100 branches and agencies, a few savings and mortgage banks, and numerous rural banks. Banking operations are also conducted by the Postal Savings bank, the Agricultural Credit and Cooperative Financing administration, the Rehabilitation Finance corporation, building and loan associations and pawnshops.

2. Trade.—During the period the Philippines were under Spanish rule, external commerce for the most part was limited to trade with Spain and Mexico. Under United States sovereignty, foreign trade expanded. With the passage of the Paine Tariff act of 1909 and later the Underwood act of 1913, providing for unrestricted free trade between the two countries, the Philippines became largely dependent on the U.S. market. In pre-World War II years more than 65% of Philippine trade was with the United States. During the years after independence trade with the United States declined from 86% of the total trade of the Philippines in 1945 to about 50% in the mid-1960s.

Although the Philippine prewar exports were sufficient to offset imports, the wartime scarcity of consumer and hard goods resulted in an unfavourable balance of trade in the postwar period. The leading postwar exports were copra, sugar, abacá, abacá manufactures, coconut oil, base metals, lumber, canned pineapple, dried coconut and embroideries. Among the principal imports were textiles, grains and preparations, petroleum, automobiles, iron and steel, tobacco, dairy products, paper and machinery.



JOHN LAUNOIS FROM BLACK STAR

WOMAN COLLECTING RICE SEEDS IN A COURTYARD OVERLOOKING ANCIENT RICE TERRACES OF NORTHERN LUZON

B. Production

1. Agriculture.—The fertile soil and tropical climate of the Philippines are well adapted to the raising of agricultural products, and farming engages about two-thirds of the employed population.

The total land area of the Philippines is 29,741,000 ha. (1 ha. = 2.471 ac.). The 1962 area planted totaled about 8,000,000 ha., with 70% in domestic food crops, and 30% in export crops. Rice is the principal staple food of the Filipinos, and in 1962 it was harvested from about 3,000,000 ha. (40%) of the cropland. The 1962 yield of about 4,000,000 metric tons was the highest on record and fulfilled the domestic requirement. Corn, another important food crop, also increased steadily to 26% of the cropland, about 2,000,000 ha., in 1962. Fruits, nuts and root crops occupy significant shares of the cropland, and vegetables, beans and peas, coffee, cacao and peanuts are domestically important.

Among the export crops, coconut was the leader in 1962, occupying over 1,000,000 ha., or 16% of the total cropland; this was slightly lower than the 1940 figure. Coconut products such as copra, coconut oil, desiccated coconut and copra cake form the leading export of the islands. Sugar cane revived to exceed its prewar acreage and production, but is no longer the chief money crop. Abacá declined slightly in relative importance in the economy. Tobacco is a minor crop and export, as are ramie, kapok, rubber, pineapple and derris.

Next to farming, livestock raising engages the greatest number of persons. The carabao (water buffalo) is the beast of burden upon which the Philippine farmer depends. As a result of the destruction of livestock during World War II the total number remaining in 1949 was estimated at less than 2,000,000. By 1962 the livestock population was as follows: carabao, 3,500,000; cattle, 1,000,000; horses, 210,000; hogs, 6,725,000; goats, 628,000; sheep, 23,000; and poultry, 53,000,000.

2. Forestry.—The Republic of the Philippines is one of the world's largest lumber-producing countries, ranking fifth in the ratio of forests to total land area. Commercial forests, which cover 34% of the total area of the Philippines, were placed under the administration of the bureau of forestry under a licencing system. In addition to building lumber and hardwoods, forest products include dyewoods, rattan, tanbarks, bamboo, gutta-percha, gum copal and fibres.

3. Fisheries.—Fishing is an important industry, ranking next to farming and livestock raising in the number of persons depending upon it for their livelihood. Fish comes next to rice in importance in the Filipino diet. About 1,900 different species of fish are found in Philippine waters, of which the commonest are milkfish, mackerel, snappers, sea bass, porgies, pompanos, mullets, anchovies, barracuda, tuna and bonito. Before World War II the average annual commercial inshore catch amounted to about 21,000 tons in addition to 25,000 tons produced in fish ponds. Total fish production in 1961 was 455,000 metric tons. Canned tuna is the principal fish exported. Other marine products include coral, pearls, shells and sponges. Among the shells and shell products are mother-of-pearl, trochus, tortoise, green snail shells and shells used for windows.

4. Mining.—The mineral wealth of the Philippines includes deposits of gold, silver, iron, copper, chrome, manganese and lead.

BY COURTESY OF PHILIPPINE ASSOCIATION; PHOTOGRAPH, CHARLES MILLER

PART OF DOWNTOWN MANILA AND THE PASIG RIVER. THE BUILDING IN THE CENTRE IS THE POST OFFICE

In addition to the base metals, such nonmetallic minerals as asbestos, asphalt, marble, coal, gypsum, limestone, clay, petroleum and building stone are found.

Gold deposits are in Baguio on Masbate; and in Surigao, Davao and Zamboanga on Mindanao. Iron deposits are found in Camarines Norte and Bulacan on Luzon and in Surigao. Chromite and copper are mined in Zambales on Luzon. Manganese is found in Ilocos Norte and Zambales on Luzon; on Palawan and Siquijor.

Gold and iron mining are old industries, with records of gold mining by crude methods prior to the arrival of Magellan. Coal mining dates from the early Spanish period. Petroleum formations are known to exist, and prior to World War II there were a few producing wells; in 1939, however, all petroleum lands were withdrawn from entry for five years pending the development of exploitation plans. During the Japanese occupation the mining industry suffered from lack of maintenance and the looting of equipment. After independence, the mining industry was the last of the major prewar industries to be rehabilitated.

While gold production had been 1,033,037 oz. in 1939, representing a 64% increase over production in 1929, in 1961 production was only about 424,000 oz. Silver production in 1961 was 813,000 oz. as compared with the production of 1,175,000 oz. in 1938. The production of other minerals in 1961 (in metric tons) was: zinc, 3,000; lead, 100; copper, 57,000; iron ore, 1,170,000; coal, 152,000; chromite ore (refractory) 485,000 and (metallurgical) 145,000; and manganese ore, 19,000. Total value of mineral production in 1961 was more than 300,000,000 pesos.

5. Industry.—Industrial development, speeded during the period of the commonwealth, was devoted primarily to the manufacture and processing of agricultural products. Among these were: sugar, rope, cigar and cigarette, cordage, wood and rattan furniture factories; sugar, rice and lumber mills; pineapple and fish canneries; beer distilleries; and spinning mills. During the years immediately preceding the war, modern factories were established for producing shoes, hats, leather products, perfume and pearl buttons. Household industry produced embroideries, candies and fibre hats.

After independence in 1946, new industries were developed as a result of government-imposed import controls, government loans and legislation exempting new industries from taxation for a period of four years. These included an oil refinery and factories producing chemical products, fibre products, aluminum and enamelware, medical supplies, radios and musical instruments, wood and pulp products, knitted goods of rayon and cotton, plastics, rubber and steel products.

The National Development company, established during the commonwealth period and reorganized following independence, engaged in enterprises deemed in the interest of a systematic development of Philippine resources. Its subsidiary corporations included the National Food Products corporation, National Rice and Corn corporation, Peoples Homesite corporation, National Footwear corporation, Insular Sugar Refining corporation, National Tobacco corporation, Manila Railroad company and others.

The National Development company participated directly in the construction of hydroelectric plants, a steel mill, shipyards, steel-products plants, pulp mills, heavy-machinery shops and spinning mills. The Rehabilitation Finance corporation granted loans to private investors for approved industrial enterprises.

C. Transport and Communications

During World War II transportation and communication facilities were badly damaged, but after the war they were substantially rehabilitated. In the mid-1960s there were about 30,000 mi. of roads in the Philippines. The railways are of the narrow-gauge type. The Manila Railroad company, owned by the Philippine government, operates a system of more than 600 mi. in Luzon extending from San Fernando, La Union, in the north to Legaspi, Albay, in the south. The Philippine Railway company has about 100 mi. of railways in the islands of Panay and Cebu.

Because of the republic's insular nature interisland shipping between the more than 200 local ports is an important factor in domestic trade and communications, and more than 3,000 vessels are engaged in this local trade. Foreign shipping, which more than doubled after World War II, is handled through the ports of entry, Manila being the largest and most important of these. Other ports of entry include Cebu, Iloilo, Zamboanga, Davao, Tabaco, Tacloban, Jolo, Jose Pañganiban, San Fernando and Aparri.

Philippine Air Lines services more than 30 stations within the islands and maintains international connections with Hong Kong. Several international airlines also stop at the Philippines.

Of the more than 130,000 telephones in use in the republic in the mid-1960s, more than half were in Manila. (R. E. He.)

See also references under "Philippines, Republic of the" in the Index.

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PHILIPPINE SEA, the name applied since 1944 to that part of the western North Pacific Ocean lying east and north of the Philippines. The floor of the Pacific in this area is formed into a natural basin by a series of geologic folds and faults in the form of arcs. These arcs protrude above the surface in many places, forming a series of bordering islands. The Philippine Islands of Luzon, Samar, and Mindanao are on the southwest; Palau, Yap, and Ulithi of the Caroline Islands are on the southeast; the Marianas, including Guam, Tinian, Saipan, and others, are on the east; the Bonin and Volcano Islands, including Iwo Jima, Kita Iwo, and others, lie to the northeast; the Japanese islands of Honshu, Shikoku, and Kyushu lie to the north; the Ryukyu Islands, including Okinawa, are to the northwest; Formosa marks the extreme western edge of the sea. Maximum measurements for the Philippine Sea are 1,800 mi. (2,900 km.) from north to south and 1,500 mi. (2,400 km.) east to west. Ocean trenches, or deeps, mark the eastern sides of the various folded arcs. Within the Philippine Sea are located the Ryukyu trench and the Philippine or Mindanao trench (Mindanao deep). The latter reaches the second lowest depths known in any section of the ocean floors. Maximum depth is achieved about 120 mi. (190 km.) northeast of the town of Surigao on northeastern Mindanao. The depth here is 34,583 ft. (10,541 m.), recorded in 1951 by the Danish oceanographic ship "Galathea," correcting a 1945 reading of 34,440 ft. (10,497 m.) recorded by the USS "Cape Johnson" and a 1927 reading of 35,400 ft. (10,790 m.) recorded by the German cruiser "Emden." The warm North Equatorial current flows westward across the southern part of the sea. Upon meeting the Philippine Islands the current divides; part swings north as the warm Kuroshio or Japan current and part swings toward the Equator as the Counter Equatorial current.

PHILIPPINE SEA AND SURROUNDING ISLANDS

During World War II the U.S. Navy achieved two significant victories over the Japanese fleet in the southern Philippine Sea. The first was fought by carrier planes alone on June 19–20, 1944. The second, sometimes called the Battle of Leyte Gulf, involved the major units of both fleets and was a decisive American victory. *See* World War II: *The War at Sea*. (R. E. He.)

PHILIPPOPOLIS: *see* Plovdiv (Bulg.).

PHILIPS, AMBROSE (1674–1749), English poet whose contemporary reputation rested chiefly on his *Pastorals*, was born at Shrewsbury, Oct. 9, 1674. He was educated at Shrewsbury school and St. John's college, Cambridge, where he became a fellow in 1699. In 1700 he published *The Life of John Williams*, an abridgment of J. Hacket's *Scrinia Reserta, A Memorial to Archbishop Williams* (1693). After traveling in Holland, he obtained a commission and served in Spain. In 1709 his *Pastorals* appeared in J. Tonson's *Miscellany* and won praise from Addison, Steele and Pope. They were later parodied by John Gay in *The Shepherd's Week* (1714). Philips became secretary to Daniel Pulteney, the British envoy at Copenhagen, in 1709 and there composed a widely admired verse epistle to the earl of Dorset, *A Winter Piece* (1709). After tutoring in Italy he returned to London, where *The Distrest Mother* (1712), his adaptation of Racine's *Andromaque*, was a success. His other plays are *The Briton* (1722) and *Humfrey, duke of Gloucester* (1723). His quarrel with Pope, described by Dr. Johnson as a "perpetual reciprocation of malevolence," resulted from an article in *The Guardian* (No. 32 of 1713) in which Philips, and not Pope, whose *Pastorals* had also appeared in Tonson's *Miscellany*, was hailed as the successor of Theocritus, Virgil and Spenser.

Gradually Philips lost his literary friends. In 1714 he was made paymaster to the lottery, and justice of the peace for Westminster; but in 1724 he became secretary to Dr. Boulter, archbishop of Armagh, whom Swift detested, and found himself the butt of literary Dublin. His poems on the children of Lord Carteret and Daniel Pulteney, scoffed at by Swift as "little flams," were parodied, and he was nicknamed "Namby Pamby." He sat in the Irish parliament and held legal positions before returning to London in 1748. He died there, June 1 or 2, 1749. His *Poems* were edited with an introduction by M. E. Segar in 1937.

PHILIPS, JOHN (1676–1709), English poet and man of letters, best known for his brilliant parody of the Miltonic style in *The Splendid Shilling*, was born at Bampton, Oxfordshire, on Dec. 30, 1676, the son of Stephen Philips, archdeacon of Shropshire. He was educated at Winchester and at Christ Church, Oxford. His poem, *The Splendid Shilling* (first authoritative edition, 1705), was called by Addison in *The Tatler* (No. 249) "the finest burlesque poem in the British language." Robert Harley and Henry St. John commissioned him to write a Tory counterblast (*Blenheim*, 1705) to Joseph Addison's *Campaign*. *Cyder* (1708), one of the earliest of the great didactic poems of the 18th century, is modeled on the *Georgics* of Virgil. *Cerealia, an Imitation of Milton* (1706), although printed without his name, may safely be ascribed to him. Philips died at Hereford on Feb. 15, 1709.

See *The Poems of John Philips*, ed. by M. G. Lloyd Thomas (1927); Samuel Johnson in *The Lives of the Poets*, vol. i (1781).

PHILIPS, KATHARINE (1631–1664), English poet known to her contemporaries as the "Matchless Orinda," was born in London on Jan. 1, 1631. She married James Philips, a Welsh Puritan and parliamentary leader, in 1648. Her home in Cardigan, Wales, became the centre of a "society of friendship," the members of which were known by romantic pseudonyms, Mrs. Philips being Orinda; her friend Mrs. Anne Owen, Lucasia; her husband, Antenor; and Sir Charles Cotterell, Poliarchus. Henry Vaughan exchanged poetical compliments with her and Jeremy Taylor addressed to her *A Discourse of the Nature, Offices and Measures of Friendship* (1657). The atmosphere of the circle is preserved in *The Letters of Orinda to Poliarchus* (1705). Her *Pompey* (1663), a translation from Corneille, was successfully acted and

her poems appeared in a pirated edition (1664). An authentic edition by Sir C. Cotterell appeared in 1667. She died of smallpox in London on June 22, 1664.

Orinda's poems represent a transition from the old courtly poetry to the Augustan manner of the Restoration. One of her lyrics was praised by Keats and she wrote the heroic couplet with skill and dignity. *The Letters to Poliarchus* are lively and spirited.

The poems were edited by G. Saintsbury in his *Minor Poets of the Caroline Period,* vol. 1 (1905). *See* also P. W. Souers, *The Matchless Orinda* (1931). (V. DE S. P.)

PHILIPS, PETER (1561–1628), important English composer of madrigals, motets, and keyboard music. He was a Roman Catholic, and in 1582 he left England for Italy, where he became organist of the English College in Rome. In 1585 he entered the service of Thomas, Lord Paget, with whom he traveled extensively. After Lord Paget's death in 1590 Philips went to Antwerp, and in 1597 he finally moved to Brussels, where he was appointed organist of the royal chapel of the archduke Albert of Austria. In 1593 he was accused by the Dutch authorities of planning the murder of Queen Elizabeth I, but after imprisonment and trial he was released. He probably took holy orders, for in 1610 he was appointed to a canonry. He died in Brussels in 1628.

Philips published volumes of his own madrigals, to Italian texts, in 1596, 1598, and 1603. Eight volumes of his church music were published between 1612 and 1633. A posthumously published volume of Masses is lost. Philips evidently enjoyed a considerable reputation during his lifetime, for many of his compositions appeared in contemporary collections, including Thomas Morley's *First Book of Consort Lessons* (1599) and the *Fitzwilliam Virginal Book,* which contains 19 keyboard pieces by him. Philips' style reveals Italian and Dutch as well as English traits; J. P. Sweelinck was a powerful influence, and his firm polyphonic passages are at times reminiscent of William Byrd. (DA. C. B.)

PHILISTINES, a people of Aegean origin who occupied the southern coast of Palestine during the 12th century B.C.

History.—According to biblical tradition (Deut. 2:23; Jer. 47:4; etc.) they came from Caphtor (Crete), but there is no archaeological indication of a Philistine occupation of the island. The name occurs for the first time, in Egyptian records, as *prst* among the second wave of the "Peoples of the Sea" who invaded Egypt during the eighth year of Ramses III (*c.* 1190 B.C.) after ravaging Asia Minor, Cyprus, and Syria (*see* SEA PEOPLES). These peoples were displaced from their original homelands as part of the extensive population movements of the latter half of the 2nd millennium B.C. After being repulsed by the Egyptians they occupied the coastal plain of Palestine from Joppa to the Wadi Ghazzeh. This area contained the five cities (the Pentapolis) of the Philistine confederacy (Gaza, Ascalon [Ashkelon], Ashdod, Gath, and Ekron; *qq.v.*) and was known as Philistia or the Land of the Philistines. It was from this designation that the whole of the country was later called Palestine by the Greeks. In Gen. 21:32, 34 and Ex. 13:17; 15:14; 23:31 the references to Philistia and the Philistines are anachronistic.

After settling on the coast, perhaps with Egyptian permission, the Philistines expanded into neighbouring areas and soon came into conflict with the Israelites, also recently arrived in the country. The Samson saga (Judg. 14–16) reflects this period. Due to their superior arms and military organization the Philistines were able (*c.* 1050) to occupy part of the Judaean hill country and to crush resistance at Ebenezer, destroy Shiloh, and capture the Ark (I Sam. 4:1–10). Archaeological evidence has shown that they devastated part of western Palestine. Saul was able to repel the Philistines (*c.* 1020), but their resurgence is shown by the Goliath story (1 Sam. 17) and the account of David's victories over them. After becoming king, David, using his intimate knowledge of their tactics, was able to defeat and subjugate the Philistines. They were reduced to a secondary role, and their history thereafter is that of the individual cities rather than of a people. After the division of Judah and Israel (*c.* 934 B.C.) the Philistines regained their independence and were often engaged in border battles with the Judahites and Israelites (I Kings 15:27; etc.).

The first nonbiblical reference to the Philistines after their settling on the Palestinian coast is in the annals of the Assyrian king Adad-nirari III (810–782), who boasted of having collected tribute from Philistia (Palastu). In the later Assyrian period the Philistine cities were involved in pro- and anti-Assyrian intrigues and suffered from Tiglath-pileser III (734), Sargon (720, 713, 712), and Sennacherib (701). Excavations in 1963 revealed fragments of a victory stele of Sargon set up in Ashdod. In the 7th century Gaza, Ashkelon, Ekron, and Ashdod were vassals to the Assyrian rulers Esarhaddon and Ashurbanipal. The city of Gath seems to have come under the dominance of nearby Ashdod.

During the later part of the century the Philistine cities were vassals to Egypt. An Aramaic papyrus from Saqqarah (Egypt) records the plea of a Philistine ruler to his Egyptian overlord for help against Nebuchadrezzar of Babylon. With the conquests of Nebuchadrezzar in Syria and Palestine, the Philistine cities became part of the Neo-Babylonian Empire. They were to remain part of the Persian Empire. During the Greek and Roman periods they were typical Hellenistic cities.

Culture and Religion.—There are no documents in the Philistine language, and the only Philistine word that can be positively identified is *seranim,* "lords," which is to be equated with Greek *turannos,* a word of Asianic origin. They were uncircumcised—their only known cultural trait—for which they were despised by the Israelites (Judg. 14:3; 15:18; I Sam. 17:26; 18:25). Very little is known of the Philistine religion since all their gods known from biblical and other sources have Semitic names—Dagon, Ashtaroth, Beelzebub (for Ba'al Zebul), and Marnas—and were surely borrowed from the conquered Canaanites. It is also most likely that Canaanite and then Aramaic gradually became the languages of Philistia, as Greek did during the Hellenistic period. Until their defeat by David the Philistine cities were ruled by *seranim,* who acted in council for the common good of the nation. After their defeat, the *seranim* were replaced by kings.

The Philistines in their period of expansion were able to muster large numbers of well-armed and well-trained troops. The Philistine warrior wore an Aegean kilt and a plumed headdress, and like Goliath was armed to the teeth and engaged in single combat (I Sam. 17:5–7). The Philistines held for some time a monopoly on smithing iron (I Sam. 13:19–22), a skill probably acquired in Asia Minor. At sites occupied by the Philistines at an early period, a distinctive type of ceramics, a variety of 13th-century Mycenaean styles, is found. This "Philistine" pottery went out of use during the 10th century. At some sites anthropoid clay coffins are also found in conjunction with this pottery.

The use of the term Philistine for a person deficient in liberal culture and enlightenment, whose chief interests are material, prosaic, and commonplace, arose in the mid-19th century. In the early 19th century German students applied the epithet *Philister* to those who had not received a university training and who were therefore considered uncultured. English writers, such as Carlyle and Arnold, took over the term and made it popular. It is now often used for those who oppose innovations in the arts.

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PHILISTUS (*c.* 430–356 B.C.), Greek historian of Sicily, born at Syracuse *c.* 430 B.C., helped Dionysius I to seize power (405), and became his right-hand man and commander of the citadel, till he was exiled (386/385) for reasons now obscure. Recalled after 20 years by Dionysius II at the time of Plato's first visit to his court, he held high command first in the Adriatic and later at home in the civil war, and died on active service when over 70 (356). During his exile, spent mostly in Epirus, he began his

history, which attained ultimately to 13 books, 7 on Sicilian affairs before 405, 4 on the reign of Dionysius I, and 2 on the early years of Dionysius II (367–363). (It was continued by the Syracusan Athanas.) Though the scanty surviving fragments do not illustrate why Cicero called Philistus "almost a miniature Thucydides," his book clearly became a standard work, used not only by Ephorus in his Sicilian sections but also by Timaeus and Plutarch, writers who disliked his pro-monarchical point of view.

See F. Jacoby, *Die Fragmente der griechischen Historiker,* vol. iii B, no. 556 and perhaps no. 577, fragments 1 and 2 (1950–55); A. Gitti, in *Atti della Accademia nazionale dei Lincei,* series 8, vol. 4, pp. 225–272 (1952). (G. T. Gh.)

PHILLIP, ARTHUR (1738–1814), British admiral, the first governor of New South Wales, was born in London on Oct. 11, 1738. Educated at Greenwich, he became a midshipman in the navy in 1755 and saw service in the Mediterranean and in the West Indies, where he was promoted lieutenant (1762). Retired on half-pay in 1763, he was a farmer for the next 13 years. He then fought with the Portuguese Navy in its war against Spain, but the outbreak of war between England and France in 1778 caused him to return to England. In 1786 he was assigned the duty of taking several ships out to Australia to form a convict settlement. The "first fleet," which set sail on May 13, 1787, consisted of 11 ships, ill-equipped despite Phillip's great efforts to obtain essentials for a settlement. After much difficulty, Phillip brought his ships first to Botany Bay (Jan. 18, 1788) and then to Port Jackson. Hampered by mutinous troops, by convicts unable or unwilling to work, and—until the middle of 1790—by the threat of famine, Phillip and a few of his officers were able to establish a settlement through their energy, humanity, and example. Phillip permanently inspired the settlement and put it on the road to becoming a colony. He left Australia on Dec. 11, 1792, and his resignation was accepted after his arrival in England in 1793. He saw further action at sea (1796–98) and was promoted rear admiral (1801), vice admiral (1809), and admiral (1814). He died at Bath on Aug. 31, 1814. *See* also Australia, Commonwealth of: *History.*

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PHILLIPPS DE LISLE, AMBROSE LISLE MARCH (1809–1878), a leading figure in the 19th-century Roman Catholic revival in England, was born at Garendon Park, Leicestershire, on March 17, 1809, the elder son of Charles March Phillipps; he took the name De Lisle in 1862 from his paternal grandmother's family, then without heir. Converted to Roman Catholicism from evangelical Anglicanism at the age of 16, he founded in 1835 the first post-Reformation English Trappist monastery, called Mount St. Bernard, presenting an estate in Charnwood Forest, Leicestershire, to a group of monks from Ireland.

He wrote a number of religious works and was the benefactor of other religious communities, the supporter of the Gothic revivalism of A. W. N. Pugin (*q.v.*), a friend of leading figures of the Oxford Movement, and an overoptimistic worker for the corporate reunion of the churches. He died at Garendon on March 5, 1878.

See E. S. Purcell, *Life and Letters of Ambrose Phillipps De Lisle,* 2 vol. (1900). (M. Dk.)

PHILLIPS, EDWARD (1630–1696?), English writer and biographer of Milton, who was his uncle, was born in London in Aug. 1630. His father, who died in 1631, was Edward Phillips of the crown office in chancery, and his mother was Milton's only sister, Anne. Edward and his younger brother John were educated by Milton, in whose house they boarded and studied the classics, mathematics and music. Edward entered Magdalen Hall, Oxford, in Nov. 1650, but left in 1651 to be a bookseller's clerk in London. He was tutor to John Evelyn's son (1663–65), and, later, in the families of Lord Herbert and the earl of Arlington. His interesting memoir of Milton (1694) is prefixed to his translation of Milton's *Letters of State.* John Aubrey states in his *Minutes of Lives* that all the poet's papers came into his nephew's hands. His other works include *A New World in Words, or a General Dictionary* (1658), which ran through many editions; an edition (1660–62) of Sir Richard Baker's *Chronicle of the Kings of England,* with the section on 1650–58 showing a strong royalist slant; and *Theatrum Poetarum* (1675), a list of great poets, principally English ones, with critical notes and a prefatory *Discourse of the Poets and Poetry* which may have been written by Milton. He also added a supplement (1676) to John Speed's *Theatre of Great Britain,* and wrote *Enchiridion linguae latinae* (1684), said to be based on Milton's notes. The date of his death is unknown, but his last book is dated 1696.

His brother John Phillips (1631–1706) has been proved to be the author of a biography of Milton which was long thought anonymous. He appears to have acted as Milton's secretary, and in 1652 published a Latin reply to the anonymous attack on the poet entitled *Pro Rege et populo anglicano.* In 1655 he wrote a bitter attack on Presbyterianism, *A Satyr Against Hypocrites,* much in line with Milton's disapproval of the sect. In 1656 he was summoned before the privy council for his share in a book of licentious poems, *Sportive Wit* (1656), which was suppressed, but only to be replaced by another, *Wit and Drollery* (1656). John Phillips was a voluminous writer, often obscene, but entertaining.

See W. Godwin, *Lives of Edward and John Phillips* (1815); H. Darbishire, *The Early Lives of Milton* (1932).

PHILLIPS, STEPHEN (1864–1915), English poet, playwright, and actor, who achieved a brief but brilliant success as a verse-dramatist in the Edwardian theatre, was born at Summertown, Oxford, on July 28, 1864, the son of a canon of Peterborough. He was educated at Trinity College School, Stratford-Upon-Avon, and at King's School, Peterborough, and was recommended for a scholarship at Queen's College, Cambridge, but did not take up residence. In 1885 he joined F. R. Benson's company as an actor and for some ten years played various parts, including Prospero in Shakespeare's *The Tempest,* but his chief accomplishment in Benson's eyes was that of a "first-class bowler of accurate length and varied pace." He had poetic gifts as well, and the publication of his *Poems* in 1897 launched his career as a poetic dramatist. Three of his verse-dramas were produced by Beerbohm Tree at His Majesty's Theatre: *Herod* (Oct. 31, 1900), *Ulysses* (Feb. 1, 1902), and *Nero* (Jan. 25, 1906). With J. Comyns Carr he also prepared for Beerbohm Tree a version of *Faust* performed on Sept. 5, 1908.

His most successful play was *Paolo and Francesca,* produced by George Alexander at the St. James's Theatre on March 6, 1902, which was rapturously received, its author being compared to Shakespeare. In fact Phillips had a gift for picturesque language and effective situations but little more, and his reputation withered, even in his own short lifetime. His last plays to be produced were *The Sin of David* at the Savoy Theatre on July 9, 1914, and *Armageddon,* staged by Martin-Harvey at the New Theatre on June 1, 1915. Phillips proved unable to withstand sudden success and gradual failure. His final years were ruined by excess and he died, penniless, at Deal, Kent, on Dec. 9, 1915.

See J. C. Trewin, *Benson and the Bensonians* (1960). (Ge. R.)

PHILLIPS, WENDELL (1811–1884), major U.S. abolitionist, orator, and reformer, was born in Boston, Mass., on Nov. 29, 1811. After graduating from Harvard College in 1831 and from Harvard Law School in 1834, he opened a law office in Boston but soon became active in the antislavery movement. In 1837 he married Ann Terry Greene, a fervent disciple of the noted abolitionist editor William Lloyd Garrison, and thereafter Phillips collaborated closely with Garrison. He lectured for antislavery societies, wrote editorials and pamphlets, and contributed financially to abolition enterprises. Public recognition as an orator came to Phillips in 1837, chiefly after his dramatic impromptu speech at Faneuil Hall in Boston denouncing the murder of the abolitionist editor Elijah P. Lovejoy in Alton, Ill. He was one of the most eloquent orators of the day and introduced to the U.S. public platform a direct and colloquial manner of speaking.

Sacrificing social status and a prospective political career, Phillips devoted himself to the unpopular cause of the slave. As a reform crusader, however, he refused to link abolitionism with political action. Like Garrison, he condemned the U.S. Constitution for its compromises over slavery and he advocated disunion

rather than association with slave states. He opposed the annexation of Texas and the Mexican War. During the Civil War he assailed Lincoln's unwillingness to uproot the institution of slavery, and after emancipation he contended that the Negroes should be guaranteed full civil rights. In 1865 he broke with Garrison over the discontinuance of the American Antislavery Society; and, after Garrison resigned, he served as its president until the organization disbanded in 1870.

Phillips was also a temperance advocate and a champion of women's rights. After the Civil War he continued his mission of moral education, advocating universal suffrage, labour reforms, prohibition of alcoholic beverages, prison reform, and issuance of paper money (*see* GREENBACKS). In 1870, in a brief and futile political episode, he was the gubernatorial candidate in Massachusetts of the Labor Reform Party and the Prohibition Party. Thereafter Phillips remained active on lyceum circuits until the 1880s, giving popular lectures on a number of noncontroversial subjects. He died in Boston on Feb. 2, 1884.

See Oscar Sherwin, *Prophet of Liberty* (1958); Lorenzo Sears, *Wendell Phillips* (1909). (R. J. Z.)

PHILLIPSITE, a mineral of the zeolite group, is a hydrated potassium, calcium and aluminum silicate. Like other natural and synthetic zeolites its unique crystalline make-up and structural porosity make it possible for the mineral to lose and regain water reversibly with little or no change in fundamental structure. Like other zeolites it has the property of exchanging electrically charged atoms (ions) with other substances. (For discussion of these properties *see* ZEOLITE.) Phillipsite is a mineral of secondary origin and occurs with other zeolites in cavities in basic volcanic rocks (basalts and phonolites); in red clay and deep sea deposits; and is formed from some hot spring waters. It has been found near Rome, Italy, in France, Germany and Australia, near Melbourne, and at the Giant's Causeway, County Antrim, N.Ire. The composition of phillipsite approximates $(K_2,Ca)Al_2(SiO_3)_4{\cdot}4H_2O$. It varies somewhat in composition, the variety pseudophillipsite having the formula $(K_2,Ca)_2Al_4Si_5O_{18}{\cdot}9H_2O$. Crystals are monoclinic, but only complex cruciform twins are known. Spherical groups with a radially fibrous structure and bristled with crystals on the surface are not uncommon. The hardness is 4.5, and the specific gravity 2.2.

The species was named in 1825 after the English mineralogist William Phillips (1775–1828); it also has been called christianite after Christian VIII of Denmark.

PHILLPOTTS, EDEN (1862–1960), English novelist, poet and dramatist, was born at Mount Abu, Rajputana, India, Nov. 4, 1862, and educated at Plymouth. A clerk for ten years in an insurance office, he then studied for the stage, but became a writer, producing over 100 novels, many of them with a Devonshire setting. Among his more important works are the novels *Children of the Mist* (1898); *Sons of the Morning* (1900); *Widecombe Fair* (1913); studies of boyhood and adolescence, *The Human Boy* (1899); *The Waters of Walla* (1950); plays, *The Farmer's Wife* (1917); *Yellow Sands* (with his daughter Adelaide, 1926); poems, *The Iscariot* (1912); *Brother Beast* (1928); *The Enchanted Wood* (1948); and *One Thing and Another* (poems and essays, 1954). He died at Broad Clyst, near Exeter, Dec. 29, 1960.

PHILLPOTTS, HENRY (1778–1869), English bishop, who combined efficient diocesan administration with vigorous and effective political controversy on almost every major issue in the mid-19th century, was born at Bridgwater on May 6, 1778, and educated at Corpus Christi College, Oxford. He was bishop of Exeter from 1831 until his death at Torquay on Sept. 18, 1869. An energetic high churchman and Tory, Phillpotts defended the Poor Law, the Test Act, the Peterloo incident (*see* PETERLOO), the Tory ministry's treatment of Queen Caroline and its policy toward Roman Catholic emancipation. He made a powerful attack on the Reform bill and on major ecclesiastical issues, including the foundation of the Anglican bishopric in Jerusalem (1841) and J. H. Newman's *Tract 90*. Unlike most Tories he opposed the Crimean War. Among various lawsuits in which he was involved, the most famous resulted in the Gorham judgment (1850), which overruled Phillpotts' refusal to institute G. C. Gorham to a living within his diocese on grounds of Gorham's unorthodox views on baptism. The Church of England owed much to Phillpotts' successful agitation for the revival of convocation.

See G. C. B. Davies, *Henry Phillpotts, Bishop of Exeter, 1778–1869* (1954).

PHILO, often called PHILO JUDAEUS (*c.* 30 B.C.–*c.* A.D. 40), Jewish philosopher, is the most important representative of Hellenistic Judaism, and his writings give us the clearest view of this development of Judaism in the Diaspora. He was probably a native of Alexandria, where he appears to have spent his whole life apart from one journey to Rome. His brother Alexander was alabarch or arabarch (*i.e.*, probably, chief farmer of taxes on the Arabic side of the Nile), from which it may be concluded that the family was influential and wealthy (Josephus, *Antiquities*, xviii, 8, 1). The only event of his life which can be actually dated belongs to A.D. 40, when Philo, then nearing the end of his years, went to Rome to persuade the emperor Caligula (Gaius) to abstain from claiming divine honour from the Jews. Of this embassy Philo has left a full account.

Philo appears to have been the greatest of all the Jewish philosophers of the Alexandrian School and has been called "the first theologian." His language is formed on the best classical models, especially Plato. He knows and often cites the great Greek poets, but his chief studies had been in Greek philosophy. His system was eclectic, but the borrowed elements are combined into a new unity with so much originality that he may fairly be regarded as representing a philosophy of his own, which has for its characteristic feature the constant prominence of a fundamental religious idea.

Philo's closest affinities are with Plato, with the later Pythagoreans and with the Stoics. Yet with all this Philo remained a Jew, and a great part of his writings is expressly directed to recommend Judaism to the respect and, if possible, to the acceptance of the Greeks. He was not a stranger to the specifically Jewish culture that prevailed in Palestine; in Hebrew he was not proficient, but he had evidently made some study of that language. His method of exegesis is similar in form to that of the Palestinian rabbinic scholars, and there are coincidences in matter. Philo recognized the Mosaic Scriptures of the Pentateuch as of absolute divine authority and as containing all truth. The other Jewish Scriptures he also recognized as prophetic (*i.e.*, as the writings of inspired men) but he did not place them on the same lines with the Law: everything that is right and good in the doctrines of the Greek philosophers had already been quite as well, or even better, taught by Moses. Thus, since Philo had been deeply influenced by the teachings of Greek philosophy, he found in the Pentateuch everything which he had learned from the Greeks. From these premises he assumed as requiring no proof that the Greek philosophers must in some way have drawn from Moses, a view which had already been expressed by Aristobulus. These presuppositions were maintained by an allegorical interpretation of Scripture. With its aid he discovered indications of the profoundest doctrines of philosophy in the simplest stories of the Pentateuch. This method of allegory is borrowed from the Stoics.

Theology.—Philo's doctrine of God starts from the idea that God is a being absolutely bare of quality, excluding any composition of body and soul, or of the four elements, or of substance and accidental quality, or of matter and form. No limitation can be predicated of God, who is eternal, unchangeable, simple substance, free, self-sufficient, better than the good and the beautiful. To predicate any quality of God would be to reduce him to the sphere of finite existence. Of him we can say only *that* he is, not *what* he is; and such purely negative predications as to his being appear to Philo, as to the later Pythagoreans and to the Neoplatonists, to constitute the only way of securing his absolute elevation above the world.

A consistent application of Philo's abstract conception of God would exclude the possibility of any active relation of God to the world, for a being absolutely without quality and movement cannot be conceived as actively concerned with the multiplicity of individual things. In fact Philo does teach that the absolute perfection, purity, and loftiness of God would be violated by direct contact with imperfect, impure, and finite things. But the pos-

sibility of a connection between God and the world is reached through a distinction which forms the most important point in Philo's theology and cosmology; the proper being of God is distinguished from the infinite multiplicity of divine ideas or forces: God himself is without quality, but he disposes of an infinite variety of divine forces, through whose mediation an active relation of God to the world is brought about.

Philo's conception of the nature of these mediating forces was self-contradictory. On the one hand they are nothing else than ideas of individual things conceived in the mind of God and, as such, ought to have no other reality than that of immanent existence in God; and so Philo says expressly that the "intellectual world" or totality of ideas is simply the Logos (*q.v.*) or Reason of God as Creator. Yet, on the other hand, these forces are represented as daemons or angels, hypostases distinct from God, individual entities existing independently and apart from him. This vacillation, however, as E. Zeller and others have justly remarked, is necessarily involved in Philo's premisses, for, on the one hand, it is God who works in the world through his ideas, and therefore they must be identical with God; but, on the other hand, God is not to come into direct contact with the world, and therefore the forces through which he works must be distinct from him.

The same inevitable amphiboly dominates in what is taught as to the supreme Idea or Logos. Philo regards all individual ideas as comprehended in one highest and most general idea or force—the unity of the individual ideas—which he calls the Logos or Reason of God and which is again regarded as operative Reason. The Logos, therefore, is the highest mediator between God and the world, the firstborn son of God, the archangel who is the vehicle of all revelation and the high priest who stands before God on behalf of the world. Through him the world was created, and so he is identified with the creative Word of God in Genesis (the Greek *logos* meaning both "reason" and "word"). Here again, we see, the philosopher is unable to escape from the difficulty that the Logos is at once the immanent Reason of God, and yet also a hypostasis standing between God and the world.

The whole doctrine of this mediatorial hypostasis is a strange intertwining of very dissimilar threads; on one side the way was prepared for it by the older Jewish distinction between the Wisdom of God and God himself, of which we find the beginnings in Job (28:12 *et seq.*) and in Proverbs (chapters 8 and 9) and the fuller development in Ecclesiasticus and in the Book of Wisdom, the last of which comes very near to Philo's ideas if we substitute for the term "wisdom" that of (divine) "reason." The Stoic teacher Poseidonius had already identified the Platonic ideas with the Stoic Logos. Philo goes a step further by placing the ideas in the Mind of God; but he makes it clear that they represent only God's relation to the world, not his essence.

The world and creation, in Philo's doctrine, rest on the presupposition of an absolute metaphysical contrast between God and the world. The world can be ascribed to God only insofar as it is a cosmos or orderly world; its material substratum is not even indirectly referable to God. Matter is a second principle, but in itself an empty one, its essence being a mere negation of all true being. It is a lifeless, unmoved, shapeless mass, out of which God formed the actual world by means of the Logos and divine forces. Strictly, the world is only formed, not created, since matter did not originate with God.

Ethical Teaching.—Philo's doctrine of man is also strictly dualistic and is mainly derived from Plato. Man is a twofold being, with a higher and a lower origin. Of the pure souls which fill airy space, those nearest the earth are attracted by the sensible and descend into sensible bodies; these souls are the Godward side of man. But on his other side man is a creature of sense, and so has in him a fountain of sin and all evil. The body, therefore, is a prison, a coffin, or a grave for the soul which seeks to rise again to God. The highest maxim of Philo's ethics is therefore deliverance from the world of sense and the mortification of all the impulses of sense.

In carrying out this thought, Philo differs from the Stoics. The Stoics cast man upon his own resources; Philo points him to the assistance of God, without whom man, a captive to sense, could never rise to true wisdom and virtue. Even in this life the truly wise and virtuous is lifted above his sensible existence and enjoys in ecstasy the vision of God, his own consciousness sinking and disappearing in the divine light. Beyond this ecstasy there lies but one further step, viz., entire liberation from the body of sense and the return of the soul to its original condition; it came from God and must rise to him again. But natural death brings this consummation only to those who, while they lived on earth, kept themselves free from attachment to the things of sense: all others must at death pass into another body. Transmigration of souls is in fact the necessary consequence of Philo's premisses.

Works.—The titles of the numerous extant writings of Philo present at first sight a most confusing multiplicity. More than three-fourths of them, however, are really mere sections of a small number of larger works. Three such great works on the Pentateuch can be distinguished.

1. The smallest of these is the *Zetemata kai lyseis* ("Questions and Solutions"), a short exposition of Genesis and Exodus, in the form of question and answer. The work is cited under the Greek title by Eusebius and by later writers, but the Greek text is almost wholly lost, and only about one-half is preserved in an Armenian translation. Genesis seems to have occupied six books. Eusebius tells us that Exodus filled five books. In the Armenian translation, edited by the Mekhitarist monk J. B. Aucher (1826), are preserved four books on Genesis and two on Exodus, but with lacunae. A Latin fragment, about half the fourth book on Genesis, was first printed at Paris in 1520. Of the Greek text there are numerous but short fragments in various ancient anthologies. The interpretations in this work are partly literal and partly allegorical.

2. Philo's most important work is the *Nomon hieron allegoriai* ("Allegories of the Sacred Laws"), a vast commentary on Genesis, dealing with chapters 2, 3, and 4 verse by verse and with select passages in the later chapters. The readers in view are mainly Jews, for the form is modeled on the rabbinic Midrash. The main idea is that the characters which appear in Genesis are properly allegories of states of the soul. All persons and actions being interpreted in this sense, the work as a whole is a very extensive body of psychology and ethics.

3. A work of a very different kind is the group of writings expounding the "Mosaic Law for Gentiles." These, in spite of their diverse contents, present on nearer examination indubitable marks of close connection. In them Philo seeks to give an orderly view of the chief points of the Mosaic legislation in the Pentateuch and to recommend it as valuable to gentile readers. The method of exposition is somewhat more popular here than in the allegorical commentaries, for, though that method of interpretation is not wholly excluded, the main object is to give such a view of the legislation as Philo accepted as historical. This work has three main divisions: (1) the interpretation of the first two chapters of Genesis, *Peri Moyseos kosmopoiias* (Lat. *De opificio mundi*), as Moses put his account of the Creation at the beginning of the Pentateuch in order to show that his legislation was conformed to the will of nature and that therefore those who followed it were true cosmopolitans; (2) the "Lives of the Wise," biographies of the three righteous men, Abraham, Isaac, and Joseph—being, so to speak, the living unwritten laws which, unlike written laws, present the general types of moral conduct; and (3) legislation proper, in two subdivisions, (*a*) the ten principal chapters of the law and (*b*) the special laws belonging to each of these ten. An appendix adds a view of such laws as could not be brought under the rubrics of the decalogue.

4. Of the miscellaneous writings attributed to Philo, some appear to have survived in their entirety, some are extant only in translation or in fragments and some have been held to be spurious. The Greek texts of the three books "On the Life of Moses" and of the treatise "On Nobility" have been preserved. Two of five books on the affairs of the Alexandrian Jews also survive in Greek: namely, "Against Flaccus," in which Philo relates how the governor Flaccus, early in Caligula's reign, allowed the mob to persecute the Jews in Alexandria; and *Peri areton kai presbeias pros Gaion* (Lat. *De legatione ad Gaium*), in which he describes the persecution following Caligula's demand for divine honours and recounts his embassy to Rome to seek relief for the Jews of Alexandria.

Of the two books "On Providence," the title of which is twice mentioned by Eusebius, we possess only an Armenian version edited with Latin translation by J. B. Aucher (1822); book i appears moreover to be in a Christian recension. Also in Armenian, except for two small fragments preserved in the *Florilegium* (anthology) of Leontius and Johannes, is the surviving text of Philo's *Alexandros* ("Alexander, or That Dumb Animals Have Reason"), mentioned both by Eusebius and by Jerome. Eusebius (*Praeparatio Evangelica*, viii, 6, 7, 11) preserves fragments of the *Hypothetika* and of a "Defense of the Jews," the latter being presumably identical with the work "On the Jews" that he mentions elsewhere.

The authenticity of the treatise "That Every Righteous Man Is Free" was disputed by Z. Frankel and by R. Ansfeld but was defended by Paul Wendland, who believed it to be an early work of Philo's. The Philonic origin of the document on the Therapeutae, *Peri biou theoretikou* (Lat. *De vita contemplativa; see* JEWISH SECTS DURING THE SECOND COMMONWEALTH) was also disputed, notably by P. E. Lucius in *Die Therapeuten* (1879), but was ably defended by L. Massebieau in the *Revue de l'histoire des religions*, xvi (1887), by F. C. Conybeare in *Philo About the Contemplative Life* (1895), and by Wendland in *Die Therapeuten* (1896). Against J. Bernays and others who denied Philo's authorship of the treatise "On the Incorruptibility of the World"—apparently one of the sources from which the suppositious treatise "On the World" was compiled—F. C. Cumont's vindication, *Philo de aeternitate mundi* (1891) may be consulted. Two discourses extant only in Armenian, one on Samson, the other on Jonah, are inauthentic. *See* also references under "Philo" in the Index.

BIBLIOGRAPHY.—Editions of Philo's works include those by T. Mangey, 2 vol. (1742); by L. Cohn, P. Wendland and S. Reiter, 7 vol. (1896–1930); and by F. H. Colson and G. H. Whitaker, 9 vol., with Eng. trans. and supplement, Loeb Series (1929–53).

For studies of Philo *see* R. Marcus, "Recent Literature on Philo (1924–1934)," *Jewish Studies in Memory of G. A. Kohut* (1935); E. R. Goodenough, bibliography in *The Politics of Philo Judaeus* (1938). The following deserve special mention: C. Siegfried, *Philo von Alexandria* (1875); B. Ritter, *Philo und die Halacha* (1879); J. Drummond, *Philo Judaeus*, 2 vol. (1888); H. Guyot, *Les Réminiscences de Philon le Juif chez Plotin* (1906); N. Bentwich, *Philo-Judaeus of Alexandria* (1910); H. A. A. Kennedy, *Philo's Contribution to Religion* (1919); T. H. Billings, *The Platonism of Philo Judaeus* (1919); E. Bréhier, *Les Idées philosophiques et religieuses de Philon d'Alexandrie*, 2nd ed. (1925); I. Heinemann, *Philons griechische und jüdische Bildung* (1932); E. R. Goodenough, *By Light, Light: the Mystic Gospel of Hellenistic Judaism* (1935), *An Introduction to Philo Judaeus* (1940); H. H. Wolfson, *Philo: Foundations of Religious Philosophy in Judaism, Christianity and Islam*, 2 vol. (1947); and S. Sandmel, "Philo's Place in Judaism: a Study of Conceptions of Abraham in Jewish Literature," *Hebrew Union College Annual*, xxv, xxvi (1954–55).

(E. Sc.; C. Bi.; A. An.)

PHILOCTETES, Greek legendary hero who played a decisive part in the final stages of the Trojan War. The son of Poeas, he held sway over a group of cities on the southeastern Thessalian seaboard. He (or his father) had been bequeathed the bow and arrows of Heracles in return for lighting his funeral pyre; Philoctetes became a famous archer. En route for Troy he was incapacitated by the bite of a water snake and was left behind by the Greeks on the island of Lemnos. A prophecy of Helenus revealed that Troy could only be taken with the aid of Heracles' bow and arrows. Accordingly Odysseus and Diomedes went to Lemnos and persuaded Philoctetes to accompany them to Troy. There he was healed of his wound by Machaon, and killed Paris in single combat, thus paving the way for the city's fall. He subsequently returned home safely, but wandered as a colonist to southern Italy, where he ultimately met his end in battle. Homer gives only a skeleton outline of this story; the details were filled in by later epic writers. All three of the great Attic tragedians handled the theme, but Sophocles' *Philoctetes* alone survives. In it Achilles' young son Neoptolemus accompanies Odysseus, and the dilemma of his divided loyalties to the Greeks and to the tormented hero is resolved only through the direct intervention of Heracles. Philoctetes is sympathetically portrayed—a symbol of a man triumphing over pain and through suffering (*see* SOPHOCLES: *His Tragic Thought: Philoctetes and Oedipus Coloneus*).

See Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. 19, col. 2500–09 (1938). (D. E. W. W.)

PHILODEMUS (*c.* 110–40 B.C.), Greek poet and Epicurean philosopher (*see* EPICURUS) who did much to spread that doctrine among Roman men of letters, was born at Gadara near the Sea of Galilee. After studying at Athens under the Epicurean Zeno of Sidon, he became the mentor of a Roman of high rank, L. Calpurnius Piso, with whom he lived in the vicinity of Naples. Horace is thought to have been much influenced by him. Cicero implicates Philodemus in a personal attack on Piso in his speech *In Pisonem* but knew his writings well and used them as a source for Epicurean doctrine. Of his poems, 34 epigrams are extant; these consist of light verse, not linked with his philosophy. Treatises by Philodemus predominate among the books of the great Epicurean Library discovered at Herculaneum; the library itself may have belonged to him, the house to Piso or to his heirs. Much of what Philodemus says evidently comes from Zeno of Sidon; but he gives glimpses of controversies between the later Epicureans and their opponents, and among themselves. (D. J. A.)

PHILODENDRON, the generic and common name for about 200 species of plants of the aroid family (Araceae; *q.v.*), many of which are prized as landscape ornamentals in moist, warm regions or as conservatory and house plants. They are native to tropical America, mostly in forests, and are valued for the gloss, sculpture, variegation and colour of their leaves. Most philodendrons are vining plants but some (*e.g.*, the "self-heading" horticultural varieties) are almost stemless, with leaves that arise from a crown. The leaf blades, which are relatively thick, vary in different species from heart-shaped to ovoid, from smooth-margined to deeply lobed and from a few inches to about three feet long; in some species the leaves are perforated, and in certain horticultural varieties they turn red in cool weather. The base of the leaf stalk, or petiole, clasps the stem. The flowers are small, without petals, and are crowded, with male above and female below, on a spikelike spadix enfolded by a leaflike spathe. The spathe, which is usually whitish, yellowish or red, persists around the cluster of berrylike fruits.

ROCHE

TWO OF THE MANY LEAF VARIATIONS OF PHILODENDRONS: (LEFT) PHILODENDRON RADIATUM (DUBIUM); (RIGHT) P. OXYCARDIUM (FLORIST'S P. CORDATUM)

As house plants, philodendrons require well-aerated soil and moderate light. They should be thoroughly watered only when the soil begins to feel dry to the touch. Daily spraying or weekly washing of the leaves with water is helpful. Stem cuttings root readily in water or in moist sand, peat moss, soil, etc. Vining philodendrons soon require support. When grown as house plants, philodendrons rarely blossom.

See also HOUSE PLANTS. (P. D. V.)

PHILOKALIA (DOBROTOLYUBIE), "Love of the Good and the Beautiful," a famous prose anthology of Greek monastic texts first printed in Venice in 1782 and quickly sold out in the Greek Orthodox world. It was edited by Bishop Makarios of Corinth and Nikodimos Hagioritis (Nicodemus the Athonite). The *Philokalia* was part of the movement for spiritual renewal in Greek monasticism, and Greek devotional life in general, by a return to Hesychast ideals (*see* HESYCHASM). Its great influence can be understood

only against the background of Hesychast teaching and mystical way of life. The 1,207 pages of the *Philokalia* consist of many long extracts from the desert fathers who since the 11th–12th century had been regarded by Byzantine monasticism as the forerunners of Hesychasm and from the Hesychast authors themselves: Simeon the New Theologian (*see* SIMEON, SAINT), Nicetas Stethatus (d. *c.* 1050), Nicephorus (2nd half of the 13th century), Gregory the Sinaite (1255–1346), Gregory Palamas (*see* PALAMAS, SAINT GREGORY), Ignatius and Callistus Xanthopulus (end of 15th century), etc.

The theme of the *Philokalia* is "inner asceticism," not merely outward obedience to one's superior or the practice of physical austerities. Inner asceticism means, above all, true repentance for one's sins, daily recollection of death and judgment, together with perpetual remembrance of God as omnipresent and omnipotent, and ceaseless prayer. A very important part is played by the "Jesus prayer," uttered in a particular bodily position with a special way of breathing.

The *Philokalia* had great success in the Slav countries, especially Russia, and a Church Slavonic version appeared in 1793 in St. Petersburg under the title of *Dobrotolyubie*. It was translated by the starets Paissy Velichkovsky, who introduced a neo-Hesychast spiritual renewal into Russian and Moldavian monasticism. Whereas in Greece the *Philokalia* apparently had little influence outside certain schools of monasticism (although attempts were made to reach a wider public with new editions in 1897 and 1957 ff.), the Church Slavonic version became through the influence of the startsi one of the favourite spiritual books of all classes of Russian laity during the 19th century. In 1877 Feofan Zatvornik (Theophanes the Recluse), former bishop of Tambov, made a Russian version in five volumes which altered the selection of extracts in a way that had been characteristic for Russian monasticism since the time of Nil Sorski in the 16th century. An interesting example of the influence of the *Philokalia* is seen in *Otkrovennye rasskazy strannika dychovnovy svoemu otsu* (1894), which was very popular in Russian and is now widely read in western Europe and America (Eng. trans., *The Way of a Pilgrim,* 1930, revised 1952, by R. M. French).

BIBLIOGRAPHY.—Partial Eng. trans. by E. Kadloubovsky and G. E. H. Palmer, *Writings from the Philokalia on the Prayer of the Heart* (1951), *Early Fathers from the Philokalia* (1954); partial French trans. by J. Gouillard, *Petite Philocalie de la prière du coeur* (1953). (F. v. L.)

PHILOLAUS (fl. in second half of 5th century B.C.), Greek philosopher of the Pythagorean School, was born at Tarentum or (according to Diogenes Laërtius viii, 84) at Crotona in southern Italy. After the death of Pythagoras great dissensions prevailed in the Italian cities. According to some accounts, Philolaus fled, taking refuge first in Lucania and then at Thebes, where he had Simmias and Cebes as pupils. Later Philolaus returned to Italy, where, it is said, he taught Archytas. He studied the Pythagorean number theory, particularly the properties inherent in the decad—the sum of the first four numbers, consequently the fourth triangular number, the *tetractys*. It is from a book of his that Plato's successor Speusippus is reported to have reproduced the doctrine. It would seem that Philolaus was the first systematizer of Pythagoreanism, but the evidence for this is a matter of dispute.

Pythagoras probably knew the construction of three of the regular solids, and Empedocles is stated to have been the first who maintained that there are four elements. Philolaus, connecting these ideas, held that the elementary nature of bodies depends on their form and assigned the tetrahedron to fire, the octahedron to air, the icosahedron to water, and the cube to earth; the dodecahedron he assigned to a fifth element, ether or the pure air surrounding the universe. The elements themselves seem to have been the product of number, and they existed in a harmony produced by the normal Pythagorean principles of Limit and the Unlimited. Similarly, in an animate body health consisted in a balance of the two further opposites, heat and cold. Philolaus regarded the soul as a "mixture and harmony" of the bodily parts; he also assumed a substantial soul, whose existence in the body is an exile because of sin, showing the religious outlook that Plato attributes to him in the *Phaedo* (61 D *ff.*). For the important astronomical theory sometimes attributed to him, *see* PYTHAGORAS AND PYTHAGOREANISM.

Both the astronomy and the physics which are credited to Philolaus have been held to be inadmissible before Plato's *Timaeus*. Certainly the discovery of how to construct the octahedron and the icosahedron is put after Philolaus' time on far better evidence. (And the only quotation about the five elements, it should be noticed, does not name the regular solids at all.) The man himself has even been considered a fanciful invention of Plato; and Erich Frank argued that his works were forged by Speusippus. If his genuineness is accepted, it is certainly necessary to be discriminating about the quotations which have survived and still more so about the descriptions of his doctrine made by ancient writers.

BIBLIOGRAPHY.—Ancient testimonies and fragments are collected by H. Diels and W. Kranz, *Fragmente der Vorsokratiker,* vol. i, 7th ed. (1954). For the case against their genuineness *see* E. Frank, *Plato und die sogenannten Pythagoräer* (1923); for a reply to Frank's arguments, E. Zeller, *La Filosofia dei greci,* Italian trans. ed. by R. Mondolfo, pt. i, vol. ii, pp. 367–382 (1938). (A. C. LD.)

PHILOLOGY, a term now rarely used but once applied to the study of language and literature. A human society is apt to be bound together by a single language, in which its entire cultural tradition, written and unwritten, is composed. As time goes by, the universe of tradition is seen to contain diverse subject matter, which for convenience of handling is classified broadly to correspond to the activities of the particular society—its law, religion, history, philosophy, for example. That part of tradition, the content of which is dominantly imaginative and the form artistic, excites its own interest and criticism and even devotion, for the sake of its better preservation and understanding: this was designated philology. Nowadays a clear distinction is made between literary and linguistic scholarship, and the term philology, where used, means the study of language. It survives in the titles of a few learned journals that date to the 19th century. *See* LINGUISTICS.

PHILOPOEMEN (*c.* 252–182 B.C.), Greek general of the Achaean League (*q.v.*), was born at Megalopolis, in Arcadia, and there trained to a career of arms by the Academic philosophers Ecdelus and Damophanes. When Cleomenes III of Sparta took Megalopolis (223), Philopoemen skilfully evacuated it, and his initiative at Sellasia (222) won the praise of Antigonus Doson, king of Macedonia. The next 11 years he spent as a condottiere in Crete; he returned to Achaea and was elected federal cavalry commander for 210/209, when his reorganized cavalry defeated the Aetolians on the Elean frontier. As general of the confederation for 208/207 he introduced heavier Macedonian armour and phalanx tactics, and so crushed the Spartans under Machanidas at Mantinea (207). This Achaean revival reduced Achaean dependence on Macedonia. General again in 206/205 and 201/200, he expelled Nabis of Sparta from Messene, and routed him at Tegea. But in the Second Macedonian War his policy of neutrality harmed him, and he returned to Crete until 193. In a fourth generalship (193/192) he failed against Nabis by sea, but almost annihilated his army near Gythium. The Roman general Flamininus prevented his taking Sparta, but on Nabis' assassination (192) he incorporated it in the confederation. Henceforth he dominated Achaean policy. He was general in 191/190 and 189/188; in 191, when trouble arose at Sparta, he closed the gates against both Diophanes, the Achaean general, and Flamininus, but in 188 he inflicted savage reprisals after a Spartan attack, and abolished the Lycurgan regime. This incurred Roman censure. He was again general in 187/186 and 183/182. When Messene rebelled, he was taken in a skirmish and given poison (182). Philopoemen's chief merit lies in his restoration of Achaean military efficiency. He was admired by Polybius, and by the unknown Roman in Plutarch who called him "the last of the Greeks"; but his general policy was narrow, and his constant assertion of Achaean rights alienated the Romans and prevented a collaboration that was inevitable from being also fruitful.

BIBLIOGRAPHY.—Polybius, *Histories,* books ii, x–xxiv; Livy, books xxxv–xxxix; Plutarch, *Flamininus, Philopoemen* (using Polybius' lost biography); Pausanias, viii, 49–51; Justin, books xxx–xxxiv; A. Aymard, *Les premiers rapports de Rome et de la confédération achaienne* (1938); W. Hoffmann in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft,* vol. xx, col. 76–95 (1941). (F. W. WA.)

PHILOPONUS, JOHN (5th–6th century A.D.), a prolific writer of the philosophical school of Alexandria who, as an expositor and critic of Aristotle, exercised a deep influence on later generations. The name John marks him as a Christian, and there is no good ground for supposing him to have been a convert. Since his earliest studies were in language and literature, he styled himself "Grammaticus," and he was also known by the surname Philoponus (("industrious"), which seems to have been the class name of a group of active Christian laymen.

In philosophy John was a pupil of Ammonius Hermiae (*q.v.*). Among his works are several commentaries on treatises of Aristotle, which seem to be partly based on Ammonius' oral instruction. He frequently adopts, on religious grounds, a critical attitude toward Aristotle, which distinguishes him from other commentators of the age. His *De aeternitate mundi*, written in 529, which has survived almost complete, is a refutation of Proclus, who, with other Neoplatonists, supposed the heavens to be divine and imperishable; a philosophical defense is given of the view that the world was created by God from nothing and will be destroyed. The work, written when Christianity was in the ascendant at Alexandria, may have been designed to shield the Alexandrian school of philosophy. Besides this, John wrote a treatise, the general outline of which is known from the bitter retort made by Simplicius (*q.v.*), against certain principles of Aristotle's physical science. John's theological writings, in which he supported the Monophysites (*q.v.; Opuscula Monophysitica*, edited by A. Sanda, 1930), were condemned as heretical in 680. (D. J. A.)

PHILOSOPHY (ARTICLES ON). The article PHILOSOPHY provides a general introduction to the subject matter of philosophical inquiry. For an outline of the course that this inquiry has pursued in the western world *see* PHILOSOPHY, HISTORY OF. Parallel to the latter from the final period of antiquity are ARABIC PHILOSOPHY and JEWISH PHILOSOPHY. CHINESE PHILOSOPHY and INDIAN PHILOSOPHY are independent.

METAPHYSICS briefly indicates the type of inquiry traditionally included under this heading. For particular aspects *see*, for instance, ABSOLUTE; ANALOGY; BODY AND MIND; CAUSALITY; COSMOLOGY; DETERMINISM; DURATION AND TIME; FORM; FREE WILL; INFINITY AND THE INFINITE; LOGOS; PLURALISM AND MONISM; PREESTABLISHED HARMONY; QUALITIES; SUBSTANCE; and UNIVERSAL. KNOWLEDGE, THEORY OF, a key article, is supplemented by the following: BELIEF; EMPIRICISM; IDEA; INNATE IDEAS; INTUITION; PHENOMENALISM; RATIONALISM; SKEPTICISM; and TRUTH. A distinct group is formed by SCIENCE and SCIENTIFIC METHOD, together with INDUCTION and PROBABILITY, and the shorter HYPOTHESIS.

LOGIC and LOGIC, HISTORY OF, with SEMANTICS IN LOGIC, are supplemented by numerous articles including ABSTRACT AND ABSTRACTION; CATEGORY; CLASSIFICATION; CONVERSION (IN LOGIC AND MATHEMATICS); DEFINITION; EXPLANATION; FALLACY; MATHEMATICS, FOUNDATIONS OF; MEANING; NAME (IN LOGIC); PROPOSITION; SYLLOGISM; and THOUGHT, LAWS OF.

ETHICS; ETHICS, HISTORY OF and ETHICS, COMPARATIVE are supplemented by EGOISM; HEDONISM; and UTILITARIANISM. *See* also POLITICAL PHILOSOPHY. For history of that discipline *see* AESTHETICS, HISTORY OF; for modern developments *see* AESTHETICS.

For schools and individual systems of philosophy the following articles, in roughly chronological order, may be consulted; PYTHAGORAS AND PYTHAGOREANISM; ELEATIC SCHOOL; SOPHISTS; ACADEMY, GREEK; PERIPATETICS; CYRENAICS; CYNICS; STOICS; NEOPLATONISM; SCHOLASTICISM; CARTESIANS; CAMBRIDGE PLATONISTS; IDEALISM; TRANSCENDENTALISM; NEO-KANTIANISM; NEO-HEGELIANISM; POSITIVISM; PRAGMATISM; PHENOMENOLOGY; LOGICAL POSITIVISM; and EXISTENTIALISM.

Expositions of the thought of major philosophers will be found in the various biographical articles: ARISTOTLE; BERKELEY, GEORGE; and so on. For medieval philosophers particularly, where the name may be one of several forms, it is advisable to consult the Index first to determine the heading under which the biography is to be found. *See* also RELIGION (ARTICLES ON).

PHILOSOPHY is a word whose range of usages can scarcely be explained without some account of its history. It is derived from the composite Greek noun *philosophia* which means the love or pursuit of wisdom. Herodotus uses the corresponding verb *philosophein* when writing of Solon's travels in search of knowledge; and Thucydides puts it into the mouth of Pericles in his account of the famous funeral speech about the Athenian way of life. In these passages it suggests especially the attempt to satisfy curiosity, but *sophia*, like the English word "wisdom," implied not only wide knowledge but also sound judgment about the values of different things in life (*i.e.*, about what is most worth pursuing for its own sake) and even sometimes shrewdness in practical decisions; so that *philosophia* was in origin a very general word for the pursuit of mental excellence. Pythagoras is said to have been the first to call himself a philosopher (*philosophos*), but we know so little for certain about him that we cannot tell what nuances of meaning the word had in his usage. In the Platonic dialogues it is often used by Socrates to describe a man engaged in the sort of inquiry that he himself pursued; and there can be little doubt that the historical Socrates called himself a philosopher, while disclaiming the title of *sophos*, which was given traditionally to Solon and the other sages of antiquity. There is here the beginning of a specialized or technical usage of the word, and Plato's representation of Socrates has had so great an influence on western thought that philosophy is still thought of as a study which deals for the most part, though not exclusively, with the subjects of Plato's dialogues and proceeds by the Socratic method.

The earliest of the Greek thinkers whose names were afterward included in histories of philosophy recognized no divisions of knowledge. The records of their sayings contain material of all sorts, from speculations about the constitution of the world by condensation and rarefaction of a single stuff to reflections about forms of government, and from observations of eclipses to advice on the management of children. By the end of the 5th century B.C., however, arithmetic, geometry, astronomy and music had been recognized as distinct studies. They are the *mathemata*, or disciplines, from which the word "mathematics" is derived, and for a long time they retained their special position as the first of the special sciences; thus they were still grouped together as the *quadrivium* in the curriculum of seven liberal arts taught at the medieval universities. The historical Socrates seems to have had no more than an intelligent layman's appreciation of these studies, and we are told that he gave up speculation about the nature of the physical world in order to concentrate attention on the search for definitions of universal notions and especially of those notions that have to do with human conduct and human character. But in the dialogue of Plato called the *Republic* he is represented as saying that the mathematical studies are a necessary preliminary to philosophical training. According to the scheme of education outlined there, anyone who would be a philosopher must learn the interconnections of the various sciences that are commonly taught separately, and no one can hope to make progress who lacks the power of *synopsis* (*i.e.*, of seeing things together). But all this is preparatory to the understanding of a system in which all "forms" (*i.e.*, characters in which individual sensible things may participate) have their places determined by their relation to the supreme Form of the Good.

It is difficult to work out any really convincing development of the scheme suggested by Plato in this dialogue, where his thought seems to be most ambitious; and we may reasonably suspect that Plato himself was unable to produce any detailed formulation that satisfied him. For he had recourse on various occasions to various analogies and sometimes even used the language of mystical illumination. But there can be found here already a number of features which recur constantly in the work of those later writers who are commonly accounted philosophers and which may therefore be taken as marks of philosophical thought.

Plato's Four Marks of Philosophical Thought.—First, there is the notion of a study in which the various special sciences are to be related together and understood as parts of one system. In recent times the increase of knowledge has been so rapid that it is difficult if not impossible for anyone to be master of the whole of a science such as chemistry, and we have therefore much more reason than Plato ever had to be worried about the dangers of spe-

cialization in education. So long as our plans for counteracting these evils do not take us beyond the boundaries of a single science, such as chemistry, we do not think that they have any connection with philosophy; but if we are more ambitious and try to provide a conspectus of all the sciences, this seems to us still a philosophical enterprise. To make clear the distinction between the *a priori* and the empirical sciences and to show the relations within the latter group between the physical, the biological and the psychological sciences—these are philosophical tasks, whether or not they are performed by professional philosophers. So too is the clarification of notions of high generality such as that of causation. If, as in physics, the development of a science makes it necessary to raise questions about concepts of this level, the scientist who tries to answer them is conscious that he is engaged for the time being in philosophy. Sometimes, indeed, the word "philosophy" is used popularly to mean any formulation of very general basic principles for a practical activity, such as politics or strategy.

Second, there is a contrast between sensible appearance and intelligible reality. Only those are philosophers who "contemplate things as they are in themselves and as they exist ever permanent and immutable" and "set their affections on that which in each case really exists" (Plato, *Republic*, 479–480). According to Plato's account, the realm of appearance is the ordinary world of *genesis*, or happening, about which we can never have more than opinion, while the realm of intelligible reality is the timeless system of mathematical objects and of "forms" such as goodness and justice (*i.e.*, the realm of ideas in the original sense of the word "idea," from which our modern colloquial usage is derived through a long and devious history). In the thought of some later philosophers (*e.g.*, Leibniz, Kant and Hegel) the contrast of sensible appearance and intelligible reality is drawn in a different way, and it may therefore be objected that our second common trait is no more than a superficial resemblance in terminology. Yet, however it may be evaluated, the resemblance is there; it can be found in the works of Indian and Chinese philosophers, who have not been bewitched by the powerful magic of Plato's style, and also in the philosophical utterances of modern physicists, who are certainly not Plato's disciples, though subject to his influence, like all other men of western civilization.

Third, in Plato's writings there is the suggestion that there can be no finally satisfactory account of the system of the sciences which does not connect all reality with the Form of the Good by showing why it is best that things should be as they are. In the *Republic* he makes Socrates assert that the Form of the Good is the source both of being and of intelligibility. Almost certainly Plato did not wish to identify it with the god of whom he speaks in other places; but his language in this passage is like that of theists, and the intellectual satisfaction which he promises is like that which many later philosophers have hoped to furnish by relating all things to God. In Plato's argument the study which enables certain carefully selected guardians of his state to understand the system of "forms" by relating each to the Form of the Good is supposed to be also of the greatest practical importance because it enables the guardians to discern the best way of life for men and so to guide their fellow citizens aright; and again similar claims have been made by many later philosophers on behalf of their study. When men speak of a philosophy, they commonly mean a very general account of things which is likely to affect the outlook or emotional attitude of those who accept it (*e.g.*, by making them more contented or more confident) and also possibly to influence their conduct by making them prefer some course that they might otherwise have found uninteresting or even distasteful. In the West such claims have most often been made on behalf of systems which are in some way descended from Plato's, but talk of philosophy as a world view which affects practical life is to be found also among thinkers whom Plato would condemn as heretics (*e.g.*, among materialists of the Marxist persuasion). Nor is this surprising, since to most persons of any education "philosophy" still suggests the pursuit of wisdom.

Fourth, the intellectual insight of the philosopher-guardians in Plato's *Republic* is supposed to be gained by practice of a special method called dialectic. If we may judge by etymology, this word originally meant the art of discussion, but it was used by Zeno of Elea as a name for his own technique of establishing a conclusion by showing that the opposite thesis, put forward by a critic, led to self-contradiction. One of the difficulties in the interpretation of Plato's account of philosophy is to know whether he fully accepted Zeno's account of philosophical method and, if so, how in detail he thought this would help him to carry out his program. There is a less strict sense in which Socrates might be said to have practised dialectic when he asked his companions for definitions and then tested their suggestions for consistence with ordinary usage. In Aristotle's works an argument is called dialectical when it proceeds from commonly received opinions as distinct from premisses already known to be necessarily true. In later times, for example among the Stoics and again in the Middle Ages, the word "dialectic" was often used as a general name for logic; and later still it was applied by Hegel and Marx to a special pattern of development by thesis, antithesis and synthesis which they supposed to be characteristic of philosophical thought. Clearly there is room here for a great deal of misunderstanding, and we may suspect without much uncharitableness that a great deal of misunderstanding and muddle has in fact occurred. But it is safe to say that when philosophical method has been explicitly distinguished from the method of other studies it has commonly been held to consist in the clarification of concepts by a technique like Zeno's *reductio ad absurdum*.

"Natural Philosophy" and "Moral Philosophy."—Here, then, in Plato's work we can find four marks of that kind of thought which we in retrospect call philosophical. But it was a long time before the name "philosophy" came to be restricted in ordinary usage to such thought. In the work of Aristotle and his successors for many centuries it still covers all that now would be called science. When he required a name for the Platonic study, including his own criticism of Plato's theses, Aristotle called it "first philosophy"; but the collection of treatises which he wrote about it came to be called the *Metaphysics*, because it was placed "after the *Physics*" (*meta ta physika*) in the ordering of his works by his pupils. His other works were treatises on logic (though not under that name), physics, botany, animal anatomy and physiology, psychology, ethics, politics, rhetoric and poetics. For many centuries to come these treatises were regarded as sections in an encyclopaedia of philosophy; and, long after their authority had been attacked by thinkers of the Renaissance, the subjects of which they treated were still described as parts of philosophy. Apparently this usage continued in England when it had become obsolete in some other countries; at the beginning of the 19th century Hegel found it curious that opticians and the like should advertise themselves in English learned periodicals as "philosophical instrument makers." And even now there are survivals of the usage in the titles of certain old foundations: the *Philosophical Transactions* contain papers of all sorts submitted to the Royal Society; and there are professors of "natural philosophy" who are engaged in nuclear research.

When the term "natural philosophy," which is a rendering of Aristotle's "physics," was appropriated in the 17th century to the new natural science of Galileo and Newton, it became customary to use the phrase "moral philosophy" to cover not only the field of Aristotle's "ethics" and "politics" but also psychology and all the other traditional parts of philosophy except logic. When he published his first work in 1739, David Hume called it *A Treatise of Human Nature, Being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects*. Except in such survivals as the name of the Moral Science faculty at Cambridge, the usage has now disappeared, but the explanation of its origin throws light on the development of men's conception of philosophy.

After the time of Aristotle, observational science was continued for a time in the Museum of Alexandria and in some of the medical schools, but it ceased to have any place in the curriculums of the philosophical colleges which existed side by side in Athens until the time of Justinian I. It is true that the Stoics and the Epicureans talked much of physics in their courses of instruction;

but they meant by "physics" speculative systems of cosmology not subject to empirical test, and the philosophers of each school valued their own system chiefly for the bearing that they thought it to have on the way in which men should think of themselves and of their destiny. Thus universal determinism was an important doctrine for the Stoics because it suggested to them an attitude of religious resignation such as that found in Cleanthes' *Hymn to Zeus;* and atomism (which was later to inspire great scientific discoveries) found favour with Epicureans such as Lucretius because it could be made to furnish arguments against superstition. When a young man of Cicero's age went to study philosophy in Athens, the lectures that he heard consisted mostly of arguments for a certain way of life. No intelligent man could find a sufficient guide in the public religion of the time, and an interest in philosophy was not a sign that a man was more unsettled than his neighbours but rather a sign that he was more serious. All the schools preached imperturbability (*i.e.*, the calm which we still call philosophical), but they differed in the accounts which they gave of the good life; and so it was, for example, no accident that under the Roman empire many great servants of the state belonged to the Stoic school.

The idea of philosophy which educated men of the 17th and 18th centuries got from their classical reading was that of a study concerned before all else with ends and duties; it was therefore not surprising that they called it moral philosophy when they wished to distinguish it from the new experimental science, then called natural philosophy. If they had read the works of the medieval schoolmen, they might perhaps have come to think of philosophy as something more ambitious; but they had no taste for the metaphysical subtleties of St. Thomas Aquinas or of Duns Scotus. Moreover, apart from all literary influences, there was a special reason why they should be interested at this time in moral philosophy. According to the new physics, nature was like a vast machine and all its parts, including living bodies, like smaller machines. If this was correct, how could men be held responsible for their behaviour? How indeed could purposive action of any kind be explained? Stoics and Epicureans had both said that all things were corporeal, but in their time such a declaration meant little more than a rejection of Platonism, because their natural philosophy was vague and undeveloped. Having said that souls consisted of a special sort of matter, they had been content to go on talking about their thoughts and actions in the usual way. Now such talk seemed silly, because men had come to think of matter as that which obeyed the laws of mechanics and this conception left no room for spiritual attributes. At this time there was therefore a great need for some account of human life which would show how talk of purpose and responsibility could be reconciled with talk of mechanical regularity, and the attempt to find such an account was not unreasonably called moral philosophy, though it included difficulties that had not worried the ancients.

Many of the books written to satisfy this need had titles such as *An Essay Concerning Human Understanding.* Sometimes the authors explained their choice by saying that they thought philosophy must begin with an examination of the faculties by which men acquire knowledge, but there were many who thought that a correct theory of knowledge would provide also an immediate solution of the problem about the status of minds and their connection with bodies. In their different ways Spinoza, Leibniz, Berkeley, Hume, Kant and Hegel all held this view of the task of philosophy. Dugald Stewart probably went too far when he wrote at the beginning of the 19th century for the *Encyclopædia Britannica* (8th ed., vol. i, p. 227) that a change in the pursuits of philosophers had so altered the meaning of the word "metaphysics" that it was now applicable to "all those inquiries, which have for their object to trace the various branches of human knowledge to their first principles in the constitution of our nature." But it is true that all philosophy other than natural science was thought to be concerned with the mind. If, as sometimes happened, the title "moral philosophy" seemed too narrow, it was replaced by the fuller phrase "mental and moral philosophy."

Philosophy Distinguished from the Special Sciences.—Since the middle of the 19th century it has become customary to describe physics, chemistry and biology as natural sciences rather than as branches of natural philosophy, and some parts of what was once called mental and moral philosophy have also attained independent status. Psychology, economics, comparative philology, social anthropology and the theory of political institutions are all now established as empirical sciences. We may hesitate to call them natural sciences, "nature" being still used in some contexts to make a contrast with "man"; but we no longer count them parts of philosophy, since they are now studied by specialists without regard to the other parts of the traditional field. In the 20th century even formal logic has become independent as the basic discipline of mathematics. What then is left for the philosopher? Only a study like that which Plato prescribed for his guardians, but one which is inevitably more complicated than his because of what has happened in the interval.

When we in our time say that philosophy is concerned with the relations of the sciences, we must take account of the distinction between the *a priori* and the empirical sciences and, within the latter group, of the distinctions between the physical, the biological and the psychological. None of these distinctions is wholly new, but none of them could worry the ancients as they worry us. Plato was content to say that the study of the sensible world never deserved the name of science, and even Aristotle, who was himself a good observer, had no clear conception of the inductive method by which the empirical sciences have advanced since the 17th century. There are also now difficulties of another kind that arise from the development of philosophy itself since antiquity. The demands that Plato and Aristotle hoped to satisfy seem to be natural in the sense that they arise whenever men think seriously about their situation; but it has been argued that some of them are misconceived, and that there must therefore be included within the scope of philosophy the question whether some parts of the traditional enterprise are possible. Discussion of this matter is not wholly new; it began with the skeptics of antiquity and was revived many times, notably by Hume and Kant in the 18th century. But it has become especially important in the 20th century when philosophy has been finally disentangled from the special sciences and criticism is more vehement than ever before.

No one wishes to deny that there are genuine problems about the relations of the sciences that can be solved only by hard thinking. The status of *a priori* truth in relation to empirical science—in particular, the problem of the foundation of mathematics—is obviously one such. Another that looks as though it could never be solved by empirical methods is that of the connection between mind and body. From time to time we may despair of our ability to answer these questions, because none of the suggestions that has been put forward seems satisfactory and we can think of nothing better; but to admit this is not to say that there are no such questions. Similarly, no one wishes to deny that the hard thinking required to solve philosophical problems must be dialectical in a large sense of that word; *i.e.*, not Hegelian or Marxian, but simply thinking in which we clarify concepts by exhibiting the relations between them and showing that denial of these relations would lead to absurdity. Many modern philosophers follow G. E. Moore in calling such thinking "analysis," and some use that word as a synonym for philosophy much as Plato used his word "dialectic."

There are advantages in the adoption of a new name for the philosophical method, since "dialectic" may lead to misunderstandings for the reason explained above. But "analysis" in its turn may introduce the misleading suggestion that it is the business of philosophers to find what Lord Russell once called logical atoms.

Positivist Criticism.—So far there is no radical departure from the Platonic tradition. On the other hand, there has been strong opposition in the 20th century to all talk of a distinction between appearance and reality (in any but the common-sense way in which it may be said that someone appears bad-tempered but is really quite amiable) and to all talk of justifying a religious outlook by proving something about the world as a whole (as, for example, that it was created by a benevolent God or that it will inevitably evolve toward some highly desirable consummation such

as a classless and stateless society). The writers who are most active in this opposition sometimes call themselves positivists; but unlike Auguste Comte, who invented the name, or Kant, who preceded Comte in rejection of transcendent metaphysics, they do not base their case on the supposed difficulty or impossibility of getting any knowledge about objects that cannot be investigated by the methods of the positive sciences. Their thesis is more like the contention of Hume that it makes no sense to speak of such objects, but is based on considerations about language derived in large part from Ludwig Wittgenstein.

At first the philosophers of this modern positivist school maintained that no utterance in statement form could be literally significant unless it was either (*a*) a tautology, interesting only as an expression of conventions for the use of words, or (*b*) verifiable in experience. According to one epigrammatic formulation of their view, the meaning of a statement is the method of its verification. Taken strictly, this thesis commits the holder not only to phenomenalism (*i.e.*, to the doctrine that statements about material objects are reducible to statements about the sense experiences to be expected in various conditions) but also to solipsism (*i.e.*, to denial of the existence of other minds) and even to the assertion that statements about the past are meaningless unless they can be taken as predictions of the experiences which would be said to establish their truth. Phenomenalism was once favoured by many philosophers, in particular by positivists like Ernst Mach who disliked talk of imperceptible physical objects such as atoms; but solipsism is a doctrine that no one outside a lunatic asylum can find congenial, and the reduction of statements about the past to statements about the future is plainly absurd. There have therefore been various attempts to avoid these unpleasant consequences; it was argued by some enthusiasts, for example, that the really important task for a positivist philosopher is to show the possibility of the unification of science by the formulation of all significant statements in the language of physics. Whether this thesis about the sufficiency of the language of physics is true or false (and it seems to be false), it clearly involves a large departure from primitive positivism, since modern physics is full of statements about objects that are essentially imperceptible.

When theoretical physicists constantly make successful use of hypotheses about electrons that are much further from the realm of common sense than any speculations of St. Thomas about the behaviour of angels, even those who pride themselves most on the hardness of their heads must allow that there can be no objection in principle to talk of nonsensible objects. But critics of traditional philosophy may still argue with justice that it is powerless to prove all those propositions about suprasensible objects which have been asserted by philosophers in the past; for instance, such propositions as that the world was created by a benevolent God or that souls survive the death of their bodies. For the special method of philosophy is dialectical analysis, and it is evident (or can be made so without much difficulty) that a proof of such a proposition cannot be merely the clarification of a concept.

In the past there has been some confusion about this because different kinds of inquiry have not been distinguished clearly one from another. Thus the proposition that there is a God has been taken by most people to be one that can receive empirical confirmation (*e.g.*, from events that look like answers to prayers), and philosophers who have tried to prove it have usually made some appeal to empirical evidence. But this same proposition has also been treated by some philosophers as one that cannot be weakened empirically (*e.g.*, by the *absence* of events that look like answers to prayers). The two views are incompatible, since no hypothesis can receive confirmation from experience unless it is also at least open to infirmation by experience. Another example of such confusion is to be found in the Marxist account of the evolution of society. According to its supporters, this is not only a scientific theory, well supported by historical evidence and useful for the making of predictions, but also a metaphysical principle that could never be thrown into doubt by the failure of the predictions which enthusiasts professed to have derived from it.

Since the peculiarity of such theses was first noticed it has sometimes been suggested that it is characteristic of metaphysics to present as *a priori* truths propositions which could be established, if at all, only empirically. This is an unfortunate generalization (or, on another interpretation, an unfortunate proposal for a definition), because the work of Aristotle called *Metaphysics* contains only one book to which the criticism applies. For the most part he and his followers have discussed under this title such questions as the status of universals, the existence of substances (or basic entities) and the nature of causation: in short, problems that can be solved only by dialectical analysis, since they arise from puzzlement about concepts.

Clarification and Discovery.—In an account of the task of philosophy in the 20th century it is not necessary to strike out Plato's suggestion that dialectic will lead to knowledge of the nonsensible; for even positivistic philosophy is concerned with abstractions. But it must be appreciated that this study is something quite different from the concern with nonsensible objects noted in theology or in modern physics. Whereas the theologian and the physicist both profess to give us information of which we should otherwise have no inkling, the philosopher, whose work is clarification, not discovery, can only set the familiar in a new light. As Socrates said, the answers to the questions which he asks must be known already in some fashion, though never before explicitly formulated. Admittedly, philosophers in all ages have discussed questions about the existence of God and the survival of human souls, and many have professed to give proofs or disproofs of these theses. But this is not surprising; for such inquiries are closely connected with the conceptual inquiries of the philosopher. If, for example, the immortality of the individual soul were proved empirically, we should say that the conclusion was of philosophical interest, not only because it has in the past interested some persons called philosophers, but also because the settlement of the question would involve the drawing of conceptual boundaries in a field which has so far been mapped only with dotted lines and pictures of monsters.

It may perhaps be thought curious that empirical discoveries should have any bearing on conceptual inquiries; for we have an inclination to say that all questions about meaning must be settled before any questions about fact can be raised. But this is a mistake. In ordinary language, as distinct from the language of a strictly axiomatized system such as geometry, the boundaries of the applicability of words are not drawn in advance of all applications; on the contrary, such rules as exist are established by usage, and it is often quite easy to think of circumstances for which there is as yet no rule. When the need arises, a rule is established by the adoption of some analogy which seems decisive at the time, and from then on the language is more determinate than it was before.

"Soul," which is the key word of the example, does not occur in ordinary talk, except in such phrases as "the life and soul of the party." It has, indeed, a usage in religious contexts, but this depends on assertions that have not been verified in a fashion generally acceptable to scientists or even developed imaginatively to any satisfying degree of detail. We are therefore unable to understand exactly what we are asked to believe. Sometimes it seems relatively easy to imagine situations in which we should feel constrained to say that the survival of a soul had been proved; but at other times the supposition seems senseless, because personal identity is connected so intimately with bodily continuity that no incidents of the kind described by spiritualists could ever satisfy us. Getting messages through a medium from a dead man would undoubtedly be something like getting messages through the post from an absent friend; and, if the latter is to be taken as evidence of personal survival, why, it may be asked, should not the former also? On the other hand, the survival of a friend who sends messages through the post cannot consist solely in our receipt of the letters; we must assume that he wrote the letters and dispatched them. Do we know even in outline what it means to say that the soul of a dead man has sent a message through a medium? And if not, what is the use of making the remark? The bewilderment which these reflections produce is a sign of the incompleteness of our intellectual map; but the recognition of that incompleteness is itself a philosophical achievement. In ordinary

life continuity of memory and bodily continuity are both used as criteria of personal identity. Often one is used without the other, but only because they always give the same result when they can be applied together; and so our present use of the word "person" is tied to both, though we might come to use the word differently if the normal association of phenomena were not maintained.

Philosophy and Language.—In the latest phase of the philosophical movement started by Wittgenstein there is no longer any attempt to formulate a general principle for distinguishing between sense and nonsense, not because the supporters of the movement are less critical of the utterances of older philosophers but because they have come to appreciate that language is much more complicated than they once supposed and may therefore "go wrong" in very many different ways. According to this view, ordinary language—that is, the language in which men conduct their practical affairs—is part of the way of life to which it belongs, and all philosophical troubles arise from perversion of it. Words and phrases have meaning not necessarily by standing for things, as proper names may be said to do, but by having a customary use in communication. So long as speakers observe the customs, what they say must at least make sense, though it may of course be unfortunate in various ways. If, however, speakers depart from ordinary usage and introduce novelty, there is always a danger of their talking nonsense, even though the novelty has been suggested by an analogy with something in ordinary usage. Bad philosophy is the theorizing which arises in such situations, and good philosophy consists in making clear the conventions that have been violated. When we are caught by bad philosophy, we are like flies trapped in a bottle; we buzz about continually, hurting ourselves against invisible barriers, unless we are clever and patient enough to crawl out slowly by the way by which we came in. In short, good philosophy is just liberation from bad philosophy, and its method is a therapeutic technique something like that of psychoanalysis.

It is not difficult to find examples of bad argument into which great philosophers have been led by false linguistic analogies. One about which there is no longer any serious dispute is the ontological argument for the existence of God. According to this, God must exist, because we mean by "God" a being such that nothing more perfect could be conceived, and there would therefore be a self-contradiction in saying that God does not exist. The reasoning is obviously based on the assumption that the word "exists" may be said to ascribe a perfection; that is, a character for the possession of which a thing is to be praised. But the word "exists" is not in fact used to ascribe a character to things. When we say that a so-and-so exists, we mean that something is a so-and-so; *i.e.*, we assert a proposition which is entailed by every proposition to the effect that a particular thing is a so-and-so. Before Wittgenstein wrote, this truth had already come to be generally accepted as a notable result of analysis in the philosophy of logic, and so there is here a clear case in which good and bad philosophy are related according to the account given above. It would be a serious mistake, however, to suppose that the history of philosophy is nothing but a succession of linguistic muddles. Even the debate about the ontological argument has an interest that is not explained by this description. In a society whose language did not allow for an assertion of existence by any such formula as "God exists" or "God is," the argument could never have occurred to anyone; but what made it seem plausible to Anselm and to a number of very intelligent men after him was something in their religious attitude. They used the word "God" to refer to the object on which that attitude could be appropriately directed, and it seemed to them plainly absurd to say that God's existence was contingent; *i.e.*, that there might have been no God. Now the fact that men have a disposition to take up a certain attitude furnishes no proof of the existence of anything that would be an appropriate object of that attitude; and it might be contended that our ancestors fell into a new and even more serious mistake when they passed from polytheism, with its stories of the birth of the gods, to monotheism, with its assertion of the absolute independence of God. But if there was any such mistake, it occurred long before anyone thought of the ontological argument, and there can be no satisfactory philosophy of religion which ignores this fact.

So too in other fields of philosophy, linguistic confusions when they occur are only incidental to larger problems that cannot be posed or solved without reference to the progress of the special sciences. Men do indeed misuse their language from time to time, but when such misuse has a philosophical interest it is a symptom rather than a cause of intellectual malaise. The patient who has brought himself to a metaphysical neurosis by a purely grammatical eccentricity does not exist outside the imagination of the would-be therapist. Nor is it much better to say, as some modern philosophers do, that all philosophical questions are concerned with "logical grammar." For if "logical" is to be taken in its usual sense (*i.e.*, as signifying connection with the science of logic), the statement is false; and no one has explained any other sense for the word that allows the statement to be both true and useful.

Relation of Philosophy to the Sciences.—The chief point of interest that has emerged from modern attempts to characterize philosophy is the importance of distinguishing dialectical or analytical inquiries about meaning from empirical inquiries about fact. Recognition of this should produce a becoming modesty in those who profess philosophy, but it should not make them abandon the Platonic ideal of a study that is synoptic, gives mastery of abstractions and leads to wisdom of attitude. By continuing to make the last of these traditional claims they do not commit themselves in advance to support of any religious system but simply undertake to present things in such a light that men's feelings may be reasonably grounded. The need for this is especially obvious in moral philosophy, since persons who are conceptually muddled often manifest great moral earnestness in defense of positions that are quite irrelevant to morality. But the need remains the same in all philosophical inquiries, including even discussions of the foundations of mathematics. For it is obvious to a careful observer that persons who put forward theses about the nature of mathematics are emotionally involved, and while it must be supposed that some of them are just confused, it must also be allowed that a certain attitude may perhaps be a necessary condition for the making of discoveries. Thus it can scarcely be an accident that no great mathematician has ever accepted the conventionalist view according to which mathematical truths are man-made.

It follows from the account of philosophy given here that it is impossible to summarize its results in the way appropriate to an article on any of the special sciences. The results of the philosophical work that has been done in the past are to be found in the present organization of studies. It cannot, indeed, be claimed yet that there is a single, coherent world view; but apart from the observations and hypotheses of scientists, there are some pieces of conceptual framework about which there is no serious disagreement among educated men. These are the principles used for the classification of studies in the universities and in encyclopaedias. In order to convince himself of their philosophical character the reader need only contrast, say, the *Encyclopædia Britannica* with Pliny's *Natural History* and notice that the intellectual progress of the intervening 2,000 years has involved a clarification of ideas of explanation as well as an accumulation of discoveries. If anyone claims that the clarification of ideas was incidental to the development of the special sciences, we can agree without difficulty; for the distinction made here between clarification and discovery is not supposed to be a division of labour among different faculties.

Organization of Philosophical Studies.—There must nevertheless be some division of academic labour in the modern world, since it is no longer possible for any one man to be a leader in all branches of learning. Perhaps Leibniz, who died in 1716, was the last universal scholar, and his life is a warning rather than an example. In this situation the teaching of philosophy is more difficult than ever before, but also more important. Since no one can hope to contribute much to the clarification of ideas in mathematics who is not himself a mathematician, or to the clarification of ideas in physics who is not himself a physicist, and so on throughout the table of the sciences, it seems inevitable that there should be evolved a number of philosophical disciplines corre-

sponding to the various branches of study whose concepts need investigation. We have philosophy of mathematics (or the theory of foundations), philosophy of physics (including cosmology), philosophy of history (no longer understood in the Hegelian sense as the setting out of a plan to be realized by events, but consisting in a study of historical ideas and methods), philosophy of law (or jurisprudence), philosophy of criticism (or aesthetics), philosophy of language and philosophy of religion. We may expect to hear also of philosophy of biology and philosophy of psychology. Whereas previously many scientists were frightened by talk of philosophy (and not without reason, since professional philosophers were sometimes obscurantists who opposed the growth of new studies), it seems now to be admitted that discussion of the philosophy of his subject (preferably in connection with its history) may be a useful part of the education of a future specialist.

Although some philosophical studies can be distributed among the various faculties of a university in the way suggested, there are others, including some of the most important, that cannot be associated with any specialism because the ideas with which they deal are common to all studies or not involved in any.

First there is epistemology, or the theory of knowledge and its relation to experience, to belief and to language. For Plato this was already an important philosophical inquiry, and in the 17th century it came to be regarded as the necessary preliminary to all other philosophical studies. The reasons for which epistemology obtained this primacy may have been bad; but if philosophy is the dialectical clarification of concepts, it may reasonably be expected to include some explanation of the need for such clarification, and the explanation should come early in a systematic course of study. At the beginning we need some examples of philosophical work taken from one of the special branches of philosophy mentioned above; but when we have learned to distinguish this kind of inquiry from others, we can profitably investigate the nature of the thinking that gives rise to it. This leads on naturally to a philosophical inquiry about the status of minds in the world.

Next there is metaphysics. Here belong not only the task of clarifying very general notions, such as those of substance and causality, but also attempts to throw light on the relations of the sciences (in particular of physics and psychology) by philosophical method. System building has led to so many failures in the past that it must always be regarded with caution; yet it is important that the project should never be wholly abandoned by academic persons. For if academic persons behave as though they had no interest in the intellectual questions that seem most important to other men, the gap that they leave will soon be filled by others less qualified. By the study and transmission of the history of thought academic persons can at least make it possible for men to see modern difficulties in perspective, and if the difficulties are of a sort to be solved by philosophical analysis, this is some contribution toward a solution.

Third there is ethics, or the philosophy of moral judgment. This cannot be assigned to any specialism other than philosophy itself, because moral judgment is not an activity for experts but something in which we are all authorities. In the past the teaching of ethics has often been confused with casuistry (*i.e.*, the attempt to set out a detailed moral code by the compilation of moral judgments on situations of all possible varieties) or with exhortations to virtue. Like all other branches of philosophy, ethics is in fact a theoretical study in which we try to clarify concepts. If it has more immediate practical importance than any of the others, that is because muddles about the fundamental notions of morality can have serious consequences in human action.

See also references under "Philosophy" in the Index.

(W. C. K.)

PHILOSOPHY, HISTORY OF. Separate histories of the numerous philosophical schools, surveys of the development of separate disciplines such as logic and ethics, accounts of the central problems such as skepticism, and, finally, studies of individual philosophers appear under appropriate headings throughout this encyclopaedia. Here we shall attempt to give a more comprehensive view of the history of Western philosophy from ancient Greece onward and to show the succession of the various schools of thought and their reaction in response to criticism from one another.

This article is composed of sections as follows:

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  1. Pre-Socratic Philosophy
  2. From Socrates to Aristotle
  3. From Aristotle to the 1st Century A.D.
  4. Later Greek Philosophy
II. Patristic and Medieval Philosophy
  1. Patristic Philosophy
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  7. Empiricism, Logical Analysis, and Linguistic Philosophy

I. ANCIENT PHILOSOPHY

The name "philosophy" is itself Greek, and ancient philosophy will, in the survey which follows, be understood to be limited to the philosophy of the Greeks, with its continuation during the Roman period down to the reign of Justinian I. Such a restriction sounds at first arbitrary but is perhaps justified by these considerations. The contact of the Greeks with foreign religion and ideas was only spasmodic. The mythologies of Babylonia and of Egypt, within which the germ of science was included, were not without influence upon the earliest Greek thought. Later, the Platonic Academy (4th century B.C.) showed knowledge of and interest in the dualistic religion of Persia. Some scholars think that there are traces of oriental influence in the system of Plotinus, though others again assert its wholly Greek character. Alexandria, in any case, was a centre In which Jewish and Greek ideas came together. Yet these influences are not close or continuous or certain enough to make it worth while to compare Greek and oriental philosophy in one survey, and it seems to have been always the Greek genius which converted mythology into science or philosophy as we should today understand them. The medieval thinkers, Arabic and Jewish as well as Latin, derived their view of the scope and problems and methods of philosophy from the Greeks. Chinese philosophy and Indian philosophy (*qq.v.*) must be considered quite separately.

In the development of ancient philosophy, four phases may conveniently be distinguished.

1. Those who belong to the first phase, commonly termed pre-Socratic, try to give a rational account of the origin and existing state of the world and the powers operative within it. Parmenides and the Eleatics, who directed their attention not to the physical world but to being in general, nevertheless come within this first phase; it was their historical function to show the complexity and difficulty of the concepts of change and movement; and by doing this they deflected for some time the course of physical inquiry, though they did not arrest it. The science of mathematics probably emerged during this first period.

2. A new phase opens when, in the 5th century B.C., moral and practical problems are brought to the front by Socrates and the Sophists. Socrates, however, did not urge men to desist from scientific inquiry (that is a false, though ancient, view of the part that he played) but, as will be explained, gave a new impulse to science itself. During this period, likewise under the impulse of Socrates, the question within what limits scientific knowledge is possible begins to be recognized as one of the problems of philosophy; and both logic and the theory of knowledge date from this time. Otherwise, the confident endeavour to gain the widest possible knowledge of nature, because of its intrinsic interest, goes forward. Aristotle and his immediate successors may in this way be considered the latest representatives of a movement having its centre at Athens and initiated by Socrates and the Sophists.

3. A third phase extends from the early 3rd century B.C. to the

1st century A.D. With the decline of the self-governing city-state, social conditions were transformed and at the same time the speculative spirit was beginning to grow weary. There now appeared rival systems of "philosophy," which agreed in offering such a world picture as might bring peace of mind to the individual, however little favoured by circumstances. Happiness was no longer associated with political exertion. The disinterested pursuit of knowledge was no longer recognized as essential to philosophy, and ethics (in a practical sense) became its vital part. It is true, however, that the sciences were at this time beginning to flourish independently of philosophy.

4. Finally, from the 1st century A.D. onward, there is a revival of speculative confidence, accompanied by an intelligent and respectful interest in the classics of earlier philosophy.

1. Pre-Socratic Philosophy.—In the *Theogony* of Hesiod we have a description in epic style of the formation of the world from chaos, the emergence of several generations of gods, and the successive ages of man. These, with frank pessimism, are depicted as a decline from the Golden toward the Iron Age. This is already not far from philosophy, and the borderline will be crossed when the narrative form and the reference to personal agents are abandoned, when prose is employed instead of poetry, and when a system resting on rational deduction and to some extent on observation is put forward. In the 6th century B.C. these conditions are fulfilled in men who flourished at Miletus and elsewhere on the Greek fringe of Asia Minor. These thinkers all deal with the development of a varied world out of one basic substance (not yet called by that name). This is not supposed to be lifeless, but rather endowed with some intrinsic power of development. As for the law by which development is governed, Anaximander holds that there is a "justice" in the cosmos whereby each particular substance, having exceeded its bounds for a time, must pay recompense to others. It appears also that, in accordance with this law, the cosmos will at fixed intervals be dissolved to allow chaos to resume its rights. Anaximenes, somewhat later, introduces the influential idea that it is by a process of contraction and expansion that the one substance appears as many.

The use of systematic observation by these thinkers is at best occasional, they assume no necessary sequence of cause and effect, and their thought has many archaic features. They regard the world as "divine" and do not seem to see themselves as antagonists of the traditional religion. They come to fulfill, rather than to destroy. In Xenophanes of Colophon, however, we find a hard-hitting critic of the theology handed down from Homer and Hesiod. He seems to have asserted the unity and omnipresence of God; and he is ranked by Plato and Aristotle as a precursor of Parmenides.

In such cosmogonies as those of Hesiod and Anaximander, one basic entity is supposed to grow into many and to become possessed of diverse qualities. Parmenides, by an analysis of the idea of "being" itself, arrives at the view that this change is impossible. He returns to the poetical form of exposition and gives two alternative and, in his opinion, discontinuous accounts of the world. The first is an account of reality, which, as it is based on reason alone, is true. The second is a description of appearance and takes the form of a cosmogony not unlike those which previous thinkers had offered. Only at this level are qualitative change and movement admitted. "Being" itself must be perfectly homogeneous, immune from change, and timeless; *i.e.*, beyond any distinction of past, present, and future. Being cannot have an origin, for this would have to be "not-being," which is unnameable and inconceivable. The being of Parmenides is not personified; and though a theology could be founded on his deduction, his own use of it is purely logical.

At this point some mention must be made of Heraclitus and of Pythagoras and his early followers, whose systems have always been supposed to precede Parmenides' but are only to be understood, according to the more probable view of Karl Reinhardt, as a later response to his thought. Heraclitus replies that the tension between opposites, governed by a rational principle which holds them in balance, is the key to an understanding of the world. (It seems to have been the self-styled Heracliteans of a later day who developed this into a belief in universal change, involving the consequence that all judgment is relative and science impossible. From such a conclusion Heraclitus was held back by his insistence that "measure" and "logos" [= reason] remain firm in a changing world.) As for Pythagoreanism, it seems to have been, in its first form, a system whereby the series of numbers was made to evolve from more abstract principles and the sensible world was in turn derived from number.

Whatever may be the relation between Parmenides and these two movements, the effect of his argument upon subsequent philosophy, for a long time to come, was decisive. No one was able to question this reasoning, which seemed to show the need for a persistent substance; but no one could resign himself to the belief that a moving, physical world is forever beyond the range of rational explanation. Systems therefore now arose in which, in deference to Parmenides, qualitative change was abandoned, but plurality and local movement were retained. This is the procedure of Empedocles, of Anaxagoras, and of the first atomists, Leucippus and Democritus. There are important differences between these systems. The Parmenidean attack on "not-being" involved the denial of empty space or void, and in this both Anaxagoras and Empedocles concurred, professing to be able to explain movement without such an assumption. The atomists, being persuaded that the void was really essential to the possibility of movement, sought to establish its existence both experimentally and by reasoning. Again, Anaxagoras in contrast with the atomists boldly accepted the view that matter is infinitely subdivisible, precisely as abstract extension is. Moreover, Anaxagoras and Empedocles raised two new questions and gave contrasted answers to them: how does movement first originate? and what is the cause of structures and processes which seem to be purposive in character, especially in the plant and animal world? Greek philosophy was now passing beyond the belief that the power of movement might be assumed as a datum in the original substance.

Apart from such indirect influence, Parmenides also had followers of his own, Zeno of Elea, Melissus, and the rhetorician Gorgias. Zeno of Elea is responsible for a modification of the Eleatic thesis, inasmuch as he starts not, as Parmenides did, from "being" but from "the one." For Parmenides, unity was rather the first attribute of being. Zeno shows that plurality in any form, including the abstract units demanded by the arithmetician, is monstrous and inconceivable. His famous paradoxes about movement, reported by Aristotle in the *Physics*, have a similar purpose. In Zeno and Gorgias, the dialectical technique which Parmenides had adopted with a metaphysical purpose in view has obviously become an end in itself; the latter should probably be regarded as a critic, not as a follower, of Parmenides. (*See* also articles ELEATIC SCHOOL; and IONIAN SCHOOL OF PHILOSOPHY.)

2. From Socrates to Aristotle.—There is a change of atmosphere during the second half of the 5th century B.C., and the principal scene of events during this and the following century is not Ionia or Italy but Athens.

Socrates.—There were two sides to the change of atmosphere. On the one hand, there was a general tendency to turn from natural science and speculative cosmology toward human affairs and practical problems. Socrates (*c.* 470–399 B.C.) certainly pointed out this road (*see* Plato, *Phaedrus*, 229e–230d); and in this he was assisted or preceded by the older Sophists, such as Protagoras, who made it their business to provide an intellectual training for the man of action in the democratically governed Greek states. On the other hand, there was the aspect in which Socrates alone was the innovator: it was his mission to propound basic questions hitherto overlooked, both in the sphere of physics and in that of ethics, and thereby to expose latent dogmatism and to make his contemporaries aware, for the first time, of problems concerning philosophical and scientific method; and here the Sophists were no longer the allies of Socrates but his opponents. His classic debate with them, recorded in several of Plato's earlier dialogues, turns on the questions whether moral virtue can be taught and whether there is one form of moral goodness or several; and the Sophist professes to *know* the answer to these questions, while Socrates does not. Hence the difficulty of deciding whether to

range the Sophists together with Socrates or in the earlier period.

The former aspect of Socrates' work is well enough expressed in the aphorisms which Cicero derived from his Greek teachers; namely, that he brought philosophy down from heaven to earth, introduced it into the cities and houses, and made it inquire into manners and morals. Yet if this were all, he would have been only one moralist among others, and full justice is not done to his achievement unless he is viewed as an innovator in the sphere of method, who opened up new possibilities to physical science itself and posed new problems to the philosophers. He was no despiser of physical science and did not wish to make other men desist from it as fruitless or impossible. He himself had soon abandoned it, but only in order to raise problems which were not without a bearing on its future progress. The earlier physicists had emphasized matter at the expense of form, and the Sophistic contemporaries who shared his interest in practical questions were more concerned with describing the moral qualities than with defining them. He inferred, apparently from the example of the practical arts, that the great test of knowledge is the ability to state what a thing *is*, what is the unvarying essence which a word, if rightly used, denotes. His persistence in posing this question and subjecting others to cross-examination led, in due course, to the discipline which came to be known as logic; and another offshoot of the same demand for a definition of moral ideals was the Platonic doctrine of transcendent ideas or forms (*see* FORM).

This view, whereby Socrates is an important figure within the progress of science, is stressed by Plato, in the *Phaedo*, and by Aristotle, in the *Metaphysics*, both of whom would claim to be following in the Socratic tradition. (*See* further ETHICS, HISTORY OF; LOGIC, HISTORY OF; SOCRATES; SOPHISTS. The first two of these articles are relevant also for all that follows.)

Cynics, Cyrenaics, and Megarians.—Plato was only one of several writers who commemorated Socrates, and various schools were commonly supposed to be affiliated to him. Antisthenes seems to have held up for admiration the physical sturdiness of Socrates, his self-control, and his contempt for worldly goods; he declared himself an enemy to pleasure, and he opposed the Platonic doctrine of ideas (presumably in what he thought to be the true spirit of Socrates). From him, through Diogenes of Sinope, descend the Cynics, preachers and moralists contemptuous of all conventions, who reappear in one guise or another on several occasions in the Hellenistic and Roman periods. On the other hand, the Cyrenaics, who considered that pleasure in itself is good and pain evil, were affiliated to Socrates through Aristippus; such a thesis is, in fact, maintained by Socrates in Plato's dialogue *Protagoras*. Another member of the Socratic circle founded a school which lasted for several generations; this was Euclid of Megara (*see* also MEGARIAN SCHOOL OF PHILOSOPHY). He upheld the Socratic procedure of teaching by dialogue and, like Socrates, had a moral and practical purpose. In other respects his doctrine owed something to the Eleatics. Later there was some hostility between his followers and Plato's, and the Megarian school became a nursery of dialecticians.

Plato.—Whereas the sources for all the doctrines mentioned above are fragmentary, the entire writings of Plato (428/427–348/347 B.C.) are extant and there is even, from Aristotle and Theophrastus, some indication of his unwritten teaching. Plato remains faithful to the dialogue form, and, until a late stage in his career as a writer, uses Socrates as the principal interrogator; but Socrates then subsides into a listener's role, other speakers come to the front, and Plato begins to define his position with reference to the older systems—to Parmenides, to Heraclitus, to Pythagoras, and their surviving representatives. The subjects treated are: the nature of the soul and of causation; the presence of design in the physical world; "being" and its various senses; human knowledge and the relation between thought and sense perception and language. It is convenient here to concentrate upon the first two of these. The doctrine of the *Phaedo* is that the soul is akin to the permanent and invisible, the body to the changing and perceptible. The nature of this affinity was not, at that time, further explored (the soul is never declared to be a "form"); but, together with other arguments, Socrates says that it is enough to give us confidence that the soul will survive the body. The soul is not, at this stage, regarded as a source of change but rather as a perfectly unchanging being. In the *Theaetetus*, Plato demonstrates that the senses alone can present only a series of changing impressions. They cannot even relate these to one another, still less convey knowledge of forms which have no sensible counterpart. In the *Phaedrus* and in the *Laws*, he develops a new doctrine of the soul which is also a theology (since God is a perfect soul). The soul is by its essence a self-motion, the source of every movement which bodies display. Bodies, once they have received movement from soul, can impart it to one another; but there is no movement not initiated by soul. This does not mean that the soul is in space, for the primary movement with which soul stirs itself is that of reflection or foresight, and the physical movement is secondary.

There are, however, random and irregular movements in the cosmos; and it is only soul with mind or reason (*nous*) inherent in it which can impart regular movement. The word *nous* has a complex previous history. Plato tells us repeatedly that *nous* cannot exist alone, that it must inhere in a soul (*Sophistes, Philebus*, and *Timaeus*). The doctrines of forms and reminiscence (the argument of Plato's *Meno*, that knowledge is "recollection" of truths already known by the soul) do not seem to have been abandoned by Plato at the time when he was working out this later system; and presumably a soul with *nous*, or rational soul, would be one which is guided by steady intuition of the forms. Making the best use of the science available at the time, Plato undertakes to show, or rather says it can be shown, that the principal movements in the cosmos, including that of the sun and planets, are in fact perfectly regular. Given the principles that he has just stated, it follows that the world is controlled by divine beings, perfect souls to whom we are akin. He presents this teaching (*Laws*, books x and xii) as the exact reverse of what many persons, under the influence of the Sophists, were coming to believe. In the *Timaeus* there is an account of the origin of the world in which the following factors are involved: (1) the forms; (2) the "artificer," a personal agent who is guided by intuition of the forms and from whom regular movements in the physical world, as well as all adaptation of things to a purpose, are derived; (3) the world-soul, which is formed by the artificer and serves, as it were, as his representative; (4) the "receptacle," within which qualities or powers exist in shuffling disorder, until the artificer regulates them by measure and number. This last factor is identified with space, but also has some of the functions which in Aristotle's terminology belong to "matter." In view of later developments in theology, it is to be noticed that Plato's "artificer" is not the source of all reality and is not the creator, in the full sense, of either form or matter. Another important metaphysical distinction made in the later dialogues is that between "limit" and "the unlimited," two factors which combine to form a "mixture"; the mixture must have a "cause" and, where this cause is "reason," will be harmonious and durable. Here there is an even closer approach to the Aristotelian distinction of form and matter (*Philebus*, 23–26).

Aristotle.—According to Aristotle (384–322 B.C.) there are four factors in every process of causation, whether natural or artificial: form and matter, which never exist apart from one another, being correlative; the motive cause, from which the change immediately proceeds; and the end "for the sake of which" the process occurs. This analysis is meant to be applied not only to physical change but also to such processes as teaching a science or imparting moral discipline to a child. The "matter" upon which form is imposed will in that case be the untrained capacities or emotions, and it is plain from this that the Aristotelian "matter" is quite different from what is so termed in modern physics. Another point to be noticed is that Aristotle is here distinguishing factors in causation rather than causes in the modern sense and that his "causes" may be contemporary with, or even subsequent to, the processes caused; *e.g.*, if a man walks for the sake of health, health is a "final cause."

Aristotle applied his analysis to the criticism of his predecessors, including Plato. For a long time, matter had been the only one of the causes to be recognized; subsequent thinkers had had a glimpse of the efficient and formal causes, but no one had yet suc-

ceeded in naming all four. No addition to the analysis was conceivable, and in this respect it was the completion of all previous thought, the goal to which others had struggled without clearly perceiving it. Plato is complimented by Aristotle for his clear recognition of the formal cause (and here Aristotle shows the genesis of his doctrine from Socrates and the Pythagoreans); moreover, in his physical doctrine and in his unwritten teaching, he recognizes the need for a material or nonformal factor; but he has failed to give any consistent account of efficient causation (Plato's derivation of movement from the soul is, apparently, viewed in this criticism not as a part of his regular doctrine, but as a tentative suggestion).

Aristotle's positive views grow naturally out of this criticism. By "movement" is meant a transition from a "potential" state to one of "actuality," and such transition will take place only under the influence of a subject which is itself actual and can bring out the potentiality in another ("movement" here has a wider sense than in modern usage and applies to all qualitative change, whether physical or not). Once the thing has reached maturity (a state for which Aristotle coins the term "entelechy"), it will from time to time, but not continuously, display its powers in action. This display of powers ("activity," or "energy") is not exactly "movement" in the sense above defined, for it is not the realization of something incomplete. An illustration may be drawn from the acquisition and use of scientific knowledge: a boy's power of learning is developed under the influence of a teacher, this transition corresponding to "movement"; but once he has acquired the scientific knowledge, it will be latent in him whenever it is not in actual use. Hence a new contrast between possession and use is, as it were, superimposed on that between the potential and the actual. We ourselves and the beings who surround us are complex and have to inhibit one activity in order to engage in another. Growth and change in the physical world are to be explained in analogous fashion.

This conceptual analysis is then applied by Aristotle in the following way. God alone is fully actual—a form without matter, who does not have to be raised from the potential to the actual state. His activity is the uncaused cause of all change; but he is its "final cause" or goal and he does not, as in the Platonic system, design the world. The efficient cause of change is "nature"; *i.e.*, an inherent impulse in things, both living and lifeless, leading them to develop their capacities and to make use of them when developed. The Platonic definition of soul as a self-moving agency is rejected on the ground that soul cannot participate, even incidentally, in movement; and instead, soul is regarded as the "form" proper to an organic body. Such a definition does not apply to God, who is incorporeal (and, perhaps, not to the human soul *qua* rational). God is therefore viewed not as a soul but as a mind engaged in unbroken reflective activity; and Plato's axiom that "mind" must always inhere in "soul" is also silently discarded.

This survey, concentrating on the theory of causation, will perhaps have shown why Aristotle is the parent of biological science and Plato rather of mathematical physics. (For other aspects of their thought, *see* the articles ARISTOTLE; ETHICS, HISTORY OF; LOGIC, HISTORY OF; PLATO.)

3. From Aristotle to the 1st Century A.D.—The years from approximately 310 B.C. to the 1st century A.D. form another distinct epoch. Philosophy was now regarded primarily as a way of life. Scientific knowledge was no longer pursued with enthusiasm by the philosopher as such; he valued it only insofar as it made clear the position of man in the world. This was an era of increasing specialization in scientific, historical, and philological studies. Because of the changed circumstances, the philosophical idea of the good life was no longer bound up with the city-state. Slavery persisted, but the division between Greek and barbarian began to break down, and men recognized one another as brothers, with one God for their parent, whether this view was developed by the Stoics or, as Sir W. W. Tarn maintained, by Alexander the Great himself.

Epicureans, Stoics, and Skeptics.—After the first generation, the schools of Plato and Aristotle themselves began to succumb to these dominant influences (*see* ACADEMY, GREEK; and PERIPATETICS). Among newer systems, that of Epicurus (341–270 B.C.) may be considered first. Epicurus held that the physical world came into being from the spontaneous downward movement of atoms in an infinite void and that nothing further is needed to explain its existing state. It is, however, destined to be destroyed; *i.e.*, not annihilated, but dissolved into its component atoms, which will then enter into fresh combinations. Similar worlds doubtless exist elsewhere and have existed in the past. The soul is material and is enclosed in the body, from which it will escape and be dispersed at death. The gods live at peace in the spaces between the worlds, which they did not organize and for which they assume no responsibility. For the demonstration of these truths physical science is essential; beyond this it becomes superfluous. The one criterion of truth, which cannot possibly be disputed, is sense perception. The wise man will live in prudent enjoyment of physical pleasures, free from all anxiety about the future life, unconcerned with fame and other dubious goods. He will, however, for this very purpose need to acquire justice and the other commonly recognized virtues. Epicurus showed, as no one before him had done, the happiness of an inner life which is available to all; and no doubt this was why he was hailed by his followers as a "saviour." But his theory of knowledge is weak (the "ultimates" in his system, the atoms and the void, lie beyond perception, which he says is the criterion of truth), and he frankly discouraged all innovation which would disturb the basis of the system.

Stoicism on the other hand was a more flexible system which could and did develop in response to circumstances or to effective criticism from without. For a general view of this system, *see* STOICS. The doctrine was first laid down by Zeno of Citium (*c.* 320–*c.* 250 B.C.) and reestablished with far greater precision by Chrysippus (*c.* 280–206 B.C.). The Stoic ethical system at this time was strange and uncompromising, oriental rather than Hellenic in character. In the 2nd century B.C. appeared Panaetius of Rhodes (born *c.* 180), who reinterpreted the psychology and ethics of the Stoa in such a way as to stress its close affinity with Platonism and the common descent of both doctrines from Socrates. Soon after this, Poseidonius (*c.* 135–*c.* 50 B.C.) gave a new form to the physical and theological doctrine inherited from the older Stoics. As a result of the work of these powerful thinkers, Stoicism secured a new lease on life and awakened great and enduring interest in Roman circles. But throughout the last two centuries B.C. the Stoics, as the most prominent dogmatic school, came under fire from skeptics of more than one variety. The skepticism of Pyrrho of Elis, though founded on epistemological arguments which he collected from earlier writers, was really a moral doctrine; he made "indifference" in face of all external circumstances into a cardinal principle of ethics (*see* SKEPTICISM). The skepticism of the Middle or New Academy, associated mainly with the name of Carneades, was of a more intellectual character and arose rather within the main Greek philosophical tradition.

Controversies of the Schools.—The history of the years from 200 to *c.* 50 B.C. is roughly, therefore, as follows. Epicureanism, always attractive, but not participating in any development, stood in the background. The leading dogmatic system (and the only one which, in the sphere of morals, could put forward ideas acceptable either to the Roman rulers or to their subjects) was Stoicism. And while the Stoics had appropriated the moral teaching of Plato (and probably some part of the system of Aristotle), the Academy, which had surrendered those doctrines, had become the focus of skepticism. In the 1st century B.C. there was, however, the attempt of Antiochus of Ascalon to revive the atmosphere of the "Old Academy" and to pretend that Zeno, in spite of the appearance of novelty which his terminology creates, contributed nothing new to the Platonic doctrine. The debates arising from this situation are reflected in the philosophical writings of Cicero (106–43 B.C.). Historians sometimes write of a specific phase of Eclecticism, which pieces together a system from previous systems. But if there ever was such a movement, Cicero at least ought not to be assigned to it. He is a consistent representative of the New Academy, wielding a method, but hostile to the very idea of system.

When Zeno and Epicurus first established their systems, they seem to have been less conscious of opposition toward one another

than of the need for joining forces in the attack on the two reigning schools, the Academy and the Peripatos. Aristotle, being judged mainly from his dialogues, was still ranked as an idealist; Zeno and Epicurus had in common a thoroughgoing materialism. The Platonic theory of knowledge, in which the mystical belief in reminiscence always played a part, was disparaging to the senses, whereas the new schools refused to accept any foundation except the unshakable certainty of perception. Both Platonists and Aristotelians held that a wide culture in the sciences was necessary to the philosopher; Zeno and Epicurus made physics subordinate to ethics and gave it a form which even the late learner (who to Plato and Theophrastus is a comic figure) could grasp. The Platonists maintained, and both the Stoics and the Epicureans denied, the eternity of the physical world. Even in ethical doctrine the two latter schools were linked by the wish to offer some means of attaining independence of mind. When, however, their joint attack had been crowned with success, the equally important contrasts between them could not for long be disguised: one was a system of duty, the other one of Hedonism. The Stoics were believers in divine providence and regarded the world as a single divine being permeated by *logos* (reason), which attains to self-consciousness in man. In the Epicurean "theology," the gods are not allowed to design the worlds but are placed in the interspaces where they cannot do harm or have harm done to them. Thus after an interval Panaetius was able to bring round the Stoic school into alliance with the Academy in the manner above described.

4. Later Greek Philosophy.—Stoicism itself after the 1st century A.D. has little history as an organized school, though it produced writers whose names are still famous, such as Epictetus and Marcus Aurelius Antoninus. It had, however, far-reaching influence as a fertilizer in many different fields. The Stoic ethics remained prevalent, both among philosophers and among the public, as the best that pagan antiquity had to offer; the important conception of a law of nature, which all men as rational beings ought to recognize in their dealings with one another, rests on a Stoic foundation. From the Stoic armoury, Christian theologians were able to borrow many arguments concerning design in the physical world. As a coherent system, Stoicism did not survive. Not only had its dogmatic pretensions been fatally injured by criticism from the Academy; but also, from the Augustan Age onward, men sought more and more a religious view of the world such as no materialistic creed could provide.

Those thinkers who did not lapse into skepticism, which was revived by Aenesidemus, turned naturally toward some version of Platonism or to Neopythagoreanism, which is by this time not easy to distinguish from contemporary Platonism. The works of Plato were edited in the 1st century A.D. by Thrasyllus, and the treatises of Aristotle, after centuries of obscurity, had been brought to light and edited in the previous century by Andronicus of Rhodes. These are the editions from which modern texts descend. Both Plato and Aristotle were now classics in the philosophical schools and became the subject of learned expositions still preserved, in which much valuable information is embedded.

Middle Platonism and Neoplatonism.—The revival of interest in Plato took various forms. As has been mentioned above, Antiochus (1st century B.C.) went back to the ethical doctrine of the early Academy and cast doubt on the originality of the Stoics. Far more thinkers were inspired by the cosmology of Plato and by his theory of the soul, and the first development of this tendency was the so-called Middle Platonism: for example, a treatise by Albinus, of uncertain date, consists of a systematic exposition of Platonism, free use of Aristotelian terminology being made in it; in Philo is found another such exposition, this time from the point of view of a Jew of Alexandria; and in Plutarch of Chaeronea interest in the religion of Plato is especially prominent. Plutarch's attack in some of his treatises upon Stoic and Epicurean doctrines, from a Platonic point of view, seems to show that these still had some vitality.

The Neoplatonic system of Plotinus (A.D. 205–270) resembles Middle Platonism in its general intention but is much bolder and rests on a broader historical basis. He and his followers were profound students of Aristotle as well as of Plato and were deeply interested in the pre-Socratic philosophy. Giving a relatively unimportant place to the doctrine of forms, Plotinus develops Plato's doctrine that soul is the motive principle from which bodies (if they can be said to exist at all) derive their power of action; and by this means he corrects the materialism of the Stoics and others influenced by them. He proceeds to draw, much more firmly than Plato, the general picture of a graduated immaterial world. For the soul, though it is the principle of physical change, occupies only a middle position in the entire scale of reality. Above particular human souls is the world-soul, above this again the mind (Plato's "artificer") which fabricates the world-soul and in which the highest knowledge is located. Beyond mind, knowledge, and existence lies the One, which no human language can suffice to describe. The heavenly bodies are divine beings (and in defense of this view the Neoplatonists make use of arguments dating back to Plato and Aristotle); the part of the visible world in which we live is admittedly imperfect by absolute standards, but has its proper place in the graduated scale and ought not to be regarded as the work of a malicious spirit working against the Good. Astrology is condemned, as presupposing a false view of the mode of action of the celestial deities.

Plotinus entered into no controversies resulting from his work, but Porphyry (234–*c.* 305) took the offensive in a criticism of Christian doctrine, and the Athenian Neoplatonists Proclus (410–485) and Simplicius (6th century) assembled all the resources of Greek philosophy in the attempt to present a religious view that could be set up in rivalry to Christianity. Christian thinkers naturally protested against the belief in the divinity of the stars and in the eternity of the physical world and against the associated belief in precisely similar cycles of human history. On their side, the Neoplatonists thought it impiety to deny the divinity and intelligence of the stars, regarded the Incarnation as unthinkable, and held fast to their arguments which seemed to show the eternity of the world. (*See* NEOPLATONISM.)

From the point of view of a later age, this controversy seems to tend toward an issue of which none of the disputing groups was at the time aware. The created world of the theologians is a possible object of science (and, indeed, as proceeding from the inscrutable will of God, of humble experimental science), whereas the besouled cosmos of the Neoplatonists, to which man feels himself akin, is not such an object. This is a defect which neither the genius of Plotinus nor the learning of his various successors could outweigh, though it did not become obvious for many centuries. Although Greek philosophy failed in its last contest, it had provided many of the arms by which it was defeated.

(D. J. A.)

II. PATRISTIC AND MEDIEVAL PHILOSOPHY

Early Christian thinkers could not be indifferent to philosophical doctrines aiming at human happiness and dealing with the questions which religion also was intended to answer. For similar reasons some Jews, for example Philo, had interpreted Scripture in terms of philosophy and vice versa. Philosophy (particularly Platonism and Stoicism), when it was not rejected as impious, was in turn accepted as supporting revelation and used for apologetics, being considered as foreshadowing, or sharing in, Christian doctrines, or as likely to add something, in certain fields, to the incompletely revealed truth, or again as ready to be combined, in a semimythological form, with elements derived from religious texts and traditions. In the first five centuries A.D. there were no Christian philosophers in a strict sense, but the influence of Greek and Roman philosophy was widespread and deep; some doctrines were developed with originality, and the new problems of the relation between reason and faith, of the possibility of rationalizing dogmas, and of fitting new historical facts or interpretations and psychological experiences into the usual categories of thought were faced in ways which were important for the future.

Philosophical speculation from the 6th century to the 16th was mainly concerned with the issues already debated, in Greek and in Latin, by pagan and Christian thinkers, and was based on their doctrines. Interest spread to new provinces, east, west, and north. Philosophical language was created on the Greek pattern in Ar-

menian, in Georgian, and in Persian, in Syriac, in Arabic, and in Hebrew; it developed enormously in Latin and, mainly from Latin, was inserted into the European vernaculars, French, Spanish, Catalan, Italian, English, German, and Irish; it thus became part and parcel of modern speech, both technical and ordinary.

The continued interest in philosophical studies was ensured above all by the late Greek schools of Constantinople, Athens, Alexandria, etc. Foreign students transplanted in their countries some of the Greek doctrines and methods from the 5th century onward; thus the Armenian, Georgian, and Syriac schools came to life, and Latin thought was being enriched until early in the 6th century. Refugees from Athens in the 6th century and from Alexandria in the 7th carried the philosophical tradition into Persia and strengthened the Syriac schools. From these and through new contacts with Constantinople, there arose in the 9th century the cosmopolitan philosophical tradition in Arabic; and later this tradition appears in Hebrew. The Greek inheritance passed again (and much more extensively) into Latin in the 12th–15th centuries, both from Constantinople and from the Arabic west. On the other hand, Latin philosophy influenced the Greek, Hebrew, and Armenian cultures in the 14th and 15th centuries. The works which contributed most to speculation were Aristotle's treatises on logic, psychology, metaphysics, physics, ethics, and politics, several Peripatetic and Neoplatonic commentaries on the same texts, and a few independent Neoplatonic works, principally Proclus' *Elements of Theology*. Plato was directly known almost only through his cosmology (*Timaeus*) and, among the Arabs, through the *Republic* and the *Laws*. The logical principles of philosophical method, the dualities of matter and form, substance and accidents, potency and act, the four causes, the notions and classifications of virtues, the idea of man as a "political animal," and the doctrine of experience as the basis of knowledge were taken over from Aristotle and became instruments of thought through these ten centuries. Among the permanent Neoplatonic contributions to medieval speculation were the doctrines of a hierarchical organization of the world, subject to the law of efficient causality and to the one First Cause; of spiritual beings ("Intellects," etc.) as intermediaries between man and God; and of the tendency of everything to return to its origin.

The purely philosophical tradition was often supplemented, sometimes almost superseded, in those ten centuries by the philosophico-theological tradition of the Fathers of the Church and of some heretics; Christian, Muslim, and Jewish philosophers had to face all or some of the problems which they had faced. The Fathers provided, directly or indirectly, inspiration, materials for discussion, and solutions. They also added to the purely philosophical legacy by passing on Platonic and Stoic doctrines and original theories of their own. Above all, St. Augustine was ever present as an authority and a model for those who read Latin; and Pseudo-Dionysius (*see* DIONYSIUS the Areopagite) powerfully affected philosophy and theology among Greeks and Latins, Armenians and Syrians.

Starting from these premisses and often accepting the older doctrines, medieval philosophers (especially those of the Latin and Arabic tradition, to a smaller extent those of the Byzantine and Jewish) pushed further and deeper the study of the workings of the mind; attempted new or more convincing answers to old questions (*e.g.*, those of the existence of God and of the immortality of the soul); examined with refined techniques the claims of *a priori* and *a posteriori* knowledge; considerably advanced the inquiry into the functions and pitfalls of language; debated and clarified the concepts of knowledge, certainty, belief, faith and probability; tried to organize all human knowledge systematically; often asserted the supreme value of intelligence in a humanistic sense; reasserted the importance of sense experience and induction; enlarged and made more concrete the scope of social and political philosophy; and opened the way to the mathematical interpretation of physical phenomena.

1. Patristic Philosophy.—St. Paul's words "the invisible things of God from the creation of the world are clearly seen, being understood by the things that are made" (Rom. 1:20) suggested to Christian thinkers how to combine philosophy and religion; and the obviously philosophical account of the *Logos* (Word) at the beginning of St. John's Gospel would give a doctrinal basis to such a combination. The apologists of the 2nd century took a definite stand with regard to philosophy: Justin Martyr and Athenagoras confirmed Christian doctrines by showing that they agreed either with Plato's or with the Stoics' views and borrowed Philo's idea that the Greek philosophers derived their best opinions from Moses; Tatian, on the contrary, claimed that philosophy is misleading and God unknowable to human reason. At the same time, new half-philosophical doctrines were propounded which took into account the basic worry to which religion was to be a remedy: the problem of evil. The best among the Gnostics, Valentinus and Marcion (*see* also GNOSTICISM), opposed the view of evil as a positive being to the optimism of most Greek philosophy. The history of the world is one long or ever-renewed strife between Good and Evil; Evil will disappear with the destruction, not with our perfect knowledge, of this world (*see* also MANICHAEISM). In Clement of Alexandria (*c.* 150–*c.* 215) philosophy appears partly as the best instrument for molding Christian theology, partly as a forerunner of revelation; this view was to reappear in Abelard nine centuries later. Origen (*c.* 185–*c.* 254) answered Celsus' objections to Christian doctrines with philosophical arguments: the Christian God is still the "eternal immutable activity" of the philosophers, because before creating our world he may have created others and because the Incarnation meant a change in the mind of men, not in the nature of God.

St. Augustine (354–430) transformed some aspects of Platonism and Stoicism, the two doctrines which most inspired him after he abandoned Manichaeism. According to him knowledge is, above all, the result of illumination coming from God and manifesting itself within and through our own mind, whether it is concerned with dispelling the ultimate doubts about our existence or with the highest notions. Matter was not created as a barren receptacle of forms, but enlivened by *rationes seminales*, principles of development. Thence forms will supervene, each as a mark or imitation of the "exemplar" which is in the perfection of God's nature; each thing may have many forms, but every created thing, however spiritual (souls, angels), will have its own matter; this distinguishes creatures from Creator. The idea of mankind's forming the *civitas terrena* in its passing on earth looked backward to the cosmopolitanism of the Stoics and forward to the *humana civilitas* of Dante and to the more modern doctrines of a universal polity.

Pseudo-Dionysius (late 5th century) interpreted much of the Neoplatonic metaphysics of Proclus in terms of Christian theology. His analysis of the "names of God" suggested discussions on the philosophy of language, not only of theology; his *Caelestis Hierarchia* and *Ecclesiastica Hierarchia* gave the blessing of a supposed friend of St. Paul's to that theory of the degrees of being which, also from a work of Proclus summarized in the *De Causis*, implanted itself in most philosophical systems of the 13th century; while his negative theology often set the rules for the doctrines on the limits between rational and revealed knowledge.

2. Byzantine Philosophy.—After the closing of the Athenian schools (529), philosophical activities continued for more than a century in Alexandria and other centres; the Theodosian university of Constantinople probably kept them alive through the 6th, 7th, and 8th centuries, while St. Maximus interpreted and expanded Pseudo-Dionysius' doctrines and St. John of Damascus presented philosophy as a discipline introductory to theology. Photius and Michael Psellus, respectively in the 9th and in the 11th century, upheld the primacy of rational inquiry over mythological fiction and over mysteries and magic, the former supporting Aristotelianism and positive research, the latter preferring Platonism and intellectual intuition. The revival of Aristotelian studies in the 11th and following centuries (John the Italian, Michael of Ephesus, Eustratius, Theodore Metochites) spread from Constantinople into the Latin West. In the 15th century the philosophical optimism of the Platonist Gemistus Pletho, according to which all men may agree on the same "philosophical religion," and the view of Cardinal Bessarion on the fundamental agreement between Platonism and Aristotelianism directly influenced philosophers in

Italy. To Italy was transferred, after the fall of Constantinople (1453), what remained of the Byzantine philosophical tradition.

3. Arabic Philosophy.—After the early Mu'tazilites (8th century), who confined themselves to philosophical apologetic of Islam, mainly discussing the unicity of God, free will, evil, and creation, a more definite philosophical tradition in the Arabic language arose in Baghdad and spread to Persia and to Spain. The attempts of al-Kindi, an Arab, in the 9th century to combine with Islam Aristotelian and Neoplatonic theories, particularly concerning the noneternity of the world, the independence of the soul, and prophetic knowledge, were succeeded by more constructive thinking. The Persian Rhazes (*i.e.*, Razi; d. 923 or 932), a rationalist for whom science and philosophy stand higher than religion and a man of great medical doctrine and experience, expounded a system based on five eternal principles: the Creator, the soul of the world, matter, time, and space. Al-Farabi (*c.* 870–950), a Turk, again asserted the superiority of philosophy as the highest of human achievements, accessible to all men and the best instrument for establishing a sound political organization.

Avicenna (980–1037), another Persian, a more systematic and universal thinker (his *Shifa* is the first great philosophical encyclopaedia, mainly organized on the model of the traditional order of Aristotle's works), examined and elaborated most problems discussed and solutions given by authors known to him. Religion and philosophy have, according to him, an equal status, or religion is superior; this attitude is reflected in his doctrine of prophecy (*i.e.*, that it is one of the highest intellectual faculties) and in his interpretations of Aristotle's theory of the soul and of active and passive intellect. A strong reaction against philosophy came from al-Ghazzali (1058–1111), who "demolished" it by exposing its inner contradictions and established the primacy of sacred texts and rationalized dogmas. But he was soon powerfully contradicted by the greatest Spanish Arab, Averroës (1126–98) of Córdoba.

According to Averroës, philosophy alone leads to complete, pure, final truth, while sacred texts contain at best a simplified and childish account for less-gifted people, and rational theology is muddled, pretentious and misleading (the theory of "double truth" which often goes under his name was completely alien to his doctrine). His penetrating, extensive analysis of Aristotle's works was a model and a mine of ideas and information for philosophers of the Latin tradition from the 13th century onward. His commentaries and his views on philosophical truth led, probably more than anything else, to the establishment of a "free" philosophy in the west; while Avicenna's systematic order and his psychological and gnosiological analyses were of continuous inspiration in the 13th century, particularly to Duns Scotus. (*See* Arabic Philosophy.)

4. Jewish Philosophy.—If we except the syncretism of Philo and the philosophical elements in the Cabala, Jewish philosophy is closely connected with the Arabic tradition and often, indeed, written in Arabic. Jewish attempts at adapting Platonism and Aristotelianism so as to avoid contradictions with the Bible anticipated and sometimes influenced the views of Christian thinkers. Saadia ben Joseph in the first half of the 10th century proved against Aristotle that the world has a beginning and that the soul is a substance; against the Platonists, that every soul is created for its body; against the Neoplatonists, that the world resulted from creation, not from emanation. The doctrines of the plurality of forms and of the presence of matter in spiritual creatures were expounded by the 11th-century Ibn Gabirol (Avencebrol) in more definite and clearer terms than by St. Augustine and thus were taken up by the most representative Latin thinkers of the 13th century. Judah ben Samuel Halevi (*c.* 1085–1141), the Jewish equivalent to al-Ghazzali, opposed philosophy; but Maimonides (1135–1204), a man from Córdoba as was Averroës, maintained that theology and philosophy necessarily agree in spite of their different methods (this view was later held by St. Thomas Aquinas, who knew Maimonides' work). His theory that immortality consists in participation in knowledge (*i.e.*, in the eternal "active intellect") is comparable with that of Spinoza, one of his later admirers. Hillel ben Samuel, Gersonides, Hasdai Crescas, and others in the 13th and 14th centuries did not produce any important or independent doctrine. The only prominent thinker of the 14th–15th centuries, Judah ben Isaac (Leo Hebraeus), already belongs to the Platonism of the Italian Renaissance. (*See* Jewish Philosophy.)

5. Western Philosophy.—Boëthius (*c.* 480–524) did not carry out his plan of harmonizing Plato and Aristotle; but his translations and unoriginal elaborations of Aristotelian, late Peripatetic, Stoic, and Porphyrian logic provided the basis for much of the philosophical revival of the 9th and following centuries and for most logical studies until recent time. His application of philosophical methods and categories to theological problems was followed and carried further in the 12th and 13th centuries. His exaltation of philosophy as the greatest of human possessions was influential in less professional philosophical circles. Three centuries later an Irishman, Johannes Scotus Erigena (*c.* 810–877), favoured by the Frankish kings' cultural policy and influenced by Greek and Latin Fathers, especially by Pseudo-Dionysius, produced the first great synthesis of the Latin Middle Ages, the almost pantheistic *De Divisione naturae*. This, however, was to be less important than the frequent theological debates on substance and accidents and the scholastic training on Porphyry's *Isagoge* and on Aristotle's *Categories* and *De Interpretatione*. On the basis of these texts much thought was given to the relations between words and things and to the different functions of words. In particular, the question whether universal words ("man," "animal," "white," "humanity," etc.) correspond or not to definite things provided the opportunity for shaping and expounding various metaphysical and epistemological views; for example, the "nominalism" of Roscelin (*c.* 1050–*c.* 1125), the "realism" of Anselm (1033–1109), etc. On the other hand, logic was often but an instrument of apologetics; even Anselm's famous proof that God exists because we have in our mind an idea of Him harnesses some rules of logical consistency in order to make explicit a religious intuition. (*See* also Ontology.)

In the 12th century dialectic is still in the forefront. For Peter Abelard (1079–1142) philosophy meant the dialectical elaboration of religious and moral problems, supported by views from ancient philosophers. His interest was often more genuinely philosophical: systematic doubt and inquiry into the meanings of words and into the propriety of their usage were his rules in the *Sic et non;* and the true value of words, their functions in clauses, and the psychological processes connecting things and words were the subject matter of the best sections in his commentaries. At this time, the preeminence of philosophy of language is also manifest in the study of sophisms (a new and henceforward permanent feature of philosophical studies) and in other new chapters of logic (*suppositiones, relationes*, etc.). A more metaphysical interest was shown by Gilbert de La Porrée (*c.* 1075–1154), who thought it possible to separate universals, such as "humanity" or "divinity," from particulars, such as "men" or "God"; while cosmological doctrines, partly inspired by Plato's *Timaeus*, were prominent in the school of Chartres.

The bulk of the Greek and Arabic legacy was then discovered. Scholars of the Western world collected and translated books of science, philosophy, theology: Aristotle's physical, psychological, ethical, and metaphysical treatises, something of Plato, texts from Proclus, some sections of Avicenna's encyclopaedia, something of al-Kindi and of al-Farabi, Ibn Gabirol, Euclid, Ptolemy, Archimedes, Galen and Hippocrates, John Chrysostom and John of Damascus.

Some logical works of Aristotle in Boëthius' translation were also rediscovered. The first signs of the assimilation of some of these works are found in Spain (with Dominicus Gundisalvi or Gundissalinus) and possibly in the pantheistic doctrine of Amalric of Bena and in the materialistic monism of David of Dinant.

Complete assimilation was the work of the 13th century. The Church's cautious attitude toward unknown doctrines slightly delayed it; but in Oxford and soon in Paris (where a few works were excluded from the schools for some time) the process of analyzing and commenting on many of these writings led to the newly discovered doctrines being used in debates and for new constructions. Averroës became available in Latin in the 1230s, and other Aris-

totelian works, including the *Politics*, followed. Doctrines already popular in Latin had to be revised and refined. The theory of light as an element in the world and a means of knowledge was Augustinian in origin but was advanced by Robert Grosseteste (*c.* 1168–1253) in a new, more scientific spirit. Franciscan philosophers, such as St. Bonaventura (1221–74), would still accept the theories of the multiplicity of forms, of exemplarism, of matter in spiritual creatures, of knowledge by illumination, of *rationes seminales*, but they tempered them under the impact of the new texts; they faced the new doctrines or tried to find in them some support for their views. Philosophy asserted itself as something valuable in its own right; according to Roger Bacon (*c.* 1220–*c.* 1292) it can be a means of domination and well-being for mankind. The new urge to discover truth, either in the writings of philosophers, or by deduction, experience, and experiment, led to the encyclopaedic works of Albertus Magnus (*c.* 1200–80) and Bacon.

Competition between theology and philosophy, between faith and reason, became a burning issue. Although criticism was alert on all sides and Aristotle was more often than not simply *an* authority and hardly ever *the* authority, nevertheless some views that were either his or ascribed to him, as well as certain views of other "pagans" (Proclus, Avicenna, Averroës), were such as might carry too much conviction and endanger more "orthodox" doctrines (*e.g.*, the doctrine of creation or that of individual immortality). Enthusiasts and reasoning thinkers (such as Albertus) would alike proceed with their philosophical inquiries, fearless of possible conflicts, but add from time to time the rider that "this is what philosophers teach," implying or stating that in case of disagreement they themselves would be on the side of orthodoxy. Thus philosophy would be pursued for its own sake, and its value as a giver of truth would be impaired only slightly. This was notably the case with the "Averroists" like Siger of Brabant (13th century), who would adhere as much as possible to Aristotle and try to develop a more coherent Aristotelian system than Aristotle had ever produced. They avoided speaking of double truth, but came near to it; their ideal was a satisfactory account of reality independent of theological interferences.

An attempt at producing a comprehensive philosophical doctrine based on the conviction that faith and reason—philosophy on the one hand and Scripture and Fathers of the church on the other—are in agreement was made by St. Thomas Aquinas (1225–74): a magnificent compromise between orthodoxy and Aristotelian philosophy. Some provinces of knowledge are the preserve of faith; but sense experience, aided by the "first principles" (which are present in the "active intellect" of every man) and by logic, reveals the structure of the universe and allows men to approach the less accessible realities, including the existence of God. Thomas took Aristotle as his model for most basic doctrines (matter and form, efficient and final causes, categories of being, movements, and elements) but often "adapted" him and sometimes abandoned him. Thus the matter of each thing, not form, bears the marks of individuality; the highest level of reality (being) characteristic of each thing is its *one* form ("rationality" in man supersedes "animality" and other forms, it is not added to them); human soul is the form of the body, but, being individually created, is separable from it; the world is created, although "created *ab aeterno*." The Aristotelian theory of knowledge is systematized, the emphasis being put on sense experience. In this lies the philosophical importance of Thomas' criticism of the *a priori* (ontological) proof of the existence of God and its replacement by the hardly original "five ways": all of these start from sense experience. It is mainly due to Thomas that Aristotle's *Politics* and the naturalistic view of man as a political animal became the starting point of all future social and political philosophy, to which he also contributed his doctrine of the fundamental agreement between individual and common good and his elaboration of the idea of natural law.

Duns Scotus (*c.* 1265–1308) extended, in a sense, the province of philosophy. His theory of the "univocity of being," contrasted with Thomas Aquinas' "analogy of being," allowed him to apply to God, significantly and positively, our categories of thought as expressed by means of the verb "to be." His Neoplatonic vision of a perfectly organized world in which various degrees of causality keep things closely knit together is coupled with an extreme doctrine of individuality: perfect knowledge is knowledge of individuals (but again, universals are somehow existent in things). On the other hand, our rational knowledge is limited—it even seems to be made insecure—by the absolute freedom of God, who might even change the order of the world. Duns's individualism and doctrine of God cooperated with Thomas' emphasis on experience to prepare the ground for the more extreme doctrines of the 14th century.

The 14th century was a period of constructive criticism; the process of assimilation was over, and philosophy had its own independent life. Absolute determinism or indeterminism, probabilism, empiricism and rationalism, and extreme Averroism were being propounded, defended, and faced. According to Petrus Aureoli (d. 1322) knowledge is appearance of objects: we know what exists by direct impressions, more or less clearly, but without intermediaries; forms, essences, and universals are fictions. For Nicolas of Autrecourt knowledge is a bundle of appearances giving probability, never certainty. According to William Ockham (*c.* 1280–1349) we know only individuals, and only through our senses: the structure of the world, relations, classes, space and time are constructions of our mind. The order of our world of knowledge is the logic of our construction. Analyzing our language, we discover all that has been ascribed to the extramental world; only individual things resist this analysis. God's existence cannot be proved; even the "five ways" lead us beyond experience, away from the truth. Knowledge of God belongs to faith, according to which God is absolutely free; "laws of nature" or knowledge of immutable facts and entities would impair God's freedom. The fideistic side of these doctrines recommended them also to less extreme thinkers such as Jean de Gerson and Pierre d'Ailly. The opposition to what was termed "nominalism" or "Ockhamism" failed to produce positive constructions; such "realists" as Walter Burley were not very original. Even the extreme deterministic doctrine of Thomas Bradwardine seems to be partly inspired by Ockham's idea of God's absolute power. The Averroism of John of Jandun followed a middle course. A positive doctrinal contrast to those trends is to be found in the speculative mysticism of Eckhart (1260?–1328?) and his followers; by reviving the Neoplatonic doctrines of the unity of the real, of the negative nature of individuality and of the inherent need for every thing to annihilate itself in God, they strongly influenced later German philosophy.

"Free" inquiry into metaphysical issues was accompanied by new developments in several sciences and sectors of philosophy. These included formal logic (Albert of Saxony) and the mental grammar of the *modi significandi* (Thomas of Erfurt); the doctrine of the independence of political life from ecclesiastical power and of the right of citizens to choose their rulers (Ockham, Dante Alighieri, and Marsilius of Padua); the theory of "impetus" and the numerical interpretation of qualitative changes (Jean Buridan, Thomas Bradwardine, and Nicole Oresme); and the study of the nature of money (Oresme).

In the 15th and 16th centuries the main trends of thought of the 13th and 14th (Thomism, Scotism, nominalism) were kept alive in the schools (hence the term "scholasticism"); but Platonism and the idea of life as animating all things in nature inspired, outside the schools, more original thinkers. A restatement of Neoplatonism, bordering on mysticism and foreshadowing idealism, accompanied by a penetrating analysis of the incongruities of the traditional doctrines of definition and noncontradiction if metaphysically applied to things, was presented by Nicholas of Cusa (*q.v.*; 1401–64); the mathematical problems of the limits of infinite series are for him examples of the *coincidentia oppositorum*. This is the fundamental rule of a world where everything somehow includes everything else, where God (the expanded, "explicit" being) can be compared with things (the contracted, "implicit" being). Together with Marsilio Ficino (1433–99), Nicholas shared Gemistus Pletho's optimistic aspiration toward a universal philosophical religion.

In the latter half of the 16th century and early in the 17th, how-

ever. Platonism was interpreted in a more pantheistic and naturalistic vein by the south Italian philosophers Bernardino Telesio, Giordano Bruno, and Tommaso Campanella. Telesio wanted to provide an explanation of nature that would start from "its own principles" and forgo all *a priori* doctrines; for Bruno, the whole world is a living "animal" that renders explicit what its essence (*i.e.*, God) contains implicitly; and Campanella professed an extreme animism (things "sense," they are because they sense: *cognoscere est esse*). Pietro Pomponazzi (1462–1525), the leading Averroist, had also tried to find in nature the solution to all problems; he thus denied the immortality of the soul. Direct concern with nature led such men as Michel de Montaigne (1533–92) to pursue detailed observation of how beings, particularly human beings, behave; and their keen sense of realities in limited spheres was accompanied by skepticism as to the possibility of solving the "great problems" of philosophy. Similar interests, coupled with knowledge of mathematics and mechanics, made of Leonardo da Vinci (1452–1519) the pioneer of the new science of nature. (*See* further SCHOLASTICISM; also AVERROISM, LATIN; CONCEPTUALISM; NOMINALISM; REALISM; UNIVERSAL.) (L. M-Po.)

III. MODERN PHILOSOPHY

More than any other intellectual discipline, philosophy derives its stimulus from events outside its own immediate sphere. Behind the rise of a new philosophy in the 17th century lay two major happenings: the Reformation and the scientific movement initiated by Copernicus (1473–1543) and continued by Kepler (1571–1630) and by Galileo (1564–1642). The Reformation had little immediate effect on philosophical speculation, for the reformers laid primary stress on faith and inspiration rather than on reason and learning; it was not till the time of Kant that Protestantism found philosophical expression. Nevertheless, by challenging the old order in the sphere of religion Luther and Calvin facilitated its overthrow in other fields. The scientific movement, by contrast, exercised a powerful and direct influence on philosophical thought almost from the first. The new scientific attitude, with its emphasis on those aspects of natural phenomena which were quantitatively comparable as opposed to those which were qualitatively different, had, it is true, been partially anticipated in Platonism; and Platonism was not only influential in the thought of the early Middle Ages but had survived as an undercurrent throughout the period when Aristotle was in the ascendant, to be revived at the Renaissance in the manner just described. The break with familiar conceptions was, however, sufficiently sharp to present an intellectual challenge of the first importance. It became imperative for thinking men to ask what were the implications of the new view of nature and to what extent they could be reconciled with existing beliefs in other fields, in particular that of religion. The great impression made by Descartes on his contemporaries owed much to the fact that he answered this question in a way which seemed to do justice to religion and to science at once. The whole of nature constituted a great machine; there was nothing in it—not even the human body—which could not be explained in mechanical terms. But the mind or spirit of man belonged to another order altogether, an order to which God also belonged, and had to be dealt with in quite another way. Hence the new science could be admitted to the community of learning without its being necessary to show religion the door.

1. Cartesianism.—The common ascription to René Descartes (1596–1650) of the title "father of modern philosophy" has been disputed by some in favour of Francis Bacon (1561–1626). Bacon's reputation rose as that of Descartes fell. The shortcomings of Descartes's philosophy of nature, cast in the form of a rigid deductive system, stood in contrast with Bacon's preoccupation with induction; and it was asked whether Bacon, a precursor of modern empiricism, had not a better grasp of the truth. In fact, however, Descartes's account of scientific method seems, despite its obvious errors, to correspond better than anything in Bacon to the procedures of the advanced physical sciences today, and historically there can be no question of the comparative influence of the two thinkers. For all his acuteness, Bacon could scarcely claim to have provided his age with a new philosophy; nor was it Bacon's ideas which, for good or ill, set the stage for philosophical discussion during the next 300 years.

Even the briefest sketch of the Cartesian system must take some account of its genesis, for Descartes is important not merely for his positive conclusions but also for the way in which those conclusions were reached. He began, in effect, as a logician. Confronted by the confusion and stagnation which characterized many forms of learning in his day, he sought a method or standard procedure for attaining to truth in the sciences. The method, closely based on mathematics, was to start from premisses of which our knowledge was "sure and indubitable" and to proceed only to conclusions clearly seen to be implied by those premisses. But though he began as a logician, Descartes did not remain long on the purely logical level. Skeptical doubts about the applicability, as opposed to the internal consistency, of scientific systems had troubled him from an early date, and it was to quieten them that he proceeded to construct a metaphysic. The skeptical arguments which, he believed, showed the untrustworthiness for theoretical purposes of all sense judgments were powerless when directed against the existence of the self; for to doubt the self was itself to affirm it, since to doubt is to think. There was thus one firm fact on which knowledge could be built. What the argument proved, however, was very limited: only the existence of the self as a thinking thing, not that of body or matter. To prove the latter, Descartes maintained, further steps were required. We must first demonstrate the existence of God; then show that, if God exists, whatever we conceive clearly and distinctly must be true; finally establish that we have a clear and distinct idea of body or matter. Descartes proceeded to try to make good each of these points. The final system which emerged, incidentally thought of by its author as no more than the prelude to a comprehensive philosophy of nature, was a simple dualism of mind and matter as separate substances, a substance being defined (*Principles of Philosophy*, i, 51) as "a thing which so exists that it needs no other thing in order to exist."

Modern historians of philosophy, notably Étienne Gilson, have stressed the extent to which Descartes's thought connects with medieval ideas; and the terminology in which his views found expression was certainly often that of his predecessors. Nevertheless, it would be wrong to ignore the profound novelty of the Cartesian system as a whole. We have already seen how by his metaphysical dualism Descartes met one of the primary intellectual needs of his age, in a manner which may now seem crude but was certainly effective at the time, by assigning distinct spheres of influence to scientists and to theologians. At the lowest estimate this must be counted a service, though perhaps an unintended one, to the cause of science. But the novelty did not stop there. The method sketched in the second part of the *Discourse on Method* and worked out in more detail in the unfinished *Rules for the Direction of the Mind* was revolutionary not only in its bold refusal of the name of knowledge to whatever was capable of being doubted but still more in its author's conviction that "all the sciences are conjoined with one another and interdependent." Knowledge was one, and hence any suggestion that method should vary with subject matter could be ruled out. This conclusion stood in such sharp contrast with the Aristotelian assumptions hitherto prevalent that men forgot that in many points Descartes and Aristotle were in agreement about scientific method. But it was in the field known now as "theory of knowledge" that Descartes's thought was newest and most influential; indeed, he may be said to have discovered (or invented) the subject in its modern form. The famous arguments at the beginning of the *Meditations* provided a starting point for the many subsequent discussions of knowledge and certainty, with the respective cognitive claims of sense and reason; while Descartes's contention in the same context that he could be certain that he had ideas but not certain that anything independent of himself corresponded to them generated the celebrated problem of the external world. It is worth noting that on this and similar topics philosophers of an empiricist turn of mind accepted Descartes's statement of the question equally with rationalists, though they disagreed with his way of answering it. (*See* further KNOWLEDGE, THEORY OF.)

The power of Descartes's thought was clearly appreciated by his contemporaries and immediate successors, and it was not long before a flourishing school of Cartesians developed (*see* CARTESIANS). Of these Nicolas Malebranche (1638–1715), who gave an Augustinian or Platonic twist to Descartes's doctrine of ideas, is perhaps the most notable. Among Descartes's own contemporaries there were, however, two thinkers of major stature who would certainly not have called themselves Cartesians, though each felt the force of Descartes's ideas: Thomas Hobbes (1588–1679) and Blaise Pascal (1623–62). Hobbes, remembered today primarily for his views on politics, agreed with Descartes in his acceptance of mechanical principles of natural explanation and in his confidence in the powers of human reason; where he differed from Descartes was in believing that nothing existed except matter in motion and thus that there was no such thing as mental substance. Pascal, a genius of the first order whose contributions to mathematics, physics, and Christian apologetics were alike remarkable, found himself entirely out of sympathy both with Descartes's observations on method, which struck him as much too dogmatic, and with his metaphysical synthesis, which he thought did something less than justice to religion. In a century notable for its intellectualism Pascal had the insight to ask if intellectualism was enough; but since he was not strictly a philosopher (and indeed doubted the value of any kind of constructive philosophy), his influence on subsequent philosophical thought was small.

2. Spinoza and Leibniz.—Benedictus de Spinoza (1632–77) and Gottfried Wilhelm Leibniz (1646–1716) shared many of Descartes's fundamental assumptions as well as much of his terminology and were much preoccupied with difficulties which had arisen, inside the Cartesian system, about the relationship of mind and body, the role of sense experience in knowledge and the question of innate ideas or *a priori* knowledge, as it was later to be called. In addition, Spinoza was so far in agreement with Descartes's account of method that he attempted to set out his own philosophical conclusions in the form of a deductive system in his *Ethics*. Nevertheless, each was too original a philosopher to be described as a mere follower of anyone.

Spinoza began by accepting the Cartesian definition of substance and went on to argue that there could be only one substance, which he called indifferently God or Nature. Descartes himself had allowed that mind and matter were substances only in a secondary sense, for though each was otherwise complete in itself they each needed the concurrence of God in order to exist; God alone was "absolutely self-sustaining." Spinoza's version made mind and matter attributes of his single substance, the reality of which was, he said, presupposed by the reality of anything less than itself. God was to be thought of as a being of infinite attributes, but two attributes only, thought and extension, were known to human beings. Since each attribute was complete in itself, interaction between the mental and the material was strictly speaking impossible; but since God manifests himself in every attribute, whatever happens in one has its counterpart in all the rest. Thus to every mental event there corresponds a physical event, and vice versa.

The originality of Spinoza lay in his presenting a de-Christianized version of Cartesianism. Descartes had accepted the orthodox Christian conception of God as pure spirit endowed with will and intellect and had followed Augustine in laying particular stress on freedom of the will both in God and in man. All this disappeared in Spinozism. God was as much body as spirit, and there could be no question of his doing other than acting according to the necessities of his nature; free will was an illusion fostered by ignorance. Spinoza added that the philosopher could attain to freedom of a sort by recognizing the true nature of things and accepting it. It was in this sense that he sought to deliver men from "human bondage," as expressed in the eloquent concluding sections of the *Ethics*.

Spinoza's philosophy, though it had a semimystical side which was later to appeal to the Romantics, seemed in his own time to be dangerously close to materialism; Hume's (perhaps ironical) description of him as "that famous atheist" with his "hideous hypothesis" represented a common reaction. Certainly Leibniz, though he had known Spinoza personally as a young man, was anxious to avoid being thought to share his views. His own philosophizing can be represented as a sustained if not very successful attempt to avoid falling into Spinozism. Against Spinoza's all-embracing monism he maintained the existence of a vast number of individual substances, each complete in itself, of which the human soul was the most familiar example. These "monads" were spiritual realities and, indeed, the only realities, for material things did not in the strict sense exist; it was only at the confused level of sense perception that men took them to be real. Each monad was self-determining, the internal nature of each being the source of whatever happened to it, though thanks to God the activities of all were harmonized. Determinism was avoided (or so Leibniz thought) by distinguishing between truths of reason, which were logically necessary and therefore could not be other than they were, and truths of fact, which were contingent and depended only on God's decision to bring into existence the best of all possible worlds.

Leibniz had a mind which was at once highly acute and comprehensive in its range; on many points of detail he made suggestions which later philosophers found instructive. In some branches of philosophy, notably in logic, his ideas were revolutionary. But he was not a gifted writer, and he lived at a time when a new method of philosophizing was beginning to come in, making his own approach appear dogmatic and uncritical. Except in his native Germany, his philosophical work had little immediate effect. (*See* further BODY AND MIND; IDEALISM; RATIONALISM.)

3. Locke and the "New Way of Ideas."—The new method of philosophizing, mentioned above, owed its origin to John Locke (1632–1704). More than any other philosopher of his time Locke bridged the gap between two ages and two traditions, for though he shared much of the rationalistic outlook of the 17th century and indeed was in some respects a very conservative thinker (as witness his political theory, which falls firmly into the natural-law tradition), he even so initiated methods and procedures which were to be typical of the following century. His work led to a shift in the interests of philosophers and to a diminution in their ambitions.

Descartes, Spinoza, and Leibniz had each sought to construct an elaborate metaphysical system, and Descartes at least had hoped to make his metaphysics the basis for a speculative physics. Locke, as he made clear in a famous passage at the beginning of his *Essay Concerning Human Understanding*, was more modest. "In an age that produces such masters as the great Huygenius, and the incomparable Mr. Newton," he wrote, "it is ambition enough to be employed as an under-labourer in clearing the ground a little, and removing some of the rubbish that lies in the way of knowledge." This task could be achieved if philosophers would turn their attention from the construction of systems to the examination of ideas and to the question of their significance; in more recent terminology, to problems of philosophical analysis. It was with the analysis and clarification of the idea of knowledge that the *Essay* was explicitly concerned.

What makes this passage of special interest is that here for the first time in modern philosophy there is suggested a clear division of function between philosopher and scientist, hitherto thought of as one. But Locke's innovations were not confined to this major step. He suggested not only a task for philosophers but also a way of solving philosophical questions: by the use of what he called the "historical, plain method." This was, in effect, an appeal to experience and, in particular, to the experience of consciousness as revealed in introspection. By taking this simple step, Locke believed, men could eliminate from their thought much pretentious but unfounded dogma, for instance that associated with the contemporary doctrine of innate ideas. Men had only to look at their own thoughts to see that there was nothing to be said for that doctrine. In introducing the "historical, plain method" Locke gave a psychological twist to philosophical investigation which remained a prominent feature of the study till the beginning of the 20th century.

Locke was neither a wholly consequential nor even a very powerful thinker, yet the *Essay* proved a fertile starting point for subsequent discussion. The problem of the origin of ideas, which

so largely occupied 18th-century philosophers, was clearly stated there; and the ideas to which they gave particular attention, substance, "power" and self-identity, for instance, had all been examined by Locke. The difference between Hume and Kant about the function and status of *a priori* propositions arose, in effect, out of the treatment of knowledge in book iv. Similarly, Locke's interpretation of "reflection" as a kind of "inner sense" set the stage for later discussions of the problem of self-knowledge. On these and other points Locke may often have proved misleading, but that he was influential could not be denied. (*See* further CAUSALITY; INNATE IDEAS; PSYCHOLOGY, HISTORY OF.)

4. Sense and Reason in the 18th Century.—The 18th century, so often described as the Age of Reason, began philosophically with a sharp reaction against rationalism. The prestige of Descartes and the Cartesians slumped, partly because of the work of Locke, but still more because of the supersession of Cartesian physics by the less speculative theories of Newton. It was only in the field of mathematics, as Hume observed, that the claims of reason had been vindicated, and they were successful there because what was in question was relations between ideas, not matters of fact. For knowledge of matters of fact and of existence, experience (by which was meant sense experience) was essential.

This movement toward empiricism, as it was subsequently called, had its counterpart in the ethical sphere when the intellectualistic accounts of such writers as Ralph Cudworth and Samuel Clarke gave way to the "moral-sense" theories of the 3rd earl of Shaftesbury and of Francis Hutcheson (*see* also ETHICS, HISTORY OF). It was carried to its furthest extent when Hume declared, in his *Treatise of Human Nature*, that belief (*i.e.*, what had traditionally been called "judgment") was "more properly an act of the sensitive, than of the cogitative part of our natures." It should be pointed out, however, that despite such remarks Hume's outlook was rationalist in a different sense, insofar as he attached no importance to immediate feeling or "enthusiasm" in the sphere of religion. In this respect he and other writers of the Enlightenment (*q.v.*) did not diverge from the Cartesian tradition.

Hume's philosophy is partly built on certain theories of George Berkeley (1685–1753), who in turn was much indebted to Locke. The debt was, however, negative rather than positive, insofar as passages in Locke's *Essay* set Berkeley thinking and provided him with premisses from which he drew conclusions of his own. These conclusions principally concerned the status of the so-called "external" world. Locke, following Descartes, had held that the immediate objects of human perception are ideas in the mind, but had added that we must suppose these ideas to be caused by independently existing material things, of which we could have no direct knowledge. Berkeley showed that, given Locke's premisses, no such inference was warranted. There could be no causal inference from the occurrence of ideas to the existence of "inert" material bodies, for nothing in experience justifies us in thinking that such bodies could be causes, and indeed we had difficulty in attaching a meaning to the very idea of such entities. The only possible cause of our ideas was a "spirit." Hence Berkeley drew two conclusions: first, that the familiar things of sense must be thought of as collections of ideas, having no existence "without the mind"; and second, that we must suppose the existence of an infinite spirit who excites ideas in us and thus makes our experiences correspond.

Berkeley's philosophy was written, as the title of his *Three Dialogues* put it, "in opposition to Sceptics and Atheists"; but it is doubtful whether it ever achieved much for the antiskeptical cause. Plain men from Samuel Johnson onward have found its argument against matter paradoxical in the extreme, while its constructive side is too lightly sketched to be convincing. Historically, its main effect was on David Hume (1711–76), himself a notorious skeptic, who drew from it arguments to strengthen his own radical empiricism. The features in Berkeley on which Hume fastened were (1) his polemic against abstract ideas, which had been introduced by Berkeley to discredit the notion of material substance, but the antimetaphysical implications of which were, as Hume saw, much wider; and (2) his explanation of the causal relation as met with in nature as being no more than a relation of regular succession or, as Berkeley had it, of "sign" and "thing signified." Using Berkeley's polemic as a means of eliminating spiritual as well as material substance, Hume went on to argue that Berkeley's analysis of the causal relation was valid for all cases of causation, including the activities of human agents. All events are "loose and separate," no one happening relates intrinsically to any other. Connections between events there are, but they are external connections only, for "*A* causes *B*" means no more than, roughly, that (1) *A* precedes *B* in time; that (2) similar sequences have been observed in the past; and that (3) as a result there is a strong tendency in the mind to expect something like *B* when *A* occurs. It should be noticed that accepting this analysis of causality means recognizing that causal relations can hold only between what is capable of being experienced—a consequence which casts grave doubt on the use of the concept made by many earlier philosophers.

Hume's thought is misrepresented if we lay exclusive stress on his empiricism. There is another side to it, which he himself called "scepticism," though he used the word in a different sense from Berkeley's. The object of his skepticism was human reasoning, or rather that part of it which concerns questions of fact, the reasoning which we employ in history and in daily life as opposed to that which we employ in mathematics. Hume pointed out that all such "probable" or "moral" reasoning, as he calls it, proceeds on a principle which cannot be proved, the principle that the future will resemble the past; and he argued that because our confidence in this principle cannot be rationally justified, it must be derived from custom and habit; that is, it must have a nonrational basis. Men therefore deceive themselves if they suppose that their possession of reason makes them superior to animals, for in this all-important matter both are in precisely the same case. Outside the field of strict demonstration, human thought and animal thought proceed on the same lines. (*See* further INDUCTION; SKEPTICISM.)

These challenging observations were little appreciated by Hume's contemporaries. The *Treatise of Human Nature*, as its author complained, "fell dead-born from the press"; and the two *Enquiries*, in which Hume served up his ideas again in a somewhat emasculated form, attracted little intelligent comment. It was not till the time of Kant that the force of Hume's thinking was recognized. Meanwhile his fellow countryman Thomas Reid (1710–96) sought to answer skepticism by elevating common sense to be the criterion of philosophical truth, in a way that anticipates the work of G. E. Moore in the 20th century. The Scottish school founded by him (*see* COMMON SENSE, PHILOSOPHY OF) was, however, largely undistinguished and left little permanent mark on philosophical thought.

5. The Enlightenment, Kant and Hegel.—The most striking feature of the intellectual life of the 18th century was the way in which traditional Christian beliefs, still largely accepted by Descartes and even by Locke, lost their hold over men's minds and gave way to a different creed. There were, of course, many educated men, including some of the most eminent, such as Newton, who remained pious Christians; and indeed it was the exception rather than the rule for a man to proclaim himself an atheist or a materialist. But the atmosphere of the age, that of the Enlightenment, was hardly congenial to the claims of religion. Emphasis was everywhere laid on the need for tangible evidence and for clarity of thought, in a way hostile to anything that savoured of the mysterious. Science, which had already done so much to explain the wonders of nature, was confidently expected to proceed to fresh triumphs, and it was widely believed that these would be in the world of human affairs. Meanwhile the banishment of superstition and "metaphysics" (already a term of abuse) was an essential condition of further advance.

It is against this background that we must judge the philosophies of Kant and his successors. Kant himself was in many respects a child of the Enlightenment; he shared its great respect for science and sympathized with its humanist ideals. But he emphatically protested, in the name not so much of religion as of morality, against the prevailing tendency toward naturalism. The belief of the *philosophes* that the moral nature of man could be

compassed in scientific terms was, he maintained, plainly false. His successors, notably Hegel, went further. Living at a time when Romanticism was in the ascendant, they put forward radical criticisms of the Enlightenment's whole outlook, alleging that its intellectualism stood condemned for utter failure to do justice to the rich individuality of things as we are immediately aware of them, and demanding a more adequate philosophy that should do just this. Yet it is notable that Hegel at least did not propose to turn the clock back to the simplicities of a prescientific age; if he questioned the omnicompetence of science, this did not blind him to its achievements. Whatever defects the Enlightenment's ideal of clear and precise thinking might have, it was no remedy to proceed to the opposite extreme and abandon the attempt to think altogether. Mere feeling was as one-sided and inadequate as mere thought.

Immanuel Kant (1724–1804) was a student at Königsberg at a time when the prevailing philosophy in the German universities was that of Christian Wolff (1679–1754), a follower and popularizer of Leibniz. Kant, however, had the good fortune to be introduced by his teachers not only to the ideas of Leibniz but also to those of Newton, whom he never ceased to admire. His early work was as much scientific as philosophical, and though the balance of his interests shifted later he continued to follow scientific developments with close attention. Philosophically, he was influenced by Hume as well as by Leibniz, while Jean Jacques Rousseau, with his emphasis on the priority of the moral over the intellectual nature of man, also affected his thought decisively. His development was slow; it was not till the 1760s that he began to write philosophical essays of importance and not till 1781 that his first major work, the *Critique of Pure Reason,* was published. Thereafter he poured out an astonishing series of treatises on a wide variety of philosophical topics. His ideas were, more often than not, obscurely and pedantically expressed, but their force and originality were apparent from the first.

The aim of the *Critique of Pure Reason,* in the words of its author, was "to abolish knowledge in order to make room for faith." The declaration can easily be misunderstood. Kant was far from being antirationalist in his general outlook; on the contrary, he pointed out—indeed overemphasized—the role of reason in natural science and questioned its pretensions only when employed outside what he thought to be its proper sphere. The target of his polemic, in fact, was metaphysics, understood as a study which claimed to give knowledge of a suprasensible world. There were three issues, Kant declared, which were of fundamental concern to human beings: the existence of God, the freedom of the will, and the immortality of the soul; and metaphysicians claimed to deal with each of these burning topics. Unfortunately for their pretensions, however, they had never been able to establish anything definitive on any one of them, and the time had now come, Kant thought, to make clear why they never had and never could. The truth was that such questions were beyond the competence of human reason, which could be put to work effectively only when it had empirical data on which to operate and could continue to function properly only if it remained within the sphere of experience. Since God and the soul as discussed by metaphysicians were not objects of experience, reason could decide neither for nor against them. But Kant did not draw the conclusion, as some later philosophers have done, that all talk about such topics must be meaningless; he argued rather that belief in God, freedom and immortality, though not capable of justification on intellectual grounds, was nonetheless necessary for moral purposes. The moral agent, whether conscious of it or not, acted as if he accepted these beliefs, and indeed his actions made no sense without them. Thus morals or "practical reason," as Kant called it, filled the gap which critical scrutiny of the pretensions of speculative reason had revealed. (*See* further Ethics, History of.)

Kant is important historically not only for his attempt at a large-scale synthesis but also for many of his detailed suggestions. He succeeded in sharpening many old issues and in bringing to the fore many new ones. Thus his dichotomy of analytic and synthetic judgments, with the accompanying attempt to show that there are judgments which are at once synthetic and *a priori,* made possible a fresh treatment of the problem of innate ideas in the celebrated doctrine of categories, while his stimulating handling of the concept of teleology in the *Critique of Judgment* both illuminated old controversies and revealed fresh problems implicit in the language of the newly developing science of biology. For better or worse, his philosophical vocabulary affected the usage of philosophers for the next century and longer. His introduction of the notion of a "transcendental" argument, alleged to be neither deductive nor inductive, was part of an attempt to distinguish clearly between philosophy and the empirical and exact sciences; if not wholly successful, it nevertheless called attention to logical questions which previous philosophers had overlooked. (*See* further Category; Transcendentalism.)

Kant wrote his main works at a time of intellectual ferment in Germany, and his ideas had scarcely been made public before they were criticized by his younger contemporaries. The cautious empiricist strain in his disposition, his antipathy to speculation which could not be tested by evidence, his liking for cut-and-dried formulas and sharp dichotomies—none of these were to the taste of a generation already infected with Romantic ideals. Johann Gottlieb Fichte (1762–1814), who at first claimed to be his disciple, developed Kant's ideas in a way that tended to play up the role of the *a priori* factor in knowledge, which Kant had recognized but strictly circumscribed, and to play down that of the empirical element. F. W. J. von Schelling (1775–1854) carried the same tendency further and at the same time attempted a fresh metaphysical synthesis, in which the idea of life was made central at the expense of the mechanical concepts on which Kant had laid particular stress. Neither of these writers made much of a lasting impression, however; the thought of both was too lightly sketched to bear serious examination. It was not long before both were superseded in the public eye by Hegel.

The reputation of G. W. F. Hegel (1770–1831) has varied more than that of any other major philosopher. Admired almost to the point of adulation by some of his contemporaries, he has subsequently been denounced as guilty of almost every intellectual crime. A metaphysical word-spinner, seeking to replace clear thinking and patient empirical inquiry by alleged speculative insight and intuition; the father of political Fascism and the grandfather of political Communism; an enemy to science and the patron of obscurantism: these are among the descriptions which have been applied to him. In fact his views were often sober in comparison with others current at the time; they were not deliberately obscurantist though they were often obscurely expressed; and if they were opposed to the intellectual and political ideals of the Enlightenment, the opposition was openly avowed and an attempt made to offer a rational justification of it.

The basis of Hegelianism, as already indicated, lay in a contrast between life as immediately experienced and thought as commonly conceived in the generation immediately preceding Hegel's own. Like Schelling, Hegel was opposed to the mechanical interpretation of nature favoured by the physicists and by Kant; but his philosophy was not biologically centred as Schelling's was. The models from which he drew his key notion of a whole which combines unity with self-differentiation were rather, as his early writings show, certain human experiences and institutions; it is notable that his earliest criticisms of Kant were not of the latter's general philosophy but of his ethics. Hegel held that a more adequate logic than the logic of tradition was needed to think the world as it really is; and he believed that he had found the key to such a logic in his dialectical principle. Traditional logic applied only to the operations of the understanding (illustrated *par excellence* in the thinking of natural scientists), which certainly had their uses but could issue only in abstractions; dialectical logic alone was sufficiently supple to do justice at once to the similarities and to the differences of things.

Hegel was a great systematizer; and one result of his work was to reverse, temporarily at any rate, that tendency to make a modest estimate of philosophy's competence which had set in with Locke. The Hegelian philosopher, like Plato, took all knowledge and all existence for his province. What is more, Hegel was not content simply to affirm this as a matter of principle; he himself had con-

siderable knowledge in many diverse fields and brought his philosophical theories to bear on all of them. Not surprisingly, the degree of success that he achieved in attempting a uniform philosophical interpretation of a wide variety of phenomena varied; he himself showed more understanding in some fields than in others, and his principles (which sprang from reflection on particular conceptual schemes) could not be applied with equal facility to all types of material. Later critics have tended to fasten on those parts of his system, philosophy of nature in particular, in which he was least successful. From the historical point of view, however, it is well to stress not these, where his influence was negligible, but rather his writings on such topics as religion, law, aesthetics and history, where he often displayed real insight and where his detailed suggestions have proved of interest even to those who disagree with his philosophy. (*See* further ETHICS, HISTORY OF.)

6. 19th and 20th Centuries.—Philosophy after the death of Hegel no longer presents the spectacle of order which it is possible to discern without undue distortion in the thought of the two preceding centuries. There were a number of reasons for this state of affairs. One was quite simply that, in the rest of the 19th century at any rate, no major thinker of outstanding originality arose to dominate the philosophical scene. Men of ability worked at the subject, but they mostly followed one of the existing traditions rather than try to branch out on lines of their own. The fact that many of them were professional teachers in universities, well acquainted with the work of past philosophers, may be partly responsible for this. At all events it is noteworthy that the publication of Charles Darwin's *Origin of Species* in 1859, while it had its philosophical repercussions, led to no development of importance inside philosophy in the way in which Galileo's work had led to Descartes and Newton's to Kant.

A further factor was the increasing effect of national differences on philosophical practice. Descartes, Spinoza, and Leibniz were men of international repute, who had their correspondents in most of the countries of western Europe; that one was a Frenchman, one a Netherlands Jew, and the third a German had little importance. But by the end of the 18th century the most original and significant contributions to European philosophy were being made by men who wrote a language which few outside Germany could understand and whose background included elements, such as German mysticism, which were certainly not the common possession of the whole continent. The result was not only that Kant and Hegel won little general appreciation in their own lifetimes, but, more serious, that philosophers in different countries tended to conceive of their subject on widely different lines. While Germans tried to construct elaborate metaphysical systems, Frenchmen carried on the Enlightenment tradition of empirical psychology as practised, for instance, by Condillac, and Englishmen engaged in philosophical analysis in the manner of Locke and Hume. There was indeed, as the remainder of this article will show, a good deal of cross-fertilization among these different strains; yet, to speak broadly, the divergences remained and indeed were still to be found in the middle of the 20th century.

It will be possible here to give only the briefest of sketches of some of the main philosophical currents after Hegel.

Hegelian Influence.—The system of Hegel came under sharp attack within a few years of its author's death, yet Hegelian ways of thinking were persistently influential throughout the 19th century. The notion that philosophy is a synoptic study appealed to the age, and there were many attempts, by writers who acknowledged no debt to Hegel as well as by professed Hegelians, to construct metaphysical syntheses. Herbert Spencer (1820–1903), who tried to apply the concept of evolution throughout the sciences, may be mentioned as belonging to the first class; even Auguste Comte (1798–1857), despite the hostility to metaphysics which was so prominent a part of his "positive" philosophy, recalls Hegel in his attempt to present a unified picture of the whole of knowledge and in trying to find a law of development in history. Comte's preoccupation with the social sciences also has its parallel in Hegel. The "dialectical materialism" of Karl Marx and Friedrich Engels is easily the most celebrated system to admit indebtedness to Hegel, though few non-Communists have ranked it high from the purely philosophical point of view. Among more academic thinkers who continued the Hegelian tradition or felt Hegel's influence may be mentioned Thomas Hill Green, Francis Herbert Bradley, Josiah Royce, Alfred North Whitehead, Henri Bergson, and Benedetto Croce (*see* further NEO-HEGELIANISM).

The 19th century admired Hegel as a system builder; it regarded his *Encyclopaedia of the Philosophical Sciences*, which summarized his completed philosophy, as his masterpiece. But after 1905, when Wilhelm Dilthey published his pioneer study of Hegel's philosophical development, interest shifted to the *Phenomenology of Mind*, which Hegel described as his "voyage of discovery." It was the less abstract and less systematic Hegel of this work who proved philosophically stimulating in the middle decades of the 20th century. The stimulus was not confined to professing Hegelians, but affected writers as remote from Hegel in their general position as the existentialist Jean Paul Sartre and the Marxist György Lukács.

7. Empiricism, Logical Analysis, and Linguistic Philosophy.—Throughout the period of the Romantic movement and its philosophical counterpart there were philosophers in Great Britain and France who remained true to the ideals of the 18th century. Jeremy Bentham (1748–1832), whose main debts were to the associationism of David Hartley, to C. A. Helvétius and, through these two, to Hume, is only the best-known example. His follower James Mill (1773–1836), more important as a philosopher if less noteworthy for his practical influence, is another instance. The Benthamites as a group were strongly rationalist in their outlook; they were also passionately convinced that mental phenomena can all be explained in natural terms. They could see only confusion, or worse, in talk about philosophy's needing to engage in "transcendental" arguments, or in attempts to distinguish the faculties of reason and understanding: as a contemporary said, the Germans were "metaphysically mad."

Bentham and James Mill would doubtless have described themselves as empiricists, yet neither contributed much to the theory of empiricism (Bentham was primarily interested in ethics and politics and Mill in psychology). James Mill's son John Stuart Mill (1806–73) is more notable in this connection. J. S. Mill's *System of Logic* (1843) contains a fairly comprehensive restatement of the case for empiricism, as well as an attempt to work out the inductive logic which he thought to be of far greater utility than the deductive logic of tradition. Mill had little difficulty in exposing the hollow character of the "intuitions" on which his opponents, whose affinities were with the Scottish school, mostly relied; but the case that he made out for his own positive principles was far from watertight, as Bradley and others were later to show. It is astonishing, indeed, that he could have written so naïvely with the discussions of Hume's *Treatise* before him. (*See* further INDUCTION.)

Mill's conception of deductive logic was wholly conservative; he equated "ratiocination," as he called it, with syllogism and took his account of syllogism, on the formal side at least, entirely from Aristotle. The rest of the century, however, saw considerable changes in the state of formal logic, changes which, in time, had important philosophical repercussions. George Boole (1815–64) in his *Mathematical Analysis of Logic* (1847) began a process which served to bring out the restricted and incomplete character of the common textbook account of deduction. The essentials of truth-functional logic, which is altogether more comprehensive than the syllogistic logic of tradition, were formulated by Gottlob Frege (1848–1925), who also instituted important inquiries into the foundations of mathematics, arguing that the concepts of arithmetic can be reduced to those of logic. Frege made little immediate impression, partly because of clumsy symbolism, but the importance of both sides of his work was seen by Bertrand Russell (1872–); and the three volumes of *Principia Mathematica* which Russell published with A. N. Whitehead in 1910–13 both consolidated the revolution in logic and attempted to extend Frege's "logicist" thesis about arithmetic to the whole of mathematics. (*See* LOGIC, HISTORY OF.)

Principia Mathematica more than any other work gave impetus to the empiricist, analytic, and linguistic movements which were so prominent a feature of philosophical life in the English-speaking

countries in the next 50 years (elsewhere it had little important effect, except on the short-lived "Vienna circle"). It fostered the impression that the speculative philosophers of the past had based their ambitious constructions on bad, because wholly inadequate, logic; and it offered a dazzling example of a different mode of philosophizing, in which concepts were rigorously analyzed and scientific authority claimed for the results. Furthermore, by insisting on differences between the grammatical form of statements and their "underlying" logical form, it focused attention on the importance of language and raised the question whether it would not be desirable for philosophers to devise a logically perfect language if they were to avoid ambiguity and error.

Analytic and linguistic philosophers came to be divided into two main groups. One, which derived from Russell himself and claimed support from the enigmatic *Tractatus logico-philosophicus* of Ludwig Wittgenstein (1889–1951), was especially strong in the United States: it was avowedly empiricist and interested above all things in clarifying the concepts of science; and its pursuit of unambiguous expression led it to set store by formalized languages like that of mathematics and to find fault with everyday language as vague and inexact. The other group, predominant in Great Britain, owed most to George Edward Moore (1873–1958), who had defended common sense against the skeptical doubts of philosophers, and to Wittgenstein's later work, embodied in his posthumous *Philosophical Investigations*. There Wittgenstein argued, in a way which recalled Burke's defense of established political institutions, that natural language is a complex structure which is "in order as it is" and stands in need of no philosophical reform. The puzzles which philosophers raised, about meaning for example, depended on misconceptions which a closer look at the actual workings of language would dissipate. Wittgenstein wrote as if philosophy could henceforth be no more than therapeutic, but his own work included striking, if informal, analyses of a wide range of ideas which had figured in traditional theory of knowledge, and its immediate effect was to stimulate fresh discussion, particularly in the field of philosophy of mind. A central feature of this discussion was a tendency in those taking part to move away from the dualism of mind and body preserved in classical empiricism toward a position akin to that of the pragmatists. (*See* further Logical Positivism.)

Pragmatism and Antirationalism.—Where a British philosopher calls himself an empiricist, an American tends to call himself a pragmatist. Not that pragmatists would allow an absolute antithesis between the two. William James (1842–1910), who did most to put pragmatism on the philosophical map, described himself as a "radical empiricist"; and C. S. Peirce (1839–1914), who invented the word "pragmatism," not only shared the common empiricist interest in natural science but had a far better grasp of scientific procedures than any of his British contemporaries. Historically, the difference between the two doctrines rests on the fact that, whereas British empiricism looks straight back to the 18th century, American pragmatism, despite James' suspicion of Bradley with his "block universe," clearly owes a debt to Hegel. The debt comes out in the distrust of formal logic shown by such a writer as John Dewey (1859–1952) and in the related refusal to consider concepts and statements in isolation from the contexts in which they are used. The Hegelian polemic against the "abstractions" of the pure understanding reappears here.

There is a further and more substantial difference which deserves to be noted. The British empiricists, from Locke to Russell, tended to assume with Descartes (and for that matter with Plato) that there are always two distinct components in knowledge: the knowing subject and the known object. They agreed with Descartes again that knowledge ideally occurs where the subject, which they identified with mind, is in the presence of, or directly acquainted with, the object, so that the latter can be grasped by the former. The whole operation is conceived as passive, like seeing: the object imprints itself on the mind without effort on the mind's part. This analysis is decisively rejected by pragmatists. The typical cognitive situation for them is one where an animate body seeks through its sense organs to learn about its environment, with a view to acting on it later. A living thing is most truly itself not when it is passive but when it is doing something, with the result that knowledge is an activity and, for that matter, an activity of the whole organism. It should be obvious that this divergence brings to light a profound contrast of metaphysical outlooks, a contrast which may even reflect a significant difference of national temperaments. (*See* further Pragmatism.)

James is sometimes described as "anti-intellectualist" because he said that men's "passional and volitional" natures were, in certain circumstances, entitled to consideration when it was a question what to believe; the same charge was brought against Henri Bergson (1859–1941) for arguing that the intellect is a practical instrument which distorts the nature of fact even if it distorts it to good biological purpose, and for maintaining that the road to ultimate truth must accordingly be through "intuition." Later thought, however, showed a more thoroughgoing antirationalism than is to be found in either of these writers. Soren Kierkegaard (1813–55), a Danish theologian, had developed a bitter criticism of what he took to be the panlogism and optimism of his older contemporary Hegel. The notion that reality can be comprehended by reason, however refined that faculty was taken to be, broke down in face of the facts, for there were elements of the "absurd" in the real world which could not be fitted into any tidy intellectual scheme. It was decision, Kierkegaard argued, which introduced these elements. No amount of comprehension of the facts of a situation would make a man's mind up; a man had to commit himself when he made a decision, and his doing so was a leap in the dark which at once affirmed his existence and could not in principle be predicted. Kierkegaard had little influence in his own time or immediately after (though some of his views have parallels in the thought of Arthur Schopenhauer and Friedrich Nietzsche); but the rediscovery of his work in the 20th century gave his outlook wide currency. The German philosopher Martin Heidegger (1889–), the first part of whose obscure but original work *Sein und Zeit* appeared in 1926–27, was profoundly affected by him; and it is from the thought of Kierkegaard and of Heidegger that the various existentialist philosophies which were so popular on the continent of Europe immediately after World War II drew most of their ideas.

See Existentialism; *see* also references under "Philosophy, History of" in the Index. (W. H. W.)

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PHILOSTRATUS, the name of at least three members of a family of ancient Greek writers. They are often confused, and the attribution of certain works among them is controversial.

Flavius Philostratus (*c.* A.D. 170–*c.* 245), called "the Athenian," born perhaps in Lemnos, studied at Athens, and some time

after 202 entered the circle of the philosophic Syrian empress of Rome, Julia Domna, whom he probably accompanied on her travels. On her death he settled in Tyre. He wrote the *Gymnasticus* (a treatise dealing with athletic contests); a life of the Pythagorean philosopher Apollonius of Tyana (*q.v.*); *Bioi sophiston* (*Lives of the Sophists*), treating both the classical sophists of the 5th century B.C. and later philosophers and rhetoricians including some members of the second sophistic movement near to his own day; a discourse (*Dialexis* ii) on nature and law; and the epistles ("Love Letters") of which the 32nd (in the Loeb edition) forms the basis of Ben Jonson's "Drink to Me Only with Thine Eyes." Flavius Philostratus may have been the Philostratus who wrote the *Heroicus*, a dialogue about the cult of Protesilaus, and the dialogue *Nero* wrongly included among the works of Lucian, but these are sometimes attributed to other members of the family.

PHILOSTRATUS (b. *c.* A.D. 190), called "the Lemnian," son of Nervianus, son-in-law of Flavius Philostratus, was the author of a letter to Aspasius of Ravenna (*Dialexis* i) and of the first series of the *Imagines* in two books, discussing 65 real or imaginary paintings on mythological themes in a portico at Naples. They are an important source for the knowledge of Hellenistic art and roused the enthusiasm of Goethe who wrote an essay on them in 1818 entitled *Philostrats Gemaelde*, but they are not now regarded as providing serious artistic criticism.

PHILOSTRATUS (late 3rd century A.D.), called "the Younger," grandson of "the Lemnian," wrote the second series of 17 *Imagines*.

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PHILOXENUS (AKSENAYA) OF MABBOG (d. A.D. 523), one of the best Syriac prose writers and a vehement champion of Monophysite doctrine, was born of Persian parentage at Tahal in the district of Beth Garmai east of the Tigris. He was educated at Edessa and soon attracted notice by his strenuous advocacy of Monophysite doctrine. In 485 he was made bishop of Mabbog (Hierapolis) by Peter the Fuller (d. 488), Monophysite patriarch of Antioch. Later he bitterly opposed Flavian II, Peter's orthodox successor. In 519 he was banished to Philippopolis in Thrace, and later to Gangra in Paphlagonia, where he was murdered in 523.

It was probably during the earlier years of his episcopate that Philoxenus composed his 13 homilies on the Christian life. Later he revised the Syriac version of the Bible, and under his direction his chorepiscopos Polycarp produced in 508 the so-called Philoxenian version of the New Testament, used by the Monophysites during the 6th century. Philoxenus also wrote three treatises on the Trinity and the Incarnation, tracts on Christ, confessions of faith, commentaries on the New Testament, works against the Nestorians and other heresies, prayers, and letters. Not all of these have been published.

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PHINEUS. The most famous figure of this name in Greek mythology was a Thracian king who appears in the saga of the Argonauts (*q.v.*). They found him at the entrance to the Euxine Sea, blinded for a sin against the gods and plagued by the Harpies, who carried off or defiled his food till he was starving. In return for his prophesying the Argonauts' future course, Zetes and Calais, the winged sons of Boreas, drove away the Harpies. This is the core of the legend.

Variations occur in explaining Phineus' offense. Probably the oldest version was that by his prophecies he had revealed divine secrets. Alternatively he had blinded the sons of his first wife, Cleopatra, daughter of Boreas, persuaded by the slanders of their stepmother. (H. W. PA.)

PHITSNULOK, a province (*changwad*) and town in north central Thailand. Area 3,729 sq.mi. Pop. (1960) 351,642. The province extends from the Laos border in the northeast to the Nan-Yom River system in the southwest. The population is concentrated in the western plains, the eastern districts of Nakhonthai and Wangthong being isolated and underdeveloped. The province is a major producer of rice and has several commercial rice mills. The provincial capital Phitsnulok, pop. (1960) 30,364, is situated about 240 mi. from Bangkok on the railroad to Chiengmai, which runs along the east bank of the Nan. During most of the Ayutthayan period (1350–1767), Phitsnulok town ranked second in size and importance to the royal capital; two of the greatest kings of the era, Naresuan and Ekathotsarot, were native sons. Near the centre of the old walled city is one of Thailand's most revered Buddhist temples, Wat Phra Si Rattana Mahathat, which houses an early bronze Buddha famed for its beauty. The town's commercial centre, which lies south of the city walls, grew rapidly after the construction of the motor road to Sukhothai and Tak in the 1940s. (G. W. SK.)

PHLEBITIS: *see* VEINS, DISEASES OF.

PHLEGYAS, in Greek mythology, son of the war-god Ares and eponymous king of the savage Phlegyae in Thessaly, but also associated with central Greece and the Peloponnese. His daughter Coronis, seduced by Apollo, gave birth to Asclepius, god of medicine. Phlegyas in revenge for the seduction set fire to the Temple of Apollo at Delphi and was killed by the god. (D. E. W. W.)

PHLOGISTON: *see* CHEMISTRY: *The Phlogiston Theory*.

PHLOGOPITE, a mineral of the mica group used as an electrical insulator. Mica mined in Canada and Ceylon is mainly phlogopite, a magnesium mica differing from biotite (black mica) in containing little iron. Sometimes brownish-red and coppery in appearance, it is named from the Greek for "fiery-looking." Usually yellowish-brown, sometimes quite colourless and transparent, it often has a silvery lustre on the cleavage surfaces, hence the names "amber mica" and "silver mica" for some varieties. Phlogopite occurs chiefly as scales and plates embedded in crystalline limestones. The cleavage flakes are not so elastic as those of muscovite (white mica). In Canada it occurs with apatite in pyroxene rocks associated with Laurentian gneisses and crystalline limestones. The principal mining district is in Hull County, Quebec, and near Burgess in Lanark County, Ontario. In Ceylon the mineral forms irregular veins, rarely exceeding one or two feet in width, traversing granulite, especially near the contact of this rock with crystalline limestone. For the chemical formula and optical and other characters, *see* MICA.

PHLOX, the common and generic name of hardy perennial plants, natives of North America (one Asian), which, introduced widely in temperate-zone countries, have become favourite garden subjects. It is the typical genus of the phlox family (Polemoniaceae), and consists of about 60 species. The plants have entire, usually opposite, leaves and showy flowers, generally in terminal clusters. Each flower has a tubular calyx with five lobes, a salver-shaped corolla with a long slender tube and a flat flaring edge. The five stamens are given off from the tube of the corolla at different heights and do not protrude beyond it. The ovary is three-celled with one to two ovules in each cell; it ripens into a three-valved capsule. Many species and varieties are tall herbs yielding a wealth of bloom throughout the summer and early autumn. They require a deep, rich, rather heavy loam and a cool moist position.

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PHLOX (PHLOX DRUMMONDI)

The so-called blue phlox (really a mauve colour), or wild sweet william (*P. divaricata*), is found throughout the woods of east coastal, central, and southern North America.

The dwarf perennial species and varieties, the moss pinks or creeping phlox of gardens (*P. subulata*), are suitable plants for the rockery, and as edging to beds and borders. They are trailing and tufted in habit, the branches rooting at the nodes. They succeed in poorer soil and drier situations than the tall kinds. Seed is seldom produced. Propagation is effected by cuttings in July and early August (placed in a cold frame) and by division of the plants, which should be lifted carefully and cut into rooted portions as required. The tufted kinds decay in patches in winter if the situation is too moist.

Annual or Drummond phlox (*Phlox drummondi*), often called Texan pride, and its numerous varieties are annual, small-growing, hairy plants up to 1½ ft. in height, flowering profusely during the summer months. For early flowering they should be sown indoors in March and April and transferred out-of-doors in June; they succeed if sown out-of-doors in midspring, but the flowering season is later and shorter.

The tall-growing border phloxes are divided into early- and late-flowering kinds respectively, the former derived mainly from *P. glaberrima* and *P. carolina*, the latter from *P. maculata* and *P. paniculata*, both groups being common in moist woods in eastern North America. Over 200 horticultural varieties, comprising some of the finest garden perennials, have been derived from these species by selection and hybridization. Phlox come in a large variety of colours, but there are no yellows or true blues.

Since practically all the phlox species are natives of North America, with handsome representatives in every section of the United States, adoption of the genus as the floral emblem or national flower of the U.S. has been urged.

The night phlox is *Zaluzianskya capensis* and the prickly phlox is *Gilia californica*. (N. Tr.; X.)

pH MEASUREMENT: *see* HYDROGEN IONS.

PHNOM PENH, capital of Cambodia, is situated 125 mi. NW of Saigon at the confluence of the Mekong River and the Tonle Sap. Pop. (1962) 403,500.

According to the legend of the town's history, a woman called Penh came in the 14th century to live on the slopes of the hill (Phnom in Cambodian) overlooking the town. A bronze statue of Buddha, which she found in a tree trunk, swept to the foot of the hill during a flood and attracted a crowd of pilgrims, many of whom settled in the vicinity. In 1434 King Ponhéa Yat built his capital on the site. Subsequent kings chose Oudong, but in 1865 King Norodom I once again established the capital in Phnom Penh.

It is a picturesque town at the centre of which is the royal palace with its silver pagoda, throne room and museum. As well as archaeological museums there is the Jayavarman VII Art Museum. In the associated art school the traditional crafts of weaving and goldsmith's work are taught with modern adaptations. Mimed performances of Buddhistic and Brahminical legends are given by the Royal Company of Cambodian Dancing Girls, wearing gorgeously embroidered clothes. There are schools and a Buddhist university for Pali and Buddhist studies. Although 173 nautical mi. from the sea, Phnom Penh is a major trading port in the Mekong Valley. It is accessible all year round to shipping. Cattle, dried fish, rice, maize, cotton, and pepper are the chief items of trade. Textiles and soft drinks are manufactured. Steamers connect Phnom Penh with Saigon and many towns on the Mekong and Tonle Sap. Excellent roads lead to Saigon, Angkor, and Bangkok; Phnom Penh is also connected by road with Kompong Som, the new seaport being built on the Gulf of Siam about 137 mi. (220 km.) from the capital. There are railways to Bangkok, Saigon, and (via Bangkok) Singapore. The airport, from which services operate to Bangkok, Hong Kong, and Saigon, is at Pochentong, 5 mi. from the city.

PHOBIA, from the Greek *phobos* ("fear"), is a pathological fear of a specific object or situation. In psychiatry such (phobic) reactions are classed as a single form of the neuroses (*q.v.*), although hundreds of prefixes have been used to specify the nature of the thing feared (*e.g.*, hematophobia: fear of the sight of blood). While fear of water may be a symptom of hydrophobia (*see* RABIES), the condition is an infectious disease rather than a neurosis.

See J. R. Ewalt and D. L. Farnsworth, *Textbook of Psychiatry* (1963); S. Arieti (ed.), *American Handbook of Psychiatry*, 2 vol. (1959).

PHOCAEA, an ancient Ionic city in a sheltered bay on the northern promontory of the Gulf of Smyrna. The modern town of Foça in the *il* of Izmir, Turk., preserves its name, but little survives of its buildings. Coming late to Asia (perhaps 10th century B.C.) and possessing little arable land, the Phocaeans took to the sea and sailed the Mediterranean waters in long boats. They founded colonies in the Dardanelles at Lampsacus, on the Black Sea at Amisus (Samsun) and the Crimea, and on the Mediterranean as far west as Massilia (Marseilles) and Emporion (Ampurias in northeastern Spain); and traded with Tartessus (near Cádiz). Besieged by the Persians *c.* 545 B.C., they took to their ships; and the bolder spirits sailed to Corsica, which they evacuated after destroying the navies of Carthage and the Etruscans in a battle of annihilation. Phocaea itself was unimportant thereafter, though its captain Dionysius was chosen admiral of the Ionic fleet at Lade *c.* 494 B.C. Supporting Antiochus the Great against the Pergamene upstarts in 190 B.C., the Phocaeans so savagely repelled the Roman forces that the praetor L. Aemilius Regillus was obliged to withdraw his men and entreat the citizens not to take the war so seriously; the infuriated troops then took advantage of the truce to sack the city. After helping Aristonicus in his popular rising (132) Phocaea was sentenced to destruction by the Romans but reprieved through the intercession of its daughter-city Massilia. (Jo. M. Co.)

PHOCAS (d. 610), Byzantine emperor from 602 to 610, was a Thracian centurion in the army at the time of its rebellion against Maurice (*q.v.*) in 602. Sent to Constantinople as spokesman, he took advantage of revolts in the capital to get himself chosen emperor in place of Maurice, who was executed with his sons. Phocas' most successful relations were with Rome, where his recognition of the primacy of the apostolic see of St. Peter won him the praise of Pope Gregory I. He made peace with the Avars and in 604 agreed to pay them an increased annual tribute. He had to face the avenging forces of Maurice's ally, Khosrau (Chosroes) II, under whom the Persians pressed into Asia Minor and by 608 had reached the Bosporus. In the eastern provinces Phocas was hated because of his persecution of the Monophysites and Jews; in the capital he grew increasingly tyrannical. General discontent and fear of the Persians led to an appeal to the exarch of Carthage. In 610 the exarch sent an expedition under his son Heraclius, who had Phocas executed and was proclaimed emperor on Oct. 5, 610.

See J. B. Bury, *Later Roman Empire*, vol. ii (1889); N. H. Baynes in *Cambridge Medieval History*, vol. ii, ch. 9 (1913). (J. M. Hv.)

PHOCION (*c.* 402–318 B.C.), Athenian statesman and general, an opponent of the anti-Macedonian party of Demosthenes and others, and virtually ruler of Athens between 322 and 318. He was a pupil of Plato and in later life a close friend of Xenocrates. He distinguished himself under Chabrias in the naval battle of Naxos (376), and subsequently won the confidence of the Athenian allies by his justice and integrity. At some date (either *c.* 350 or 344/343) he served Artaxerxes III of Persia as a mercenary commander and helped to subdue a revolt in Cyprus. At Athens he was elected general 45 times in all, according to Plutarch. In 348 he saved the Athenian force operating in Euboea by the victory of Tamynae. He assisted Megara and Byzantium against Philip II of Macedonia; but he defended Philip's supporter Aeschines in 343 and was one of the envoys sent to treat with Philip after his victory at Chaeronea (338).

Phocion opposed the Lamian War which followed the death of Alexander the Great (323), though he led the defense of Attica against a Macedonian raid. The failure of the war (322) and the subsequent enforced restriction of the democracy at Athens established him as the leading man. He acted with great moderation, but in 319 he failed to prevent the Macedonian seizure of the Piraeus, and when full democracy was restored in spring 318 he was deposed. He fled to the Macedonian regent Polyperchon, but was sent back to Athens to be tried for treason and was condemned to death unheard. Shortly afterward the Athenians decreed a public burial and a statue in his honour.

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PHOCIS, an ancient district of central Greece, bounded west by Ozolian Locris and Doris, north by Opuntian Locris, east by Boeotia, and south by the Gulf of Corinth (Korinthiakós Kólpos). It covered the southeastern parts of the two modern *nomoi* (departments) of Phthiotis (Fthiótis) and Phocis (Fokís) (areas 1,620 sq.mi. [4,325 sq.km.] and 806 sq.mi. [2,087 sq.km.]; capitals Lamia and Amphissa [Ámfissa]; pop. [1961] 160,035 and 47,842 respectively) and the northwest corner of modern Boeotia (Voiotía). The massive ridge of Parnassus (Parnassós; 8,061 ft. [2,457 m.]) traverses the heart of the country. Between this and the northern frontier range of Kallídhromon (4,000 ft.) is the narrow fertile valley of the Cephissus (Kifissós or Sarandapótamos) River along which lay most of the Phocian townships, including Amphicaea or Amphicleia (Amfíklia), Tithorea, Elatea (Elátia), Hyampolis (Bogdhánou), Abae (Éxarkhos), and Daulis (Dhávlia). South of Parnassus the small plains of Crisa (around modern Itéa) and Anticyra are separated by Mt. Cirphis. Phocis was mainly pastoral.

The district's early history is obscure. Its population was thought to be Aeolic, but the dialects are of the northwest Greek group, more akin to Doric. There was a tradition that the Phocians once owned land around Daphnus, opposite Euboea, and had their frontier at Thermopylae. Later restriction of territory was due to the hostility of the Boeotians and the Thessalians. The latter in the 6th century even raided the Cephissus Valley. In early days Phocians controlled the sanctuary of Delphi (*q.v.*). But about 590 B.C. a coalition of Greek states proclaimed a "sacred war," destroyed the city of Crisa, and put the sanctuary under the control of the amphictyonic council.

During the Persian invasion of 480 the Phocians at first joined in the national defense, but their irresolute conduct lost Thermopylae for the Greeks; and at Plataea they were on the Persian side. In 458 or 457 an attempt to control the headwaters of the Cephissus in the territory of Doris brought a Spartan army into Phocis in defense of the "metropolis of the Dorians." In 449 or 448 the Spartans expelled the Phocians from Delphi, but not long afterward the Phocians recaptured the sanctuary with the help of the Athenians, with whom they had become allied in 458 or 457. When Athenian land power declined, Phocian friendship waned, and in the Peloponnesian War Phocis was nominally an ally of Sparta and had lost control of Delphi.

In the 4th century Phocis was constantly endangered by Boeotian oppression. After helping Sparta to invade Boeotia during the Corinthian War (395–394), the Phocians received assistance from Sparta in 380, but afterward submitted to the growing power of Thebes. Phocians took part in Epaminondas' earlier inroads into the Peloponnese (370–366), but took no part in the campaign of Mantinea (362). In return for this negligence the Thebans secured a penal decree against them for religious offenses from the amphictyonic council (356). The Phocians, led by two capable generals, Philomelus and Onomarchus, replied by seizing Delphi and using its riches to hire mercenaries with whose help they invaded Boeotia and Thessaly, and though driven out of Thessaly by Philip II of Macedonia, maintained themselves for ten years, until the exhaustion of the temple treasures and the treachery of their leaders placed them at Philip's mercy. Their towns were split up into villages and an indemnity was exacted (346). In 339 the Phocians began to rebuild their cities; in 338 they fought against Philip at Chaeronea; in 323 they took part in the Lamian War against Antipater; and in 279 helped to defend Thermopylae against the Gauls.

During the 3rd century Phocis passed into the power of Macedonia and of the Aetolian League, to which in 196 it was annexed. Under Roman rule its league was dissolved, but was revived by Augustus, who also restored to Phocis the votes in the Delphic amphictyony which it had lost in 346 and enrolled it in the new Achaean League. The Phocian League is last heard of under Trajan.

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(W. G. F.)

PHOCUS, in Greek mythology, the son of Aeacus and the Nereid Psamathe who had assumed the likeness of a seal (Gr. *phoce*). Peleus and Telamon, Aeacus' legitimate sons, resented Phocus' superior athletic prowess, and at the instigation of their mother, Endeis, plotted his death, drawing lots to decide which should destroy him. The lot fell on Telamon, who murdered Phocus, feigning an accident. Aeacus, however, discovered the truth, and banished both his sons for this crime. (D. E. W. W.)

PHOCYLIDES (fl. *c.* 600 B.C.), of Miletus, Greek gnomic poet, a few fragments of whose maxims (almost all in hexameters and beginning "This too is Phocylides' ") have survived in quotations. Byzantine manuscripts also ascribe to him a poem in 230 hexameters, entitled *Gnomai,* which was composed perhaps in the 1st century A.D. by someone acquainted with the Old Testament; about 70 lines of it are also to be found in the so-called *Oracula Sibyllina* (ii:56–148). The orator Isocrates (*Ad Nicoclem* 43) mentions Phocylides along with Hesiod and Theognis as an author of "admonitions" (*hypothecai*).

See E. Diehl, *Anthologia Lyrica Graeca,* 3rd ed., vol. i (1949) for the genuine fragments and vol. ii (1961) for the spurious poem. *See* also W. Jaeger, *Paideia,* Eng. trans. by G. Highet, vol. i, 189–190 (1939).

(Js. A. D.)

PHOEBE (*Sayornis phoebe*), the name given a sparrow-sized bird of the American flycatcher family (Tyrannidae). Gray-brown above and whitish below, it perches with flirting tail and, in sudden flight, captures aerial insects. The abrupt, burry "phoebe" of the male is heard incessantly in the spring woods. Under an old bridge or overhanging ledge the phoebe builds a cup nest of mud and moss, lining it with grass and feathers; in it the three to seven white eggs are laid. The young emerge after an incubation period of 16 days and fly after an added 15 days of nest care by both parents. This species breeds in eastern North America, wintering as far south as Mexico. Say's phoebe (*S. saya*) is a western species, and the black phoebe (*S. nigricans*) lives in the southwest. (W. J. Be.)

PHOEBUS: *see* APOLLO.

PHOENICIA, in ancient geography, was the name given to a region corresponding to modern Lebanon (*q.v.*) with adjoining parts of modern Syria and Israel. Its inhabitants, the Phoenicians, occupied the mountainous area of the Lebanon and Anti-Lebanon and the seaboard between the Eleutherus River (Nahr al Kebir) in the north and Akko (modern Acre) in the south. Their chief cities (excluding colonies, for which *see* below) were Gebal (Gr. Byblos; modern Jebeil); Sidon (modern Saida); Tsur (Gr. Tyros; modern Tyre; Arabic Es Sur); and Berot (Gr. Berytos; modern Beirut), a city not mentioned before the 14th century B.C. Others of lesser importance were Simirra; Arka (perhaps Tell Arga, northeast of Tripoli); Sianu; Zarephath (mentioned in I Kings, 17:9; modern Sarafand); Achzib (Arabic Es Zib); Akko; Botrys (modern Batrun, between Tripoli and Jebeil), founded in the early 6th century B.C.; Tripolis (modern Tripoli), a colony of Tyre, Sidon, and Aradus, probably founded in the 4th century B.C.; and Orthosia, just north of Tripoli, founded in Hellenistic times. To the north lay the island stronghold of Aradus (Hebrew Arvad; modern Arwad or Ruad) (Gen. 10:18; Ezek. 27:8–11).

It is not certain what the Phoenicians called themselves in their own language. The term "Phoenician" is evidently derived from the Egyptian word *Fenkhw,* meaning an Asiatic, which is found as early as the Egyptian 5th dynasty and seems to have passed from Egyptian into Greek; but the Egyptians normally refer to them under geographical appellations, such as "Retenu." The Old Testament merely uses the city name and speaks of Sidonians or Tyrians. The Homeric poems do the same but add the name

of *Phoinikes,* "Phoenicians," which was interpreted to mean "red-skins," from Greek *phoinos,* "blood red." The only general term they would have used for themselves would appear to have been *kena'ani* (Akkadian *kinahna*), "Canaanites," a term which underlines the Phoenicians' racial identity with the pagan, pre-Hebraic population of neighbouring Palestine. (*See* CANAAN.) It is noticeable that in Hebrew the word *kena'ani* has the secondary meaning of "merchant," which well characterizes the Phoenicians. The earliest occurrence of the name is in the Akkadian form in a cuneiform inscription of the 16th century B.C. from Alalakh.

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I. HISTORY

1. Origins and Relation with Egypt.—The Phoenicians probably arrived in Phoenicia *c.* 3000 B.C., although one of their native traditions, preserved by Philo of Byblos, claims that they were autochthonous. In fact excavations at Byblos itself indicate that a different population preceded the Phoenicians there in the Neolithic Period. Nothing is known of their original homeland. Classical writers (*e.g.*, Herodotus, vii, 89) preserve traditions that they came from the coast of the Red Sea (*i.e.*, the Persian Gulf), an area which excavations (*e.g.*, at Bahrain) have shown to have had a high culture at least in the late 3rd millennium B.C., in touch both with Sumer and India. But it is premature to detect there any possible ancestors of the Phoenicians. The Roman historian Justin (xviii, 3) records that the earliest Phoenicians fled from their original home because of an earthquake, pausing on the way at the "Tyrian marsh," presumably the Dead Sea, and perhaps implying an occupation of Jericho; after which they founded Sidon. This was believed to be their earliest settlement, and according to Philo it was built by a divine hero, Usoos. Some scholars have interpreted certain passages of the 14th-century-B.C. *Legend of Keret* found at Ras Shamra (Ugarit) as suggesting that the Phoenicians came via the Negev, in southern Palestine. This interpretation is not widely accepted, but discoveries of Chalcolithic settlements near Beersheba and in caves near the Dead Sea show that there were many agricultural and metalworking settlements which marked the road (and relieved its hardships) at least from the Red Sea at this period.

Except at Byblos, no excavations have produced any information concerning the 3rd millennium in Phoenicia before the advent of the Phoenicians. At Byblos, the first urban settlement (level IV, Early Bronze Age I) is dated *c.* 3050–2850 B.C. Level VI, designated as proto-Phoenician by the excavator, shows an age of prosperity already reached, the site having passed through five building levels by 2750 B.C. Commercial and religious connections, probably by sea, with Egypt are attested from the Egyptian 4th dynasty (*c.* 2613–*c.* 2494 B.C.). The earliest artistic representation of Phoenicians is found in a damaged relief at Memphis of Pharaoh Sahure of the 5th dynasty (early 25th century B.C.). This shows the arrival of an Asiatic princess to be the pharaoh's bride, in a fleet of seagoing ships, probably of the type known to the Egyptians as "Byblos ships" (see *Navigation and Seafaring*, below), manned by crews of Asiatics, evidently Phoenicians.

Soon after 2200 B.C. the Egyptian Old Kingdom was brought to an end by a movement of Asiatic nomads. Level VI at Byblos was destroyed by fire about 2150 B.C., probably by the invading Amorites (*q.v.*). The Amorites rebuilt Byblos (level VII) and a period of close contact with Egypt was begun. The fears and foreign policy of the Middle Kingdom pharaohs, particularly those of the 12th dynasty, are illuminated by the discovery of figurines representing hostile Semitic princes, which had been inscribed with their names and elaborate curses on them, then broken and thrown away; and by the discovery of costly gifts from the pharaohs to those Phoenician and Syrian princes such as the rulers of Ugarit and Qatna who were loyal to Egypt.

The skill and beauty displayed in such Egyptian imports profoundly influenced the taste and fashions of these northern courts; and the Phoenician craftsmen set themselves to imitate the elegance and ingenuity of these Egyptian works of art and to master their craftsmanship. Glazing, goldsmith's work, fresco painting, and other arts were imitated, though at first local products were somewhat clumsy.

In the 18th century B.C. new invaders called Hyksos (*q.v.*) destroyed the Amorite rule in Byblos and, passing on to Egypt, brought the Middle Kingdom to an end (*c.* 1720 B.C.). Little is known about the Hyksos' origin, but they seem to have been ethnically mixed, including a considerable Semitic element, since the Phoenician deities El, Baal, and Anat figured in their pantheon (see *Religion*, below). The rule of the Hyksos in Egypt was brief and their cultural achievement slight, but in this period the links with Phoenicia and Syria were strengthened under a single empire. When the Hyksos were finally expelled by Pharaoh Ahmose I (*c.* 1567 B.C.) he and his successor Thutmose I (*c.* 1525–1512) instituted the New Kingdom policy of conquest in Palestine and Syria. In his annals, Ahmose records capturing oxen from the *Fenkhw*, a term here perhaps referring to the Phoenicians.

Fuller information about the state of Phoenicia in the 14th century B.C. comes from the "Amarna Tablets," diplomatic texts belonging to the Egyptian foreign office, written in cuneiform and found at Tell el Amarna (*q.v.*) in Middle Egypt. Among these letters are many documents addressed by the subject princes of Phoenicia and their Egyptian governors to the pharaoh. It was a time of much political unrest. The Hittites (*q.v.*) were invading Syria; nomads from the desert supported the invasion; and many of the local chiefs were ready to seize the opportunity to throw off the yoke of Egypt. The towns of Phoenicia were divided: Aradus, Simirra, and Sidon supported the rebellion; Rib-adda, the regent of Byblos, and Abimelech, king of Tyre, held out for Egypt. But while all the towns made professions of fidelity, they were scheming for their own interests, and in the end Egypt lost them all including Byblos. The tablets which reveal this state of affairs are written in the language and script of Babylonia, and thus show the extent to which Babylonian culture had penetrated Palestine and Phoenicia; at the same time they illustrate the closeness of the relations between the Canaanite towns (*i.e.*, those in Palestine) and the dominant power of Egypt.

After the reign of Ikhnaton (Amenhotep IV; 1379–*c.* 1362), that power collapsed altogether; but his successors attempted to recover it, and Ramses II reconquered Phoenicia as far as the Nahr el Kelb. In the reign of Ramses III (1198–1166) many great changes began to occur owing to the invasion of Syria by peoples from Asia Minor and Europe, which ended in the establishment of the Philistines (*q.v.*) on the coast near Ascalon. The successors of Ramses III lost their hold over Canaan; the 21st dynasty no longer intervened in the affairs of Syria, but Sheshonk (Shishak) I, the founder of the 22nd dynasty, about 928 B.C. endeavoured to assert the ancient supremacy of Egypt (*cf.* I Kings, 14:25 ff.). His successes, however, were not lasting, and, as is clear from the Old Testament, the power of Egypt became thenceforward ineffective.

2. Assyrian and Babylonian Domination.—Between the withdrawal of Egyptian rule in Syria and the western advance of Assyria comes an interval during which the city-states of Phoenicia owned no suzerain. Byblos had kings of its own, Ahiram, Ithobaal, Abi-baal, in the 10th century, as excavations have shown. The history of this period is mainly a history of Tyre, which not

only rose to a hegemony among the Phoenician states but also founded colonies beyond the seas. Unfortunately, the native historical records of the Phoenicians have not survived, but it is clear from the Bible that the Phoenicians lived on friendly terms with the Israelites. Hiram, king of Tyre, built the Temple of Solomon at Jerusalem in return for rich gifts of oil, wine, and territory.

In the following century, however, the independence of Phoenicia was increasingly threatened by the advance of Assyria. In 868 B.C. Ashurnasirpal II reached the Mediterranean and exacted tribute from the kings of Tyre, Sidon, Byblos, and other cities. His son, Shalmaneser III, took tribute from the Tyrians and Sidonians and established a supremacy over Phoenicia, at any rate in theory, which was acknowledged by occasional payments of tribute to him and his successors. In 734 B.C. Tiglath-Pileser III in his western campaign established his authority over Byblos, Aradus, and Tyre. A fresh invasion, by Shalmaneser V, took place in 725 when he was on his way to Samaria, and in 701 Sennacherib, facing a rebellion of Philistia, Judah, and Phoenicia, drove out and deposed Luli, king of Sidon, from Tyre, forcing him to flee to Cyprus. In 678 Sidon rebelled against the Assyrians, who marched down and annihilated the city, rebuilding it on the mainland. Sieges of Tyre took place in 672 and 668, but it resisted both, only submitting in the later years of Ashurbanipal together with Manasseh of Judah.

During the period of Neo-Babylonian power which followed the fall of Nineveh in 612 B.C., the pharaohs made attempts to seize the Phoenician and Palestinian seaboard and the important land bridge between two continents which they represented. Nebuchadrezzar II, king of Babylon, having sacked Jerusalem, marched against Phoenicia and besieged Tyre, but it held out successfully for 13 years, after which it capitulated, seemingly on favourable terms.

3. Persian Period.—Phoenicia passed from the suzerainty of the Babylonians to that of their conquerors, the Persians, in 538 B.C. Not surprisingly, the Phoenicians turned as loyal supporters to the Persians who had overthrown their oppressors, and reopened to them the trade of the Orient. At the time of Xerxes I's invasion of Greece, the city of Sidon was considered to be the principal city of Phoenicia, and the ships of Sidon were considered the finest part of Xerxes' fleet, its king ranking next to Xerxes and before the king of Tyre.

Toward the close of the 5th century, Phoenician coins began to supplement historical sources. From the time of Darius I the Persian monarchs allowed their satraps and vassal states to coin silver and copper money at discretion. Hence Aradus, Byblos, Sidon, and Tyre issued a coinage of their own. The coins are stamped as a rule with the emblem or name of the city, sometimes with the ruler's name. Several inscriptions on stone of this period also exist. In the 4th century Tyre, and later Sidon, revolted against the Persian king. The revolt was suppressed in 345 B.C. In 332 B.C. Tyre resisted Alexander the Great in a siege of eight months. Alexander finally captured the city by driving a mole into the sea from the mainland to the island. As a result Tyre, the inhabitants of which were largely sold into slavery, lost all importance, soon being replaced in the leadership of the Oriental markets by Alexandria. After the cities of Phoenicia had changed hands many times between the rulers who succeeded Alexander, the Romans arrived to restore order. In 64 B.C. Phoenicia was incorporated into the Roman province of Syria, though Aradus, Sidon, and Tyre retained self-government. (For later history, *see* SYRIA: *History;* LEBANON: *History.*)

4. Constitution.—Little is known about the constitution of the Phoenician states. All Canaanite analogy speaks for kingship as the oldest form of Phoenician government. In the native inscriptions the chief of the city, in Phoenicia itself and in Cyprus, is always called king. The royal houses claimed divine descent, and the king could not be chosen outside their members. His power, however, was limited by the wealthy merchant families, who possessed great influence in public affairs. The priest of Melkarth at Tyre was the second man in the kingdom. Associated with the prince was a council of elders; such at least was the case at Byblos, Sidon, and perhaps Tyre. Inscriptions of the 3rd and 2nd centuries B.C. mention a *rab* (chief) in Sidon, Cyprus, and Gaulus; what his position was it is difficult to say; in the colonies he may have been a district governor. During Nebuchadrezzar II's reign (605–562 B.C.) a republic took the place of the monarchy at Tyre, and the government was administered by a succession of suffetes (judges); they held office for short terms, and in one instance two ruled together for six years. Much later, in the 3rd century B.C., an inscription from Tyre also mentions a suffete. Carthage was governed by two suffetes, and these officers are frequently named in connection with the Carthaginian colonies. But this does not justify any inference that Phoenicia itself had such magistrates. Under the Persians a federal bond was formed linking Sidon, Tyre, and Aradus. It was their duty to contribute 300 triremes to the Persian fleet (Herodotus, vii, 89). Federation on a larger scale was never possible in Phoenicia, for the reason that no sense of political unity existed to bind the different states together. Commercial interests dominated everything else, and while these stimulated a municipal life that was not without vigour, civil discipline and loyalty were but feebly felt. On occasion the towns could defend their independence with strenuous courage; the higher qualities which make for a progressive national life the Phoenicians did not possess.

II. COLONIAL AND COMMERCIAL ACTIVITIES

1. Colonies.—By the 2nd millennium B.C. the Phoenicians had already extended their influence along the coast of the Levant by a series of settlements, some well known, some virtually nothing but names. Well known throughout history are Joppa (Tel Aviv-Jaffa) and Dor (later Tantura, modern Nasholim) in the south. In the north, the island city of Aradus planted its colonies on the mainland opposite, beginning with Antaradus (modern Tartus). The earliest site, however, outside the Phoenician homeland known to possess important aspects of Phoenician culture is Ugarit, which was identified in 1929 in excavations at Ras Shamra, about 6 mi. N. of Latakia. The site was already occupied before the 4th millennium B.C., but the Phoenicians do not appear to have become prominent there until the time of the Egyptian 12th dynasty (1991–1786 B.C., level IV), when the position of the site as a stepping-stone to the wealth of Anatolia and Cyprus first became appreciated.

In level IV two temples first appear, dedicated to the Phoenician gods Baal and Dagon, although the ruling family appears to have been of a different, non-Phoenician stock, and the population was probably much mixed. The 15th century B.C. shows strong cultural influences already established there from Cyprus and the world of Mycenaean Greece. In the latter part of the 13th century B.C., a flood of land and sea raiders descended on the Levant coast, destroying many of the Phoenician cities and rolling onward to the frontier of Egypt, from which they were beaten back by the Pharaoh Ramses III. Ugarit was destroyed, together with Aradus and Byblos, though the latter were afterward rebuilt. Though Sidon was destroyed only in part, its inhabitants fled to Tyre, which from this time was regarded as the principal city of Phoenicia, and begins its period of prosperity and expansion.

Tradition places the founding of Utica in North Africa, Tyre's first colony, at 1140 B.C., or 1101 according to other sources. Archaeological discoveries do not today support so early a date, though some objects found there may go back to the 10th century. Similarly, the statement of Strabo (1, 48) that the Phoenicians settled at Gadir (Gr. Gades; modern Cádiz in Spain) shortly after the Trojan War has found no archaeological support. It is likely that the expansion of the Phoenicians at the beginning of the 1st millennium B.C. is to be connected with the alliance of Hiram of Tyre with Solomon of Israel in the second half of the 10th century B.C. In the following century, Phoenician influence in the north is shown by inscriptions at Sam'al (Zincirli) in eastern Cilicia, and in the 8th century at Karatepe (*q.v.*) in the Taurus Mountains. Both these cities acted as fortresses commanding the routes through the mountains to the mineral and other wealth of Anatolia. In the mid-7th century B.C. a short-lived Phoenician state was similarly established at Kundu and Sisu (modern Siz) in eastern Cilicia.

FROM D. HARDEN, "THE PHOENICIANS," 1962; THAMES AND HUDSON, LTD. AND FREDERICK A. PRAEGER, INC.

PHOENICIAN COLONIZATION IN THE MEDITERRANEAN

The great island of Cyprus early became a Phoenician colony, at least in part. A Phoenician inscription of the 9th century B.C. in the Cyprus Museum probably comes from the northeast corner of the island. The principal colony of the Phoenicians there was Citium (*q.v.*), known to the Greeks as Kition (biblical Kittim), in the southeast corner. A Phoenician text of the 8th century B.C. which was found near Amathus, and an Assyrian inscription of Esarhaddon of the 7th century, mention Qart-hadasht ("new town"), but it is not clear whether this refers to Amathus or perhaps Citium under an original name. Other sites in Cyprus, such as Idalium, Tamassus, Chytri, Lapethus, Golgi, and the site today called Athiénou, were all probably Phoenician. Others, however, such as Amathus, Salamis, and Marium may have been only partly so. Idalium itself was a Phoenician city only from the 5th century B.C., when it was captured by Citium.

Several smaller Phoenician settlements were planted as stepping-stones along the route to Spain and its mineral wealth in silver and copper. Greek tradition placed one at Cythera (an island south of the Peloponnese), but this is unconfirmed in any way. The islands of Lampas (modern Lampedusa), Cossyra (modern Pantelleria), Gaulus (modern Gozo), and Melita (modern Malta) certainly carried Phoenician trading stations, although only at Malta have early remains going back to the 7th century B.C., been found.

In Sicily the Phoenicians were established by the end of the 8th century B.C. Motya, near Marsala, has produced many Phoenician relics. According to Thucydides, the Phoenicians originally controlled a large part of the island but withdrew to the northwest corner under pressure from the Greeks. Modern scholars, however, disbelieve this and contend that the Phoenicians arrived only after the Greeks were installed.

In North Africa, the next site colonized after Utica was Carthage (*q.v.*). The Phoenicians claimed that it was occupied 287 years after Utica; *i.e.*, in 814/813 B.C. if Utica was founded in 1101. Archaeological finds made there, however, go back only to the second half of the 8th century B.C. A list of 26 sites in Tunisia bearing Punic remains has been compiled, most of them being along the coast. (The adjective Punic is derived from *Poeni*, the Latin name for the Carthaginians, derived in turn from *Phoenikes*, Phoenicians.) The finds range from the 5th to the 2nd century B.C. In Algeria the earliest is Djidjelli (7th century B.C.). In Morocco (ancient Mauretania) there are remains from Lixus (modern Larache) and Melilla and from Mogador on the Atlantic coast.

In the Balearic Islands, tradition places the earliest Phoenician colony at Ebusi (Ibiza), founded in 654/653 B.C. (*see* Diodorus v, 16, 3). The archaeological findings there, however, do not appear to date earlier than the 6th century B.C.

In Sardinia there were Phoenician sites at Nora (near Cagliari), Bosa, Sulcis (the island of Sant' Antioco, near Tortoli), and Tharros (Oristano). Inscriptions found at Tharros and Bosa have been claimed to belong to the 9th century B.C., but this is not accepted by all scholars. As far as can be seen, the material from Tharros does not go back before the 7th century B.C. at the earliest and is mostly Punic rather than Phoenician. Indeed it would appear that there was no substantial settlement in Sardinia until after the Battle of Aleria (Alalia) in about 535 B.C., which secured the island to the Carthaginians.

In Spain, the settlement of Gadir (Cádiz) at the mouth of the Guadalquivir evidently gave the settlers access to the gold, silver, and copper of Tartessus (possibly around Seville; *see* the remarkable finds illustrated by J. de M. Carriazo in *Illustrated London News*, Jan. 31, 1959). Nevertheless the earliest material so far obtained at Cádiz is regarded as not earlier than the late 6th century, though the splendid jewelry from La Aliseda is probably of the 7th century B.C.

In short, there is little factual evidence to confirm the presence of any settlement in Spain earlier than the 7th century B.C. (though for another view *see* CÁDIZ), and those settlements should be viewed as Punic rather than Phoenician, though of course it is likely that the colonizing expeditions of the Carthaginians were supported by many emigrants from the Phoenician homeland. It is in fact very probable that the tremendous colonial activity of the Phoenicians and Carthaginians was stimulated in the 8th to 6th centuries B.C. by the military blows which were wrecking the trade of the Phoenician homeland in the Levant.

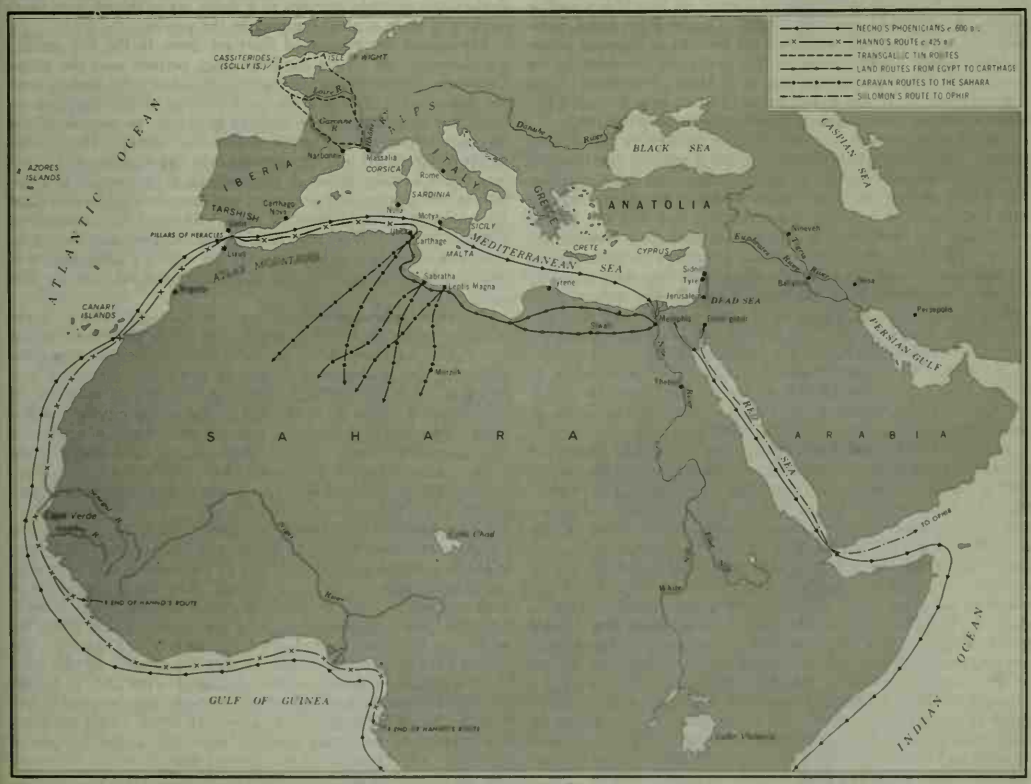
While the Greeks were repelling the invasions of the Persians and their Phoenician ally in the Aegean, the Greeks of Sicily similarly were called upon to resist the Carthaginians, and defeated them. To restore their power, the Carthaginians set up an empire in North Africa over the older Phoenician settlements. A fresh war in Sicily between 346 and 339 B.C. resulted only in a partition of the island. Carthage, led by the family of Barca, embarked on a further imperialistic phase in Spain in the following century, founding settlements at Qart-hadasht (Cartagena) and elsewhere. Carthage grew enormously, its population being claimed to reach the figure of 700,000. In 146 B.C. it was captured by the Romans, led by P. Scipio Africanus, and was totally destroyed and razed to the ground (for the history of the long preceding struggle between Rome and Carthage *see* PUNIC WARS). It was rebuilt as a Roman colony in 44 B.C. The site today lies east of the city of Tunis. Under the Roman Empire, certain of the lesser Punic cities (Leptis, Utica, Hadrumetum, Thapsus, Theudalis, Acholla, and Usula) were proclaimed autonomous. In them the ancient Phoenician language survived in use as a vernacular at least until the time of St. Augustine, bishop of Hippo (5th century A.D.).

2. Commerce.—The role which tradition especially assigns to the Phoenicians as the merchants of the Levant was first developed on a considerable scale at the time of the Egyptian 18th dynasty. The position of Phoenicia, at a junction of both land and sea routes, under the protection of Egypt, favoured this development, and the discovery of the alphabet and its use and adaptation for commercial purposes and the invention of the abacus for ready calculation assisted the rise of a mercantile society, well supplied with artisans organized in guilds and provided with slave and free labour. A fresco in an Egyptian tomb of the 18th dynasty, photographed in the 1890s and since unfortunately destroyed, depicted seven Phoenician merchant ships which had just put in at an Egyptian port to sell their goods, including the distinctive Canaanite wine jars in which wine, a drink foreign to the Egyptians, was imported. About 1100 B.C. the *Story of Wen-Amon* recounts the tale of a Phoenician merchant, Werket-el of Tanis in the Nile delta, who was the owner of "50 ships" which sailed between Tanis and Sidon. The Sidonians are also famous in the poems of Homer as craftsmen, traders, pirates, and slave dealers. The prophet Ezekiel (ch. 27 and 28), in a famous denunciation of the city of Tyre, catalogues the vast extent of its commerce, covering most of the then-known world.

The exports of Phoenicia as a whole included particularly cedar and pine wood from Lebanon, fine linen from Tyre, Byblos, and Berytos, cloths dyed with the famous Tyrian purple (made from the snail *Murex*), embroideries from Sidon, metalwork and glass, glazed faience, wine, salt, and dried fish. They carried these goods to Egypt and to the less-developed nations of Anatolia, Africa, the Aegean, and the western Mediterranean, receiving in return raw materials, such as papyrus, ivory, ebony, silk, amber, ostrich eggs, spices, incense, horses, gold, silver, copper, iron, tin, jewels, and precious stones. They established a network of trading stations and colonies over the Mediterranean shores along the route to Spain and beyond, while in the east it is possible that they found their way to India, if Ophir (*q.v.*) is to be identified with the ancient port of Supara. Hiram I, king of Tyre, and Solomon, king of Israel, formed an alliance to send a trading expedition to Ophir every three years from Ezion-geber (on the Gulf of Aqaba), and it is told that these expeditions brought back rich cargoes of gold, silver, ivory, apes, peacocks, and sandalwood (I Kings, 10:11 and 22; II Chron. 9:10 and 21). Expeditions were also sent around the coasts of Africa, and it is possible (see *Navigation and Seafaring*, below) that they reached the coasts of Britain, then called the Cassiterides, or Tin Islands, in search of the tin of Cornwall; but this rests at present only on the authority of Diodorus and Strabo and is not supported by archaeological finds.

In addition to these exports and imports, the Phoenicians also conducted an important transit trade, especially in the manufactured goods of Egypt and Babylonia (Herodotus, i, 1). From the lands of the Euphrates and Tigris regular trade routes led to the Mediterranean with trading stations on the way, several of which are mentioned by Ezekiel. In Egypt, the Phoenician merchants soon gained a foothold; they alone were able to maintain a profitable trade in the anarchic times of the 22nd and 23rd dynasties (*c.* 945–*c.* 730 B.C.). Though there were never any regular colonies of Phoenicians in Egypt, the Tyrians had a quarter of their own in Memphis (Herodotus, ii, 112). The Arabian caravan trade in perfume, spices and incense passed through Phoenician hands on its way to Greece and the west (Herodotus, iii, 107).

Between Israel and Phoenicia relations naturally were close; the



FROM D. HARDEN, "THE PHOENICIANS," 1962, THAMES AND HUDSON LTD AND FREDERICK A. PRAEGER, INC.

THE SPREAD OF PHOENICIAN TRADE AND EXPLORATION

former provided certain necessaries of life and received in exchange articles of luxury and splendour (Ezek. 27:17). After the return from the exile Tyrians sold fish and all manner of wares in Jerusalem (Neh. 13:16) and introduced other less desirable imports, such as foreign cults.

The Phoenician words which made their way into Greek at an early period indicate the kind of goods in which the Phoenicians traded with the west, or made familiar through their commerce. Some of these may well prove in the light of future study of the Minoan Linear B script to have been endenizened in the Greek language as early as the Late Bronze Age. Examples of these Semitic words in Greek guise include words for various sorts of textiles and dress, minerals, precious stones, spices, food and drink, and musical instruments. The reflection of Phoenician embroidery, weaving, and metalwork is clearly seen in the decoration and shapes of Greek pottery of the 7th century B.C., aptly called the "orientalizing period," especially in the animal friezes and the borders of lotus and palmette patterns.

Greek architecture also was deeply influenced by Phoenicia. Both the Ionic and the Aeolic capitals (*see* CAPITAL), probably also the Corinthian capital, and in Hellenistic times the Pergamene capital of palm leaves are derived from Phoenician models, as is also the ovolo (egg-and-dart) molding. The words *bōmos* from the Semitic *bamah* ("high place"); *lesche,* meaning "hall" (Phoenician *lishkah*); and *plinthos,* "brick" (English plinth), connected with Assyrian *libittu,* must have also come by the same route. It is not always easy to pinpoint these routes exactly. Naturally, the Phoenician influence made itself most strongly felt upon Greece through Rhodes and Cyprus, where strong Phoenician settlements existed; in the latter island a hybrid Greco-Phoenician art resulted. But on the mainland and islands of Greece, no Phoenician trading station or settlement has been found. On the other hand, paradoxically, excavation has produced the remains of vigorous settlements of Greek traders, from the 8th to the 6th centuries, in the homelands of the Phoenicians; *e.g.,* at Al Mina (Poseidion) on the coast of north Syria and at Tell Sukas (Paltos) near Tripoli, a site which was being excavated by a Danish expedition in the 1960s.

The Phoenicians were not mere passive peddlers in art or commerce. Their achievement in history was a positive contribution, even if it were only that of an intermediary. In the Early Iron Age they provided the newly arisen world of the Mediterranean with both material comforts and necessities and with the artistic vocabulary and techniques in which to express their feelings and tastes. The East contributed various influences to make up the "orientalizing period," but in these the Phoenicians were probably the most important force. Oriental bronze bowls, ivories, goldsmiths' work, alabaster, glazed beads, and figurines and glass objects found in ancient sites are probably all originally either imports from or through Phoenicia or imitations of them. The extent of the debt of Greece to Phoenicia may be fully measured by its adoption, perhaps in the 9th century B.C., of the Phoenician alphabet with very little variation, and by the universal use in Greece of the Phoenician standards of weights and measures.

3. Navigation and Seafaring.—For the establishment of commercial supremacy an essential constituent was the Phoenician skill in navigation and seafaring. The Phoenicians are credited with the discovery and use of Polaris (the pole star). Fearless and patient navigators, they ventured into regions where no one else dared to go, and always, with an eye to their monopoly, they carefully guarded the secrets of their trade routes and discoveries and their knowledge of winds and currents. In the 3rd and 2nd millennia B.C. they were already building and manning seagoing ships known in Egypt as "Byblos ships." Their fleets were divided into two types—"long ships" or galleys, for speed and rapid maneuver, armed with a sharp ram at the bow and propelled by two or three banks of oarsmen (these are almost certainly what are called in the Bible "ships of Tarshish"); and "round ships" called *gōlah* (Gr. *gaulos*) for trade. Both sorts are represented on an Assyrian sculpture of Sennacherib (*c.* 700 B.C.). A third division of craft was a kind of barge called by the Greeks *hippos* because the prow was formed as a horse's head.

Pharaoh Necho II (610–595 B.C.) organized the Phoenician circumnavigation of Africa (Herodotus iv, 42). Hanno, a Carthaginian, led another in the mid-5th century. The Carthaginians seem to have reached the island of Corvo in the Azores, where a pot containing Punic and other coins was found in 1740. They may even have reached Britain, for many Carthaginian coins have been found there.

III. ART, MANUFACTURES, AND WRITING

The frescoes which enliven the walls of Egyptian tombs of important personages in the 18th dynasty show tributaries bringing as gifts vessels of precious metal and other works of art, evidently of a sort particularly prized, which were imported from the north. There is general agreement that these were Phoenician manufactures. At the same time, the royal records of the pharaohs tell of rich tribute from Syria and Phoenicia. The craftsmen of those countries evidently set themselves to work for the Egyptian market in supplying its nobility with luxury goods. The illustrations of these Asiatic imports show much humour and inventiveness: vases, to be filled with water, suggesting pools, have ducks' heads peeping out of artificial flowers, while cattle hide in thickets of papyrus. Sometimes the handles are formed in the shape of captured Asiatics. Some of the foreign craftsmen settled in Egypt, and the workmen's quarters of some have been excavated at Deir el Medineh, near Thebes. In the products of Phoenicia, Egyptian motifs and ideas were mingled with those of Mesopotamia (*e.g.,* that country's love of symmetrical groupings); from the Aegean, from Crete and Mycenae was taken the taste for galloping or flying animals. To these were added the ever-present sphinxes and griffins which were native products of the Phoenician and Syrian imagination. The Phoenicians showed special skill in fusing these various devices and symbols together in a single style, though sometimes weakening their original meaning in the process.

Throughout the history of their art down to the 6th century B.C., however, the strong Egyptian tinge persists over the native Canaanite, Semitic basis. Certain classes of objects, such as scarabs and amulets, in which the great prestige of the Egyptian religion was paramount, were modeled as closely as possible on the Egyptian originals. By the 5th century B.C., however, the achievements of Greek art and craftsmanship in the mastery of the human figure, in composition, in the conquest of perspective and representation of space and movement and emotion were so great that Phoenicia was overwhelmed by them. Thus, at the cemetery of Umm al Awamid Phoenician priests, men and women, are represented in relief in a purely Greek style, and the same is true in the satrap sarcophagi from Sidon, although the subjects are Persian.

The same hellenization took place in Carthage, where Greeks settled or were employed as slaves, and in the Hellenistic period this victory of Greek taste naturally continued even more completely, a fine example in Phoenicia being the Alexander sarcophagus. Yet, at Carthage, Egyptian influence in religious art still remained strong up to the destruction of the city by the Romans. An example of this is the splendid sarcophagus of a priestess from Carthage, carved with her figure wearing the costume of the goddess Astarte-Isis; it also appears that Carthaginian priests understood the purposes of Egyptian magic and could read the hieroglyphs until the last days of the city.

1. Architecture.—Information about this subject from excavations is restricted mainly to Byblos and Ras Shamra. At Byblos in the first urban settlement (level IV) houses consist of several rooms often attached to an initial cell. The walls, apparently of mud and wattle, were founded on stones dressed at the corners. The roofs were supported by posts placed axially and along the walls. An early sanctuary existed. In level V (2850–2750), the houses have proper foundations of split limestone. In this level the first monumental temples, that dedicated to the Lady of Byblos and that of Resheph and two others, are built, and the town is surrounded by a huge rampart. In level VII (2150–1800) the practice appears of dedicating obelisks, especially in the Temple of Resheph. (The survival of this type of dedication may be traced through Canaanite religion of the Late Bronze Age, via the miniature stelae at Hazor, to the stelae set up in vast numbers in Car-

thaginian temples and sanctuaries.) A small model of a house or temple exists, found in the foundations of the Resheph Temple at Carthage. It represents a square building with two lofty doors in each side, the doorposts of which appear to be crosshatched.

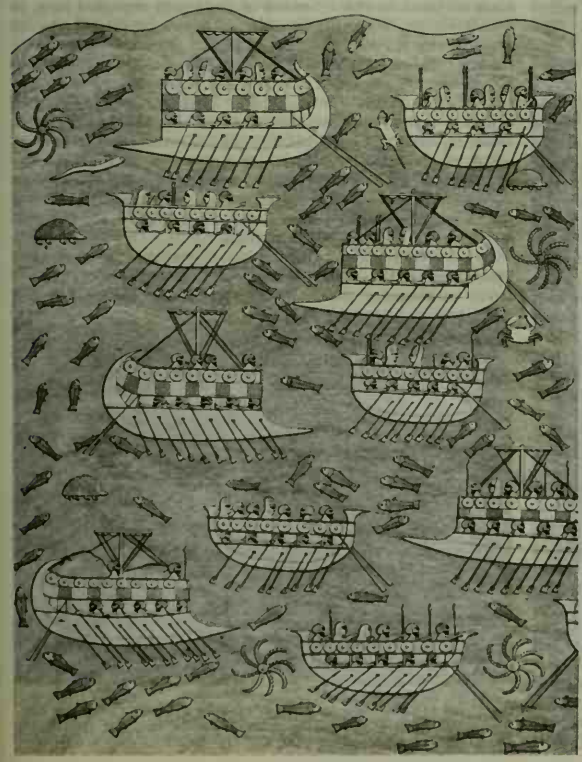
No archaeological information is yet available about the details of a Phoenician temple. At Hazor, however, in Galilee, and at Naharia in Israel, Canaanite temples have been found with a tripartite division of the ground plan of court, sanctuary, and Holy of Holies, which clearly repeats that of the 10th-century temple built for Solomon at Jerusalem and described in the Bible (I Kings 5 and 6), a passage which constitutes virtually a good description of a Phoenician temple. The most striking external feature of Solomon's Temple was the pair of pillars of bronze which stood free beside the doorway and which carried elaborate capitals decorated with "lily work." In this particular, and perhaps in many others, there is evidence that the temple at Jerusalem was modeled on the Temple of Melkarth at Tyre. The latter was very ancient, founded about 2750 B.C. according to Herodotus (ii, 44). A representation of it survives in a drawing of a lost Assyrian relief from the palace of Sennacherib at Nineveh. It shows a building which resembles the Temple of Solomon in having two floors separated by a roof with a broad cornice. Before its main doors are a pair of columns with proto-Ionic or lily-shaped capitals, standing free. These are the twin columns of gold and "emerald" which Herodotus describes as "shining with great brilliancy at night." A model shrine of terra-cotta from Idalium in Cyprus, now in the Louvre, perhaps representing the Temple of Resheph-Apollo at Idalium, has a similar pair of columns. The capitals of this type are connected with the so-called proto-Ionic capitals which have been found in excavation in Palestine.

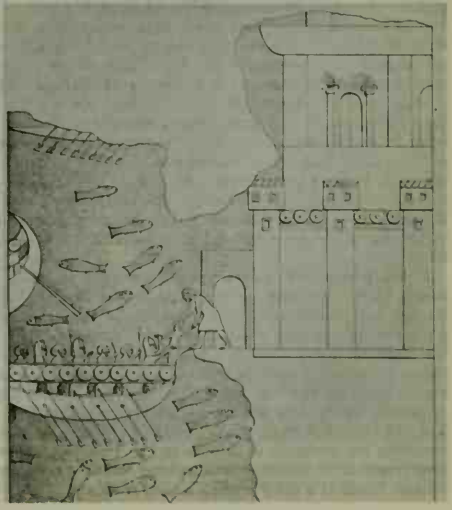
The entrances of some shrines in Phoenicia were flanked with figures of sphinxes. Other shrines, however, were built in a purely Egyptian style, as, for example, the pair of rock-carved water shrines at Amrith.

For knowledge of the appearance of Syrian and Phoenician secular architecture in the Bronze Age it is necessary to fall back on illustrations in Egyptian art. Narrative reliefs in Egyptian temples are the principal source of information, but there also exists at Medinet Habu (Thebes) a full-scale reproduction of a Canaanite fortress, which Ramses III introduced into his temple group there. These illustrations show lofty gateway buildings with windows above the gate, and a second story surmounted by a flat roof fortified with rounded crenellations. In fact, these crenellations continued in use well into the Iron Age, examples being found at Motya. The lofty upper rooms with windows above the gate were a convenient habitation for the women and the reliefs carved on the Medinet Habu building show them used so. Such buildings were famed in Egyptian fable. In the *Story of the Doomed Prince* (possibly the origin of the story of Rapunzel) a chief of Naharain (Phoenicia) has built for his only daughter a harem with 70 windows 70 cubits above the ground, which any would-be suitor has to scale. This the visiting Egyptian prince succeeds in doing.

The brief account of Solomon's palace (I Kings 7) furnishes a link between Phoenician architecture of the Bronze Age and that of the Iron Age. It was a hypostyle hall built of cedar wood, and his harem was of colossal hewn and sawn stone and cedar wood, probably laid in alternate courses as was done at Atchana and Zincirli, the techniques surviving in parts of the Middle East until modern times. Another Assyrian relief from the palace of Sennacherib depicts a Phoenician city of palaces and imposing buildings, apparently with roof gardens. Several of the tallest buildings have upper floors lit by windows, which are closed at half their height with a balustrade supported on four columns.

A relief from the palace of Sargon at Khorsabad shows a differ-





DRAWING OF A LOST ASSYRIAN WALL RELIEF FROM THE PALACE OF SENNACHERIB AT NINEVEH

Relief shows the flight of Luli, king of Tyre and Sidon, from Tyre in 701 B.C. On the left are seen the two types of Phoenician ships, the armed "long ships" or galleys and the "round ships" for trade. Below is the only known representation of Phoenician temple architecture

(LEFT) FROM A. H. LAYARD, "MONUMENTS OF NINEVEH," (BELOW) FROM THE ORIGINAL SKETCH BY LAYARD; PHOTOGRAPHS, BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

BY COURTESY OF MUSÉE DU LOUVRE

LIMESTONE STELE FROM AMRITH (ABOUT 8TH CENTURY B.C.) SHOWING THE GOD SHADRAFA STANDING ON A LION ABOVE MOUNTAINS AND SWINGING A SMALL LION IN HIS HAND. HEIGHT 1.8 M. IN THE LOUVRE

ent type of Phoenician building. Beside a lake in wooded hills is set a kiosk, or hunting lodge, the roof supported by columns with proto-Ionic capitals. The presence of the horse-headed barge, a Phoenician *hippos*, and of officers holding Phoenician sceptres clearly indicates the location in which this building is set.

Conventional Assyrian illustrations exist of the city of Tyre perched on its island (on the bronze gates of Shalmaneser, from Balawat) and probably of Aradus also on a sculpture from Khorsabad (in the Louvre). A detailed view of the quay and seawall of Tyre in the relief from the palace of Sennacherib referred to above shows that the curtain walls between the towers are hung with shields. This agrees perfectly with the description of the city in Ezek. 27:11.

A silver bowl from Amathus in Cyprus (in the British Museum) shows a presumably Phoenician city with gateway towers undergoing assault by an enemy. Within the gateway are seen a number of beehive-shaped houses. Such houses (called *magalia*) were built by Carthaginians. A clay model of one was found at Ras Shamra. The custom of building round houses must have been imported into North Africa from the Levant, for whole villages of such houses are still found in north Syria (Neirab, Arslan Tash, etc.).

2. Funerary Architecture.—In the Middle and Late Bronze Age the inhabitants of Phoenicia and Palestine constructed tombs in the form of caves cut in the soft rock and reached by vertical shafts. At Byblos the kings of the early 2nd millennium were buried in tombs of this kind, inside a stone sarcophagus. At Ras Shamra, however, under Aegean influence, the cavern took the form of a beehive tomb of carefully hewn blocks of stone. In Cyprus this tradition of a stone-built vault continued into the 6th and 5th centuries, the cavern being regarded as a sort of underground house reproduced in stone, approached by a descending flight of steps. In a tomb at Tamassus the wooden beams of a gabled roof are clearly represented, and at Amathus and Pyla the stone doorway is surmounted by a carved gorgon's head. But some strange funerary buildings were also erected above ground; *e.g.*, the two cylindrical and dome-capped monuments at Amrith, one being flanked by figures of lions. They perhaps reflect the Phoenician circular houses. E. Renan also records a pyramidal tomb obviously inspired from Egypt. In Tunisia the well-known 2nd-century-B.C. mausoleum at Thugga (Dougga), which contained a bilingual Phoenician and Numidian inscription, represents a fusion of the Egyptian pyramidal funerary building and a Hellenistic Greek temple.

3. Sculpture.—Of monumental Phoenician sculpture in the round, hardly anything survives. At Byblos, in the Temple of Baalat, only shapeless remains, chiefly the legs, exist of large statues depicted seated or standing in the forecourt of the temple. One large statue alone is complete, showing a stocky figure of Egyptian type, wearing a kilt, the hands firmly clenched and close to the hips, advancing with the left foot in the Egyptian manner and suggesting the type of archaic Greek *kouros* statue (*see* GREEK ART: *The Greek Archaic Period* [*c. 650–c. 480* B.C.]). Its date is uncertain but probably it belongs to the Iron Age. There is a long tradition of Phoenician limestone statuary in Cyprus. A colossal figure of a deity rending a lion, from Amathus in Cyprus (in the Louvre), belongs to the 6th century B.C.

Sculpture in relief, on the other hand, has a very long tradition. The excavations at Ras Shamra have produced a number of stelae belonging to the 14th–13th centuries B.C. One shows two men wearing the wrapped-round garment of the period, apparently kings swearing a contract together. Others show deities, such as Teshub, Resheph, or El. At Byblos was found the earliest major work of Phoenician sculpture to survive, the sarcophagus of Ahiram, who is dated to the end of the 11th century B.C. This limestone sarcophagus, bearing a long inscription, has carved figures of men and lions on the lid and base, and its sides are decorated with funerary scenes showing worship of, and lamentation for, the dead man. There are (or were) traces on the lid of painting in red and blue, on the dresses of the figures. This sarcophagus obviously reproduces in stone a contemporary decorated wooden chest with carved panels, and is the earliest example of what became later the established type of Phoenician funerary furniture, continuing with little change through stone sarcophagi, such as those from Amathus and Tamassus and Athiénou (late 6th and 5th centuries B.C.) to the "satrap" and "Alexander" sarcophagi and that of the "Pleureuses" at Carthage. In the 8th century B.C., relief slabs were employed architecturally (*e.g.*, at Karatepe in the Taurus Mountains). The tradition of the relief stele persists strongly in Phoenician art. From Amrith comes the fine stele in the Louvre, showing Shadrafa swinging a lion (*c.* 8th century B.C.). From near Aleppo comes a relief of Melkarth, the god of Tyre, of similar date.

In the Persian period there was a return to Egyptian models, *e.g.*, in the stele of Yehawmilk of Byblos (in the Louvre), but from Umm al Awamid there is a graceful series of funerary stelae deeply influenced by Greek art of the 5th century. The Sidonians for a time tried to synthesize Greek and Egyptian currents of art; the sarcophagus of Tabnith, king of Sidon, substitutes idealized Greek heads as portraits of the dead on the lid of the sarcophagus, now made of Greek marble. Several of the artists employed may, in fact, have been Greeks, and it is debatable how far these works are to be strictly regarded as works of Phoenician art at all. Nevertheless, these sarcophagi were very popular among wealthy Phoenicians and are found not only at Sidon but exported also to Cyprus, Egypt, Tartûs, Motya, Malta, Carthage, and Cádiz. But it is clear that by the time Greek art had begun to flourish Phoenician art had spent itself and was quite derivative and secondary, simply employing the motifs and ideas of others. At Carthage, the decadence of the relief, a genuine Phoenician tradition, could not be more complete. By the 3rd century B.C. it was reduced to a few simple subjects (the Tinit sign, a bull, sun disk and moon crescent, etc.) coarsely scratched within a shrine.

4. Carving in Wood and Ivory.—One of the chief sources of Phoenician wealth was the much-sought-after timber of the famous cedars of Lebanon. Its beams were prized for shipbuilding and

BY COURTESY OF THE NATIONAL MUSEUM OF ANTIQUITIES, BEIRUT

LIMESTONE SARCOPHAGUS OF AHIRAM, KING OF BYBLOS (ABOUT 11TH CENTURY B.C.), WITH A PHOENICIAN INSCRIPTION ON THE SIDE OF THE LID AND CARVED FIGURES ON THE BASE AND LID

BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

PHOENICIAN IVORY PANEL (ABOUT 8TH CENTURY B.C.), FROM NIMRUD; IN THE BRITISH MUSEUM

architectural purposes, but cut into panels it could also be carved in relief. At this too the Phoenicians were skilled, probably as early as the Bronze Age. The sarcophagus of Ahiram clearly reflects a carved wooden prototype. I Kings 6 and 7 describes the use of cedar for both functional and decorative purposes in Solomon's Temple and palace at Jerusalem under the influence of the Phoenicians. No examples, however, of this type of wood carving have survived. Ivory carving, being closely related to carving in hard woods, also became a Phoenician specialty, probably before the 14th century B.C., especially for the decoration of furniture. It was then aided by the convenient presence of a local supply of ivory derived from a native Syrian breed of elephant (which, however, it soon became necessary to supplement with ivory from India and Africa). At Ras Shamra a carved round table of ivory and a group of 16 carved ivory panels was found, bearing religious or mythological scenes; they evidently formed part of the decoration of a royal, perhaps ritual, bed. Such princely furniture of ivory came into fashion in the Levantine courts and shrines at the turn of the 9th–8th centuries, and ivory couches, even "ivory houses," became a symbol of luxury and oppression and social injustice to Old Testament authors (I Kings 22:39; Amos 6:4; Ps. 45:8). Remains of such ivory furniture, in the form of carved panels, in relief or open work, and various fittings, have been found in excavations at many sites in the near east.

During those years, however, the Syrian elephant herds were hunted into extinction by the Assyrian kings, and the Phoenician cities themselves were repeatedly pillaged or taxed, their markets being sometimes ruined and their craftsmen enslaved. Thus the craft died, at least in Phoenicia. In the far west its traditions lingered a little longer in decadence probably into the 5th century B.C., examples being the ivories found at Carmona in the Guadalquivir Valley in Spain. These probably were of Carthaginian manufacture.

5. Metalwork.—At Byblos in the foundations of the Temple of Resheph (*c.* 2000 B.C.) vast numbers of dedicated metal objects were found. They showed that the wealth of Phoenicia then lay as much in exploiting copper and gold deposits, probably in the Lebanon and Cyprus, as in other forms of wealth such as the cedar and pine forests. In gold working the Phoenicians were already brilliantly skilful, as may be seen from some of the finds in the Resheph Temple. After the finds of Byblos, Phoenician goldsmiths' and metalsmiths' work is well represented by two splendid gold bowls of the 14th century B.C. found at Ras Shamra, decorated with hunting and animal scenes. One of their specialties and perhaps inventions was the art of decorating a surface with tiny globules of gold to form a pattern. This art, called granulation, was later adopted by the Etruscans, on a considerable scale. But with them the secret of its technique died until rediscovered in modern times.

From Tell el Ajjul, near Gaza, comes a collection of fine jewelry of the 15th century. Some splendid Iron Age jewelry was recovered from La Aliseda (on the Guadalquivir) in southern Spain, and from Tharros in Sardinia came jewelry of the 6th century (now in the British Museum). In the poems of Homer the Sidonians are reputed the most skilful bronze workers, but it is not possible yet to ascribe such Phoenician bronzes as survive to any particular city. At Nimrud in 1847–48 was discovered a fine series of bronze engraved bowls which are probably Phoenician. Phoenician or Punic jugs and bowls of silver and bronze have been found in Spain. A spectacular account of the work of a Phoenician master craftsman and metalworker in the 10th century B.C. is that given of Hiram, who cast the great bronze pillars for Solomon's Temple at Jerusalem (I Kings 7:13–15; II Chron. 2:13). Other great works of metal-casting in the temple (I Kings 7:16 ff.) were also clearly of Phoenician inspiration, small versions of the colossal wheeled bases executed in bronze having been found in Cyprus.

6. Textiles.—Phoenician textiles were world famous. The finest linen came from Byblos, Tyre, and Berytos. The name of Motya in Sicily itself means "loom." The purple dye made from the *Murex* snail, another Phoenician specialty, made Tyrian dyed cloth famous all over the ancient world until Byzantine times. Homer describes patterned textiles (whether embroidered or woven is not clear) as a specialty of the Sidonian women (Odyssey xv, 415–418), much prized in archaic Greece. Nothing of this, however, has survived.

7. Glass.—An important part is claimed traditionally for the Phoenicians in the invention of glass, according to Pliny the Elder. This probably reflects the fact that about 1500 B.C. the manufacture of glass vessels was suddenly developed out of the age-old techniques of glasswork in the Near East, and Phoenicians possibly took an important part in this achievement. The method of manufacture was to use a sand core, decorating the surface of

ARCHIVES PHOTOGRAPHIQUES

GOLD BOWL IN PHOENICIAN STYLE (DIAMETER 19 CM.) FROM RAS SHAMRA (14TH CENTURY B.C.) WITH HUNTING SCENE IN RELIEF. IN THE LOUVRE

BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

PHOENICIAN GLASS VESSELS INLAID WITH THREADS OF DIFFERENT COLOURS: (LEFT) DARK BLUE WITH OPAQUE YELLOW AND LIGHT BLUE TRAILS, FROM CAMIRUS (5TH CENTURY B.C.); (RIGHT) DARK BLUE WITH OPAQUE WHITE TRAILS, FROM THARROS, SARDINIA (3RD CENTURY B.C.). IN THE BRITISH MUSEUM

dark blue with undulating lines in a lighter colour. This technique continued until glassblowing was invented. From the mid-8th century B.C. until Hellenistic times Phoenicia was very probably one of the main centres for fabricating glass.

Glassblowing was probably invented in the coastal area of Phoenicia in the 1st century B.C. or, according to some, as early as the 3rd century. During the 3rd and 2nd centuries B.C. the art of blowing into molds was evolved. Many pieces bear the artist's signature.

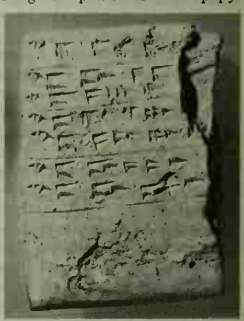
8. Writing.—By the second half of the 2nd millennium B.C. two systems of writing, Egyptian and Mesopotamian, both conveying only whole syllables, were in use in the Levant. The former was the hieroglyphic, with perhaps also the cursive hieratic of Egypt, but there was also an experiment in using the hieroglyphic script more or less alphabetically. The latter was the cuneiform writing. (*See* CUNEIFORM; HIEROGLYPHS.) While the Phoenicians were undoubtedly familiar with the Egyptian writing employed on stone, papyrus, or leather, they seem to have been strongly inclined to use cuneiform. The correspondence of the Egyptian chancery of Amenhotep IV (Ikhnaton) with the cities of the Levant, found at Tell el Amarna, was conducted in Akkadian written in cuneiform; and there exist many Phoenician cylinder seals (which were used only for signing clay tablets) exhibiting a mixture of Mesopotamian, Syrian, and Egyptian elements. But the Phoenicians' practical nature evidently urged them to produce a script of their own, which would effectively express the sounds of their own Northwest Semitic language and would be at once easy to write (like the Egyptian hieratic) and to learn (unlike the cumbrous Egyptian and Mesopotamian syllabaries), thereby removing its mastery from the exclusive professional monopoly of priests and scribes and breaking much of their power. Before the final alphabet was achieved there were several local experiments:

1. The "Sinaitic" or "proto-Sinaitic" script, an acrophonic adaptation of Egyptian hieroglyphs, used apparently for a Semitic script by some of the Canaanite, perhaps even Phoenician, workers in the Egyptian turquoise mines at Sarabit al Khadim in Sinai. This is largely undeciphered, except for the beginning of a dedication to Baalat on a sandstone sphinx in the British Museum. This script is dated to about 1500 B.C. (*See* also WRITING: *Phonography;* LOGOGRAM AND SYLLABARY: *Syllabic Systems: West Semitic Syllabaries.*)

2. The Ras Shamra script, discovered on clay tablets found at Ras Shamra in 1929, by the brilliant excavations of C. Schaeffer. This is a true alphabetic script of Semitic type of 30 signs, dispensing with the vowel sounds and using only consonants, written, like cuneiform, with a stylus on a clay tablet; but, though the signs are wedge-shaped, they have nothing else in common with cuneiform, and the choice of letter forms is occasionally influenced by the other alphabet of the Phoenicians. The original order in which the letters were taught is now known, and conforms to the standard order of the later Phoenician and Hebrew letters of the alphabet. The tablets which were found written with it cover myths and legends, administrative and commercial matters. Strangely enough, this script appears to be almost exclusively confined to Ugarit. (*See* also ALPHABET: *Origin.*)

3. At Byblos, in level VII (*c.* 2000 B.C.), appeared a hieroglyphic script, *sui generis,* which in fact used pictograms, though not of Egyptian derivation, and without any pictorial meaning; this script, found used on a few stone and metal documents, has been brilliantly deciphered as Phoenician by E. Dhorme.

The Phoenician script of 22 letters, purely alphabetic and abstract, purged of pictorial associations, appears at Byblos already complete by the 15th century B.C., if not earlier. M. Dunand would derive this script from an adaptation of the Egyptian hieratic. Be this as it may, this was the method of writing which was to issue from Phoenicia to conquer the world, and it is the Phoenicians' most remarkable and distinctive contribution to human arts and civilization. The fact that it is always written from right to left suggests that it was first evolved by stonemasons, holding a hammer in the right and working with a chisel in the left. But it was equally adaptable to writing with pen or brush on papyrus or leather. It is only the more to be regretted that the resultant works of Phoenician literature, written on these softer materials, have all perished, and are represented, unfortunately only in part, by the discoveries at Ras Shamra. It is recorded that Sanchuniathon of Byblos wrote nine books of mythology. There were also historical works drawn on by Menander of Tyre and others, while at Carthage works on agriculture were composed.



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM AND THE MUSÉE DU LOUVRE

CLAY TABLET FROM RAS SHAMRA; IN THE BRITISH MUSEUM

A Neo-Punic script appears on funerary monuments of North Africa in the 2nd century A.D., and, though relatively uninteresting in its contents, shows from its cursive, if degenerate, forms that the art of writing the Phoenician language long survived the destruction of the empire of Carthage.

IV. RELIGION

1. Mythology and Pantheon.—The religion of the Phoenicians, as of the Canaanites in general, was inspired by the great powers and processes of nature. Many of the gods whom they worshiped, however, were localized, and are now known only under their local names. A full knowledge of the Phoenician religion is unattainable, but a greatly revised understanding of it has been made possible by the discoveries at Ras Shamra, consisting of original epics written down in the 14th century B.C. and perhaps already much older. (*See* BAAL.) These may represent the mythology of Sidon, of which Ras Shamra-Ugarit was a colony. They may be supplemented by (1) the traditions of Byblos, quoted by Philo of Byblos, in Roman times, from an author of the 13th century B.C., Sanchuniathon (humorously referred to in Goldsmith's *The Vicar of Wakefield* but now known to have been an authentic person); and (2) inscriptions and other monuments of various

dates. These show a pantheon consisting of the forces of nature, presided over by the father of the gods, El, who has Asherah of the Sea as his wife and their mother.

How are these deities depicted in art? El, according to Philo, has four wings and two faces. Such a figure may be seen on a gold ring from Aliseda in Spain, seated on a boat, presumably on the sea. He is also shown winged, in Roman coins of Byblos, of which city he was the patron god. Of his family, Baal—a mere title concealing usually the name of the widely worshiped Syrian and Canaanite storm-god Hadad (Adad [*q.v.*], Addu; known in Mesopotamia as Amurru, god of the Amorites)—is said to be the son of Dagon, the god of corn. Baal-Hadad is shown as an elder deity with a beard; *e.g.*, on the statue of Hadad of Panammu II from Zincirli. A stele from Ras Shamra shows him with club and thunderbolt, standing above the waters of the earth. Often he has, as there, a horned headdress. His son is Aliyan-Baal, a god especially of springs, wells, and fertility, who is perpetually engaged with another deity, Mot (death), in a seasonal struggle, in which, like many other similar harvest deities, he is annually vanquished and slain. In this fight he is aided by his beloved sister, the virgin, Anat. Canaanite illustrations of Aliyan-Baal are not yet known, but a series of stelae from Egypt show a nude goddess standing facing frontally, often standing on a lion and holding flowers, between a figure of the ithyphallic Egyptian god Min and a representation of the warlike Semitic deity Resheph. An inscription on one of these stelae in Winchester (England) College Museum shows that the goddess is Astarte-Anat-Qedesht (*see* ASTARTE), three forms of the same person.

Anat's companion, Resheph ("the burner"), is a war-god, shown as a bearded man, brandishing an ax, holding a shield, wearing a tall pointed headdress (a version of the Upper Egyptian crown), with a goat's or gazelle's head on his forehead. This is no doubt the Resheph—sprm, "Resheph of the Goats," mentioned in the Karatepe bilingual inscription. He is probably a form of Baal. In Egypt from the 17th dynasty he is identified with Setekh (Set), the enemy of Osiris. Resheph was worshiped at Ras Shamra, Byblos, and Arsuf (near Jaffa); under the title Mikal he was also worshiped at Beth-shan in eastern Palestine and at Idalium in Cyprus (where he is equated punningly with Apollo Amyklaios). He appears to be represented on a Carthaginian razor of late date standing beneath a star. Another bearded god of fertility, resembling Resheph, wearing a pointed hat with pendant tassel, is depicted at Utica, Sousse, and elsewhere.

A youthful, beardless god of benevolent character is Shadrafa, depicted on the stele from Amrith (in the Louvre), standing on a lion above mountains, wearing a long trailing garment and a pointed headdress, and holding a small lion in one hand and a whip (?) in the other. A similarly dressed figure appears on ivories from Nimrud and Arslan Tash, plucking fruit from the "tree of life." An approximation to Eshmun of Byblos (equated with Adonis and perhaps also to Aliyan-Baal) seems suggested. Shadrafa was worshiped in North Africa as the tutelary deity of Leptis Magna, being equated with Liber-Dionysus.

Melkarth (Melkart, Melqart), "Lord of the City," was the patron deity of Tyre, where his temple was seen and described by Herodotus (who calls it that of Heracles). As Malku, he is equated with the Babylonian Nergal, god of the underworld and death, and thus may well prove to be related to the god Mot of Ras Shamra. His appearance is attested by an inscribed stele from north Syria which shows him bearded, wearing a high rounded hat and a kilt and holding, significantly, an Egyptian ankh, symbol of life, and, as symbol of death, a fenestrated ax, a type of weapon used in Canaan in the Middle and Late Bronze Ages. This stele makes it possible to recognize him in gems of the 6th century B.C. from Tharros in which he is seen slaying a lion, and it explains his Greek equation with Heracles, the vanquisher of the Nemean lion. On a silver bowl from Praeneste he is depicted in mythological drama in which he has various adventures while hunting. At Tyre, Melkarth had an annual winter and spring festival, during which he made an epiphany between the columns of his temple when he represented the rebirth of the sun. At Carthage he was represented still in his traditional form, bearded, with high hat and fenestrated ax, on late terra-cottas. Another important centre of his cult was Gadir (Cádiz). As Baal of Tarsus, he was equated with the Anatolian god Santas or Sandon, and his burning on a pyre was annually commemorated at Tarsus in classical times. It is likely that he was thus equated with the sun. Baal Amon (Baal Hamman), "Lord of the Burning Altar," was perhaps his title in this capacity. A scaraboid from Ibiza shows him standing before an incense altar under a winged disk. A rectangular altar beneath a circular disk is depicted on a miniature altar (at the Louvre) found at Ras Shamra. It is reasonable to suppose that this is a symbol of Baal Amon. Similar rectangular altars were found at Beisan and Hazor. Baal Amon is the chief god of Carthage, consort of the goddess Tinit (Tint).

Baal Shamin, "Lord of the Heavens," is identified by Sanchuniathon with the sun. But there is reason rather to identify him more correctly with Hadad, whereas at Ras Shamra the deity of the sun is a goddess, Shapash. Possibly Baal Shamin was her consort or parent. A winged sun-goddess appears on the silver bowl from Praeneste.

The goddess Astarte (Ashtart) remains the principal figure of the Phoenician pantheon. In her virgin form she is Anat. The cycle of myth associating Astarte with Byblos as the Baalat Gebal, "Lady of Byblos," is very ancient and goes back to the Egyptian Old Kingdom, where, with her son, Eshmun, she was assimilated to Isis and her son, the child Horus, who is attacked by his brother Set. Sometimes the relationship of Astarte and Eshmun is symbolized by a group of a cow suckling a calf, and a further assimilation is made to the Egyptian goddess Hathor, whose horns and disk the Baalat Gebal wears on the stele of Yehawmilk of Byblos. Astarte is further symbolized by a sphinx, while the palm tree and various forms of the "tree of life" represent her son Eshmun. On a bronze bowl from Nimrud (in the British Museum), showing the pantheon, Astarte is shown seated beneath the canopy of stars as queen of heaven. Eshmun is a child like Horus, seated on a lotus flower. Similar scenes showing Eshmun occur on ivories from Nimrud and Arslan Tash. On an ivory panel from Ras Shamra, Astarte, wearing the horns of Hathor, suckles him when already a youth. A similar scene under a palm tree occurs on a relief from Karatepe and on a bronze razor from Carthage. In the form of the beautiful youth Adonis (as he was known to the Greeks from the Semitic *Adon*, "master") Eshmun was believed slain and was mourned annually in the Iron Age in an elaborate ritual—the Adonia—which is described by Theocritus as it was practised in Hellenistic Sicily. In north Syria he seems to have been represented differently: as a four-winged figure wearing a triple *atef* crown, holding ears of grain. This grain deity seems to have found entry through Assyria into the art of the early Persian Empire, being depicted on the doorway of Cyrus' palace at Pasargadae.

In Punic North Africa, Astarte rapidly assumed a predominant place, being worshiped with Baal Amon under the name Tanith (Tinith), "face of Baal." In Ibiza a rock sanctuary was found dedicated to her at Cueva d'es Cuyram. In terra-cottas found there she is represented partly in the form of a Greek goddess, wearing a *polos* (headdress), but with her lower body truncated and wrapped in a pair of falcon's wings, like a priestess. At Carthage, however, she is still represented in a Greek style, wearing a richly ornamented crown and heavy breast ornament. By the 3rd century B.C. she is represented uniformly aniconically, by a sign somewhat resembling an Egyptian ankh with a triangular base, probably evolved from the truncated type of figure seen at Ibiza. In Roman times, her astral capacity becomes supreme and she is called *Caelestis* or *Genius Terrae Africae*, and her consort Baal Amon is identified with Saturn. At this period, though still sometimes represented by the ankhlike symbol on Neo-Punic stelae, she is also illustrated as a woman with a lion's head and once more wearing the enveloping falcon's wings. In the worship of Tanith and Baal Amon, children, probably first-born, were sacrificed; remains have been discovered in the *tophet* at Salammbo and at Motya, at Sulcis and Tharros.

A curious design on a ring from Carthage, showing a foot sur-

mounted by a bearded head, may be presumed to represent Pumai Elioun, "Foot of Elioun." That this deity was worshiped at Carthage is shown by a dedication inscribed on a gold pendant from Douimes. He is none other than the character known to Greek mythology as Pygmalion.

From Punic and Phoenician names it is clear that the worship of Osiris, probably equated with Eshmun, was included in their cults.

2. Religious Practices.—Probably, like other Canaanites, the Phoenicians offered worship "on every high hill and under every green tree"; but, to judge from the allusions to sanctuaries in the inscriptions and elsewhere, the Baal or Astarte of a place was usually worshiped at a temple, which consisted of a court or enclosure and a roofed shrine with a portico or pillared hall at the entrance. In the court sometimes stood a conical stone, probably the symbol of Astarte, as on the Roman coins of Byblos. Stone or bronze images of the gods were set up in the sanctuaries, along with the *baetyli* (meteoric stones) which were regarded as symbols of the gods. Pillars, again, had a prominent place in the court or before the shrine, but it is not known whether the sacred pole (*asherah*), an invariable feature of a Canaanite sanctuary, was usual in a Phoenician temple. The inscriptions mention altars of stone and bronze, and from the sacrificial tariffs (lists) which have survived it is clear that the chief types of sacrifice among the Phoenicians were analogous to those found in the Old Testament. The practice of sacrificing human victims was resorted to in times of great distress (*e.g.*, at Carthage, according to Diodorus, xx, 14) or to avert national disaster (Porphyry, *De Abstinentia*, ii, 56). It was regarded as a patriotic act when Hamilcar threw himself upon the pyre after the disastrous Battle of Himera (Herodotus, vii, 167). The god who demanded these victims, and especially the burning of children, seems to have been the Moloch or Molech of the Old Testament, though according to some scholars this is the name not of the god but of the sacrifice. In this connection may be mentioned the custom of burning the chief god of the city in effigy, or in the person of a human representative, at Tyre and in the Tyrian colonies, such as Carthage and Gadir; the custom lasted down to a late time. Another sacrifice was regularly demanded by Phoenician religion: women sacrificed their virginity at the shrines of Astarte in the belief that they thus propitiated the goddess and won her favour. *See* also references under "Phoenicia" in the Index.

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PHOENIX, in Greek mythology, the son of Amyntor, king of Thessalian Hellas. After a violent quarrel Amyntor cursed him with childlessness, and Phoenix escaped to Peleus, who made him responsible for Achilles' upbringing. Phoenix accompanied the young Achilles to Troy, and was one of the envoys who vainly tried to reconcile him with Agamemnon. (D. E. W. W.)

PHOENIX, capital and largest city of Arizona, U.S., and seat of Maricopa county, occupies approximately 187 sq.mi. of an arid saucer-shaped valley formed by the Salt river, midway between El Paso and Los Angeles. The city is the commercial focus of large irrigation projects, important to its growth, which are fed from the T. Roosevelt dam, 70 mi. N.E. The hub of an area of scenic grandeur, it is also a health and tourist centre.

The Salt river valley was occupied as early as 1300 A.D. by prehistoric Indians known to anthropologists as Hohokam (*q.v.*) or "the people who have gone." They developed a system of primitive irrigation canals, erected early buildings and then vanished mysteriously. An historic gap followed until the first white men came during the American Civil War. One, an imaginative prospector, Jack Swilling, noticed the visible remnants of ancient Indian canals and realizing irrigation possibilities, organized an irrigation company. Canals and harvests followed and a crude village was founded.

An associate of Swilling's, Darrel Duppa, English adventurer and scholar, was impressed by the evidences of prehistoric culture. Like the legendary phoenix which, consumed by fire, arose from its own ashes, so, Duppa predicted, would the Salt river city be born from ancient Indian ruins. Thus the settlement was named Phoenix. Incorporated in 1881, it acquired its first railroad in 1887. Phoenix, with a population of about 3,000, became the seat of the territorial government in 1889, and remained the capital when Arizona attained statehood in 1912. The city has been council-manager governed since 1914.

The economy is based on agriculture, tourism and manufacturing. The fertile Salt river valley produces long-staple cotton, forage, vegetables and fruits. Manufacturing, almost nonexistent before 1940, later became the chief source of income. Aircraft and electronic components, aluminum extrusions, air-conditioning equipment and many small manufacturing enterprises add to the economic wealth of the city.

More than 30 secondary schools and Phoenix college, a two-year college established 1920, are in the city proper. Independent school districts are in outlying communities. Parks, playgrounds, an adult recreational centre, an active little theatre, a professional winter theatre, a symphony orchestra and professional baseball provide recreational and cultural opportunities. Notable annual events are the Copper Bowl parade and football game, the World's Championship rodeo and the Arizona state fair.

The state capitol consists of an original building of native tufa and of neoclassic design, with two additional wings for the house of representatives and the senate. These buildings are set in a 10-ac. park, where trees and shrubs indigenous to the region are represented. Papago park (1,094 ac.) lies within the city limits to the east and to the south is the city's South Mountain park of 14,000 ac.

The Phoenix standard metropolitan statistical area comprising Maricopa county includes: Mormon-founded Mesa, site of the state experimental farm; Glendale, a farming community with nearby Luke air force base; and Tempe, location of Arizona State university (established in 1885 as Arizona Territorial Normal school). A post-World War II population boom, with Arizona's warm climate and clear air (85% average "possible" sunshine) as the main enticements, made Phoenix one of the fastest growing cities in the United States. Between 1950 and 1960 its population increased from 106,818 to 439,170 within the city limits and from 331,770 to 663,510 within the standard metropolitan statistical area. For comparative population figures *see* table in ARIZONA: *Population.* (Jo. S.)

PHOENIX, a fabulous bird connected with the worship of the sun especially in ancient Egypt and in classical antiquity. It was known to Hesiod, and descriptions of its appearance and behaviour occur in ancient literature sporadically, with variations in detail, from Herodotus' account of Egypt onward. The phoenix is said to be as large as an eagle, with brilliant scarlet and gold plumage and a melodious cry. Only one phoenix exists at any time. It is very long-lived; no ancient authority gives it a life

span of less than 500 years; some say it lives for 1,461 years (an Egyptian Sothic Period): an extreme estimate is 97,200. As its end approaches the phoenix fashions a nest of aromatic boughs and spices, sets it on fire, and is consumed in the flames. From this pyre miraculously springs a new phoenix, which after embalming its father's ashes in an egg of myrrh flies with them to Heliopolis in Egypt where it deposits them on the altar in the Temple of the Sun. One variant of the story makes the dying phoenix fly itself to Heliopolis and immolate itself in the fire burning on the sun's altar, a young phoenix being born from the flames.

The *bennu*, a kind of heron, is traditionally associated with sun worship in Egypt, appearing on monuments as a symbol of the rising sun and of the life after death. Classical authors who allude to pictorial representations of the phoenix almost certainly have the *bennu* in mind. But despite the etymological similarity and the common religious associations, it remains true that the phoenix as described in literature does not at all resemble a heron in appearance and that its home is not in Egypt but nearer the rising sun (normally in Arabia or India, where spices for the nest and egg were plentiful). Clearly the colouring of the phoenix, its miraculous rebirth, its connection with fire, and other features of its story are symbolical of the sun itself, with its promise of dawn after sunset, and of new life after death. Probably the phoenix story originated in the Orient and was assimilated to Egyptian sun worship by the priests at Heliopolis. The adaptation of the myth to an Egyptian environment helped to bring about the connection between the phoenix and the palm tree (also called *phoinix* in Greek). A holy tree was long associated with the worship of the sun in Egypt, and the sacred palm tree was said to live as long as the phoenix and to die at the same time.

As has been shown, the Egyptians associated the phoenix with intimations of immortality, and this symbolism had a widespread appeal in late antiquity. The Latin poet Martial compared the phoenix to undying Rome, and it appears on the coinage of the late Roman Empire as a symbol of the Eternal City. It is also widely interpreted as an allegory of resurrection and life after death. These were ideas which appealed to emergent Christianity; Church Fathers and the *Physiologus* (*see* BESTIARY) use the phoenix as an illustration of Christian doctrine concerning the raising of the dead and eternal life. Its miraculous birth was also sometimes compared to the virgin birth of Christ. The *Phoenix*, a Latin elegiac poem 170 lines long, generally ascribed to Lactantius, exemplifies the Christian attitude.

See A. Rusch, in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. xx, col. 414–423 (1941). (D. E. W. W.)

PHOLIDOTA, an order of placental mammals, comprising only the scaly anteaters or pangolins of Asia and Africa. The pangolins were at one time grouped with the true anteaters, sloths and armadillos in the order Edentata, mainly because of their likeness to the South American anteaters in the absence of teeth, the weakness of the jaws, the enlargement of the salivary glands and the length of the wormlike, extensile tongue; and to the armadillos in the possession of a hard dermal exoskeleton. But the resemblances to the edentates are adaptive and due to similarity of diet and of habitat. The exoskeleton is of a totally different type from that of the armadillos, since it consists of large, erectile, overlapping horny scales, composed of cemented hairs, there being no trace of bony matter in the skin. They show no resemblances to the edentates of any systematic importance and differ from them fundamentally in many anatomical characters.

The head is short and conical, with apparently functionless facial whiskers and a moist elongate muzzle; the ear sometimes has a distinct pinna, but may be represented by a vertical slit only. The legs are short, but the feet, whose five toes are armed with large claws (curved on the forefeet), vary in structure according to habit. The tail, sometimes excessively long and prehensile and sometimes comparatively short, forms, with the hind legs, a kind of tripodal support. The anus and external genitalia are situated close together on an eminence formed mainly by the enlarged anal glands, and the anus is sunk in a depression into which the ducts of the glands open; both the penis and clitoris are quite small.

Pangolins range in Asia from north India and south China to Ceylon and Borneo and in Africa from Sierra Leone and Uganda to the Cape of Good Hope. There are several different kinds. Some are almost entirely arboreal, some purely terrestrial and others intermediate in habitat; all, however, are nocturnal and are able to swim a little. They feed mostly on termites, ripping open the nests of these insects with the strong claws of the forefeet. Their means of defense are emission of a repulsive odour from the large anal glands and rolling into a compact ball with the hard, often sharp, erected scales presented to the enemy and the soft-skinned hairy underside protected from injury.

There are several fairly distinct types, all usually referred to genus *Manis* and to the family Manidae, but there is some dispute about the scientific names. In the Asian pangolins the hinder end of the breastbone is shaped like the blade of a spade, having a convex posterior edge and two forwardly directed spinous angles. To this group belong the northern Indian and Chinese eared pangolin, the Indian and Ceylonese thick-tailed pangolin and the Javanese and Bornean pangolin, all of which differ in many external characters.

In the African pangolins the end of the breastbone is prolonged into two rods running back to the posterior ribs. There are two groups differing in habitat and correlated structural characters: the terrestrial, including the so-called giant pangolin, with the feet and tail adapted for ground life; and the arboreal containing the small west African pangolins, which differ from all other pangolins in being exclusively adapted to life in the trees, the tails being exceedingly long and prehensile, and the feet with only four functional toes, the upper side of the forefoot being without scales.

The earliest evidences of the Pholidota are the bones of a large pangolin, indistinguishable from those of the African giant pangolin, found in a cave in Madras, India. These remains date to the Pleistocene, beginning about 1,000,000 years ago.

See also PANGOLIN.

PHONEMATICS: *see* LINGUISTICS; PHONETICS.

PHONETICS is the study of speech sounds, their physiological production and acoustic qualities. It deals with configurations of the vocal tract used to produce speech sounds, the resulting acoustic patterns and the manner of combining sounds so as to make syllables, words and sentences. On another level it compares the speech sounds of different languages.

Phonetics, since it is part of the analysis of the phenomenon of human language and speech behaviour, contributes to the fields of anthropology, linguistics, psychology, sociology and related fields. Furthermore it has several practical objects: (1) to help in learning to pronounce foreign languages; (2) to contribute to speech therapy; (3) to record previously unwritten languages and to develop writing systems for them; (4) to develop more efficient electrical and electronic speech transmission systems (speech compression).

History.—Although phonetics as an independent field of study did not come into being until the 19th century, speculations regarding the nature and origin of human speech, usually connected with magical or religious practices, are found in ancient civilizations. The use of alphabetic or syllabic notation, as opposed to pure ideographs, to record human speech shows an at least intuitive knowledge of speech units and their relationships. One of the earliest attempts at a systematic description and classification of speech sounds was that of the Sanskrit grammarians, whose work came to its climax with Panini (4th century B.C.). From the classical era until the end of the 17th century, however, more emphasis was placed on the process of phonation rather than on an explicit analysis of speech units. Such descriptions can be found among the works of Hippocrates, Aristotle, Galen and, later, Leonardo da Vinci. Near the end of the 18th century considerable interest was shown in speech synthesis. In 1791 Wolfgang von Kempelen invented a machine which could produce speechlike sounds.

During the 19th century a number of recording devices, such as the kymograph, became available for the quantitative measure of speech phenomena. These devices, along with the artificial palate and X-ray photography, gave impetus to the quantitative study of

the physiology of speech. Comparable studies in the acoustic structure of speech were made available through Helmholtz resonators and phonographic devices. By 1881, when Eduard Sievers published his *Grundzüge der Phonetik*, phonetics had become an independent discipline. While the quantitative aspects of speech developed into experimental or instrumental phonetics under the influence of the abbé Jean Pierre Rousselot, another group of phoneticians became preoccupied with the classification of speech sounds and the creation of a notation system for recording speech in a written form. Leaders among this group were Paul Passy, Henry Sweet and Daniel Jones, all of them prominent in the sponsorship of the International Phonetic association which was inaugurated in France in 1886. The association soon drew up the International Phonetic Alphabet, which was designed to be applicable to all languages and which has become not only the most widely used phonetic alphabet but also the basis for many succeeding systems.

Jan Baudouin de Courtenay (1845–1929) is credited as being the first to insist on the distinction between the speech sound and the phoneme, although Henry Sweet (1845–1912) also was aware of the necessity to make this distinction. With the formation of the Cercle Linguistique de Prague in 1926, led by V. Mathesius, N. S. Trubetskoi, Roman Jakobson and S. Karcewski, new impetus was given to the development of phonemics and phonemic theory as distinct from phonetics.

After World War II, improvements in recording devices made available such instruments as the sound spectrograph, which permitted the analysis of speech sounds in great detail, and brought the acoustic study of speech sounds into the foreground. The interest in speech phenomena on the part of communication engineers and others outside the field of phonetics gave rise to an unprecedented study of all aspects of human speech.

Phonetic Analysis.—Speech sounds are recorded and analyzed in two general ways, either by ear or by machine. In the former method, the phonetician listens to a person speaking and writes what he hears in the symbols of a phonetic transcription system, recording in as detailed a manner as he can or as suits his purpose. In the latter method, speech is recorded with an instrument such as the oscilloscope, kymograph, spectrograph or X-ray camera. This usually transforms the speech behaviour into a visual form which can then be measured, and various samples of speech can be compared. In either case, when the object of the analysis is to describe the speech sounds of a given language, the nature and mode of formation of every speech sound of the language must be ascertained with the greatest possible accuracy; long passages of the language must then be transcribed phonetically as accurately as possible with the object of finding out how the sounds may be grouped into distinctive sounds, or phonemes. The usage of the particular language as regards the duration of sounds, the stress of syllables and the intonation (pitch, musical accent) of words and sentences must be examined in detail. To obtain the best results, investigations must be made by both methods.

Analysis by ear can be carried out only by an observer who is a trained phonetician; *i.e.*, a person who has been trained to distinguish and recognize minute shades of sound and recognize and imitate a number of foreign sounds and sound combinations. He must have as a collaborator a native speaker of the language to be analyzed. The phonetician asks the native speaker to repeat words and phrases of his language a number of times. He may find these words and phrases to be composed of sounds already known to him. If so (and if the language does not present special difficulties in the matter of length, stress or intonation), he will at once be able to repeat them to the native's satisfaction. If the native is not satisfied, it means that the word or phrase contains one or more unfamiliar sounds or that the language contains some unusual features of length, stress or intonation. To acquire the

TABLE I.—*The International Phonetic Alphabet**

		Bilabial	Labio-dental	Dental and alveolar	Retroflex	Palato-alveolar	Alveolo-palatal	Palatal	Velar	Uvular	Pharyngal	Glottal
Consonants	Plosive	p b		t d	ʈ ɖ			c ɟ	k g	q ɢ		ʔ
	Nasal	m	ɱ	n	ɳ			ɲ	ŋ	ɴ		
	Lateral Fricative			ɬ ɮ								
	Lateral Nonfricative			l	ɭ			ʎ				
	Rolled			r						ʀ		
	Flapped			ɾ	ɽ					ʀ		
	Fricative	ɸ β	f v	θ ð | s z | ɹ	ʂ ʐ	ʃ ʒ	ɕ ʑ	ç j	x ɣ	χ ʁ	ħ ʕ	h ɦ
	Frictionless Continuants and Semivowels	w | ɥ	ʋ	ɹ				j (ɥ)	(w)	ʁ		
Vowels		Rounded						Front Central Back				
	Close	(y ʉ u)						i y ɨ ʉ ɯ u				
	Half-close	(ø o)						e ø ɘ ɵ ɤ o				
	Half-open	(œ ɔ)						ɛ œ ɜ ɞ ʌ ɔ				
	Open	(ɒ)						æ ɐ a ɑ ɒ				

*Secondary articulations are shown by symbols in parentheses.

OTHER SOUNDS.—Palatalized consonants: ʇ, ɖ, etc. Velarized or pharyngalized consonants: ɬ, ɗ, ƶ, etc. Ejective consonants (plosives with simultaneous glottal stop): p', t', etc. Implosive voiced consonants: ɓ, ɗ, etc. ɾ fricative trill. ʊ, ǫ (labialized θ, ð, or s, z). ʕ, ʒ (labialized ʃ, ʒ). ɪ, ʗ, ɔ (clicks, Zulu *c*, *q*, *x*). l (a sound between ɾ and l). ʍ (voiceless w). ɪ, ʏ, ʊ (lowered varieties of i, y, u). ɜ (a variety of ə). ɵ (a vowel between ø and o).

Affricates are normally represented by groups of two consonants (ts, tʃ, dʒ, etc.), but, when necessary, ligatures are used (ʦ, ʧ, ʤ, etc.), or the marks ‿ or ⁀ (t‿s or t⁀s, etc.). c, ɟ may occasionally be used in place of tʃ, dʒ. Aspirated plosives: ph, th, etc.

LENGTH, STRESS, PITCH.—ː (full length). ˑ (half length). ˈ (stress, placed at beginning of the stressed syllable). ˌ (secondary stress). ˉ (high level pitch); ˍ (low level); ˊ (high rising); ˏ (low rising); ˋ (high falling); ˎ (low falling); ˆ (rise-fall); ˇ (fall-rise).

MODIFIERS.—˜ nasality. ˭ breath (l̥ = breathed l). ˬ voice (s̬ = z). ʻ slight aspiration following p, t, etc. ˈ specially close vowel (e̝ = a very close e). ˌ specially open vowel (e̞ = a rather open e). ̫ labialization (n̫ = labialized n). ̪ dental articulation (t̪ = dental t). ʲ palatalization (ż = ʒ). ˠ tongue slightly raised. ˞ tongue slightly lowered. ˃ lips more rounded. ˂ lips more spread. Central vowels ɨ (= i̽), ʉ (= u̽), ɘ (= e̽), ɵ (= o̽), ɜ, ɞ. ̩ (e.g. n̩) syllabic consonant. ̯ consonantal vowel. ʃ̡ variery of ʃ resembling s, etc.

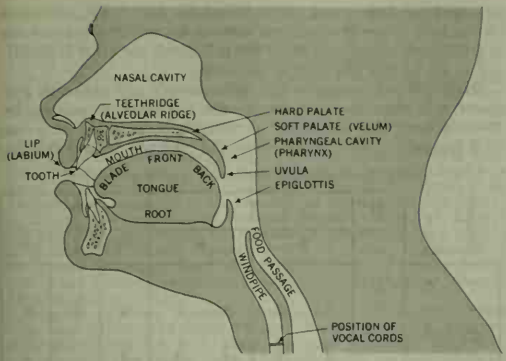

FIG. 1.—THE ORGANS OF SPEECH

correct pronunciation, the phonetician makes fine adjustments in the positions and movements of his own speech organs in repeating the words to the native speaker. He tries one variation and then another until he succeeds in pronouncing the word or phrase to the native's satisfaction. He then knows by his own muscular and tactile sensations what is the exact manner of formation of the unfamiliar sounds of the language.

Analysis of speech sounds by the acoustic method may be checked by experimental methods; *i.e.*, investigation by instruments. The positions of the tongue and velum (soft palate) and of the shapes assumed by the pharyngeal cavity may be more easily ascertained with the help of X-ray photography. Indications of tongue positions may also be found by the use of a special kind of artificial palate.

Phonetic Symbols.—In nearly every language the number of distinguishable sounds is greater than the number of letters in the Roman (Latin) alphabet. It is therefore impossible to represent most languages unambiguously by means of the ordinary Roman letters only. Any "romanic" phonetic system, therefore, whether designed as a current orthography or as a transcription for the use of language learners, must contain new letters to supplement those of the present Roman alphabet.

Classification of Speech Sounds.—Table I, showing the International Phonetic Alphabet (IPA), taken in conjunction with the chart of the organs of speech (fig. 1), shows the chief principles of sound classification. The meanings of most of the technical terms describing the various classes of sounds are self-evident. Attention may be called, however, to the following, which require some explanation: The back of the tongue is the part which lies normally opposite the soft palate; the front is the part which lies normally opposite the hard palate; the blade is the part which lies normally opposite the teethridge (upper gum, alveolars). Palatal consonants are those formed by the front of the tongue against the hard palate, such as the English sounds of *y* or the German *ch* in *ich*. Retroflex consonants are those made by the tip of the tongue against the hard palate, such as the Hindi sounds of ट ड. (*See* also VOICE; PRONUNCIATION.)

Intonation.—An important branch of phonetics is that which deals with intonation, or the rise and fall in the pitch of the voice. In the languages called tone languages (*e.g.*, Chinese and most Sudanic and Bantu languages) intonation is used to distinguish one word from another. Thus in Cantonese the syllable *fan* said with a high falling tone means "divide"; said with five other tones it means "powder," "sleep," "burn," "courageous" and "duty," respectively. In the Sechuana language (Bantu) of South Africa, *metse* said with a mid-level tone on each syllable means "villages," but with a mid-level tone on the first syllable and a high-level tone on the second it means "water."

In languages which are not tone languages intonation affects the meaning of whole sentences, but it is not an integral part of any word. Intonation gives expression to sentences; it conveys shades of meaning which cannot conveniently be expressed by other means. Thus in English the two meanings of *I beg your pardon* ("I am sorry" and "What did you say?") are distinguished by intonation. It is not practicable to mark this kind of intonation in orthography, though slight indications of it may be given by the use of punctuation marks or italics.

Phonetic Description.—The sounds of speech are usually described either in articulatory or in acoustic terms.

Articulatory descriptions are based on the parts of the vocal tract which are used in forming a given sound (*see* fig. 1). For instance, vowel sounds can be classified according to several positions of the articulators such as the tongue, the lips and the degree of mouth opening. Fig. 2 shows the tongue positions for several vowels. Fig. 2 (left) shows a series of front vowels, so-called because the tongue is bunched forward in the mouth as opposed to the back vowels in fig. 2 (right) in which the tongue is bunched toward the back of the mouth. In fig. 2 (left) the letter [i], which is the phonetic symbol for the "ee" sound in "meet," is the highest of the front vowels, and [a] as in "cat" is the lowest of the front vowels, since the tongue is not so high toward the roof of the mouth. In fig. 2 (right), [u] as in "who" and [ɑ] as in "father" are the highest and lowest back vowels, respectively.

In some languages, such as Russian and Spanish, it is more efficient to describe the vowel sounds in terms of lip rounding and mouth opening. In such languages [i] is described as an unrounded close vowel since the mouth opening is slight and the lips are not rounded or pursed as they are in [u], which is a close rounded vowel. These two vowels differ from the vowel [ɑ] which is open and has no significant rounding or unrounding. (It is rather difficult to drop the jaw and purse the lips at the same time!) Nasal vowels are produced by dropping the velum (soft palate) so that the nasal passage is open. (In the case of nasal vowels, the air does not usually pass through the nose, which is used only as an additional resonator for the sound.)

Consonantal sounds are described in terms of point of articulation. For instance, [p] is called a bilabial because both lips are brought together to produce the sound, as opposed to the [t], which is called a dental sound because the tip of the tongue is at or near the upper front teeth. Both of these differ from [k], which is articulated with the back part of the tongue somewhere in the region of the velum; hence it is called a velar sound. Consonants are also described in terms of the activity of the air stream in the mouth and the activity of the vocal cords. When the vocal cords are vibrating the sound is said to be a voiced sound; otherwise it is voiceless. When the air stream must pass through a narrow opening, as in [f] or [s], the sound is called a fricative. The air stream is continuous in the fricatives but interrupted in the plosives or stops ([p], [t], [k]).

In the case of the nasal consonants such as [m] and [n], the velum is dropped, as it is for nasal vowels, and part of the air stream passes through the nose. Finer degrees of articulation are shown in the IPA chart (Table I).

In describing the acoustic qualities of speech sounds it is convenient to consider their source and transfer functions. The former refers to the kind of excitation involved; *i.e.*, whether the sound is periodic or random (turbulent). When the vocal cords vibrate they produce a complex periodic wave form composed of

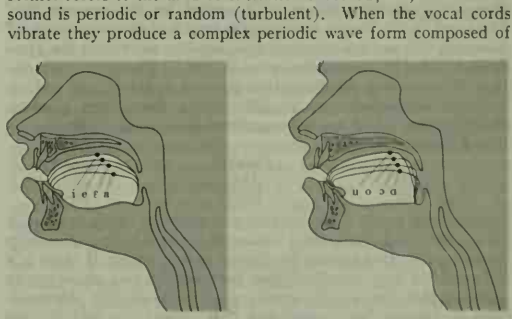

FIG. 2.—TONGUE POSITIONS OF (LEFT) THE FRONT CARDINAL VOWELS AND (RIGHT) THE BACK CARDINAL VOWELS

a fundamental and its harmonics. On spectrograms (narrow band) such a wave form appears as a series of horizontal lines, longer or shorter depending on the duration of the sound. When the air stream is caused to pass through a narrow constriction, as in the fricatives (*e.g.*, [s], [f]), the spectrogram shows a gray smear covering the entire frequency range.

The various cavities in the vocal tract act as resonators which either reinforce or cancel out some frequencies or frequency regions of the original excitation function. Hence it is convenient to consider the source function to be the substance of the sound and the transfer or resonance function as its form. In vowels, for instance, the source is periodic and the resonators cancel out certain groups of harmonics and reinforce others. A typical sound spectrogram of a vowel resembles music notation paper, a series of staves composed of lines, with blank spaces between. Such a staff of harmonics is called a formant or a bar, and indicates a resonance region.

Except under very special circumstances, these formants are independent of the pitch or fundamental frequency at which the vocal cords are vibrating, since they are given their form by the shape of the resonating cavities in the vocal tract. Since the vocal tract assumes a different shape for each of the vowels, as explained above, the resonances or formant frequency regions of each vowel differ from those of other vowels.

It has been found that the vowels of most languages can be differentiated by describing the lowest two (or three) formants, which occur between 250 and 3,000 cycles per second (c.p.s.). Thus the two significant formants of the [i] sound occur at the lower and higher limits of this region, those of the [u] both at the lower end of the region and those of [a] in the centre of the region.

When the source function is not periodic, the resonators also reinforce certain frequency regions and cancel out others, but these regions are usually called resonance regions rather than formants. Thus a spectrogram of [s] will show a gray smear in a high-frequency region (around 6,000 c.p.s.) and [f] a weak smear at a very-low-frequency region. The stops differ from the fricatives in the way they begin. The stops begin abruptly and have a short spike-like appearance on spectrograms, whereas the fricatives begin smoothly and are longer in duration.

The Phoneme.—The only significant difference between the English words "ban" [bæn] and "man" [mæn] is in the first sound. While both are labial sounds, one is a nasal and the other is a stop. When a word can be transformed into another word by such a change, the two sounds are said to be distinctive or phonemic. They are, or they represent, two different phonemes. Phonemics (an alternate term, phonematics, is preferred by some linguistic authorities) is the analysis of the distinctive sounds or phonemes of a language.

Phonemic distinctions differ from one language to another, hence each language has its own set of phonemes or distinctive sounds. For instance, in Czech there is a difference between long and short vowels: *náraz* [na:ras], "shock"; *naráz* [nara:s], "at once." This distinction does not hold for most varieties of English, although there is a phonetic difference in vowel length between "hit" [hɪt] and "hid" [hɪ:d]; changing the length of the vowel in "hit," however, will not transform it into another word, and the same holds true for shortening the vowel in "hid." Phonemic transcriptions indicate only the distinctive qualities of the sounds and are enclosed in slanted lines to differentiate them from phonetic transcriptions, which are not committed to indicating only distinctive differences:

	Phonetic	*Phonemic*
"hit"	[hɪt]	/hɪt/
"hid"	[hɪ:d]	/hɪd/

When two words differ by only one phoneme, such as English "bat" /bæt/ and "sat" /sæt/, the words are said to be a minimally distinct pair. In a minimally distinct pair of words, if there is a difference of only one distinction between the two phonemes in question, then the two phonemes are minimally distinct phonemes. Thus in English "pat" /pæt/ and "bat" /bæt/, /p/ and /b/ are both stops, both are bilabial and the only difference is that /p/ is unvoiced (or tense) and /b/ is voiced (or lax). The phonemes /b/ and /s/ in the previous example are not minimal because one is a fricative, the other a stop; one is bilabial, the other is dental; one is voiced and the other is unvoiced.

Distinctive Features.—For both phonetic and phonemic purposes it is often necessary to describe the relations existing between sounds, the "structure" of relations between the phonemes of a language. Most phoneticians and linguists achieve this end by using the phonetic classifications, either articulatory or acoustic (or both), such as those outlined above. A system for describing these distinctive features in binary terms was developed by Roman Jakobson and his collaborators shortly after World War II. This system describes the phonemes of a language in terms of the presence or absence of a small number of distinctive features based on articulatory or acoustic terms.

TABLE II.—*Distinctive Features of American English**

Compact	Grave	H	T				W		
			P		F		N	J	V
0	0	h							
—	—		t	d	s	z	n	j	ɪ
±	—								ɛ
+	—		ʃ	ʒ	ʃ	ʒ	ŋ		æ
+	±							r	ə
+	+		k	g	θ	ð	l		a
±	+								ɔ
—	+		p	b	f	v	m	w	ʊ
Consonantal		—	+	+	+	+	+	—	—
Vocalic		—	—	—	—	—	+	+	+
Continuous		0	—	—	+	+	0	0	0
Tense		0	+	—	+	—	0	+	—

*P = stop; F = fricative; N = sonorant; J = semivowel; V = vowel; H = /h/; T = Turbulent; W = Nonturbulent.

Source: L. G. Jones, "English Consonantal Distribution," in *For Roman Jakobson*, p. 246 (Mouton, The Hague, 1956).

Table II shows such an analysis based on one variety of American English. The plus (+) indicates the presence of that feature, the minus (−) its absence, the zero (0) its irrelevance. The (±) sign usually is used only where the feature can be described in terms of a scale of such values as high, mid or low, and is avoided wherever possible.

This type of classification, utilizing as it does the binary notation system of the mathematical theory of communication, can be used to great advantage wherever phonetics and phonemics play a role, from the learning of foreign languages to the development of more efficient electronic speech compression systems.

See LANGUAGE; LINGUISTICS; *see* also references under "Phonetics" in the Index.

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PHONOGRAPH, an instrument for reproducing sound by transmitting to the air (directly or indirectly) the mechanical vibrations of a stylus in contact with a sinuous groove in a moving record. In a wider sense a phonograph is any instrument for reproducing recorded sound. In this expanded view the record may be mechanically, optically (photographically) or magnetically recorded and reproduced as sound by appropriate apparatus.

Information on related phases of sound reproduction can be found in the articles HIGH-FIDELITY SOUND SYSTEMS; LOUDSPEAKER; and TAPE RECORDING, MAGNETIC. This article consists of the following parts:

I. History
  1. Disc Recording
  2. European Developments
  3. Technical Developments in Acoustic Recording
  4. Horns
II. Electrical Recording and Reproduction
  1. Theoretical Aspects
  2. Electrical Reproduction
  3. Evolution of Fine-Groove Records
  4. Stereophonic Phonograph Records
III. Record Materials and Processing
  1. Electroforming
  2. Record Materials
IV. Phonographs and Record Changers
  1. Stylus Shapes and Materials
  2. Reproducer or Pickup
  3. Record Changers
  4. Phonograph Motors and Drive Systems
V. Magnetic Recording
VI. Phonograph Music

I. HISTORY

A prototype of the phonograph appeared in 1857 when Leon Scott constructed a device he called the Phonautograph, which recorded, as a wavy line on the smoked surface of a rotating cylinder, the movements of a diaphragm or other vibrating body. The first record of vibrations which could be played back to reproduce sounds was invented by Thomas A. Edison in 1877. The record was in the form of indentations pressed into a sheet of tin foil by the vibrating recording stylus, which was attached to a diaphragm. The tin foil was wrapped around a cylinder that rotated as the sounds were being recorded. A thread on the shaft moved the cylinder axially as it rotated, so that the record groove was helical. A small helical groove having the same pitch was cut in the surface of the cylinder, and the recording diaphragm and stylus were positioned to bring the groove directly under the slightly rounded point of the stylus, thus making it easier to produce the indentations in the tin foil. The sound waves were recorded as variations in the depth of the groove. For reproduction the groove was again run under the stylus tip, with only enough pressure to maintain contact with the groove bottom. The term "embossing" has been widely used to designate the method of recording in which the groove is impressed in a yielding material by a rounded point.

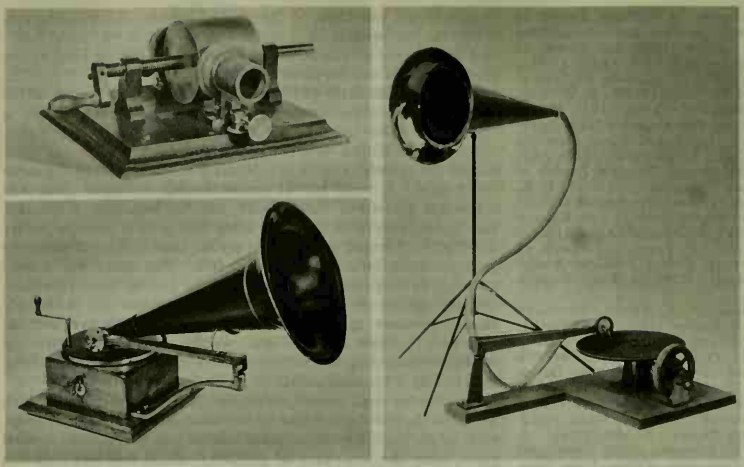
Edison took steps toward the exploitation of his invention, which he called the phonograph, but he was soon diverted to the development of the incandescent lamp and electric power systems. Several years after the first flare of publicity which followed Edison's demonstrations, Alexander Graham Bell became interested in the phonograph, and with two associates, Chichester A. Bell and Charles Sumner Tainter, began experiments in Bell's "Volta" laboratory in Washington, D.C. They had best results with an arrangement much like Edison's except that their machine cut or engraved the groove in a cylindrical surface of wax with a sharp tool carried by the vibrating diaphragm. This gave much better sound reproduction than had been possible with Edison's indented tin foil. In 1885 C. A. Bell and Tainter applied for a U.S. patent on this principle and other features of their developments, and in 1887 they organized a company to manufacture and sell Graphophones, as they called their machines. Edison returned to his experiments with the phonograph, and he too became convinced of the superiority of the engraved wax groove.

Various promotional and organizational activities took place in the next few years, the most important results of which were that the Columbia Phonograph Co. became the manufacturing and selling organization for the Bell and Tainter developments, and rights under both the Edison and the Bell and Tainter patents became available to both the Columbia and Edison companies.

1. Disc Recording.—Another inventor, German-born Émile Berliner, was responsible for a radical departure in sound recording. The initial step in Berliner's recording operation resembled that of Scott's Phonautograph, except that Berliner's mechanism traced its wavy line as a spiral on a flat disc, instead of as a helix on a cylindrical surface. The disc was of zinc, coated with a thin layer of fatty substance which protected it from the action of acid except where the scribe had traced its line. An acid bath then left a groove, the width and depth of which could be controlled by the duration and strength of the acid treatment. Berliner thus obtained a record which could be played by means of an appropriately designed reproducing mechanism.

However, he did not contemplate using this etched master as the record to be played; rather, a negative was made from the master by electroforming, and the negative then was used to mold records in some thermoplastic material, a procedure that subsequently became standard. Berliner first proposed using vulcanite or hard rubber as the molding material, but he later found a company that could mold records for him in a material much like that which later became common for all records. Berliner's records were far harder and more durable than the waxes of which the cylinders were being made. The harder material, plus somewhat greater amplitudes due to the fact that the recording stylus did not have to work against any cutting resistance, made somewhat greater volume possible in the reproduced sound.

Of still greater importance to the success of Berliner's discs, however, were the ease of molding from a flat surface and the fact that he could make his grooves deep enough to guide the



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EARLY PHONOGRAPHS

(Top left) The original tin-foil phonograph by Thomas A. Edison, 1877; (bottom left) His Master's Voice Gramophone, about 1900; (right) Berliner Gramophone, 1888

reproducing stylus across the record without the need for an auxiliary feed screw. It was to the latter feature that the most important of Berliner's patent claims were directed.

Small-scale manufacturing of the Gramophone, as Berliner called his machine, was started in 1894. The Gramophones were much simpler than the cylinder machines of Edison and Columbia, and could be sold relatively cheaply, while records for them could be made at much lower cost. But driving the record by means of a hand crank was unsatisfactory for anything but demonstrating a principle. Berliner recognized the need for a clockwork drive and controlled speed. He sought outside help, and the problem was eventually brought to Eldridge R. Johnson, who operated a small machine shop in Camden, N.J. Johnson soon worked out a practical design for a spring-driven motor with a friction governor, and in a short time (1896) was building for the Berliner Gramophone Co. not only the spring motors but all the mechanical parts of the Gramophones. Besides developing the spring motor, Johnson made various improvements in the Gramophone, including a better "sound box," the principal features of which were retained with little change throughout most of the history of the acoustic phonograph.

Johnson's experiments soon convinced him that the noisiness of the Gramophone records arose from the roughness of the etched surfaces, and he began to study the possibilities of cutting the groove in wax as Bell and Tainter had done; however, instead of recording the vibrations as variations in depth of the groove (commonly called vertical or hill-and-dale recording), he followed Berliner's practice of recording them as sidewise deflections of a groove of uniform depth (commonly called lateral recording). Johnson mastered the techniques of rendering the wax surface conductive by dusting with graphite and then electroplating, thereby producing a "negative" of the grooved wax. This negative, built up in the plating process to sufficient thickness for needed strength, could then be used to press records in thermoplastic material. The records so made were much clearer and less noisy than those produced by Berliner's process.

For several years the sale of Gramophones and records grew and Berliner prospered, but in 1900 his one sales outlet stopped ordering, and then a court injunction was obtained by competitors (based on alleged infringement of a detail patent) forbidding his company to make or sell Gramophones. Johnson had an enlarged factory and a large inventory of machines. He decided to do his own selling. He started with an advertising campaign featuring greatly improved records produced by a newly developed process and offering a free sample. The business grew and prospered.

In addition to his own technical contributions Johnson now had a going business to offer in exchange for rights under the basic Berliner patents. In Oct. 1901 a new company was formed, the Victor Talking Machine Co., the stock of which went partly to Johnson and partly to Berliner, with the controlling interest in Johnson's hands.

A serious threat to the Victor company arose shortly after its formation, when the Columbia company acquired a patent describing and claiming the process of recording by cutting a laterally varying groove of constant depth in wax, exactly as Johnson was doing. The Columbia company was just beginning to make disc machines, but in so doing it was sure to fall afoul of Berliner's patents. Rather than engage in costly litigation the Victor and Columbia companies arranged for cross-licensing. Thenceforward, competition was in terms of such factors as costs, merits of machines, prestige and quality and popularity of available records.

2. European Developments.—The beginnings of the phonograph business in Europe were limited largely to the activities of sales agents from the already established American companies. Demonstrations of Edison's tin-foil machine were given in 1878 in England and Germany, where they created much interest but little else. A decade later Edison made a serious effort to extend his beginning business by demonstrating his wax cylinder system for many distinguished persons and making recordings of the voices of celebrities. The prices of machines imported from the U.S. were too high for any considerable sales for private use, but, as in the United States, many people were willing to pay a small fee to satisfy their curiosity and hear a machine talk.

As an attraction for their tavern, two Frenchmen, Charles and Émile Pathé, procured a phonograph from England. But when customers showed more interest in the possibility of buying a phonograph than in the other Pathé business, the brothers decided to start making phonographs. They started with a small shop and by 1894 were doing a thriving business, making machines and wax blanks. They were also active in recording, using mechanical methods of duplicating the records, and by 1899 had a large list of available cylinders, principally of popular French singers.

In Italy there was no large market for machines, but the music-loving public would pay at some public installations to hear their favourite operatic songs.

Aside from a short-lived venture of making Gramophones in their simplest (hand-cranked) forms, started in 1889 by a German toymaker, there was little commercial phonograph activity in Europe, except that of the Pathé brothers, until the arrival of emissaries from the then-prospering Berliner group: William Barry Owen in 1897 to establish a branch in England, and Joseph Sanders in 1898 to help Émile Berliner's brother start a record pressing plant in Hanover, Ger. By this time the quality of reproduction had reached a point that made the Gramophone of interest as a source of home entertainment and that induced well-known artists to permit their voices to be recorded. Owen eventually interested certain British investors, and the Gramophone company was organized there in 1898; it imported parts from the U.S. and assembled Gramophones in England. Records, at least at first, were processed and pressed at the Hanover plant. As soon as machines and

records became available, extensive advertising was begun, and in the autumn of 1898 sales reached the full capacity of the manufacturing facilities. Owen opened branches for Gramophone sales and recording activities in Berlin and in Russia and Austria, and finally in France and Spain. It was in Russia in 1900 that red labels were first used to distinguish recordings of celebrated artists. For these discs the size was increased from seven to ten inches. In 1899 Owen purchased for the Gramophone company the original painting of a dog listening to a phonograph, to which the name "His Master's Voice" was given. This was soon used as a trademark by the Victor company, and about a decade later also by the Gramophone company, whose records were designated by the initials "H.M.V."

Recording the lateral-cut gramophone discs in wax began in Europe as well as in the U.S. in 1900 but did not entirely supersede the etching system for a year or so.

3. Technical Developments in Acoustic Recording.—Aside from the great growth in the phonograph business and refinements from time to time in recording equipment and techniques, the history of the acoustic phonograph was marked by the following developments:

Methods of molding cylinder records of a relatively hard thermoplastic were introduced by the Edison and Columbia companies in 1901. Since these were announced as "gold molded," it is presumable that gold sputtering was used to give an electrical conducting surface to the wax original.

The Odeon company was formed in Berlin in 1903. The following year it introduced discs with recordings on both sides. Columbia began issuing double-sided records in 1908. Pathé began making hill-and-dale cut discs in 1906 and in 1908 offered 11-in. double-sided discs.

In 1908 Edison brought out cylinders of a new material which he called Amberol, which was harder than the materials previously used. By increasing the number of grooves per inch from 100 to 200 he could offer four minutes of playing time. In 1912 Edison introduced a further improvement in material; he called the new material, which was more resistant to abrasion, Blue Amberol. Roland Gelatt noted that the Blue Amberols were relatively noiseless and, when played with an Edison diamond reproducer, produced better results than any other type of music reproducer then available. In 1913 Edison began making discs and a phonograph to play them. However, he continued to make cylinders for owners of cylinder machines until his company ceased operations in 1929.

The advent of radio broadcasting in the early 1920s brought severe depression to the phonograph industry. The Columbia company went into receivership in 1923; the competition of the fast-growing radio industry did not seriously affect the Victor company until 1925. The introduction of electrical recording (by both Columbia and Victor), improved phonographs and combination radio receivers and phonographs soon brought recovery. The British Columbia company had fared much better than the U.S. company (now unaffiliated), and its president, Louis Sterling, bought controlling interest in the American company and took licences for both companies to use the new developments.

The Victor Talking Machine Co. was purchased by Radio Corporation of America in 1929. Its plant at Camden, N.J., became the production centre for radio equipment as well as phonographs and records.

4. Horns.—The performance of an acoustic phonograph is greatly affected by the size and shape of the horn; and while there was little in the way of technical study during the era of the acoustic phonograph, there was some progress toward better horns. Ear trumpets and megaphones had long been familiar, and the developers of phonographs were quick to take advantage of what horns could do for their machines. The horns assumed various shapes according to the ideas of those who made them. The easiest horn to construct is of simple conical shape, but after about 1920 the exponential horn was the nearly universal choice of engineers. A theoretical analysis of its characteristics was published by A. G. Webster in 1919, and the subject was further elucidated by C. R. Hanna and J. Slepian in 1924.

An exponential horn is one whose cross-sectional area doubles with each increase of x inches in distance along the axis from the small end; or, if it is a round horn, the diameter doubles with each increase of $2x$ in axial distance. A small value of x therefore yields a horn of rapid flare, while a large value yields a slowly expanding horn. Every exponential horn has a critical frequency, known as its cutoff; below this frequency the horn is of practically no use, while for higher frequencies it will reproduce very effectively. The cutoff frequency is that at which the wave length is approximately $20x$; hence, to extend the range of response to lower frequencies, x must be made large. To avoid horn resonance, Hanna and Slepian recommended that the expansion be carried to the point at which the surface (of a horn of circular cross section) makes an angle of 45° with the axis. This results in a large bell or final opening.

From the time of the very first phonographs it was customary to funnel the total air displaced by a diaphragm into a horn opening of considerably smaller diameter. This results in greater loading of the diaphragm, reducing its tendency to resonate (*i.e.*, damping it) and deriving from it increased sound power. The volume of air within the sound box must be small so that appreciable compression will not take the place of air flow.

Horns can be bent or "folded" to conserve space without too seriously impeding their performance, provided the difference between the shortest and longest paths around the bend is not over about one-third the shortest wave length to be transmitted.

Comparing a conical horn with an exponential horn of the same length and initial and final openings, the cone expands much more rapidly at its small end and much more slowly near the large end. The result is that the conical horn gives some multiplication of air flow at frequencies well below the cutoff frequency of the exponential horn, and the output climbs gradually through a long range of frequency, without ever quite overtaking that of the exponential horn above its cutoff.

The horns of the early phonographs were in some cases frustums of simple cones, but more frequently they ended in a rapidly flaring bell, like a trumpet. In some cases the angle between side and axis increased toward the large end, giving a shape between that of a cone and an exponential horn. However, early horns were relatively small and were not designed to avoid resonances due to reflections at the bell. Some of the resonant points may have been regarded as desirable for increasing sensitivity. The feeble response at low frequencies was of less consequence, since there was little of low frequency on the records. Recording equipment was usually provided with larger horns, often of simple conical shape.

As experience accumulated, the sizes of horns increased, at least on the better machines. In 1906 the Victor company marketed a machine with the horn built into the cabinet. This facilitated increasing the horn size and also made it desirable to keep down the size of the middle part of the horn, thus favouring a shape somewhat closer to the exponential. The slight taper of the swinging pickup arm, which constituted the first part of the horn, increased the general resemblance to the exponential shape. In later models with larger cabinets, larger and still better-shaped horns were employed. However, it was not until the introduction of the Orthophonic design in 1925 that a definitely planned exponential expansion was followed, with considerable increase in length and with an end opening occupying practically the whole front of a large cabinet.

II. ELECTRICAL RECORDING AND REPRODUCTION

Prior to 1925 the phonograph had been developed almost wholly on an empirical or "cut-and-try" basis, with little theoretical analysis and all decisions based on listening tests. Recording was looked upon as an art, and rightly so, for the judgments of an experienced recording engineer as to balance and choice of selections were of utmost importance. Certain voices and instruments recorded well while others did not, and early recognition of poor qualities could often forestall wasted recording sessions. Details of recording equipment and practices were often treated as trade secrets. To the old-line phonograph organizations, the rapidly

developing and expanding radio and electronics industries seemed almost unrelated to their own, and few of them sought any help from electronics technicians.

The great difficulty in all direct recording lay in the extremely limited amount of acoustical power which could be collected and applied to actuate the diaphragms of the record-cutting devices. Only in the electronics field was there such a thing as an amplifier capable of multiplying sound power a thousandfold and more, with almost no loss of quality. The initiative in the development of electrical recording was taken by the Western Electric Co. Some work looking toward phonograph applications had been started as early as 1915, interrupted by the war, and then resumed soon afterward under the direction of J. P. Maxfield. The men who took part had extensive experience not only in amplifier applications but in the many electrical and mechanical problems encountered in telephone apparatus and transmission. Much use had been made of electrical-mechanical analogies which helped make experience in the electrical field applicable to mechanical problems and vice versa.

1. Theoretical Aspects.—In the development of electrical recording and reproducing apparatus an important principle of design of vibrational apparatus was introduced. The essential moving parts of either a recorder or reproducer have a certain amount of mass. Forces to actuate these masses must be produced magnetically in the case of the recorder or by the action of the record on the needle tip in the case of the reproducer. It is desirable to minimize the required forces. It happens that it is not necessary for all of the moving elements of either device to be combined into a single mass. In the recorder the armature of the electromagnetic motor can be separate from the stylus bar and stylus. In the reproducer the needle with its clamp and the lever which connects it to the diaphragm constitute one part; the diaphragm constitutes the other principal mass. If a phase difference can be permitted between the motions of the two related parts, the maximum force that must be applied to the needle to vibrate these masses can be practically halved. The introduction of an elastic connection or "compliance" permits this phase difference. In the recording cutter the torsional flexibility of a short shaft, between the motor armature and the bar carrying the stylus, offers the compliance, and there is another such flexible shaft between the stylus bar and a disk to which the mechanical resistance device is attached. The moment of inertia of each mass element, and the flexibility of each shaft, must be closely adjusted to predetermined values, and the structure of alternate masses and compliances (which is the mechanical equivalent of an electrical low-pass filter) must be terminated by a true mechanical resistance of correct value; otherwise there will be irregularities in its response. A pure mechanical resistance is not easy to provide.

Some recording heads employed oil for viscous damping; others used special solid materials. In the case of the reproducing device employed in the Orthophonic Victrola, the compliance was provided by a springy "spider" through which the lever actuated the diaphragm, and the required mechanical resistance was obtained by the reaction of the air in the "sound box" and horn throat on the diaphragm. With appropriate proportioning of the sound box volume and the relative areas of horn throat and diaphragm, and with a sufficiently slowly expanding horn, the energy was radiated as useful sound and the diaphragm worked against a substantially pure resistance. The Orthophonic design not only reduced the reaction of the needle on the record but, because of its higher efficiency in radiating the vibrations, gave greatly increased sound output.

While the input impedance of the recording device was practically pure resistance throughout most of the frequency range covered, the springs that centred the motor armature between the pole pieces added a stiffness reactance which predominated over resistance below about 300 cycles per second (c.p.s.). The resulting characteristic of the recording system (expressed as stylus movement for constant electrical input) was of constant amplitude up to 300 c.p.s., and of constant velocity from 300 to 5,000 c.p.s., the upper limit being determined by the cutoff of the mechanical filter previously discussed. Were the constant velocity range extended much lower, the amplitudes at the lowest frequencies would be excessive, necessitating wider groove spacings.

Since the sound level needed for satisfactory operation with a microphone and amplifiers was far lower than had been needed for direct recording, the introduction of electrical recording made it no longer necessary to group the players close together around the recording horns, nor to resort to instruments of special construction. Orchestras and choral groups could perform under conditions similar to those to which they were accustomed in concerts. It was not necessary to give preference to instruments of high acoustical power nor to singers with powerful voices.

Licences were taken by the Victor and Columbia companies to use the Western Electric recording system and equipment, and to build phonographs utilizing the principles and design features described above. The name Orthophonic Victrola was applied to the Victor machine. The horn in this model had considerably greater length (six feet) and final opening area (about eight square feet) than any in previous machines, the rate of expansion being slow enough to make the horn effective down to 115 c.p.s. To accommodate the length within the cabinet the passages were bent or folded several times. The improvements in records and phonographs were quickly recognized and resulted in great increases in sales.

2. Electrical Reproduction.—Although the sound quality of the Orthophonic machine (which was nonelectrical) was excellent, the advantages of electrical reproduction—ease of control, high amplification and simplification by combining the phonograph and radio receiver—made it inevitable that the electrical system would sooner or later supplant the mechanical. The electrical loudspeakers of the early 1920s left much to be desired, and the transition would scarcely have taken place when it did were it not for the advent of a greatly improved loud-speaker described in April 1925 by C. W. Rice and E. W. Kellogg of the General Electric Co. It was marketed by Radio Corporation of America (RCA) in 1925 as a separate loud-speaker for radio, known as the Radiola 104. It has frequently been called the "dynamic cone speaker." In addition to employing the dynamic or moving-coil drive and a conical paper diaphragm (about six inches in diameter), it had the following features which were equally important to the successful results: a very flexible suspension of the diaphragm (fundamental resonance about 60 c.p.s.); a baffle to prevent air circulation between the front and back of the diaphragm; and an amplifier of adequate power capacity to avoid overloading. Prior to this, the means most widely employed for actuating loud-speaker diaphragms depended on the varying pull of a polarized electromagnet on an iron armature. To maintain the armature at the proper spacing from the magnet poles, it had to be held by a stiff spring, and therefore the very flexible diaphragm mounting was not feasible with such "magnetic motors." The first electrical phonograph using the new loud-speaker was the Panatrope of the Brunswick Balke Collender Co., first demonstrated in the autumn of 1925; it employed an electromagnetic pickup. Outstanding in its sound quality was the abundant bass. Early in 1926 the Victor Talking Machine Co. brought out several models of electrical phonographs, some of which were combined phonographs and radio broadcast receivers. These used pickups of the same (General Electric) design as the Brunswick, but for a short period the loud-speaker given preference was one utilizing a large horn built into the cabinet like that of the Orthophonic, with an electrical unit employing a relatively small diaphragm, driven by a balanced armature "motor." Another electrical phonograph which achieved considerable popularity was the Majestic, similar in general principles to the Brunswick but differing in design details.

The baffle loud-speaker offered an important practical advantage for use in homes, because the space requirements were much less than needed for horns of adequate size to give good bass, but for theatre and auditorium applications the directivity of horns was important and space was not so restricted. Designs varied, but practically without exception the horns were exponential in expansion rate and after about 1926 the diaphragms were coil driven. The improved loud-speakers for auditoriums, with improved pickups for reproduction from discs, were applied in the motion-picture

field, and resulted in the rapid conversion from silent to sound motion pictures. The commercial realization of this change started in 1926, and the earliest commercially successful sound pictures made use of lateral disc records 16 in. in diameter operating at a turntable speed of 33⅓ r.p.m. and synchronized with the motion-picture film. (*See* also LOUD-SPEAKER.) (E. W. KE.)

3. Evolution of Fine-Groove Records.—A number of factors played a part in the evolution of fine-groove records. The demonstrations by H. C. Harrison and H. A. Frederick in 1931 of their new hill-and-dale acetate records showed what could be done in greatly reducing surface noise through use of refinements in record processing and a pickup with low vertical force and low mechanical impedance; the pickup permitted use of softer record material, free of any filler such as was used in the shellac records. The development of feedback recorders, the vertical recorder by L. Vieth and C. F. Wiebusch, and the lateral feedback recorder by G. R. Yenzen, also helped contribute to low distortion, extended range and smoother response obtainable with a feedback control that included the vibrating system.

But there were obstacles to change in the home phonograph field, obstacles that applied in much less degree to broadcast transcription service. The first magnetic pickups had rather high output, so their signals could be fed to the first audio stage of radio receivers without additional amplification. But they were also of high mechanical impedance (stiff needle mounting), the correction of which would reduce the output, and high mechanical impedance necessitated high vertical force. Cost-conscious designers were reluctant to put in more amplification. Because there were in existence, millions of records hard and tough enough to stand such forces, incentive to make a change was lacking. It was not until H. J. Hasbrouck's work on elimination of noise from the pickup and record that a pickup having truly low mechanical impedance was adopted. This permitted reducing the vertical force on the stylus to a few grams, but such small forces were insufficient to trip some record changers; consequently, full advantage could not be taken of the new pickups without improvements in record changers.

The reduction in necessary vertical force was so great as to make it feasible to use stylus tips of reduced radius, resting against the sloping sides of the groove instead of on the bottom; furthermore, this could be done while using records of clear vinylite, free from fillers. The advantages of using a finer stylus tip—in reduced tracing distortion, in finer groove pitch and in permitting some reduction in linear velocities—had been realized for a number of years but were especially convincingly shown in the analytical papers of F. V. Hunt, J. A. Pierce and W. D. Lewis, who also demonstrated a practical design for a low force, jewel-tipped pickup. They also showed the superior tracing possible with lateral-cut records, provided the spherical stylus tip maintained contact with the sloping side walls of the groove and cleared the bottom.

The dimensions of a record groove are determined by the lateral displacement of the groove resulting from the signal, or music, and by the dimensions of the reproducing stylus. It is evident that a reduction in either or both of these factors permits a reduction in the dimensions of the groove and thus makes possible a smaller record or a record having longer playing time. The use of less noisy record materials permits a reduction in the lateral displacement of the groove without reducing the signal-to-noise ratio. The use of pickups with a lower value of mechanical impedance permits the use of a smaller reproducing stylus. Experimental evidence proved that up to 300 grooves per radial inch and a reproducing stylus with a radius of 0.001 in. were practical.

The amount of distortion in the signal reproduced from the record groove increases as the stylus moves toward the centre of the disc—that is, as the relative circumference of the groove decreases and the relative speed of the groove past the stylus decreases. Therefore, the speed at which a disc record should rotate is related to the amount of recorded material it contains, and both speed and amount of material are governed by the circumference of the innermost groove that will give the maximum permissible distortion.

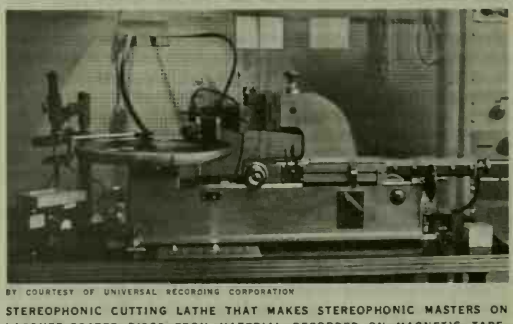
In addition, there is a definite relationship between the diameters of the outermost and innermost grooves that gives the maximum playing time per unit surface area. This relationship is such that maximum playing time for a disc of given size will be achieved if the diameter of the innermost recorded groove is one-half the diameter of the outermost groove; this relationship also is governed by the amount of permissible distortion in reproduction obtained from the innermost groove.

It is important to note that any major change in playing time calls for a change in speed of the record in order to achieve the least area or amount of record material, as the case may be. This assumes no change in the other factors, such as the radius of the reproducing stylus, the lateral displacement of the groove or the reproduced distortion at the innermost groove.

Modern disc records are designed with full knowledge of these principles. Other factors of a practical nature have resulted in some deviations from the purely theoretical considerations of disc record design. In 1948 both Columbia and RCA introduced fine-groove records of clear vinylite. The Columbia version was 12 in. in diameter, rotated at 33⅓ r.p.m. and had a maximum playing time of 30 minutes. The RCA version was seven inches in diameter, rotated at 45 r.p.m. and had a maximum playing time of eight minutes. After several months of testing the market, the change to fine-groove records became complete, with Columbia and RCA each making both versions.

The justification for these two records results from the wide difference in the playing time of "popular" and "classical" music. Each of the new records offered major improvements in cost, convenience and performance over the older 10- and 12-in. 78.26-r.p.m. records. (A. D. B.)

4. Stereophonic Phonograph Records.—Stereophonic phonograph records with two separate channels of information recorded in a single groove became a commercial reality in 1958, less than a year after the adopted system had been publicly demonstrated. A stereophonic system utilizes two or more independent channels, with separate microphones in recording and separate loud-speakers in reproduction, so arranged as to produce a sense of realism of recording hall acoustics and of location of the instruments of the orchestra with respect to directivity and depth. The effectiveness of stereophonic reproduction was demonstrated by the Bell Telephone laboratories in 1933 when the sound of an orchestra playing in Philadelphia was reproduced over loud-speakers located in Washington. The material was not recorded but was transmitted directly over telephone lines. Two-track stereophonic tape for the home became common in the 1950s, and Emory Cook produced some commercial stereophonic disc records, laterally recorded, in which the two channels of information were carried as separate inside and outside bands on the record; reproduction was through a forked arm carrying two pickups, one riding in each band.



BY COURTESY OF UNIVERSAL RECORDING CORPORATION

STEREOPHONIC CUTTING LATHE THAT MAKES STEREOPHONIC MASTERS ON LACQUER-COATED DISCS FROM MATERIAL RECORDED ON MAGNETIC TAPE. ARM ON LEFT IS FOR PLAYBACK

The system finally adopted as standard used a dual-channel feedback recorder and a single stylus with its axes of movement inclined at 45° to the record surface, the pickup being designed to produce two practically independent signals in accordance with the motion components along the two (90° displaced) axes. Since

the record groove is V-shaped and ordinarily has an included angle of 90°, the groove walls are 45° with respect to the record surface. Consequently, for the 45°–45° system the signal from one channel varies the position of one groove wall about a mean (no-signal condition) without changing the position of the other.

Operation at 45° provides a symmetrical arrangement that offers advantages both in design of recorders and reproducers and in quality of reproduction, since frequency response, distortion and other characteristics of the two channels are alike. In addition, good reproduction is possible over a single channel (monophonic) system since information from both stereophonic channels is contained in the resultant lateral modulation. However, due to the vertical modulation, monophonic pickups must have greater vertical compliance than normally required for lateral records. P. C. Goldmark recognized this problem in earlier work on stereophonic disc recording and proposed that the vertical modulation be dynamically held within limits that would not exceed the tracking capabilities of existing lateral reproducers. Such a record could be designated as "compatible" and could be reproduced either monophonically over phonograph systems designed for lateral-cut records or stereophonically over stereophonic systems. However, not wishing to risk possible reduction in quality, record manufacturers decided to follow the recommendation of the Record Industry Association of America and produce the two types of records, monophonic and stereophonic, separately. (H. E. R.)

III. RECORD MATERIALS AND PROCESSING

The early tin foil and other recording media ultimately were supplanted by materials of two general types: the wax disc (actually a heavy-metal soap with wax gel) intended for subsequent processing and duplication, and the instantaneous media intended mainly for playback directly from the embossed or engraved original record.

The necessary accuracy of the recorded groove can be judged by the requirements established for fine-groove records: that the bottom radius of the groove be less than 0.00025 in. and the width about 0.0025 in., giving a depth of about 0.00125 in. This is less than one-half the groove size of the 78-r.p.m. record.

In cutting or engraving the master record the stylus must be sharp and accurately ground so that the cut will be very clean. Lacquer-coated discs, usually on an aluminum base, were developed as an instantaneous recording medium, but because of the slightly rubbery nature of lacquer a smooth, low-noise groove was not obtained. The development of a burnishing facet on the stylus cutting edge resulted in quieter grooves but increased cross-modulation (echo) between adjacent grooves. The introduction of the heated cutting stylus about 1950 improved lacquer recording to the point where wax discs became practically obsolete for commercial master recordings.

1. Electroforming.—To make copies of the recording, dies must be made whose surface is a negative replica of the master record surface. Electroforming techniques which reproduce the surface to an accuracy of better than 0.000001 in. are utilized. In electroforming, the surface is made the cathode in an electrolyte solution containing the metal to be deposited. The neutralization (reduction) of the positive metal ions at the cathode surface forms a metal sheet whose thickness is proportional to the current and time.

Before this can be done, however, the master record surface must be made electrically conductive. Prior to 1938 wax recordings were made conductive by brushing graphite or bronze powder into the wax surface. In the 1930s Western Electric introduced gold sputtering, which was widely adopted by the major record manufacturers. With the improvements in lacquer discs and recording techniques, it was found that wet-silvering methods (*e.g.*, the chemical reduction of an ammoniacal silver solution such as that used for silvering mirrors) led to improved results. By the early 1950s, in view of the more stringent requirements of the unfilled-plastic records and particularly the fine-groove records, lacquer discs with wet-silvering metallizing had been universally adopted by major record manufacturers.

After separation from the recording, the electroformed metal master disc can be used in a plastic molding press to press records, and in cases where only up to 100 or so records are desired this usually is done. In the case of commercial records, many pressing masters, called stampers, may be needed. Therefore, it has been the practice to electroform a metal positive from the metal master. This positive, called a "mother" or mold, can be played as a record for quality approval and then used to generate a number of stampers by electroforming. By using a metal master to generate a number of molds and each mold to generate a number of stampers, it is possible to make many stampers, and thus thousands of records, from each recording.

2. Record Materials.—Commercially, records are molded from thermoplastic materials, which become soft and flow under pressure when heated but when cooled to room temperature become rigid. Shellac, a natural thermoplastic, was used in combination with a finely ground filler such as clay for many years, but after the early 1930s synthetic thermoplastic resins gradually replaced it. High-quality record compositions without filler were first used for transcription records for radio broadcast. With the introduction of the fine-grooved records, use of the higher-quality compound became necessary to reduce the noise caused by the filler particles. Of the synthetic materials, the vinyl plastics are most commonly used for records.

IV. PHONOGRAPHS AND RECORD CHANGERS

1. Stylus Shapes and Materials.—Except for the Edison hill-and-dale phonograph, which had a diamond reproducer stylus, most phonographs prior to 1935 required frequent changes of stylus or needle. Heavy pickups, weighing from 100 to 200 g. and bearing upon the small area of contact at the tip of the stylus, can exert pressures far in excess of the strength of record materials. Shellac-compounded mixtures used in records included a large proportion of abrasive filler, usually fine limestone and clay, which soon ground the tip to conform to the groove shape. In this way the contact area between stylus and groove was increased materially, thus decreasing the unit pressure so that record wear was reduced. When, between 1933 and 1935, attempts were made to use sapphire styli with electrical pickups weighing 50 to 150 g., record wear was found to be excessive, probably because the sapphire could not quickly be worn sufficiently to reduce the unit pressures at the stylus tip to a satisfactory level. It was not until the introduction in the late 1930s of pickups weighing less than 35 g. that sapphire and diamond styli became practical. The lighter pickups also permitted the use of unfilled-plastic record materials.

When comparatively large forces were necessary to extract the signal from the groove, the output was affected by the type of needle used. A short, stubby steel needle resulted in high output with good high-frequency response, but this also brought out the surface noise of the record. With a longer, thinner-shanked and more flexible needle, the over-all output was reduced but the high frequencies were attenuated to a greater degree, making the surface noise less audible. Steel needles were used most commonly during this period, although "low-noise" fibre or thorn needles, more compliant than steel, also were used.

Steel needles had to be changed after every play with abrasive-filled records. In the 1930s chrome-plated needles, which could be used somewhat longer, were introduced, and needles with hard metal tips such as osmium were also available. With the advent of light-weight pickups, jeweled styli (sapphire and diamond) became predominant.

Record styli are made to precise specifications. The point should be spherical, tapering off to a 50° cone. For the 78-r.p.m. record a 0.003-in. point radius is desirable, and for the fine-groove records a 0.001-in. radius. Specifications for the stereophonic records call for a stylus point with a maximum radius of 0.0008 in.

There is no permanent stylus. Even a diamond point will wear with time. With light pickups a diamond stylus should perform satisfactorily for 100–500 hours of playing time, a sapphire stylus about one-fifth of that time.

The needle should make contact on the sides of the groove for best reproduction. As the stylus wears, its sides become flat and the stylus rides more closely to the bottom of the groove. A stylus

riding on the bottom of a record groove results in noisy and distorted reproduction. (A. M. MA.)

2. Reproducer or Pickup.—A phonograph pickup is a device which, when actuated by the record groove, will produce a usable signal proportional to the signal (music) recorded in the groove. Common forms of phonograph pickups produce an electric signal proportional to the amplitude or velocity of the signal in the record groove.

Phonograph pickup designers have explored nearly all of the known principles of electric generation, including the piezoelectric effect from certain crystals, variable resistance, variable capacity, variable magnetic flux cutting, variable magnetic reluctance and variable light-beam photoelectric effects. In general, it is possible to design a pickup using any principle that will produce an electrical signal from a mechanical signal. The selection of the principle and the design of the pickup is usually determined by cost, environmental conditions, etc.

Because of relatively high electric output, crystals of Rochelle salts, properly cut and designed into a pickup, have been extensively used in low- to medium-priced phonographs. Barium titanate and lead titanate zirconate also have been used, as these materials are less affected by moisture and temperature variations than Rochelle salts (*see* PIEZOELECTRICITY). Mechano-electromagnetic principles have found considerable use, moving-iron and moving-coil devices being commonest. Mechano-electro-capacity principles also have been employed.

Pickup designers, for the most part, have directed their efforts toward designs of low cost, low mechanical impedance, low distortion and high reliability. Low mechanical impedance has received considerable attention because its attainment permits a low value of stylus force. The less the stylus force, the less will be the wear of the stylus and the record groove. Concentrated effort on the part of pickup designers reduced the mechanical impedance to the point where only a fraction of an ounce of stylus force was necessary to hold the stylus in contact with the walls of the groove. It was this development which permitted the use of clear vinylite record materials and a stylus radius of 0.001 in. or less. To appreciate the magnitude of this accomplishment, it is only necessary to consider that many mechano-acoustic pickups required a stylus force of over six ounces with a stylus radius of 0.003 in.

Stereophonic pickup design followed the same basic principles used for monophonic pickups. The so-called universal pickups used for hill-and-dale and lateral transcription equipment were the forerunners of the 45°–45° stereophonic pickups. In the stereophonic pickup, it was the design objective to produce two independent signals using a single stylus actuated by two independent signals recorded in a single record groove. Thus the pickup has two independent electric generating units connected to and actuated by a common stylus.

3. Record Changers.—A record changer is a mechanism designed to permit a stack of selected records to be played without further attention.

While a number of early patents were granted on automatic record-changing devices, very few machines reached the hands of the public until after the mid-1930s. The low-cost, single-play phonograph attachment, for use with a radio, stimulated interest in the playing of records. As record collections grew, the need for record changers became apparent. By 1940 many manufacturers were equipping their phonographs with record changers.

The record-changing mechanisms were of varied designs. Commonest in the early period was the edge-selector type in which the records were placed over the centre spindle and supported at their circumference on two or more shelves. Blades or knives, above the shelves, sliced in between the bottom record and the next above to drop the bottom record onto the turntable. In another design the record stack was supported at the centre on an offset portion of the spindle and at the circumference by a shelf. The top portion of the spindle was tilted slightly to provide stability to the stack. The shelf support included a mechanism designed to push the bottom record from the off-set portion of the spindle. Edges and centre holes of shellac records were damaged by these types of mechanisms.

After World War II, many improvements were made in record-changer mechanisms. The use of vinylite record material practically eliminated damage to the record by the selector mechanism. In addition, improvements were made in the turntable drive system, tone arm, tone arm landing and tripping mechanisms, etc. (A. D. B.)

4. Phonograph Motors and Drive Systems.—The first experimental machines were hand cranked, usually with some steadying effect by flywheels, but in one of his early patents Edison stressed the importance of correct and uniform speed. Battery-operated electric motors were soon used, but these were sensitive to changes in load and voltage; flyball governors were used to reduce speed variations. The most satisfactory of these governors were those with a friction disk, the friction of which increased rapidly if the speed exceeded the desired value. While Edison was reluctant to give up the electric motor, a spring-driven, governed motor developed by Frank Capp, a pioneer in many phonograph improvements, was demonstrated to Edison and adopted, and spring motors also were developed by the Columbia company and by Berliner. At the end of 1896 all three companies were using governed spring motors.

For recording, weight-driven machines with friction governors were used for many years. The weight supplied a constant torque, and the governor was connected to the turntable spindle through a worm gear. These were precision-built machines.

Electric motors did not come into very extensive use until radio-phonograph combinations were introduced, and then for many years the motor served only to provide a reasonably uniform driving torque, and friction governors, geared to the turntable, regulated the speed. The induction disk motor (like those used in watt-hour meters) was widely used in this manner. Small, high-speed, split-phase or shaded-pole induction motors with governors were among the many forms used during the 1930s, and a true synchronous motor, resembling a clock motor, was used in some machines. The latter had a multitoothed steel disk which, once started, was kept rotating by the intermittent pull of its toothed pole pieces.

"Rumble" due to vibration of the turntable or pickup pivot presents a problem. The vibration is primarily caused by the high-speed motor and transmitted through the motor supports or the speed-reduction system. Cushion mounting of the motor is therefore necessary. Problems arise because the ear is especially sensitive to slow pitch fluctuations. Successful filtering is increasingly difficult as the frequency of the disturbance is lowered. Belting between motor and turntable can give excellent results in reducing rumble. Transmission of rumble by the belts can be almost completely avoided. Very light, thin, flexible belts of exceptional uniformity are required, especially if one of the pulleys is small; usually, two stages of reduction are used. Friction drives with rubber tires also are widely used because the rubber tires can be ground to a high degree of concentricity. By grinding the end of the motor shaft in its own bearings (after balancing the motor), the shaft end can serve very satisfactorily for the first unit of the drive train, even though it is as small as $\frac{3}{16}$ in. in diameter. The inside of the flanged turntable, machined to concentricity, can be the final friction drive surface. The rubber tires can then be on the intermediate wheels. Since the load is light, the slip or "creep" is negligible. (E. W. KE.)

V. MAGNETIC RECORDING

The advantages of magnetic recording were quickly appreciated by the phonograph industry, once its excellent low-noise and audio-quality characteristics had been demonstrated. Greater recording time, immediate playback, the possibility of erasing and reusing the medium and the feasibility of editing, a feature never possible in disc recording, soon made magnetic tape a popular medium for phonograph recordings and broadcasting. In a very short time all original recordings were being made on magnetic tape; these were transferred, after editing, to discs.

Magnetic tape also offered another means of bringing recorded music into the home, with the advantage that more than one track

BY COURTESY OF UNIVERSAL RECORDING CORPORATION

MUSIC RECORDING STUDIO EQUIPPED WITH FOUR SPEAKERS FOR IMMEDIATE PLAYBACK OF RECORDED MATERIAL. GLASS WINDOWS AT LEFT SHOW ROOM TO ISOLATE VOCALIST AND AT RIGHT CONTROL ROOM WHERE SOUND FROM EIGHT SEPARATE AUDIO CHANNELS (FOUR WITH ECHO AND FOUR WITHOUT) IS MIXED AND FED TO A FOUR-TRACK MAGNETIC TAPE RECORDING MACHINE

could be recorded simultaneously, thus permitting stereophonic recording. Prerecorded tapes soon became available for home use for both monophonic and stereophonic reproduction. These appeared as two-track recordings on tape ¼ in. wide, on spools either seven or five inches in diameter, depending upon the playing time. The operating speed was 7½ in. per second. For monophonic recordings each track was used separately and a total playing time of approximately one hour was possible. For stereophonic recordings where both tracks were used simultaneously the total playing time was about 30 minutes. After tape having a thinner base became available, the playing time was increased by about 50%, thus permitting a playing time of about 45 min. for a stereophonic recording. *See* TAPE RECORDING, MAGNETIC.

(H. E. R.)

VI. PHONOGRAPH MUSIC

The day in 1877 when Thomas Edison reproduced his own voice on a tin-foil cylinder, reciting "Mary Had a Little Lamb," marked the beginning of an activity with potentialities unforeseeable even in the most extravagant dreams. Edison's "talking machine," generally regarded as an elaborate toy but offering the novelty of hearing one's voice reproduced, preserved the voices of many prominent people of the time, such as those of William Gladstone, P. T. Barnum and Robert Browning. An early musical recording was that of Brahms playing one of his own works.

Commercial recording was established in the 1890s and in spite of quantity production problems had an amazing growth. Many early records were of vaudeville skits, monologues and descriptive accounts, with some musical selections by bands, whistlers and singers. By the early 1900s many first-rank artists were to be heard on both discs and cylinders. The fact that the voice reproduced better than instruments made singers much in demand. Among the earliest artists to record were Medea Figner, Nikolay Figner and Enrico Caruso, whose great success undoubtedly influenced other artists favourably. In the United States, "Celebrity Disks" were issued by the Columbia company, followed by the Red Seal list of Victor. By 1910 nearly every first-ranking singer was represented on records. Orchestral accompaniment to vocal records began in 1906 after an unsuccessful start in 1900. Many instruments did not reproduce well; since brass instruments recorded better than others, there was a tendency toward their overemphasis, the musical result often being far removed from the composer's intention. Orchestras had to be small because of the necessity for grouping the musicians close around the recording horn. Among the first instrumental soloists to record were Sarasate (Pablo de Sarasate y Navascues), Joseph Joachim, Raoul Pugno, Fritz Kreisler, Jan Kubelik, Ignace Paderewski, Eugène Ysaÿe, Vladimir von Pachmann and Efrem Zimbalist.

Recording of orchestral repertory began in London in 1909 when the Odeon company issued the Tchaikovsky *Nutcracker Suite,* played by the London Palace orchestra under Herman Finck. The increased interest in instrumental recording brought forth a variety of works, played by various orchestras, often in condensed versions. In the United States in 1912, the Columbia company engaged Felix von Weingartner to conduct an enlarged staff orchestra for several discs. In 1917 Columbia engaged the Chicago symphony under Frederick Stock, the Cincinnati symphony under Ernst Kunwald and the New York Philharmonic under Josef Stransky; and in 1918 Victor began a series by the Boston symphony under Karl Muck and by the Philadelphia orchestra under Leopold Stokowski. Chamber music made its appearance in 1916 in Europe with recordings by the London string quartet. An occasional full-length large work was recorded, one of the earliest being a La Scala performance of Leoncavallo's opera *I Pagliacci* under the composer's direction. The main interest, however, seemed to centre on the artist rather than the music.

The introduction of electrical recording in the 1920s marked the beginning of the second period of phonograph development, during which the emphasis shifted to production of complete works. The use of microphones eliminated crowding around a recording horn; this, along with improved quality of sound and increased tonal range, opened up new fields of instrumental literature. Record catalogues listed complete symphonies, operas and chamber works by nearly all the well-known composers of the past as well as works by many contemporaries. The composer and the composition, rather than the artist, became the chief points of interest. Ironically, progress in electronics, which made such technical advances possible in the recording field, served to work against increased use of the phonograph because of the rapid growth of radio broadcasting. World War II was another restraining influence, though the end of the war brought an increased activity in recording and several improvements in reproduction techniques, such as full-frequency-range recording introduced in England by the Decca company. The real revolution, which marked the beginning of the third great period of phonograph history, was the introduction of fine-groove records in 1948. Their almost total lack of surface noise, improved faithfulness of reproduction, and the fact that they allowed recording of complete works on one or two sides of a single record meant that the fine-groove records almost immediately supplanted older types.

A development of equal importance was the introduction of magnetic tape for making original recordings. In a time of rising production costs, the advantages of tape were obvious: no longer did soloists and orchestras have to repeat compositions many times to achieve a performance satisfactory for public sale on records; instead, sections containing flaws could be rerecorded and these sections could then be patched into the tape to make a final master tape from which the master disc was transcribed. Some critics maintained that the too-perfect results thus obtained lacked the realism of actual performance, but the reaction of musicians and record purchasers was in general enthusiastic. In addition, the mobility of tape-recording equipment made it much easier to record actual performances in concert halls and theatres, thus putting on discs many performances otherwise unattainable.

Tape-recording and playback equipment was available for home use, in both monophonic and stereophonic types, and recording companies offered extensive lists of prerecorded tapes; in general, when reproduced on good equipment, the quality of these tapes exceeded that of the best disc recordings.

The educational possibilities of the phonograph were realized early in such collections as the *History of Music by Eye and Ear,* edited by Percy Scholes, *Two Thousand Years of Music,* edited by Curt Sachs, and numerous other sets of similar nature. Other special issues were tests for measuring musical talent or accomplishment, discs for technical instruction of various kinds, missing-part records for learning chamber music and numerous others. A remarkable result of the new recording techniques was the issuing of many of what might be termed rerecorded old acoustical records, making it possible to hear artists of earlier days under more favourable conditions of reproduction. Popular music, of course, was one of the mainstays of the industry, the material made available in this field being even more complete than the extensive

listing of the classical field. The popularity of dance bands on records began in 1913, gaining increasing interest each year. Folk songs from nearly every area of the world appeared both as special studies and as regular releases. Nonmusical lists, in addition to the usual numerous sketches, monologues and similar short offerings, showed an increasing number of complete plays and musical shows, as well as recordings of noted poets and authors reading from their own works. Of documentary importance as well as general interest were the collections of statements by prominent people and comments on newsworthy current events. Foreign language and other instruction, children's stories and Bible stories were among the many choices of instruction and entertainment made available. An important development for scholars was the establishment of archives by museums and libraries for preserving old and new records for their historical value.

Information regarding available records was to be found in magazines such as the *American Record Guide*, the *Gramophone* and *Disques*, devoted solely to dispensing record information, as well as in others having record sections. Numerous books on the subject were also published, some surveying the entire field and others dealing with only limited portions. (AY. D.)

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PHONOLITE, a group of alkaline lavas rich in nephelite (*q.v.*) and sanidine, an alkali (potash) feldspar (*q.v.*). The name is a Greek rendition of the German *Klingstein* (*phone*, "sound," and *lithos*, "stone"), referring to fine-grained compact lavas which split into thin, tough plates and give out a ringing sound when struck with a hammer. The presence of a feldspathoid mineral was suspected from gelatinization tests (decomposition by hydrochloric acid, with separation of gelatinous silica) as early as 1828, but it was not until 1867 that nephelite was shown to be a major constituent of the matrix.

The most important constituent of phonolite is alkali-feldspar, either sanidine or anorthoclase, which forms not only the bulk of the ground mass, but most of the large crystals in porphyritic varieties.

Nephelite rarely appears in large crystals but may occur either interstitially or in well-formed microphenocrysts. The principal ferromagnesian mineral is a pyroxene, titanaugite, aegirine or cores of the former mantled by the latter. Pyroxene in phenocrysts is sharply euhedral; in the matrix it occurs characteristically in slender unterminated needles, often so abundant as to impart a green colour to the rock.

Amphibole (*q.v.*) is practically confined to phenocrysts and is usually an alkaline variety, barkevikite, riebeckite or arfvedsonite. Feldspathoids other than nephelite may be present in accessory amount, the commonest being noselite, sodalite (*q.v.*) and leucite (*q.v.*). Glass has been reported occasionally but only in small amount.

Occurrences.—Most phonolites are of Tertiary or Recent age, but excellent examples are found at several localities in the Carboniferous strata of Scotland and also of Brazil. In terms of the numbers of recorded occurrences, though not perhaps in total volume, Tertiary or Recent phonolites are common in Europe, in the Auvergne (Mont Dore), the Eifel, the Laacher See and Bohemia. They have been described from a number of sites in the Mediterranean area, chiefly in Italy, as well as from Cripple Creek in Colorado, and the Black Hills, South Dakota. The famous Devils Tower, Wyoming, is variously described as tinguaite or phonolite, depending on whether it is considered a plug or a flow.

Leucite phonolites are perhaps best known from the vicinity of Naples. Apachite, from the Apache Mountains, west Texas, is an amphibole phonolite. Kenyite, from Mt. Kenya, east Africa, is rich in cossyrite and olivine. The phonolite of Ölbruck, Ger., a rather popular local building stone, is said to contain about 15% of noselite and 8% of leucite.

Phonolitic trachytes are found on St. Helena and a number of other oceanic islands. (F. Cs.)

PHORMION (probably died 428 B.C.), Athenian admiral, son of Asopius. He first appears in 440 B.C. among the generals bringing reinforcements to the Athenian troops before Samos. Later he was sent to help the Acarnanians and Amphilochians against Ambracia; this was the origin of Athens' useful alliance with Acarnania. In 432, after Callias' death before Potidaea, Phormion went out with fresh forces and completed the circumvallation of the city. He was still there in 431, but at the end of 430 he was sent with 20 ships to Naupactus to block the entrance to the Gulf of Corinth. There in summer 429 he won two brilliant victories. In the first he defeated 47 Peloponnesian ships on their way to support the Spartan Cnemus' campaign in Acarnania; in the second, Cnemus' fleet of 77 attacked him in the narrows, but he turned and routed them. The next spring he returned to Athens. In summer 428 his son Asopius was sent out, the Acarnanians having asked for a general from Phormion's family, which suggests that he himself had died. *See* PELOPONNESIAN WAR. (A. As.)

PHORMIUM (NEW ZEALAND FLAX; also termed NEW ZEALAND HEMP). The plant (*Phormium tenax*) is a perennial of the Liliaceae family and is propagated either by rhizomes or by seed. While termed "New Zealand flax" and also "New Zealand hemp," the plant has no relationship to either flax (*Linum usitatissimum*) or hemp (*Cannabis sativa*). Phormium is a native of New Zealand and, while known to be adapted in many other countries, is not commonly grown for commercial fibre production in any country other than New Zealand.

The thick sword-shaped leaves grow in tufts from the tips of the rhizomes and reach a length of four to six feet. The flowering stem, which also starts from the tip of the rhizome, grows out through the centre of the tuft of leaves and reaches a height of 5 to 15 ft. The flowers are usually cross-pollinated though some self-pollination occurs. The parts above ground die soon after the flowering stage, but the plant continues to live from year to year by new growth from short, thick underground stems (rhizomes).

Much of the phormium fibre of commerce has come from harvesting the volunteer growth, but considerable quantities have been obtained from cultivated fields. The crop is adapted to a wide range of New Zealand soils, but the greatest yields have been obtained from well-drained swamp lands.

The plant is grown principally for the fibre which develops in the leaves, and which is separated from the nonfibrous tissues by a process of scraping and washing. This processing is done in fibre mills by means of special machines designed for the purpose.

The cleaned, dried fibre is arranged in hands ("heads") and then packed in bales, in which form it is exported. The fibre is similar in appearance to such other leaf fibres as abaca (Manila hemp), henequen (Yucatan sisal) and "true" sisal. Its principal use has been for twines and ropes.

See H. J. Critchfield, "Phormium Tenax—New Zealand's Native Hard Fiber," *Econ. Bot.*, vol. 5 (1951). (A. H. WT.)

PHORONEUS, in Greek legend a very early king of Argos (*q.v.*), the son of Inachus. Inachus was, in one tradition, the earliest of all Hellenic rulers, but he was sometimes admitted to be simply a river-god, so Phoroneus was the first mortal king. The only legend extant about Phoroneus is that he and two river-gods had to decide between Poseidon and Hera as the deity of the land. They chose Hera, and Poseidon took his vengeance by depriving the Argolid of water. (Traditionally from Homer onward Argos was "the very thirsty" land.) (H. W. PA.)

PHORONIDA is a phylum of small, marine, wormlike animals which live in self-secreted tubes embedded in the sea bottom or attached to solid surfaces. They are found in shallow tropical and temperate waters of many parts of the world—Europe, North and South America, Australia, South Africa and Asia. Phoronids, constituting a small and relatively homogeneous group, are considered to be a separate phylum because they are structurally unique; they cannot clearly be related to any other group of ani-

mals. In the past, however, attempts were made to relate them to the Annelida, Mollusca and Chordata among other phyla. Two genera, *Phoronis* and *Phoronopsis*, and about 16 species are recognized.

Many phoronids occur in vertical tubes placed just below the

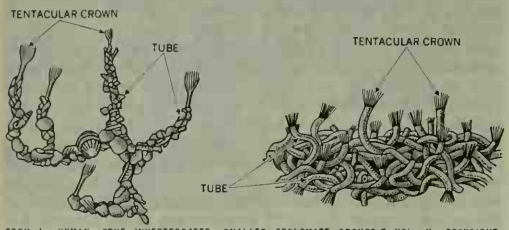

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FIG. 1.—(LEFT) PHORONIS PSAMMOPHILA, WITH TUBES COATED WITH ROCK GRAINS AND SHELLS; (RIGHT) AGGREGATION OF P. HIPPOCREPIA

surface in intertidal or subtidal mud or sand flats. Other species form dense feltlike masses of intertwined tubes attached to rocks, pilings or logs in shallow water. In both these cases the tubes are encrusted with small particles of sand or shell. A third living habit concerns those phoronids which are found living inside closely fitting channels in limestone rock or in the discarded shells of bivalve mollusks. Phoronids appear to be widely distributed in temperate and tropical seas, but there are no records from polar regions.

Structure and Function.—In all phoronids the body is more or less elongate—most species ranging in length from less than a centimetre to 20 cm.—and bears a crown of tentacles at one end. The tentacles are arranged in a double row surrounding the usually crescent-shaped mouth. The mouth is partly covered by a flap of tissue known as the epistome. The anus occurs at the same end of the body as the mouth and is borne on a small papilla located immediately outside the double row of tentacles. The digestive tract is therefore U shaped. The tentacles may form a slightly indented circle or a complex double spiral. Situated near the bases of the tentacles is a supporting structure made of connective tissue and known as the lophophore. Depending on the species, there may be from about 50 to over 300 tentacles, each one bearing fine hairs or cilia. The movements of the cilia create currents which carry food particles from the surrounding water into the mouth and waft waste particles away from the anus. Feeding and excretory currents have not been studied in great detail.

The digestive tract consists of esophagus, stomach, intestine and rectum. These various regions differ from one another in size and in the nature of the cells forming the internal lining. In some species there is a distinct muscular valve between the esophagus and the stomach. The junction of the stomach and intestine occurs at the proximal end of the body, that is, the end which does not bear tentacles, mouth and anus. The tentacular end of the body is known as the distal end. The food seems to consist chiefly of microscopic phytoplankton. Diatom shells may frequently be found in the digestive tract and in the fecal pellets.

There is a system of blood vessels in which circulate elliptical, nucleated corpuscles containing the red pigment hemoglobin, similar to the hemoglobin found in human blood. Two longitudinal vessels, known as the afferent and efferent vessels, are continuous with one another at the proximal end of the body. At the distal end both vessels connect with a pair of semicircular vessels located at the level of the lophophore, immediately below the tentacles. Within each tentacle is a single, blind vessel which branches into two at its base and so connects with both semicircular vessels. In the living animal the red blood corpuscles can easily be seen pulsating up and down in the transparent tentacular vessels. Associated with the longitudinal vessels are a blood sinus surrounding the digestive tract and a large number of short, blind vessels which are particularly numerous in, or may be restricted to, the proximal end of the body. Associated with these blood vessels is a jellylike tissue known as the fat body or the vasoperitoneal tissue. Among the large, semifluid cells of this tissue are a number of granules of varying size and shape. Some of them probably consist of guanine and may be considered to be deposits of waste material. Others may represent the products of hemoglobin breakdown.

The body cavity is subdivided by a series of long, thin membranes known as mesenteries, which extend from the digestive tract to the body wall. In most phoronids there are four such mesenteries dividing the body cavity into four longitudinal chambers. There is also a horizontal mesentery near the tentacular end of the body separating a lophophoral cavity from the four larger cavities occupying the rest of the body. In the living phoronid the body cavity is filled with a fluid which is responsible for the turgor or relative firmness of the otherwise soft body.

On either side of the papilla which bears the anus is a small pore connecting with an organ of excretion known as a nephridium. Each nephridium consists of a duct, coiled once on itself and continuous with a pair of funnels opening into two of the four larger body cavities. The walls of the funnels tend to be much folded and are heavily ciliated. The activity of the cilia probably creates a current in the body cavities which carries fluid waste into the funnels and eventually to the outside via the nephridial pores.

The body wall consists of an outer layer of epithelial cells and two layers of muscle fibres: the outer circular and the inner longitudinal. Many of the epithelial cells secrete a fluid which is used by the animal to build the tightly fitting chitinous tube in which it lives. The freshly secreted fluid is transparent and sticky, but on contact with water it gradually hardens. In some species the secreted tube becomes encrusted with tiny grains of sand, mud or shell which adhere to the surface. In many such cases the cemented particles are arranged to form a very even and beautiful mosaic. The tube is in most cases closed at the proximal end; from the distal open end the body may be extended a rather long distance. Most phoronids can shorten or lengthen the body considerably; this is accomplished by the muscles in the body wall contracting against the fluid in the body cavity.

The nervous system is also located in the body wall and consists chiefly of a nerve net lying immediately beneath the epithelial cells. This nerve net is continuous with a more dense concentra-

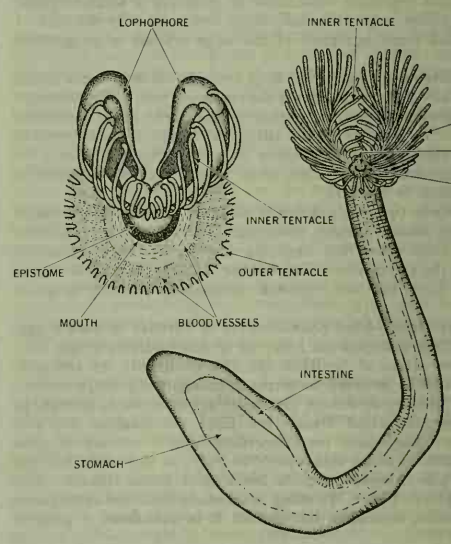

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FIG. 2.—PHORONIS ARCHITECTA (LEFT) LOOKING INTO THE TENTACULAR CROWN OF MATURE ADULT WITH FULLY DEVELOPED LOPHOPHORE. ONLY THE BASES OF THE OUTER TENTACLES ARE SHOWN. (RIGHT) YOUNG ADULT

tion of nervous tissue in the horizontal mesentery. Extending from this region and running along, in or beneath the epidermis are one or two giant nerve fibres which taper and end near the proximal end of the body. The giant nerve fibres are known in all but one species and are probably related to the animal's ability to withdraw the body into the tube with great rapidity.

Reproduction and Natural History.—Reproductive tissue is formed from cells located on the thin walls of the short, blind blood vessels in the proximal part of the body. The phylum includes species in which individual animals are either male or female and other species in which each animal is a hermaphrodite and carries both male and female organs. As the reproductive tissue grows along the walls of the blood vessels it displaces the surrounding vasoperitoneal tissue which shrinks proportionately. When the ova and spermatozoa are ripe, they are shed into the body cavity, find their way to the nephridial funnels and pass through these organs to the outside. In some species the sex cells simply pass out into the surrounding water where early development takes place. In others the ova are retained in the tentacular crown of the adult until each has developed into a tiny, transparent, free-swimming larva. The type of larva characteristic of the phylum Phoronida, an actinotroch larva, is distinguished chiefly by a ring of ciliated tentacles and a flap of tissue over the mouth.

The actinotroch larva may spend over a month swimming freely, feeding on plankton and increasing considerably in size. Eventually, it settles on the bottom and undergoes a metamorphosis whereby it is rapidly and drastically changed into a tiny adult phoronid. All phoronids can reproduce sexually, and in most cases the life history includes an actinotroch larva. Some species are known to reproduce asexually as well, by the apparently simple process of dividing the body into a number of segments, each of which then breaks off and develops into a new adult.

See L. H. Hyman, *The Invertebrates*, vol. 5 (1959). (J. R. Ma.)

PHORORHACOS, a genus of extinct flightless birds of large size, known from Tertiary formations in southern South America. They appear to have been remotely related to the living seriema (*q.v.; Cariama cristata*) of that region. *Phororhacos* (family Phororhacidae) is included in the order Gruiformes, to which the living cranes (Gruidae) and rails (Rallidae) belong. Numerous parts of specimens have been found, and the most complete fossil specimen is *P. inflatus*, of which head, pelvis, limb bones and some of the vertebrae are recorded.

BY COURTESY OF BRITISH MUSEUM (NATURAL HISTORY)

RESTORATION DRAWING OF PHORORHACOS, AN EXTINCT BIRD

The skull in this bird is about 13 in. long, with the maxilla high in profile, much compressed laterally and terminating in a strong hook; the heavy mandible is curved upward at the tip. The long legs are strong though slender, the tibia being 15–16 in. long. The small size of the wing elements, the form of the shoulder girdle and the skeleton as a whole indicate a cursorial species unable to fly. From the form of the bill, the bird was apparently a formidable predator. It is estimated to have stood about three feet high at the shoulder.

The skull of another species, *P. longissimus*, is about 24 in. long with the beak 10 in. high, indicating a bird of gigantic size. An allied genus, *Andrewsornis*, described by B. Patterson from an incomplete skull and other fragments, had a slender 15-in.-long mandible and indications of a stronger wing. Another genus, *Mesembriornis*, has been recognized from Pliocene deposits (about 10,000,000 years ago). Several workers have described a dozen or more species from fragmentary bones in addition to those mentioned, but the relationships of several of these are doubtful. The family, the earliest known representative of which appeared in the latter part of the Oligocene epoch (more than 30,000,000 years ago), continued into the early Pliocene.

See Karman Lambrecht, *Handbuch der Palaeornithologie*, pp. 494–516, fig. 147–154 (1933); Bryan Patterson, "A New Phororhacoid Bird From the Deseado Formation of Patagonia," *Field Museum of Natural History Geological Series*, vol. 8, no. 8, pp. 49–54 (1941). (A. Wt.)

PHOSGENE (Carbonyl Chloride) is a colourless, extremely poisonous gas, about three and one-half times heavier than air, having a stifling, nauseating odour resembling sour green corn or musty hay. It is a lung injurant and even in small amounts may prove to be very harmful. It may act slowly, its full effects sometimes developing several hours after inhalation. It first came into prominence in World War I, being used as an offensive poison gas either alone or mixed with chlorine.

Phosgene was first synthesized in 1812 by John Davy, the British chemist, by the reaction of carbon monoxide and chlorine in the presence of sunlight; hence the derivation of its name from the Greek *Phos* (light) and *genes* (born). It is manufactured by passing the two gases over a specially prepared charcoal catalyst. The reaction is expressed chemically by the equation $CO + Cl_2 \rightarrow COCl_2$. It has also been manufactured by the reaction of fuming sulfuric acid on carbon tetrachloride. The preparation of a number of pharmaceuticals, industrial chemicals, and dyestuffs involves its use.

Phosgene is active chemically; it fumes in moist air and reacts with water to form hydrogen chloride (hydrochloric, or muriatic, acid) and carbon dioxide: $COCl_2 + H_2O \rightarrow 2HCl + CO_2$. It is sometimes formed when chlorinated hydrocarbons are heated; *e.g.*, when carbon tetrachloride is used as a fire extinguisher. Phosgene gas can be readily condensed to a liquid, which boils at 8.2° C (46.8° F) at atmospheric pressure. It is ordinarily stored and transported under slight pressure in steel cylinders, although under certain circumstances it is stored and transported as a solution in toluene. (A. V. C.)

PHOSPHATE ROCK, a sedimentary formation of marine phosphorite usually interbedded with shales or limestones. It occurs in many parts of the world and is mined in North Africa, Germany, the U.S.S.R., the United States and several other countries. The name collophane is sometimes given to the massive, seemingly noncrystalline apatite (*q.v.*) that is the essential constituent of phosphate rock. It is composed largely of calcium phosphate, an important ingredient of bones, teeth and many shells. Other components include lime, silica, fluorine and carbonaceous (carbonate) matter. Phosphate rock is used in the preparation of fertilizers and as a source of phosphorus for matches and of phosphoric acids used in the chemical industries. It originated on the sea floor during several geologic periods at times and under conditions that favoured precipitation of the apatite from solution but retarded the addition of much land waste. For uses, occurrences, production, etc. *see* Fertilizers and Manures. *See* also Mineral Phosphates; Phosphorus. (J. T. P.; X.)

PHOSPHATES: *see* Phosphoric Acids and Phosphates.

PHOSPHORESCENCE: *see* Bioluminescence; Luminescence.

PHOSPHORIC ACIDS AND PHOSPHATES. Phosphates are salts of phosphoric acid. Phosphoric oxide, P_2O_5 or P_4O_{10}, combines with water in three proportions to form $H_2O{\cdot}P_2O_5$ or HPO_3, metaphosphoric acid; $2H_2O{\cdot}P_2O_5$ or $H_4P_2O_7$, pyrophosphoric acid; and $3H_2O{\cdot}P_2O_5$ or H_3PO_4, orthophosphoric or ordinary phosphoric acid. These acids each give origin to several series of salts, those of ordinary phosphoric acid being the most important, especially as fertilizers. *See* also Phosphorus: *The Oxyacids of Phosphorus;* Fertilizers and Manures: *Phosphorus-Supplying Fertilizers.*

Orthophosphoric acid, H_3PO_4, a tribasic acid, is obtained by boiling a solution of the pentoxide in water; by oxidizing red phosphorus with nitric acid, or white phosphorus under the surface of water by bromine or iodine; and also by decomposing a mineral phosphate with sulfuric acid. It usually forms a thin syrup which on concentration in a vacuum over sulfuric acid deposits hard, transparent, rhombic prisms which melt at 41.7° C. After long heating the syrup is partially converted into pyrophosphoric and metaphosphoric acids, but on addition of water and

boiling the ortho acid is reformed. It gives origin to three classes of salts: $M'H_2PO_4$ or $M''(H_2PO_4)_2$; M'_2HPO_4 or $M''HPO_4$; and M'_3PO_4, $M''_3(PO_3)_2$ or $M'''PO_4$, wherein M′, M″, M‴ denote a univalent, bivalent and trivalent metal. These correspond to H_3PO_4 in which one, two or three atoms of hydrogen, respectively, have been replaced by a metal. The three principal groups differ remarkably in their behaviour toward indicators. Those of the first type are strongly acid, the second are neutral or faintly alkaline, while the third are strongly alkaline and are decomposed by carbon dioxide: $Na_3PO_4 + CO_2 + H_2O \rightarrow NaHCO_3 + Na_2HPO_4$. The salts of the types NaH_2PO_4 and $CaH_4P_2O_8$ may be obtained in crystal form, but those of the heavy metals are stable only when in solution. All soluble orthophosphates give with silver nitrate a characteristic yellow precipitate of silver phosphate, Ag_3PO_4, soluble in ammonia and in nitric acid. Since the reaction with the acid salts is attended by liberation of nitric acid: $NaH_2PO_4 + 3AgNO_3 \rightarrow Ag_3PO_4 + NaNO_3 + 2HNO_3$, $Na_2HPO_4 + 3AgNO_3 \rightarrow Ag_3PO_4 + 2NaNO_3 + HNO_3$, it is necessary to neutralize the nitric acid if the complete precipitation of the phosphoric acid is desired.

The three series also differ when heated: the trimetallic salts containing fixed bases are unaltered, while the monometallic and dimetallic salts yield metaphosphates and pyrophosphates, respectively. Other common precipitants of phosphoric acid or its salts in solution are: ammonium molybdate in nitric acid, which on heating gives a canary-yellow precipitate of ammonium phosphomolybdate, $(NH_4)_3PO_4 \cdot 12MoO_3$, insoluble in acids but readily soluble in ammonia; magnesium chloride, ammonium chloride and ammonia, which on standing in a warm place give a white crystalline precipitate of magnesium ammonium phosphate, $Mg(NH_4)PO_4 \cdot 6H_2O$, which is soluble in acids but highly insoluble in ammonia solutions, and on heating to redness gives magnesium pyrophosphate, $Mg_2P_2O_7$.

Of the organic phosphates, triphenyl phosphate, $(C_6H_5)_3PO_4$, is important, acting as a filler or "dope," and as a plasticizer. It is a colourless solid of m.p. 53° C and b.p. 245° C.

Pyrophosphoric acid, $H_4P_2O_7$, is a tetrabasic acid which may be regarded as derived by eliminating a molecule of water between two molecules of ordinary phosphoric acid; its constitution may therefore be written $(HO)_2OP{\cdot}O{\cdot}PO(OH)_2$. It may be obtained as a glassy mass, indistinguishable from metaphosphoric acid, by heating phosphoric acid to 215° C. When boiled with water it forms the ortho acid, and when heated to redness, the meta acid. After neutralization, it gives a white precipitate with silver nitrate. Being a tetrabasic acid it can form four classes of salts; for example, the four sodium salts $Na_4P_2O_7$, $Na_3HP_2O_7$, $Na_2H_2P_2O_7$ and $NaH_3P_2O_7$ are known. The most important is the normal salt, $Na_4P_2O_7$, which is readily obtained by heating disodium orthophosphate, Na_2HPO_4. It forms monoclinic prisms (with $10H_2O$) which are permanent in air.

All soluble pyrophosphates when boiled with water are converted into orthophosphates.

Metaphosphoric acid, HPO_3, or more correctly $H_2P_2O_6$ as determined by vapour density, is a monobasic acid which may be regarded as derived from orthophosphoric acid by the abstraction of one molecule of water, thus $H_3PO_4 - H_2O \rightarrow HPO_3$; its constitution is therefore $(HO)PO_2$. The acid is formed by dissolving phosphorus pentoxide in cold water, or by strongly heating orthophosphoric acid. It forms a colourless vitreous mass, hence its name "glacial phosphoric acid." It is readily soluble in water, the solution being gradually transformed into the ortho acid, a reaction which proceeds much more rapidly on boiling. Although the acid is monobasic, salts of polymeric forms exist of the types $(MPO_3)_n$, where n may be 1, 2, 3, 4 or 6. They may be obtained by heating a monometallic orthophosphate of a fixed base, or a dimetallic orthophosphate of one fixed and one volatile base; *e.g.*, microcosmic salt: $MH_2PO_4 \rightarrow MPO_3 + H_2O$; $(NH_4)NaHPO_4 \rightarrow NaPO_3 + NH_3 + H_2O$. The salts are usually noncrystalline and fusible. Their solutions on boiling yield orthophosphates, while those of heavy metals give a trimetallic orthophosphate and orthophosphoric acid: $3AgPO_3 + 3H_2O \rightarrow Ag_3PO_4 + 2H_3PO_4$. Metaphosphoric acid can be distinguished from the other two acids by its power of coagulating albumen, and by not being precipitated by magnesium and ammonium chlorides in the presence of ammonia.

For perphosphoric acids, *see* PHOSPHORUS.

See W. H. Waggaman, *Phosphoric Acid, Phosphates and Phosphatic Fertilizers,* 2nd ed. (1952).

PHOSPHORITE, impure massive carbonate- and phosphate-bearing apatite (*q.v.*), or phosphate rock (*q.v.*). *See* also FERTILIZERS AND MANURES; MINERAL PHOSPHATES.

PHOSPHORUS. Phosphorus was first prepared in elemental form in 1669 by the alchemist Hennig Brand of Hamburg, who used the residue from evaporated urine as the source of the element. News of the discovery soon spread over Germany. Brand did not disclose to the public his method of producing phosphorus but he sold the secret to Johann Krafft of Dresden. The chemist Johann Kunckel sought to learn from Brand the method used, but found only that urine had been used as the source of the phosphorus. With this information Kunckel was able, after many trials, to duplicate Brand's accomplishment. Kunckel likewise attempted to keep the process a secret and, like Brand and Krafft, tried at various times to sell it.

Krafft exhibited samples of phosphorus in many countries; in 1677 he performed experiments with it before members of the Royal society in England. A few years later the British chemist Robert Boyle devised a method of preparing the element, and deposited with the secretary of the Royal society a description of his method which, however, was not published at the time. Boyle had little or no interest in alchemy. In Europe, many alchemists sought the philosopher's stone, and it was thought that such an unusual material as phosphorus might lead to the long-sought goal. It is of interest to note that Gottfried Leibniz, the German mathematician, then librarian for Duke Johann Friedrich at Hanover, arranged a contract between Brand and the duke, under which Brand was to demonstrate his process and reveal his method.

It is easy to understand the widespread interest that was aroused in the 17th century by the discovery of such a remarkable substance as phosphorus. A substance which glowed in the dark and took fire spontaneously upon exposure to the air was something startlingly new and mysterious. It is indeed notable that an element so difficult to isolate should have been discovered through the unguided fumbling of an alchemist.

In the decades that followed 1680, methods for the preparation of phosphorus from various animal and vegetable materials were developed and, in some instances, published. It was not until 1775, more than a hundred years after Brand's discovery, that Carl Scheele published the much easier method of preparing the element from bones, which then became the chief raw material used as a source of phosphorus.

The Phosphorus Atom.—The chemical atomic weight of phosphorus is 30.9738, and its atomic number of 15 indicates that there are 15 positive charges on the nucleus of the atom. Since the atomic mass number is 31, the nucleus is composed of 15 protons and 16 neutrons. The 15 electrons which revolve about the nucleus are arranged at three major quantum levels, usually referred to as the K-shell, the L-shell and the M-shell. There are two electrons at the first quantum level or K-shell, eight electrons in the L-shell, and five electrons in the M-shell.

In the nomenclature commonly used, the arrangement of the electrons about the nucleus of the phosphorus atom may be expressed as 1 s^2, 2 s^2 p^6, 3 s^2 p^3. In this expression the 1, 2, 3 refer to the major quantum levels or shells, the s and p to sublevels within the principal quantum levels, and the exponentially written numbers refer to the numbers of electrons at each sublevel.

The only stable isotope of phosphorus is P^{31}. Six unstable, radioactive isotopes have been produced: P^{28}, half life 0.28 sec.; P^{29}, half life 4.5 sec.; P^{30}, half life 2.5 min.; P^{32}, half life 14.3 days; P^{33}, half life 25 days; and P^{34}, half life 12.4 sec. Of these, only P^{32} is useful as a tracer element. Because of the important role that phosphorus compounds play in the chemistry of organic life, it is unfortunate that the only useful radioactive isotope has so short a half life in relation to the normal life cycle of higher plants and animals.

Occurrence.—Phosphorus does not occur free in nature, but its compounds are widely distributed and are found in many rocks and minerals. It ranks 11th in abundance in the lithosphere, of which the average content of phosphorus is about 0.12%. Some of the common minerals of phosphorus are apatite [$Ca_{10}F_2(PO_4)_6$], wavellite [$Al_6(PO_4)_4(OH)_6.9H_2O$] and vivianite [$Fe_3(PO_4)_2.8H_2O$].

Large deposits of rock phosphate are found in many localities. These deposits are of great economic value as a source of phosphate in the manufacture of fertilizers. In the United States the deposits of Florida and Tennessee have been exploited extensively, and exploitation of the deposits of Utah, Wyoming, Idaho and Montana is increasing rapidly. In Africa the deposits of Algeria, Tunisia and Egypt are also mined on a large scale. All these deposits were laid on the floor of shallow seas and are mostly the remains of myriads of aquatic microorganisms. The phosphate beds of the western United States are primary deposits which lie conformably with the shales, limestones and other formations of the region, whereas the main deposits of Florida, Tennessee and North Africa are secondary, being the residues from the leaching of phosphatic limestone. (*See* also MINERAL PHOSPHATES.)

Many textbooks of chemistry and technical articles erroneously refer to rock phosphate as tricalcium phosphate, $Ca_3(PO_4)_2$, although the phosphatic material present is actually a calcium fluorphosphate, or possibly hydroxyfluorphosphate, which gives the same X-ray pattern as the mineral apatite.

Phosphorus is one of about 20 elements essential to the growth, development, and maintenance of plants and animals, and the supply of phosphoric compounds in agricultural soils must be maintained. Where crops are removed, the supply of phosphorus compounds in the soil may become the limiting factor in crop production. Large quantities of phosphorus compounds are used as a fertilizer and an extensive deposit of rock phosphate therefore represents a great natural resource. (*See* also BIOLOGY: *Properties of Living Matter;* FERTILIZERS AND MANURES: *Phosphorus-Supplying Fertilizers.*)

Preparation.—Phosphorus may be prepared readily by heating metaphosphoric acid with carbon, or by heating a calcium phosphate with carbon and sand. Carbon monoxide and phosphorus vapour are evolved in both processes.

In the modern industrial method for the production of phosphorus, rock phosphate, coke and silica pebble are charged continuously into a three-phase electric furnace. The electric energy serves only to heat the charge, which melts and reacts chemically with the coke and silica to produce phosphorus vapour and carbon monoxide which pass out of the furnace, while a molten calcium silicate slag accumulates in the furnace. Any iron compounds present as impurities in the furnace charge are reduced and the molten metallic iron then absorbs phosphorus to form ferrophosphorus which is heavier than the slag and therefore sinks to the floor of the furnace.

From time to time the furnace is tapped and the ferrophosphorus is cast into pigs, while the slag is granulated by means of jets of water. The granulated slag is composed chiefly of calcium silicate. The ferrophosphorus is used in making iron alloys but the market does not utilize all the by-product ferrophosphorus produced. Several methods were developed for the recovery of the valuable phosphorus from the ferrophosphorus but none was in commercial use early in the second half of the 20th century.

The stream of gas from the electric furnace consists principally of phosphorus vapour and carbon monoxide. After the gas is freed of dust and then cooled the phosphorus condenses to the liquid and eventually to the solid form. Because it ignites spontaneously when exposed to air, the usual practice is to store the phosphorus under water.

Physical Properties.—Phosphorus exists in several allotropic forms which will be discussed later. The ordinary variety, when pure, is a colourless, semitransparent, waxy solid at room temperature, but is usually slightly yellow because of impurities present.

Although virtually insoluble in water, white phosphorus is slightly soluble in many organic liquids, in phosphorus trichloride, liquefied ammonia, and liquefied sulfur dioxide, and is extremely soluble in carbon disulfide. Its molecular weight in solvents, and in the vapour state, corresponds to a P_4 molecule. The atoms in the molecule are in a tetrahedral arrangement, the edge of the tetrahedron being 2.21 angstrom units.

When phosphorus vapour is heated, the dissociation of P_4 molecules into P_2 molecules becomes measurable at about 800° C. Spectrographic examination of hot phosphorus vapour indicates that P_4, P_2 and P molecules are present, but even at 1,200° C. the proportion of monatomic molecules is exceedingly small.

Some of the other physical properties of white phosphorus are given in the following table:

Specific gravity	1.83
Melting point	44.14° C. at 1 atm.
Boiling point	280.5° C. at 1 atm.
Heat of fusion	630 cal. ± 2 cal. per P_4 mol.
Critical temperature	720.6° C.
Heat of sublimation	14,066 cal. per P_4 mol.
Hardness	0.5 on Mohs' scale
Atomic heat capacity	5.69 cal. per gram atom
Atomic volume	16.9 c.c. per gram atom
Surface tension	43.09 at 78.3° C. 35.56 at 132.1° C.
Index of refraction	1.8244 for the D line at 29.2° C.
Parachor	37.7
Entropy $S°298$ (solid)	9.80 ± 0.02 cal. per gram atom per °C.
C_p, cal./mole P_4/° C., vapour	$= 19.25 + 0.510 \times 10^{-3}T - 2.980 \times 10^{5}T^{-2}$

Allotropic Forms.—The data accumulated from the many investigations of the allotropic forms of phosphorus are voluminous, confusing and contradictory. In the present summary the statements are those for which the experimental evidence seems most consistent and convincing.

White phosphorus exists in at least two allotropic forms. The one that occurs under ordinary conditions of temperature and pressure is called the α form. It has a density of 1.83. At −77.8° C. the α form changes to a β form which has a density of 1.88. The crystal habit of the α form is cubic whereas that of the β form is hexagonal.

The β form is strongly doubly refractive and this makes it possible to observe the transition from the one form to the other by means of a polarizing microscope.

Red phosphorus can be prepared by heating the white variety at 250° to 300° C. in a closed container. The conversion is accelerated by a trace of iodine. Red phosphorus may be obtained also by exposure of phosphorus vapour to an electric glow discharge, to a spark discharge, or to a heated tungsten filament.

Red phosphorus does not ignite in air at ordinary temperature and is not dissolved by the usual solvents for white phosphorus. The red form melts in the range 590° to 600° C. and, as ordinarily prepared, is amorphous or microcrystalline. Its colour, density and other physical properties, as well as its chemical activity, are governed by the conditions under which it is formed. Upon prolonged heating, the ordinary amorphous form of red phosphorus undergoes progressive, exothermic, irreversible transitions to crystalline modifications. Thermal analyses, X-ray diffraction measurements and microscopic observations lead to the conclusion that there are certainly three and possibly five forms of red phosphorus. At one end of this series of transitional forms stands the variety obtained by the methods ordinarily used for the conversion of white phosphorus to the red form. The density of that variety may be as low as 1.9, and its X-ray pattern is diffuse, which establishes the absence of structural regularity. As the change progresses from one form to the next, the X-ray pattern sharpens and becomes progressively more complex. The most highly crystalline modification obtained by the thermal aging of ordinary red phosphorus is probably at least monoclinic but the symmetry is usually distorted so that its optical properties are those of a triclinic crystal. This form has been called violet or metallic phosphorus. It seems best, however, not to increase the confusion with regard to red phosphorus by giving special names to any of the modifications.

Black phosphorus is deemed another distinct allotropic form of phosphorus and is obtained by subjecting white phosphorus to a pressure of 35,000 atmospheres at ordinary temperature or to 12,000 atmospheres at 200° C. This allotropic form is a flaky, crystalline material that resembles graphite and has a density of 2.699. It is a conductor of electricity with a resistivity of 0.711 ohms per centimetre cube, and is not dissolved by any of the liq-

uids that dissolve white phosphorus. Black phosphorus changes irreversibly into the red allotrope at about 550° C. under ordinary pressure.

Chemical Properties.—Phosphorus is a nonmetallic element and belongs in Group V of the periodic table. The subgroup to which it belongs includes the elements nitrogen, phosphorus, arsenic, antimony and bismuth. The transition from nonmetallic to metallic elements as atomic weights increase is unusually sharp in this subgroup. It is also characteristic of the subgroup that corresponding compounds of the five elements do not resemble each other as closely as might be expected, even when the formulas are alike. Probability of resemblance is greatest in the hydrides, less in the halides, and least in the oxides. Even in the hydrides, however, the correlation of properties for corresponding formulas is poor.

The usual valencies of phosphorus are three and five. It would be expected from the arrangement of electrons in the phosphorus atom that the valency due to exchange of electrons would be plus five when the outer shell is stripped of electrons, and minus three when the outer shell is filled by the capture of three electrons. The chemistry of phosphorus is complex, however, and the element forms many compounds wherein its valency is other than the simple kind due to loss or gain of electrons in the outer shell of the atom.

White phosphorus is relatively active. It glows in the dark and ignites spontaneously to form dense white fumes of the oxide P_4O_{10}.

It precipitates copper and lead from their solutions at ordinary temperatures and reacts with most metals to form phosphides at elevated temperatures.

Hydrides.—There are two well-known hydrides of phosphorus, namely PH_3 and P_2H_4. Phosphine, PH_3, is a colourless, poisonous gas of characteristic odour. It can be produced by heating white phosphorus in a solution of potassium hydroxide, or by the hydrolysis of a solid phosphide such as Ca_3P_2. Phosphine solidifies at −134° C. under its own vapour pressure of 27.3 mm., and there are at least four allotropic forms of the solid.

The hydrogen atoms of the phosphine molecule are replaceable by metals with the formation of unstable compounds such as PH_2K, PK_3, etc.

The hydride P_2H_4 is a liquid which boils at 52° C., solidifies at −99° C. and ignites spontaneously. Other solid hydrides such as $P_{12}H_6$ and P_9H_3 have been reported, but X-ray studies of these solids indicate that they are probably solid solutions of PH_3 in phosphorus.

The monovalent phosphonium radical PH_4^+ is analogous to, although much less stable than, the ammonium radical NH_4^+. Phosphonium iodide is a colourless, crystalline solid formed by the interaction of phosphine and hydrogen iodide; the corresponding chloride and bromide are gases.

Halides and Oxyhalides.—The halogen compounds of phosphorus are numerous. In addition to simple halides such as PCl_3 and PCl_5, there are many mixed halides such as $PFCl_2$, PF_3Cl_2, etc. Theoretically there are 20 simple and mixed halides of trivalent phosphorus and 56 such halides of pentavalent phosphorus. In addition to these halides, not all of which have been prepared, there are phosphorus halides of the type P_2I_4 which is analogous to the hydride P_2H_4.

There are also many oxyhalides of phosphorus, of formulas POF_3, $POCl_3$, $POFCl_2$, etc.; and for each oxyhalide there exists the corresponding sulfohalide, such as PSF_3, $PSFCl_2$, etc.

Oxides.—The three best-known oxides are: P_4O_6, usually called phosphorus trioxide and expressed as P_2O_3; P_nO_{2n}, sometimes written as P_2O_4 and called phosphorus tetroxide; P_4O_{10}, nearly always written P_2O_5 and called phosphorus pentoxide.

In addition to these three oxides, existence of an oxide P_2O_6 is indicated by considerable evidence, and some doubtful evidence suggests the possibility of P_4O and P_2O.

The oxide P_4O_6, phosphorus trioxide, is a colourless, crystalline substance which melts at 23.8° C. and boils at 175.4° C. It forms phosphorous acid, H_3PO_3, in cold water and therefore may be said to be the acid anhydride of this acid, but it yields phosphorous, phosphine, phosphoric acid and other compounds when treated with hot water. The vapour density, the Raman spectrum and the electron diffraction pattern of phosphorus trioxide indicate P_4O_6 molecules and the molecular formula of the trioxide when dissolved in molten naphthalene is also P_4O_6.

Its heat of vaporization is 9,400 cal. per mole at the boiling point.

The oxide P_nO_{2n} is a lustrous, crystalline substance of density 2.537 at 22.6° C. The vapour at 1,400° C. has a density corresponding to molecules of P_7O_{14}. Phosphorus tetroxide reacts slowly in water with some evolution of phosphine but the principal products are phosphorous acid and metaphosphoric acid, $(HPO_3)_n$.

The oxide P_4O_{10}, usually expressed as P_2O_5 and designated phosphorus pentoxide, is the main product obtained when phosphorus is burned in an excess of air. The vapour density, Raman spectrum and electron diffraction pattern agree in indicating a P_4O_{10} molecule of the T_d point group with a symmetry number of 12. This oxide exists in several forms which vary in appearance. The white, amorphous powder is the one most common but there is a vitreous, glasslike form and also a silky white form. The most volatile is a crystalline variety obtained by the sublimation of the ordinary white form *in vacuo*. The vapour pressure of this crystalline variety is one atmosphere at about 358° C.

Phosphorus pentoxide, P_4O_{10}, is an unusually effective agent for the drying of air. It hydrolyzes first to metaphosphoric acid. The water vapour pressure over this P_4O_{10}-acid mixture is not more than 10^{-5} mm. of mercury at room temperature. Its capacity for water absorption is low, however, since one gram of water will convert nearly eight grams of P_4O_{10} to metaphosphoric acid.

Sulfides.—The sulfides of phosphorus are not as closely analogous to the oxides as is usually the case with elements other than phosphorus. The sulfides P_4S_3, P_4S_5, P_4S_7 and P_4S_{10} are well known and there is some evidence for the existence of P_2S_5.

The Oxyacids of Phosphorus.—There are six well-known oxyacids of phosphorus, namely: hypophosphorous acid, H_3PO_2; phosphorous acid, H_3PO_3; hypophosphoric acid, $H_4P_2O_6$; metaphosphoric acid, $(HPO_3)_n$; orthophosphoric acid, H_3PO_4; and pyrophosphoric acid, $H_4P_2O_7$.

The barium salt of hypophosphorous acid can be formed through the prolonged boiling of phosphorus with an excess of barium hydroxide. The over-all equation is:

$$8P + 3Ba(OH)_2 + 6H_2O \rightarrow 2PH_3 + 3Ba(H_2PO_2)_2$$

The excess of $Ba(OH)_2$ is precipitated by means of CO_2 and the resultant $BaCO_3$ filtered off. Sulfuric acid then is added to the solution to free the hypophosphorous acid and to precipitate barium sulfate which then is removed. When the solution is evaporated, colourless crystals of hypophosphorous acid, H_3PO_2, appear. The acid is monobasic, and the Raman spectrum indicates that two of the hydrogen atoms in the molecule are linked directly to the phosphorus atom while the third hydrogen is in a P-O-H linkage. As written for organic acids, the formula would be H_2POOH. The acid and its salts are powerful reducing agents although they often react slowly.

Phosphorous acid, H_3PO_3, is a colourless, deliquescent solid which melts at about 72° C. It is a dibasic acid and is a strong reducing agent. It is prepared easily by drawing a stream of air through PCl_3 and then through cold water. The equation is:

$$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$$

Hypophosphoric acid, $H_4P_2O_6$, is formed by the slow oxidation of moist phosphorus under special conditions. Although the formula may be written as $P_4O_6.2H_2O$, the acid is not formed when P_4O_6 is brought into contact with water. The dihydrogen, disodium salt, $Na_2H_2P_2O_6.6H_2O$, can be prepared through the slow addition of red phosphorus to a cooled, alkaline solution of sodium hypochlorite. Hypophosphoric acid is a colourless, deliquescent solid which decomposes when heated. It is a tetrabasic acid, with one, two, three or four replaceable hydrogens.

Theoretically, metaphosphoric, pyrophosphoric and orthophosphoric acids can each be obtained by the reaction of P_4O_{10} vapour with the appropriate amount of water; *i.e.*,

$P_4O_{10} + 2H_2O \rightarrow$ metaphosphoric acid
$P_4O_{10} + 4H_2O \rightarrow$ pyrophosphoric acid
$P_4O_{10} + 6H_2O \rightarrow$ orthophosphoric acid

Likewise, orthophosphoric acid can theoretically be dehydrated to pyrophosphoric and to metaphosphoric acid in succession. However, phosphoric acids with compositions corresponding to these acids are not pure, simple acids, but are complex mixtures of several polymeric acids, the proportions of which depend upon the over-all concentration.

Metaphosphoric acid exists in several polymerized forms indicated by the general formula $(HPO_3)_n$. The salts of several of what were supposed to be the individual polymers are known by such names as Pascal's salt, Madrell's salt, Knorre's salt, Graham's salt, Kurrol's salt, etc. It has been found, however, that these supposed salts of individual polymers of metaphosphoric acid are mixtures of different complex polymers, the degrees of complexity of which have not been determined with certainty. The sodium salt of so-called hexametaphosphoric acid is formed by the heating of NaH_2PO_4 and is important industrially for the treatment of boiler feed water. In hard water this complex sodium phosphate forms soluble complexes with calcium ions and thereby prevents the formation of the usual insoluble calcium compounds responsible for boiler scale.

Pyrophosphoric acid, $H_4P_2O_7$, is a colourless solid. It is tetrabasic and, so far as the first replaceable hydrogen is involved, is a stronger acid than orthophosphoric acid. In aqueous solution it hydrolyzes slowly to orthophosphoric acid.

Orthophosphoric acid, H_3PO_4, is commercially the most important of the oxyacids of phosphorus. The acid and many of its salts find extensive industrial applications. Some of the most widely used salts of both metaphosphoric and pyrophosphoric acid are prepared most readily through dehydration of the appropriate orthophosphoric salt. Thus when the monosodium, dihydrogen salt of orthophosphoric acid is heated, sodium metaphosphate is formed:

$$n NaH_2PO_4 \rightarrow (NaPO_3)_n + nH_2O$$

And, likewise, when the disodium, monohydrogen salt of orthophosphoric acid is heated, the corresponding sodium pyrophosphate is formed:

$$2Na_2HPO_4 \rightarrow Na_4P_2O_7 + H_2O$$

Orthophosphoric acid is a tribasic acid and at ordinary temperatures anhydrous H_3PO_4 is a colourless, crystalline solid which melts at 42.3° C. to a syrupy liquid. It forms a hemihydrate $2H_3PO_4.H_2O$, which melts at 29.3° C.

Two methods are in common use for the manufacture of orthophosphoric acid. In the older method, rock phosphate is treated with sulfuric acid solution and the engendered calcium sulfate and other insoluble material filtered off. The impure solution of orthophosphoric acid can then be purified and concentrated. Because of the difficulties encountered in the removal of impurities and in the step of concentration, the phosphoric acid obtained by this so-called "wet method" is utilized almost exclusively in the manufacture of fertilizer superphosphate, for which purpose the impurities need not be removed from the acid. The modern method for the manufacture of orthophosphoric acid consists in the burning of white phosphorus in an excess of air to form P_4O_{10} which is cooled and the vapour hydrated to orthophosphoric acid mist, which is collected by means of an electrostatic precipitator. Acid of any desired concentration can be prepared by this method. The usual product contains about 80% H_3PO_4 and is relatively free from impurities. As produced in industrial plants the acid usually carries some solid impurities in suspension and traces of dissolved impurities, the most objectionable of which is hydrogen fluoride. The suspension can be removed by filtration or settling, and most of the hydrogen fluoride by blowing air through the acid.

It will be noted that in the case of several of the oxyacids discussed above, not all of the hydrogen atoms that appear in the formula are replaceable by metals. Inasmuch as the most common co-ordination number of phosphorus is 4, it is instructive to consider the following co-ordination formulas:

$[PO_4]H_3$; $[P\overset{O_2}{H}]H_2$; $[P\overset{O_2}{H_2}]H$; $[P\overset{O}{H^3}]$; $[PH_4]X$

These formulas lead to the expectation that the hydrogens replaceable by a basic element would be three in the case of the orthophosphoric acid molecule, two in the case of the phosphorous acid molecule, and one in the case of the hypophosphorous acid molecule. The co-ordination formulas are in agreement with the observed facts in each case.

The fourth member in the above-listed series is known only through its organic derivatives and the fifth member is represented in phosphonium compounds.

Two other oxyacids of phosphorus have been described in technical writing, namely permonophosphoric acid, H_3PO_5, and perdiphosphoric acid, $H_4P_2O_8$. It is known that a double oxygen (peroxide) group can replace one of the co-ordination elements. Thus, permonophosphoric acid would be:

$$\left[P\overset{O\text{-}O}{O_3}\right]H_3$$

and perdiphosphoric acid would be $H_2[O_3\ P\ O\text{-}O\ PO_3]H_2$.

The oxide P_4O_{10} is miscible with water in all proportions. Orthophosphoric acid contains 72.4% of P_4O_{10} equivalent, pyrophosphoric acid contains 79.8%, and metaphosphoric acid contains 88.75%. Compositions corresponding to these acids are solids under ordinary conditions. Compositions containing 75% to 76% of P_4O_{10} equivalent are liquid at room temperature. With small shift of the P_4O_{10} equivalent in either direction, solutions are obtained which will yield crystals when seeded at room temperature.

In the absence of seed crystals, however, the solutions can be strongly supercooled. Little is known about melting points in the composition range between pyrophosphoric and metaphosphoric acids.

Some Industrial Uses of Phosphorus and Its Compounds.—White phosphorus, as such, has but few industrial uses. In warfare it is used in incendiary bombs and for the generation of smoke screens. (*See* also INCENDIARY MIXTURES: *Phosphorus.*) Red phosphorus finds its main use in the match industry, as does the sulfide P_4S_5. (*See* also MATCH.)

The trichloride and the pentachloride of phosphorus are employed in the manufacture of organic chemicals.

Phosphorus pentoxide, P_4O_{10}, is used widely as a drying reagent in laboratories, but the oxide costs too much to permit its use for this purpose in industry.

Of the several oxyacids of phosphorus the one most widely used as such is orthophosphoric acid. This acid is used in dental cements, in the preparation of albumin derivatives, in the sugar and textile industries, and it serves as a substitute for the more costly tartaric and citric acids in the manufacture of food products such as jellies and essences.

Phosphoric acids are used as reactants in the manufacture of a large variety of phosphates of industrial importance. Of the sodium salts, the tripolyphosphate, $Na_5P_3O_{10}$, is used in the largest amounts.

Several other sodium salts also find wide uses.

When ground rock phosphate is treated with phosphoric acid a fertilizer known as superphosphate (sometimes called double or treble or triple superphosphate) is formed. The main reaction involved is indicated by the equation:

$$Ca_{10}F_2(PO_4)_6 + 12H_3PO_4 \rightarrow 9CaH_4(PO_4)_2 + CaF_2$$

Monocalcium phosphate, $CaH_4(PO_4)_2$, has a P_4O_{10} (or P_2O_5) equivalent of more than 60% but the concentrated superphosphate made from ground rock phosphate carries only 48% to 50% of P_4O_{10} equivalent. Hundreds of thousands of tons of this superphosphate are made annually, but several million tons of a much lower grade superphosphate are made annually through the acidulation of ground rock phosphate with sulfuric acid according to the equation:

$$Ca_{10}F_2(PO_4)_6 + 6H_2SO_4 \rightarrow 3CaH_4(PO_4)_2 + 6CaSO_4 + CaF_2$$

In this case the generated calcium sulfate is a diluent and the superphosphate made by this process contains 16% to 20% of P_4O_{10} equivalent.

Considerable tonnages of other phosphates such as $(NH_4)H_2PO_4$ and $(NH_4)_2HPO_4$ are also used in the fertilizer industry. The Tennessee Valley authority developed a process for the manufacture of a calcium metaphosphate fertilizer by the direct reaction between rock phosphate and P_4O_{10} vapour at about 1,100° C. This fertilizer carries 60% to 62% of P_4O_{10} equivalent.

Several of the phosphates of sodium, notably the so-called hexametaphosphate, tetrasodium pyrophosphate, $Na_4P_2O_7$, and trisodium phosphate, Na_3PO_4, are useful as water softeners. Disodium pyrophosphate, $Na_2H_2P_2O_7$, is used in electroplating baths and in tinning. Dicalcium orthophosphate, $Ca_2H_2(PO_4)_2$ (or $CaHPO_4$), is used as a supplement to animal and poultry food. It is also an excellent fertilizer but costs more than superphosphate upon the basis of P_4O_{10} equivalence.

Besides such inorganic phosphates as those mentioned above, several organic phosphates have industrial importance.

See also PHOSPHORIC ACIDS AND PHOSPHATES; and references under "Phosphorus" in the Index.

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(H. A. Cs.)

PHOTIUS (*c.* 820–891), patriarch of Constantinople (858–867 and 877–886) who defended the autonomous traditions of his church against Rome and was the leading figure of the 9th-century Byzantine renascence. An accomplished scholar, Photius began his career as professor of philosophy at the Imperial Academy, to which he was appointed by Theoctistus, chief minister of the empress Theodora, reigning in the name of her son, Michael III. The marriage of his brother Sergius to Theodora's sister Irene gave him an entrée to the court. He became director of the imperial chancellery and a senator. In 855 he took part in an embassy sent to the caliph al-Mutawakkil. During his absence Theodora's brother Bardas murdered Theoctistus, deposed Theodora, and made himself regent. In the strife between the intransigent elements supporting Theodora and the liberals led by Bardas, the patriarch Ignatius became involved in a conflict with the government and was induced to resign. Photius, still a layman, was elected in his place, ordained within six days, and acknowledged by all the bishops (December 858). Soon afterward the intransigents refused him obedience and, during demonstrations provoked by them, Bardas, taking sharp measures, imprisoned Ignatius, whose patriarchate and ordinations were declared illegitimate. This judgment was confirmed by the papal legates sent by Pope Nicholas I in 861 on the ground that Ignatius had not been canonically elected but appointed by the empress. Nicholas himself, however, sided with the intransigent refugee monks who claimed to represent the patriarch Ignatius, disavowed his legates, and excommunicated Photius (863). The emperor Michael III retaliated with a violent protest in 865.

When Roman missionaries replaced Byzantine priests in Bulgaria, Photius convoked a synod (867) and condemned the violation of the rights of his church by Rome; Michael asked the Western emperor Louis II to depose Pope Nicholas. However, the co-emperor Basil, murderer of Bardas, assassinated Michael III, became sole emperor, and, in order to win the support of the intransigents, reinstated Ignatius as patriarch (Nov. 23, 867). The council of 869–870 confirmed the deposition and excommunication of Photius, but the majority of the clergy remained faithful to him and the emperor recalled him from exile. Photius became reconciled with Ignatius, who asked Pope John VIII to send legates to a new council. Ignatius died in 877 before the legates arrived. The council of 879–880 confirmed Photius as patriarch and canceled all conciliar measures against him. Photius canonized Ignatius. Photius had to resign in 886 at the instigation of Leo VI (who succeeded Basil in that year), and died in the monastery of Gordon, probably on Feb. 6, 891, in communion with Rome. He had contributed to the healing of the rupture which his firm attitude and the intrigues of the intransigents had provoked; and he had extended Byzantine religious influence to Bulgaria, Moravia, and Russia. He was canonized probably at the end of the 10th century, and his feast day is Feb. 6.

Photius' most important work is the *Bibliotheca* or *Myriobiblion*, giving criticism of and extracts from 280 works which he had studied. Thanks to this immense achievement, much is known of many Greek writers, pagan as well as Christian, whose works have perished. A manuscript of his *Lexicon*, found in 1959 in the monastery of Zabora in northern Greece, completes the manuscript at Trinity College, Cambridge. Photius appears also to have taken part in the composition of the *Etymologicum genuinum*. His *Amphilochia* gives answers to about 300 questions on religion. He also wrote epistles, homilies, and other theological works, including a treatise against the Manichaeans, the *Mystagogia* (on the procession of the Holy Spirit), and commentaries on the New Testament extant in fragments only.

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(F. Dv.)

PHOTOCHEMISTRY is the study of chemical processes initiated by light or, more generally, by electromagnetic radiation. For a photochemical process to occur, energy in the form of visible, infrared, or ultraviolet radiation must be absorbed by a substance. The immediate consequence of this absorption is called the primary photochemical process. Any subsequent changes following from this process are called secondary processes, and are also included within the domain of photochemistry. The process by which a photochemical reaction is carried on is called photolysis.

The theoretical aspects of photochemistry are derived largely from the principles of atomic and molecular physics and of quantum mechanics, while its analytical methods are mainly those of spectroscopy. The reader therefore may have occasion, throughout, to consult the articles ATOM; LIGHT; MOLECULAR SPECTRA; QUANTUM MECHANICS; and SPECTROSCOPY. More particular cross references are provided in the text.

Scope.—Photochemistry differs from most other aspects of chemistry in one regard. If an atom or molecule absorbs energy from a beam of light, it gains far more energy than it ever could by other methods; *e.g.*, from ordinary heating. Consequently photochemical processes are sometimes extremely efficient for the conversion of energy from light into chemical energy. The most important single photochemical process for living systems, photosynthesis, is exactly of this type. Through photosynthesis, green plants convert light energy very efficiently into stored chemical energy, producing carbohydrates from carbon dioxide and water. Many other natural phenomena are photochemical processes or are intimately linked to photochemical processes. The ozone in the upper atmosphere, which shuts out most of the intense ultraviolet radiation from the sun, is produced by the action of light on oxygen molecules: sunlight breaks some of the molecules into atoms, and these combine with other oxygen molecules to make ozone.

Bleaching laundry in sunlight is at least partly a photochemical process and so is the darkening of white lithopone (zinc sulfide) paint. Photography is based on a photochemical process, the action of light on grains of silver chloride or silver bromide. This is a process in which conventional chemical action (development of the film) amplifies the photochemical action of light alone, converting to metallic silver only the grains of silver salt which have absorbed minute amounts of light.

(For further examples of the scope of photochemistry see *Applications*, below.)

Kinds of Photochemical Effects.—The action of light on a chemical system may take various forms:

1. Light may act as a booster to maintain a reaction which might otherwise proceed at an imperceptibly slow rate and in which the reacting molecules exchange little or no net energy with their environment. Some molecular rearrangements (isomerizations) fall

into this category (*see* ISOMERISM; MOLECULAR REARRANGEMENTS).

2. It may act as a trigger, initiating a reaction that, once started, can proceed spontaneously. An example is the initiation of the reaction between hydrogen (H_2) and chlorine (Cl_2) to give hydrochloric acid (HCl). Hydrogen and chlorine can be kept mixed together for an indefinite period at room temperature in a dark container, but if violet or ultraviolet light reaches the mixture the two substances react explosively, giving off considerable stored chemical energy as heat. The primary photochemical process in this case is the formation of two chlorine atoms from a Cl_2 molecule.

3. In some photochemical processes, absorbed light converts the reacting molecules to a new state higher in energy than their initial state; in this case the energy of the absorbed light is converted into chemical potential energy and is stored that way. Most photochemical processes occurring in biological systems are of this type; *e.g.*, ultraviolet irradiation converts ergosterol, found in plant and animal tissues, into a biologically active substance, vitamin D.

4. A photochemical system may store light energy from the sun as chemical energy and then, only incidentally to the photochemical process, release that energy as electrical energy. This is the solar battery, used to supply the power in satellites and space vehicles.

All these processes have one common characteristic: each requires, at some stage, that a large quantity of energy be available to a single reacting atom or molecule. The requirement may be a thermodynamic one, in which the products simply contain more stored energy than the reactants. Alternatively, the requirement may be kinetic; in this case the products may store more or less energy than the reactants, but some step along the reaction path requires a large quantity of energy to surmount a barrier, as it were. (The H_2-Cl_2 reaction has as its barrier the requirement that a Cl-Cl bond be broken to convert a chlorine molecule into its two constituent atoms.) In more complex molecules, the rearrangement from one shape to another exhibits an energy barrier because, between the initial and final structures, there must be a series of intermediate shapes of higher potential energy than either the initial or final shapes.

History.—The hydrogen-chlorine reaction (*see* above) was perhaps the first recognized photochemical reaction; it was observed by W. Cruikshank (1801) and studied in detail by J. W. Draper (1844). That only the absorbed light can affect a chemical reaction was recognized by T. von Grotthus (1818) and by Draper, but a century passed before this qualitative idea could be stated as a quantitative law. Between the era of Cruikshank, Grotthus, and Draper and the development of the modern theory by Einstein, photochemistry was largely confined to the identification of reaction products, often from the action of sunlight (work of A. Benrath; D. Berthelot; G. Ciamician and P. Silber; E. Paterno and G. Chieffi; and the early work of H. Stobbe and R. Stoermer).

The basic process by which light is absorbed by matter was first proposed by Albert Einstein (1905, 1912, 1916). His work was directed particularly toward the photoelectric effect (*see* PHOTOELECTRICITY) but the interpretation is general, and provides the foundation of modern photochemistry: a beam of light is a beam of photons, or quanta (energy packets) of electromagnetic radiation (see *Photochemical Quantities*, below). The energy of each photon is proportional to the frequency of the light, and the total number of photons is proportional to the intensity of the light. The primary photochemical process then follows directly from the absorption of one photon by one atom or molecule. (Exceptions may occur if the radiation field is very intense; then the concentration of photons may be so high that some molecules absorb two photons.)

After 1910 E. Warburg began his classic study of the formation of ozone (O_3) by the action of ultraviolet light on the normal oxygen molecule (O_2). This work represented the first measurement of the number of product molecules formed for each quantum of energy absorbed: the so-called quantum yield of the reaction (*see* below). In the next few years most of the foundations of modern photochemistry were completed. In 1921 O. Klein and S. Rosseland predicted "collisions of the second kind": collisions in which excess internal energy of an atom or molecule is exchanged with its collision partner or converted into kinetic energy of the colliding partners, or, from another viewpoint, collisions in which an excited atom or molecule is deactivated by energy exchange. Such collisions, involving the exchange of excitation between mercury and thallium, were observed by G. Cario and J. Franck (1922–23).

The role of chain reactions in photoprocesses was first elucidated for the H_2-Cl_2 reaction by M. Bodenstein and his co-workers in the period 1913–25, and the field grew steadily in the next three decades. From about 1955 photochemistry expanded rapidly as it came to be used as a tool for the synthesis of organic molecules, and was extended to the study of very short wavelengths (including X rays and gamma rays) and of chemical phenomena produced by the optical amplifier, or laser (*q.v.*).

THE PRIMARY PHOTOCHEMICAL PROCESS

Photochemical Quantities.—The most fundamental idea and the basis of all quantitative interpretations in photochemistry is the quantum-mechanical principle that all energy consists of packets called quanta, and that the quanta of electromagnetic radiation, called photons, act like particles. The energy E (in ergs) of each photon is related to the frequency of light, ν (in cycles per second) by the direct proportion $E = h\nu$. The constant of proportionality h is called, after its discoverer, Planck's constant; it has the value 6.67×10^{-27} erg-sec. Alternatively, since the frequency ν and the wavelength λ of light are related to c, its velocity (3×10^{10} cm. sec.) according to $\nu\lambda = c$, the energy of a quantum is related to the wavelength of the corresponding radiation by the inverse proportion $2 \times 10^{-8}/\lambda$ if E is in ergs and λ is in angstrom units; $E = \frac{hc}{\lambda}$, which is 12,400/λ, if E is in electron volts per photon and λ is in angstrom units; or $2.85 \times 10^5/\lambda$ if E is in kilocalories per mole of photons and λ is in angstrom units. The angstrom unit (Å) is 10^{-8} cm. and is commonly used to designate wavelength. The electron volt (ev), 1.602×10^{-12} ergs, is the usual unit for measuring energies of individual particles in atomic physics. The energy unit, the kilocalorie (kcal), is the standard chemical unit; chemical energies are usually given in terms of kcal/mole. The mole is Avogadro's number of particles, 6×10^{23}, so chosen because 6×10^{23} is the number of atomic mass units per gram. One mole of photons is often called an einstein.

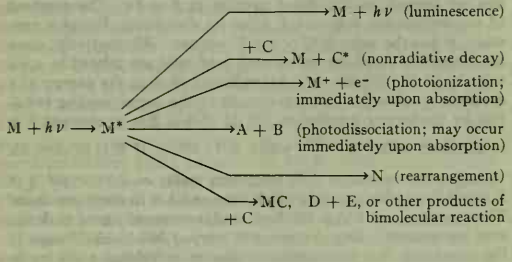
By means of these quantities we can express more precisely the relationship between ordinary chemistry and photochemistry, in terms of some simple magnitudes. Green light, for example, has a wavelength of about 5000 Å. (The entire visible region lies between about 4000 and 7000 Å.) Consequently a photon of green light has an energy of about 2.5 ev, or an einstein of green light photons has an energy of 57 kcal. Ultraviolet light of wavelength 2500 Å has just twice as much energy per photon or per mole. By comparison, a weak chemical bond requires an energy of about 1 ev to be broken, while a very strong bond requires over 10 ev. At the other end of the scale of comparison, two molecules colliding at room temperature strike each other with an energy of only about 0.05 ev.

Absorption Phenomena.—The history of a photochemical reaction necessarily begins with the absorption of a quantum of electromagnetic energy by an atom or molecule. Initially, the absorber is in a state in which its energy is relatively low. The energy contained in the absorber is essentially of four types: (1) kinetic energy of motion through space (translational energy); (2) energy of rotational motion about its centre of mass; (3) energy of vibration of the component atoms against each other, if the species is a molecule; and (4) energy of the negatively-charged electrons moving in the field of force produced by the other electrons and the positively-charged nuclei. The energy change initiating a photochemical process virtually always involves excitation of one electron from a state of low energy to a state of higher energy. When the absorber is a molecule, changes in rotational and vibrational energy usually occur also; the translational energy of an

atom or molecule is almost completely unaffected when a quantum of radiation is absorbed except in the case of gamma radiation.

Usually, in the initial low-energy state of an absorber, the electrons are in their lowest possible state of energy, or quantum state. The electrons cannot absorb all incident radiation; they can only absorb quanta whose energy corresponds to the allowed quantum jump for that particular absorber. (A hydrogen atom in its lowest state can absorb only those quanta whose energies fit the expression $13.7\ (n^2 - 1)/n^2$ ev, when n may equal 2, 3, . . . ; it cannot absorb a 6 ev photon, for example.) The energies that a quantum may have in order to be absorbed by a molecule or atom correspond to the characteristic frequencies of the absorption spectrum of that species. The spectrum of an atom consists of lines and, above a minimum energy characteristic of the element, a continuum. A molecular spectrum contains many more lines because of the many ways a molecule may absorb energy into vibrational and rotational motion; these lines generally are grouped into bands. Any molecule also has a continuous spectrum.

The occurrence of a photochemical reaction, then, begins with the absorption of a quantum whose energy corresponds to a characteristic absorption line or band of the species. Moreover the energy is used mainly or entirely to raise one electron into an excited state so that the molecule or atom is in an activated state. The primary photochemical process can be shown schematically, using the asterisk to designate an electronically excited species:

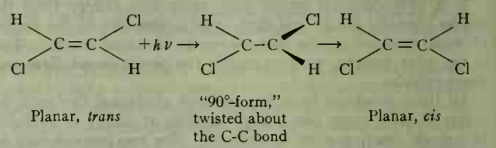


Each kind of molecule has its own spectrum, within which more than one kind of excitation usually is possible. One of the origins of continuous absorption is photoionization; in this case the excited state of the electron is one in which it is free to escape. It is the one case in which absorption and primary reaction are essentially identical. Photo-ionization can be thought of as a prototype —perhaps the most elementary photochemical process. Continuous absorption is characteristic of a transition in which a new free particle is produced: it may be an electron, as in photo-ionization, or it may be an atom or a molecular fragment. These latter two are produced by photodissociation, a second type of photochemical process, which usually occurs when the electron being excited moves away from a locale where it can participate in a chemical bond, into some other region where it is unable to use its attraction to pull two nuclei together. In normal photodissociation the excited electron remains bound to one or the other of the products of the photolysis. Photodissociation is sometimes almost as directly linked to the absorption process as photo-ionization is, but it can also be considerably slower.

Absorption in a line or band spectrum leaves all the particles bound together with their geometrical configuration of atoms essentially unchanged, at least for a short time (10^{-14} sec.). The change produced by such an absorption involves the excitation of one electron from a closely held low-energy state to a larger and more loosely bound excited state. In many cases there are two or more possible excited states and several electrons that could undergo a transition; however, since each spectral line or band corresponds to one specific electronic transition it is frequently possible for an experimenter to study one kind of electron excitation at a time. This can be done by irradiating the sample with light lying only in the energy range corresponding to the transition of interest. An experiment of this type can often be done with light of almost a single pure frequency (monochromatic light).

Subsequent States.—As soon as an electron is excited and a molecule is in an activated state, several things can follow. The molecule may return to its initial state, without reacting, in either of two ways: it may radiate, giving up a light quantum by luminescence (*q.v.*); or it may lose all its excitation energy, without radiating or reacting, by undergoing nonradiative decay, a process that requires effective collision partners to carry off the excitation energy. Nonradiative decay usually goes through two stages. In the first step, little or no energy is lost; the energy of electronic excitation is simply converted into vibrational energy by what is called intersystem crossing or internal conversion. In the second stage, the excess energy is given up to the environment gradually, through a succession of collisions.

If the excited molecule does react, it may do so in any of several ways. It may undergo photo-ionization or photodissociation. It may undergo an intramolecular reaction like a rearrangement, or it may undergo an intermolecular process. An example of rearrangement is the conversion of *trans*-1,2-dichloroethylene into its *cis* isomer:



The product, in this case, has almost the same energy as the starting compound; the excitation energy required to reach the twisted intermediate form must be given off somehow by the product, usually by collision.

Primary intermolecular reactions may involve nothing more than the transfer of a quantum of energy, as with mercury (Hg) and ethylene (C_2H_4):

$$\mathrm{Hg\ (vapour) + h\nu \longrightarrow Hg^*}$$
$$\mathrm{Hg^* + C_2H_4 \longrightarrow Hg + C_2H_4^*}$$

leaving the excited ethylene to undergo secondary reaction. The intermediate kind of primary nondissociative reaction uses collisions in a way akin to the nonradiative decay process. An excited molecule undergoes a collision which converts it into a new reactive state without removing much of its excitation energy. The collision may change the geometry of the reactive molecule into a form that can rearrange bonds or dissociate readily, or it may change the electronic state of the molecule through internal conversion or intersystem crossing. Changes in electronic state usually involve only the single excited electron, but sometimes the molecular geometry is also involved.

In order for any state, be it the initial excited state or any subsequent one, to play a part in a photochemical reaction, it must endure long enough for the reaction to occur. Each photochemical reaction competes with radiative and nonradiative de-excitation to consume the activated molecules. A few typical numerical examples will illustrate the way this competition goes on. Fast luminescence, called fluorescence, occurs with a half-life of about 10^{-8} sec.; *i.e.*, roughly half of the excited molecules in any sample will radiate their excitation energy away in about 10^{-8} sec. provided they have an allowed path for fluorescence and provided they are not destroyed faster by some other process. Simple dissociations of excited molecules occur much faster: an excited molecule in an unstable state dissociates in about the time it takes an atom to go through one vibrational period, or about 10^{-13} sec. Consequently a molecule excited to a truly dissociating state has virtually no chance to radiate and will indeed follow the path of dissociation. Other unimolecular processes may occur with characteristic times ranging from 10^{-13} sec. up to a few seconds, if no other process interferes.

Radiative processes can also be slow. Slow luminescence is called phosphorescence, and is the result of emission of a quantum from a molecule undergoing a relatively improbable ("forbidden") transition. Fluorescence is the result of an "allowed" transition. Phosphorescence frequently is characterized by a lifetime for the

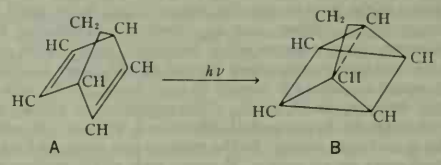
excited molecule between 10^{-5} and 10^{-2} sec., but many cases outside these bounds are known. Fluorescence, phosphorescence, dissociation, and some rearrangements involve only a single molecule and have specific rates (rate per unit of reactant concentration) or lifetimes for reactant molecules that are independent of the number of molecules present. Processes involving two molecules have specific rates that depend on the concentration of collision partners, since they depend on the frequency of collisions. The maximum rate for a bimolecular reaction is just the collision rate; this rate is attained only if the reaction occurs with every collision. The collision frequency for most molecules at a pressure of 1 atm. is above 10^9 per sec. so that the lifetime of a reactive species toward bimolecular reaction must be 10^{-10} sec. or more. Since collision frequencies increase directly in proportion to pressure, a bimolecular reaction rate can be increased or decreased over several orders of magnitude. The value of 10^9 per sec. at 1 atm. pressure corresponds to a reaction rate constant of about 2×10^{10} litres per mole-sec.; that is, the rate of reaction per unit of concentration of each species has an upper limit of about this figure. If one reactant is hydrogen, then the rate can be a bit higher simply because of the high velocity of the light hydrogen atoms or molecules.

In solution, the maximum bimolecular rate is governed by the rate at which the reactive species can diffuse together through the liquid or solid medium. This rate was derived by M. Smoluchowski and P. Debye, who showed that it is about 10^{10} litres/mole-sec. for solutions in water and other solvents of similar viscosity. Like the collision frequency, it represents an upper limit for the rate of reaction. Rates in solution are inversely proportional to the solvent viscosity so that bimolecular processes generally proceed slower in glycerin than in water, for example. Bimolecular de-excitation processes are usually limited by the rate at which the internal electronic state can change. This rate is as high as 5×10^8 litres/mole-sec. in rapid cases, and may be smaller by several powers of 10. Comparison of these various rates shows the following: (1) Dissociation will almost always occur if it is an available path. (Actually, in a solution, the dissociating species are sometimes trapped together by the surrounding solvent molecules and recombine with each other. This is the "cage effect" discovered by J. Franck and E. Rabinowitch.) (2) Fluorescence predominates over inefficient bimolecular reactions in the gas phase at atmospheric pressure, is quenched by efficient bimolecular reactions (those with a probability of reaction above 1 in 10, per collision), and is quenched in some cases by nonradiative decay. (3) Fluorescence and unimolecular reactions in solution are also likely to be slow compared with efficient bimolecular processes but are favoured by solvents of high viscosity. Again, fluorescence is sometimes less efficient than nonradiative decay, sometimes more efficient.

When a molecule changes its electronic state without direct absorption of light, as in nonradiative decay or internal conversion, it may go into a new excited state which, left alone, would be short-lived (less than about 10^{-6} sec.); or it may go into a long-lived (metastable) excited state. Both types are known in photochemistry, but the long-lived states are particularly important in storing energy for chemical processes. The most important of the last-named kind of transition is a single-triplet transition, or an intersystem crossing process.

Triplets are the most commonly found phosphorescing states. They cannot radiate rapidly, and are therefore among the most long-lived excited species. For this reason triplets are frequently the primary products of photochemical reactions. Excited singlets are sometimes found, but because of their shorter lifetimes, they are susceptible to decay processes, often to triplets. Triplets can be identified by their magnetic properties; by contrast with singlets, the individual electron magnets of a triplet do not compensate and cancel each other so that triplets exhibit weak magnetism (paramagnetism). This can be detected either by measuring the magnetic susceptibility of the material or by observing the reorientation of individual electron magnets in combined electric and magnetic fields (electron paramagnetic resonance). Triplets in irradiated naphthalene were first detected this way by C. A. Hutchinson and B. W. Mangum in 1958–61. (*See* MAGNETISM: *Paramagnetism.*)

An interesting case in which the entire photochemical process occurs in the primary reaction is that of valence tautomerism. The name is used for cases in which two molecular structures differ very little in the relative positions of their atoms, but have different arrangements of chemical bonds. One clear example is the photoisomerization of bicyclo [2,2,1]-heptadiene, or norbornadiene:

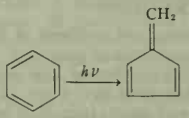


Structures A and B are nearly identical geometrically, yet represent different states of the electrons. Both are singlet states, but apparently B is stable and neither radiates nor decays nonradiatively to A.

SECONDARY PROCESSES

If an excited molecule does not return by a direct path to its lowest energy state, then it must dissociate, react with neighbours or itself, or revert to a new electronic state, still having some excitation energy. These are the primary steps. Any subsequent step is a secondary reaction. An example is Warburg's finding that when the oxygen molecule (O_2) absorbs light whose wavelength is shorter than 1750 Å, it becomes two oxygen atoms in the primary dissociation step; the only secondary reaction of importance in pure oxygen is then the reaction of oxygen atoms with O_2 to produce ozone (O_3).

Rearrangement Reactions.—These reactions, in which atoms move from one site to another within a molecule, may be interpreted as secondary reactions following the photoexcitation process. Benzene irradiated with light between 2000 Å and 3000 Å rearranges (inefficiently) to fulvene with the movement of a hydrogen atom:



In a case of this kind the first step involves only the excitation of one of the six relatively free electrons of the double-bond system of benzene. These six electrons are not strongly bonding, and especially do not participate in carbon-hydrogen bonds to any significant degree. Thus only in a secondary step following photoexcitation can the atoms rearrange to the molecular structure of the product.

Frequently the primary photochemical process is only used as a tool to permit the secondary reactions to be studied. Photosensitized reactions often fall into this category. Mercury atoms can absorb light from a mercury lamp very efficiently and then, in their excited state, collide with other molecules and transfer their excitation to these molecules. R. J. Cvetanovic (1955) used this technique to dissociate nitrous oxide (N_2O) to prepare and study oxygen atoms. The reaction sequence proceeds this way:

$$\mathrm{Hg} + h\nu \longrightarrow \mathrm{Hg}^*$$
$$\mathrm{Hg}^* + \mathrm{N_2O} \longrightarrow \mathrm{Hg} + \mathrm{N_2} + \mathrm{O}$$

(The alternative mode of decomposition, to give NO + N, does not seem to occur.) Then the oxygen atoms may react with whatever other species are present. Measuring the amount of nitrogen produced in a photolysis gives directly the number of oxygen atoms which were available for reaction. Many other sensitizers, both atomic and molecular, can absorb and then transfer energy the way mercury does; each has its characteristic energy.

Chain Reactions.—If a primary step involves dissociation of a molecule into two radicals, the secondary steps are often chain reactions (M. Bodenstein, 1913; W. Nernst, 1918; N. N. Semenov, 1930–43). J. A. Christiansen and H. A. Kramers (1923) developed the idea that there could be cycles in which reaction of an

active intermediate with a molecule of starting material to give product necessarily produces a new active intermediate. The hydrogen-chlorine reaction is an example. Light dissociates a few chlorine molecules into atoms, which then attack H_2 molecules to give HCl product and H atoms. The H atoms return to Cl_2 molecules to produce more HCl and Cl. Thus:

$$h\nu + Cl_2 \longrightarrow 2Cl$$
$$Cl + H_2 \longrightarrow HCl + H$$
$$H + Cl_2 \longrightarrow HCL + Cl$$

A reaction of this kind requires an initiator (light, in this case) and a propagating mechanism, and may involve a terminating step. Termination actually occurs either when the concentration of at least one reactant becomes very low, or when another substance, (*e.g.*, oxygen or iodine) is present to react more rapidly with the radicals than can the H_2 or Cl_2. The reaction must also be exothermic or nearly thermoneutral, otherwise it may cool the system so that it no longer reacts. In the reaction just cited, 44 kcal are given off every time 1 mole of H_2 and 1 mole of Cl_2 react to give 2 moles of HCl so that considerable heat is generated—usually much faster than it is radiated or transferred to the vessel walls, and an explosion is the result. A much more unstable situation arises if one radical initiator produces more than one new radical. This is the case in the reaction of oxygen with acetylene or of oxygen with hydrogen. In the latter case a branching chain can be initiated by the following mechanism:

$$H + O_2 \longrightarrow OH + O$$
$$O + H_2 \longrightarrow OH + H$$
$$OH + H_2 \longrightarrow H_2O + H$$

Other processes enter into the reaction but the key steps for chain branching are exemplified by the first two reactions above; the third is a normal chain-propagation step.

Chain reactions, normal and branching, always produce many product molecules for every quantum absorbed; *i.e.*, the quantum yield may be much greater than 1 for the reaction. Reactions involving no chain processes necessarily have quantum yields near or below 1, while a reaction like the H_2-Cl_2 reaction may reach a quantum yield of 80,000. Even a rough measurement of quantum yield will generally show whether a reaction proceeds through a chain mechanism.

EXPERIMENTAL METHODS

The methods of photochemistry arise from problems of three main kinds, in the following order of experimental procedure: (1) There is always the problem of getting the desired light energy into the system being studied. (2) One must have a way of determining the progress of the reaction—of getting immediate pertinent information from the experiment. (3) One must have the means of determining, from results of individual experiments, the broader inferences for which the study is carried out; *e.g.*, photochemists commonly try to determine from a series of individual reactions the mechanism of a reaction, on the detailed level of the behaviour of each atom throughout the progress of the reaction.

Illuminating the Sample.—This is largely a problem of devices. Light itself can be varied in four independent ways: (1) The frequency or energy of the light can be controlled. This determines the amount of energy given to each absorbing molecule or atom. (2) The intensity of the light can be varied, to control the rate at which photons arrive at the sample, and thereby to control the number of excited molecules present at one time. (3) The total illumination can be varied, to control the total number of excited molecules produced. (4) With the advent of lasers it became possible to control the coherence of the electromagnetic field; *i.e.*, to control the range over which the electric field of force of the light wave is really a sinusoidally oscillating force field. (*See* ELECTROMAGNETIC WAVES: *Maxwell's Field Theory.*)

In the earliest photochemical observations the white light of the sun was the source. No control could be exerted, of course, on the frequency of light coming from the source itself, but simple controls of the light received were available through the use of sample containers of differing composition; *e.g.*, heavy flint glass transmits very little ultraviolet radiation (to about 3600 Å), borosilicate (Pyrex) glass transmits light to a wavelength of about 3000 Å, and some fused silica is transparent to wavelengths shorter than 1700 Å. The next simplest way to control the wavelength reaching the sample is to interpose a suitable filter in the light path. Filters may transmit broad bands of frequencies or narrow and nearly monochromatic bands. A more complex step is the use of the monochromator, a device (usually a prism or diffraction grating) that permits the continuous variation of light frequency.

Incandescent sources like sunlight and ordinary electric tungsten-filament lamps emit light of all frequencies. The total intensity and the distribution of this intensity in any source depends primarily on the source temperature alone: intensity can only be increased if temperature is increased. Consequently the energy available for such sources is severely limited. For higher intensities it is often possible to use the emission spectrum of an atomic or molecular vapour. Some common sources use mercury, cadmium, sodium, xenon, hydrogen, or deuterium in an electric arc discharge to provide intense and steady fluxes of radiant energy. If the lamp pressures are low the atomic lines emitted by mercury, cadmium, or xenon are sharp and the lines from one element are well separated. It is easy to eliminate all the radiation from a mercury lamp except the one desired atomic line, thereby obtaining a choice of intense illumination at 1849 Å, 2536 Å, 3650 Å, 4046 Å, 4358 Å, or 5460 Å. If the pressure of the emitter is high, the emitted frequencies span a broad band and can be sorted with filters or a monochromator. Such lamps often deliver as much as 100 w. of power in just a few lines, broadened or not. (*See* also LIGHTING: *Modern Electrical Light Sources: Gaseous Vapour Lamps.*)

For very intense illumination, conventional steady arcs, discharge tubes, and incandescent sources are inadequate. If a very high flux of quanta is required, then a flash tube, a pulsed X-ray or gamma source, or a pulsed laser is required. The flash tube is a gas-filled tube, usually with a pressure of roughly 0.1 to 0.01 atm. of gas, to which a large amount of stored electrical energy is delivered in a very short time. Typically a medium-energy flash in an argon-filled tube might last 5×10^{-5} sec. and radiate 500 joules of energy as light, thereby emitting 10^7 w. (10 Mw.) of light energy. This energy is divided between continuous and line emission and is distributed over a very wide wavelength range, extending from the infrared to below 2000 Å in the ultraviolet. Pulsed X-ray sources deliver comparable amounts of energy, almost all of which is in the high-energy range; these sources characteristically achieve ionization of many molecules per absorbed photon. Pulsed electron sources, though not strictly photochemical, produce the same type of products as pulsed X-ray sources. The most intense monochromatic source is the pulsed laser, which can deliver as much as 10^8 w. of power for 10^{-8} sec. within a single spectral line. Within its range, the laser emits about 1,000 to 10,000 times the energy radiated by a flash in the same wavelength range, even though the total power delivered by both may be comparable.

Samples to be subjected to photochemical reaction may be gases, pure liquids, pure solids, or solutions. Gases must be used at low pressures to study unimolecular processes or such phenomena as the way the absorbed energy is eventually transmitted to the environment. In gases at high pressures or in condensed phases, the absorber is in intimate enough contact with its environment (or collides sufficiently often) that, apart from electronic excitation energy, it is in equilibrium with the environment. In condensed phases, therefore, electronically excited molecules have their best opportunity to be stabilized, by losing whatever excess vibrational energy they have before dissociation takes place. If the sample is in a solid, a pure or mixed crystal, or a glass, the molecules are not free to move through the medium or in many cases, even to rotate. Such an environment encourages reaction with nearest neighbours, intramolecular reaction, or simply stabilization of the primary products of the absorption process. Phosphorescence from triplet states, for example, is very commonly the result of irradiation of an organic substance in a glassy solution at −195.8° C, the normal boiling temperature of nitrogen.

Monitoring the Reaction.—The problem of monitoring the photochemical reaction may be solved by many physical and chemical methods. The experimenter simply suits the method to each

specific problem in turn. It is often sufficient just to know what the final reaction products are. Naturally this level of monitoring relies on all the methods of qualitative identification—often, particularly, on methods well suited for identifying small amounts of samples. Vapour chromatography, mass spectroscopy, and conventional spectroscopy (visible-ultraviolet electronic spectroscopy, infrared vibrational spectroscopy, electron paramagnetic resonance spectroscopy, and nuclear magnetic resonance spectroscopy) are powerful tools for these analyses. Furthermore, they can all be used at the next level of inquiry, the stage at which one asks for the relative amounts of each final product.

Often the information sought from a photochemical reaction can only be derived by examining the intermediates—the species present during the course of the reaction but not at the end. Sometimes an indirect observation identifies an intermediate; methyl (CH_3), ethyl (C_2H_5), and other radicals react with metal surfaces and can be detected by their ability to remove a metal mirror from a vessel's walls. Radical intermediates can also be detected if a "radical quencher" is added to the reacting mixture. Quenchers (*e.g.*, I_2, NO, sometimes O_2) react very rapidly with free radicals to form identifiable products. In their presence reactions involving radical intermediates usually do not go on past the stage of radical production because the quenching process consumes the radicals faster than does the reaction under study. Ionic intermediates can sometimes be inferred from the products that still appear even in the presence of radical scavengers.

More direct methods of studying the intermediates are available in many cases. If a reaction is made to go slowly enough the intermediates can sometimes be observed by conventional means. Many simple radicals can be detected in glassy solutions at low temperatures (below about −190° C). In this method, a hydrocarbon or hydrocarbon mixture is cooled enough to form a glass and then irradiated with high energy radiation, either X rays or gamma rays. Examination of the glass by electron paramagnetic resonance spectroscopy shows the presence of simple free radicals like ethyl or methyl, and usually gives enough information for their unambiguous identification.

Transition intermediates can be found and identified in some photochemical reactions proceeding at their natural rapid rates. One method of doing this is flash-kinetic spectroscopy, advanced first by R. G. W. Norrish and G. Porter (1949) and independently by G. Herzberg and D. Ramsay (1950) and N. Davidson and co-workers (1951). It is based on a rapid photolysis effected by an intense flash, followed by a second flash from a small lamp acting as a light source for absorption spectroscopy. Reactions can be studied at time intervals as short as 10^{-9} sec. after they are initiated, although most work based on this method has been carried out on microsecond and millisecond time scales. The method has been particularly successful for identification of spectra of small transient species like the radicals NH_2, HCO, NCO, CH_3, and CH_2 and of more complex species like the phenyl radical (C_6H_5). Gases, liquids, and solids can be examined by flash-kinetic spectroscopy to determine the time dependence of the absorption spectrum. One way this can be carried out is to do a series of photolyses, taking spectra at progressively later times after photolysis and accumulating the data experiment by experiment. An alternative procedure makes use either of a photographic film moving past a fixed image or a moving image of the spectrum traveling along a fixed film. Either gives a streak spectrum photograph, in which wavelength varies along one direction on the film in the conventional way and the time of incidence varies in the other direction. The streak spectrum is thus a continuous representation of the spectrum of the reacting system. Time-resolved spectra have been used to determine the lifetimes of triplet excited states, to measure the rates of product formation, and even to measure the quantitative dependence of rates on concentrations, in cases where spectral intensities can be measured quantitatively. The limitations of the method are twofold. First, the method requires that the transient species absorb in the spectral wavelength region being observed; and it must absorb strongly enough to be detected in the presence of unphotolyzed starting material.

Second, it is not always possible to identify the absorber from its spectrum alone; this is a much greater problem with large polyatomic molecules than with small molecules, but even there identification can cause considerable difficulty.

As a complement to optical absorption spectrum of a rapidly reacting mixture, one can study the time dependence of the mass spectrum. G. B. Kistiakowsky and P. H. Kydd (1957) introduced the time-of-flight mass spectrometer into photochemistry to study reactions of ketene ($CH_2{:}CO$) and of NO_2. This device is capable of scanning the mass spectrum of a gas being sampled as often as once every 10^{-5} sec. The appearance of a particular mass only during the middle stages of a reaction indicates that the mass is associated with an intermediate, which may be either a transient electronically-excited state of one of the starting materials or products, or a true intermediate species. It is generally possible to identify the mass of each intermediate and to distinguish it from its own fragments which are formed in the mass spectrometer (and not in the reaction). A combination of kinetic mass spectrometry with optical flash-kinetic spectroscopy can sometimes solve a photolytic kinetic problem almost completely, as in the case of the flash-photolytically generated transient species benzyne (C_6H_4); this species was identified and its rate of reaction ($2C_6H_4 \rightarrow C_{12}H_8$, biphenylene) was measured by just such a combination of techniques.

Flash methods use a sharp pulse of light to carry out the photoexcitation step. Two other approaches based on discontinuous illumination are also useful. In one approach, the exciting light is simply turned on (or off) very suddenly and left that way, while the concentration of intermediates, starting materials, and products changes. Any fast method of monitoring the concentrations (usually absorption spectroscopy) is used to follow the actual change. What is actually measured is a relaxation time for the concentration being observed; *i.e.*, the time it takes for the chemical system to adjust to the instantaneous change in the light level.

In the second approach, the light is made to vary periodically (most commonly just on-off, but it may vary sinusoidally). With this technique the rate of reaction is most easily found by varying the rate of alternation of light and dark, and measuring the dependence of stationary concentrations as a function of this frequency. If the switching frequency is faster than the chemical relaxation time the system will begin to respond as though the light was continuous at an intensity level corresponding to the average illumination from the intermittent lamp.

Possibly the most fundamental quantitative measurement of a photochemical process is that of quantum yield, or actinometry. This process may be carried out from a knowledge of the absolute emission characteristics of the exciting source and of the absolute absorbing ability of the absorbing species; or the measurement may be made as a relative one, by using as a comparison and standard a reaction whose absolute quantum yield is precisely known. Absolute measurements are usually much more difficult than relative ones, so the relative method is more common; but the standards must come from absolute measurements. Absolute measurements have been made of rates of the photo-ionization of atoms (*e.g.*, by H. Beutler, 1933–40; R. W. Ditchburn, 1928–60) and molecules (*e.g.*, by M. G. Inghram, 1960; J. D. Morrison, 1960; G. L. Weissler, 1952–58), and of the photodetachment of electrons from negative ions (by L. M. Branscomb and co-workers, 1958). In these undertakings the light intensity, emitted electron current, and, where appropriate, the atom concentration and ion current had to be measured absolutely. Other absolute measurements have been based on measurements of light intensity, absorption coefficient, and the number of moles of a characteristic product.

Light intensities can be measured with thermocouples, bolometers (*q.v.*), photomultipliers, or photoconductive devices. These detectors all give signals whose strength varies directly with the intensity of the light incident on them, but only the thermocouple and bolometer detectors are also relatively independent of the wavelength of the light. Detectors are ultimately calibrated in terms of standard sources whose spectral properties are well known. One of the common standards is a block of carbon floating

in gold, at the melting temperature of gold, 1,063° C. The radiation from such a source, which is a nearly perfect radiator, follows Planck's radiation law well enough that its absolute intensity at all wavelengths is rather precisely known.

The actinometer (*q.v.*) that is most reliable for solutions makes use of the photolytic decomposition of highly purified uranyl oxalate. It was developed by G. S. Forbes and his co-workers (1930–34). The net reaction is the decomposition of oxalic acid: $H_2C_2O_4 + h\nu \rightarrow H_2O + CO_2 + CO$. The amount of unreacted oxalate can be determined quite precisely by titrating the solution with permanganate. The quantum yield of this reaction is well established as a function of wavelength, temperature, intensity, and concentration of various ions, particularly hydrogen ions. For gas phase actinometry, other reactions are available; *e.g.*, the photolysis of hydrogen iodide, whose quantum yield is precisely 2 for a wide range of conditions.

Determining the Mechanisms.—Determining the actual path of a photochemical reaction frequently requires setting up hypothetical models corresponding to different possible mechanisms; finding from its kinetic equations how each model system depends on concentrations, light intensity, and any other pertinent variables; and then deciding, from experimental variation of these variables, which model best describes the system. (*See* REACTION KINETICS.) This is how a succession of investigators have shown how simple alkyl iodides, *e.g.*, CH_3I, decompose on photolysis and how the fragments must react. The methyl iodide system is interesting in that at least part of the energy of the absorbed photon stays in the reactive species long enough to assist in one crucial step. The steps of the mechanism and the variables used to determine the role of each step are as follows:

(1) Primary step:

$CH_3I + h\nu$ (near ultraviolet) → $CH_3 + I$	Quantum yield approximately 1, shown by independent use of scavengers for iodine and CH_3; presence of radicals shown by kinetic spectroscopy

(2) Normal secondary steps (M = inert collision partner to carry away energy):

$2CH_3 (+M) \rightarrow C_2H_6 (+M)$ $2I (+M) \rightarrow I_2 (+M)$	From product analysis

(3) Inhibiting secondary steps (recombinations):

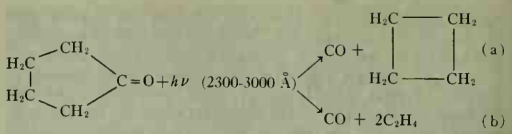
$CH_3 + I \rightarrow CH_3 + I$	Rate determined from low-pressure, low-intensity photolyses to minimize three-body reactions
$CH_3 + I + M \rightarrow CH_3I + M$	Rate determined from high-intensity photolysis to maximize frequency of radical-radical collisions

(4) Other secondary steps:

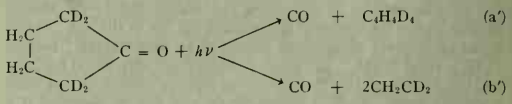
$CH_3 + CH_3I \rightarrow CH_4 + CH_2I$	Inferred from methane in products; thermochemistry requires either reactant to have 9 kcal/mole excess energy
$CH_2I + I (+M) \rightarrow CH_2I_2 (+M)$	From CH_2I_2 in products
$2CH_2I \rightarrow CH_2ICH_2I$	From 1, 2-di-iodoethane in products

The presence of activation energy in either CH_3 radical or the CH_3I molecule is confirmed by the quenching effect of foreign gases and the rise of quantum yield of methane (CH_4) as the photon energy is increased. The actual photon energy is about 50 kcal/mole or more, so that only a small fraction of this need remain available for the methane-formation reaction.

Other than direct detection of intermediates, the most powerful tool for elucidating mechanisms is probably the use of isotopic labeling. For example, deuterium can be used in place of hydrogen, or one of the other carbon isotopes instead of C^{12}, at selected sites in the starting material; the tagged atoms then can be located at particular positions in the product molecules. A method that is similar but not quite so clear-cut is the use of relatively inert substituents like alkyl groups on carbon atoms. An example of the unequivocal information isotopic substitution can give in a favourable case is in the photolytic decarboxylation (loss of carbon monoxide) of cyclopentanone. The process has alternative paths (a) and (b):



The use of a specific tetradeuterated species shows that the paths are mutually exclusive. No C_2D_4 is formed and therefore the ethylene cannot be a product of an intermediate in which all four carbon atoms are equivalent. The isotopically labeled reaction is this:



Another application of isotopic labeling occurs in photosensitized reactions. For example, a photoexcited mercury atom gives up its excitation directly to a collision partner, which may be an unexcited mercury atom or a complex molecule. If it collides with a complex molecule the mercury atom may simply transfer its energy or it may react to form a mercury compound which can be isolated as a product. Suppose the mercury photoexcitation is effected by a cool, low-pressure lamp containing a single pure mercury isotope. Since each isotope radiates a characteristic spectrum, and in a cooled low-pressure lamp the spectral lines are well separated, the light from a monoisotopic lamp will excite only those mercury atoms in the sample cell which are the same isotope as that in the lamp. If the product (the mercury compound formed in the photosensitized reaction) contains the same pure mercury isotope as the lamp, the observer knows that the product is formed in a single step involving excited mercury and the complex starting material. If, on the other hand, the mercury in the product has the normal mixed isotopic composition, the observer knows that the product was formed after the photoexcited mercury had lost its extra quantum and returned to the pool of unexcited mercury atoms. This method shows that the direct reaction (a) is about one-third as efficient as the two-step process (b);

$$Hg^* + HCl \longrightarrow HgCl + H \quad (a)$$
$$Hg^* + HCl \longrightarrow Hg + Cl + H \quad (b)$$

The same result holds for the alkyl halides.

A good method (and one of the oldest in photochemistry) for determining both kinetic constants and mechanisms is the study of fluorescence quenching. If a large molecule (*e.g.*, anthracene, pyrene, or acridine) is photoexcited and does not react, in general it will fluoresce. If a species is added which reacts rapidly with the photoexcited substance, fluorescence will no longer occur; *i.e.*, it will be quenched. In practice, the quantum yield for fluorescence (ϕ) or the ratio of quanta absorbed to quanta emitted in fluorescence (I_a/I_f) is used for systems representing several concentrations of the nonfluorescing reactant. If $1/\phi$ or I_a/I_f is plotted as a function of the quencher concentration, then a simple reaction of the following type must give a linear dependence of $1/\phi$ or I_a/I_f on quencher concentration:

$A + h\nu \longrightarrow A^*$		(1)
$A^* \longrightarrow A + h\nu$	Fluorescence	(2)
$A^* + A$ (or B) $\longrightarrow A + A$ (or B)	Deactivation	(3)
$A^* \longrightarrow D_1 + D_2$ or $A^* + B \longrightarrow C$	Reaction	(4)

The slope of the line, for I_a/I_f, is the ratio of the rate constants for reaction (4) to that for fluorescence, while the intercept on the axis corresponding to zero concentration is 1+ (the ratio of the rate constant for deactivation to that for fluorescence). If ϕ is used, the roles of the constants for fluorescence and for deactivation are interchanged. This method was developed by O. Stern and M. Volmer (1919) and refined by many later workers. It has made possible the determination of the strengths of acids in excited electron states (T. Förster, 1949); of rate constants for formation of complexes with excited states (A. Weller, 1960); of the rate of

dimer formation in anthracene (E. J. Bowen and co-workers, 1939); and of rates of long-range transfer of energy (T. Förster, 1960 and previously).

Fluorescence has been the key to understanding two kinds of fundamental processes in the photochemistry of liquids and solids. In the first of these, investigated by S. Boudin (1930), H. Kautsky (1935), and G. N. Lewis and co-workers (1941), an irradiated glassy or liquid solution of an organic dye or aromatic species (*e.g.*, anthracene or pyrene) emits both its normal rapid fluorescence and slow phosphorescence radiation and, in addition, a delayed fluorescence whose emission rate is comparable to that of phosphorescence but whose spectral distribution is that of fluorescence. The intensity of delayed fluorescence relative to that of phosphorescence decreases as temperature is lowered. In the case of dyestuffs it was shown (C. A. Parker and C. G. Hatchard, 1961) that thermal excitation alone, from the upper state of the phosphorescence (triplet) to the slightly more energetic fluorescing excited singlet state, led to the delayed fluorescence. The delayed fluorescence of anthracene and other aromatics, by contrast, exhibits a temperature dependence too complex to be due to the simple re-excitation mechanism; moreover its intensity depends on the square of the incident light intensity, so two quanta must be involved. The responsible mechanism is the collision of two long-lived triplets, producing one excited fluorescing singlet and one normal unexcited singlet.

The second photochemical process, which often appears in systems which also exhibit delayed fluorescence, is the formation of dimers in the excited state only. These photodimers of molecules or atoms that do not combine in their ground state are called excimers (B. Stevens, 1961); their existence was first proven in irradiated solutions of pyrene (T. Förster and K. Kasper, 1955). Excimers can fluoresce normally or in a delayed process. They play an important role in the mechanism of the action of plastic (polystyrene) scintillation counters (F. Hirayama, 1963). An excited phenyl ring interacts with a neighbouring ground-state ring along the chain to form an excimer—provided the chain is flexible enough for the rings to come close together (M. Vala and S. A. Rice, 1964). Photoexcited atoms (*e.g.*, of argon, krypton, and xenon) form excimers in solid, liquid, and gas phases. In both atoms and molecules, chemical binding of excimers occurs in the excited state only because in that state one antibonding electron is removed from the immediate vicinity of the two atoms, permitting the effect of the bonding electrons to dominate over the remaining antibonding electrons.

APPLICATIONS

Synthetic Chemistry.—Since absorption of a light quantum is frequently a property of a single group within a molecule, photochemistry sometimes offers a highly specified tool for including a chemical reaction at a specific molecular site. This becomes especially valuable in cases where thermal excitation would be very unspecific or where heat would destroy the reactant. Photochemical syntheses include the formation of valence tautomers, isomers, and single dimers, and elimination reactions.

Photolytic syntheses are sometimes most effective if the reactants are held rigidly by a solid lattice so that a reactant molecule absorbing a quantum is in a favourable and fixed orientation for reaction. Solid-state photolyses of this kind have been used by G. Griffin and co-workers in the synthesis of the dimers of maleic and fumaric acids (1960). The photographic process is essentially a photoinitiated synthetic process in a solid. The property peculiar to solids which the photographic process uses is the easy diffusion of both the photoexcited electron and the vacancy it leaves on a halide ion. Eventually the electron vacancy can diffuse to a crystal surface to form neutral bromine, forcing the electron to recombine with a positive silver ion and thus giving a neutral atom.

Radiation Chemistry.—The photochemistry associated with high-energy radiation (X rays and gamma rays) is closer to the chemistry of electron-bombarded materials than to the photochemistry of visible-ultraviolet radiation. This is because a high-energy process (radiolysis) of electron or photon bombardment produces ionized species in addition to excited neutrals, and these ionized species are products of very fast secondary processes, not of the primary quantum absorption process. The primary processes associated with high-energy radiation are simply too fast to lead to any chemistry in the traditional sense of bond formation or breakage. Radiation chemistry is largely concerned with determining what the first-formed new chemical species are and what reactions they undergo. Three examples of radiolysis will exhibit the extent of this branch of photochemistry:

1. Since the chemical species differ from their precursors by one or more charges, it is natural to examine oxidation-reduction ("redox") processes induced by gamma-radiolysis. One type of radiolytic redox reaction involves a rigid organic glass containing a substance (*e.g.*, paraphenylenediamine) which is susceptible to oxidation processes. Radiolysis leads first to mobile electron vacancies or electronic excitation in the solvent; this travels rapidly through the glass until it meets a solute molecule, and then oxidizes the paraphenylenediamine, leaving an ion or ion-pair (W. H. Hamill and co-workers, 1964).

2. Radiolysis is a natural approach in the study of ion-molecule reactions and, in the gas phase, ion-radical reactions and the secondary processes leading to the final ions. Ions are very reactive toward neutral molecules because their attractive force of interaction is rather long-range, varying as the inverse fifth power (r^{-5}) of their separation, instead of the inverse seventh power. A saturated-hydrocarbon ion-molecule colliding with neutrals readily undergoes transfer of an atom of hydrogen, a proton, or a negative hydride ion with a frequency comparable to the collision frequency of the neutral parent molecules with each other. In liquids, large free radicals and ion-molecules are produced, but in solids it seems that the cage effect of the lattice prohibits formation and diffusion of radicals. In condensed phases the ion-molecules react with their neighbours or intramolecularly to form H_2 and either unsaturated monomers or dimers (L. Kevan and W. F. Libby, 1962). In the gas phase, ion-molecules often break into fragments when ionization occurs, both because of the large energy delivered directly by the ionizing radiation and, more specifically, because the ion-molecule, formed almost instantaneously so far as the atomic nuclei are concerned (*i.e.*, according to the Franck-Condon principle), is produced in a state of very high internal potential energy—higher than that of dissociated fragments. The newly produced ion-molecule dissociates unless its excess energy is removed by collisions before the fragments can escape from each other. In a gas these collisions are not available; in a liquid or solid they are (F. H. Field, J. L. Franklin and co-workers, 1957–64).

3. The action of high-energy radiation on water and water solutions is a fundamental problem of radiolysis. Radiolysis of aqueous solutions characteristically produces reducing species; *i.e.*, molecular species which eventually add electrons to solute species capable of accepting them; *e.g.*, the ferricyanide ion $Fe(CN)_6^{3-}$, which can be converted to the ferrocyanide ion $Fe(CN)_6^{4-}$ by addition of an electron. The water radiolysis problem depends directly on determining the reducing species and characterizing them. In strong acid, at least one reducing species is the hydrogen atom; in neutral and basic solutions, both OH radicals and hydrated (or solvated) electrons are formed by the radiation. The solvated electron was first characterized by its kinetic properties and then by its absorption spectrum (M. S. Matheson and co-workers, J. W. Boag, 1963); the OH radical was long a well-known species from a wide variety of spectral and chemical properties.

Radiation chemistry assumes a particularly important role in the understanding of how living beings react to radiation and how they can be protected against its damaging effects. (*See* RADIATION: BIOLOGICAL EFFECTS.) Chemical protection can be accomplished to some degree with an amino acid cysteine and other compounds containing sulfur-hydrogen bonds. Elucidating the role of these compounds as traps for free radicals, as hydrogen sources or as fast scavengers for OH or hydrated electrons, is a major task of radiation chemistry.

Studies of the Atmosphere.—The phenomena of terrestrial

and planetary atmospheres, *e.g.*, atmospheric structure, auroras, radiation shielding, and weather, depend on the chemical constituents of the atmosphere and the radiation striking it. The earth's atmosphere is largely molecular nitrogen and molecular oxygen at the earth's surface but contains quite a different set of atomic and molecular components at high altitudes, largely because of the radiation that these upper layers absorb. The upper ionospheric, or F, layers, at heights of 150 to 300 km. (100 to 200 mi.), contain high proportions of electrons and ions; there the ion concentration is about 10^6 per cubic cm. in a total density of 10^9 particles per cubic cm.—enough to reflect relatively long radio waves effectively. The ionic constituents or the F layers are largely O^+, O_2^+, O_3^+, N^+, and N_2^+.

The most important photochemical reactions occur in the lower part of the F layers and the upper part of the lower ionospheric, or E, layers. There, oxygen molecules are photodissociated into atoms by sunlight. The oxygen atoms react with O_2 molecules to form ozone. The ozone then absorbs virtually all the solar radiation between 3000 Å and 2200 Å, protecting the earth's surface from what would be very intense energetic radiation, quite harmful to life as it now exists. The ozone is converted into $O_2 + O$ by this absorption, and the oxygen atoms can also be excited; *e.g.*, to a state whose radiation is responsible for the green auroral line (5577 Å). The most important mechanism for this process is probably $3O \longrightarrow O_2 + O^*$. Other kinds of excitation by radiation are also important in the atmosphere. The excited N_2^+ ions responsible for the blue color in the aurora are produced indirectly by high-energy ionizing particles from space. The secondary electrons produced by the high-energy particles collide with nitrogen molecules and simultaneously excite and ionize them.

Photochemical processes control another atmospheric process: air pollution and smog formation. There are several types of smog; typically they are dispersions of very small droplets or particles of reaction products suspended in air, and often contain irritating and corrosive materials. The origins of smog are varied, depending on substances distributed into the atmosphere. An automobile exhaust smog like that of Los Angeles, Calif., occurs when a mixture of unsaturated hydrocarbons (*e.g.*, ethylene), nitrogen oxides (NO and NO_2), and frequently sulfur dioxide is irradiated in air. The NO_2 and perhaps the SO_2 absorb light and react with hydrocarbons, ultimately photooxidizing the hydrocarbons to formaldehyde, acrolein, PAN (probably peroxyacetylnitrate, $CH_3(CO)OONO_2$, but unproven because of its explosive character), and other less irritating materials. The detailed mechanisms and even many of the reactions are not known; however, it is known that oxygen atoms and ozone are present, that NO_2 is regenerated by chain mechanisms probably involving higher oxides of nitrogen, and that sulfur dioxide greatly enhances the formation of suspended droplets in the photooxidation process.

Biological Processes.—The most important photochemical processes of living systems have already been mentioned. They include photosynthesis (*q.v.*), or the reduction of CO_2 to carbohydrates by the action of light on photosynthetic pigments such as chlorophyll; vision, or the absorption of light quanta by retinal pigments; photoinduced activation of vitamin D by way of a photochemical rearrangement; the damaging action of high-energy radiation, which involves inactivation of sulfur-containing enzymes, at least in part. (But even irradiated water can be toxic to living species.) On the periphery of photochemical phenomena in biology is bioluminescence (*q.v.*).

Photosynthesis, apart from its role in plant metabolism, is a unique and exceedingly complex photochemical process. It involves the absorption of eight quanta of radiation for every CO_2 molecule used, and these eight quanta are divided equally between two different pigment systems. Both systems contain at least one pure pigment in common, chlorophyll *a;* at least one system also contains accessory pigments. Moreover, light seems to be required by a plant for the manufacture of chlorophyll itself. When one also considers the elaborate chain of secondary oxidation-reduction-energy transfer steps, it is clear that the photosynthetic mechanism is much more intricate than any of the one-quantum or two-quanta processes discussed previously—so much so that these processes are almost qualitatively different from photosynthesis.

Photophysical Phenomena.—"Photophysical" is a convenient label for phenomena intimately related to those investigated in photochemistry but not part of the mainstream of photochemical kinetics. They involve some change in a physical property due to the action of light; therefore they may be classified among phenomena representing the transition from chemical to physical processes. Photochromism, photoconductivity, and some aspects of laser action are among these processes.

Photochromism.—One such phenomenon is photochromism, the reversible production of colour or of a change in colour of a substance by the action of light. Most organic photochromic materials actually undergo rearrangements, photooxidations, or photoreductions when they exhibit their peculiarity. In this sense their photoprocesses are no different from those discussed previously, except that the photoproducts of photochromes happen to absorb visible light. Some materials do not make use of rearrangements or other reactions in their photochromic mechanism. These require that a coloured "photo-accessible" state of some constituent be relatively stable. Triplet states sometimes satisfy this criterion; *e.g.*, photoexcited triphenylene in a hydrocarbon glass remains as a stable coloured triplet with a 20-min. half-life. Impurity centres in inorganic crystals (*e.g.*, traces of manganese or bismuth in calcium sulfide) are photochromic, usually as a result of photooxidation of the impurity ion. Another type of photochromism is the formation of colour centres in alkali halide crystals; *e.g.*, NaCl. (These centres are known as F centres, from Ger. *Farbe*, "colour.") Photoexcitation removes an electron from a halide ion, just as it does in a silver halide in photography. The electron then becomes trapped in a lattice vacancy to form a F centre; its colour appears because the energy required to free the trapped electron corresponds to a quantum of visible light.

Photoconductivity.—If light is absorbed by a solid, the electrons excited by the absorption process may have enough energy to leave the solid altogether. This is the photoelectric effect discussed previously. When insulating materials are irradiated, often the electrons do not have sufficient energy to escape from the material but are able to move more or less freely through the solid. Whenever the excited electrons do remain mobile but bound to the bulk material, they are able to drift, and more particularly to move under the influence of an electric field, and therefore to act as carriers for electric current. Without photoexcitation the electrons are essentially immobile: in an insulator, in general, the unexcited electrons cannot move from a quantum state located on one atom to a state on the next atom because all the available states are already filled. If an electron has been removed from one atom, *e.g.*, by photoexcitation, then it leaves a vacancy in the quantum shell where it originated. Such a vacancy, or "hole," is available for an electron on a neighbouring atom, allowing that electron to move, and therefore for the hole to move. This kind of motion can continue, so that the hole drifts through the insulator, behaving very much like an electron except that it moves in the opposite direction.

Electrons and holes both share in carrying the electric current in the phenomenon of photoconductivity. If unexcited electrons can move easily from site to site whenever a hole is available, then the mobility of the hole is high and it is an efficient current-carrier. Similarly, if the excited electron can move easily without losing its energy or being diverted by collisions, it will have a high mobility and carry current easily.

Among examples of photoconductors are those first observed by R. W. Pohl and his co-workers (1924–38). These included diamond, zinc-blende, the alkali halides, and the silver halides. Pure germanium is a photoconductor when it absorbs infrared radiation of energy greater than about 0.6–0.7 ev. Naphthalene and anthracene photoconduct when they absorb ultraviolet radiation; cadmium sulfide will do so under the action of the 4580Å line of mercury. Even liquid solutions of hydrocarbons will photoconduct when they are sufficiently concentrated.

Laser Action.—Another photophysical phenomenon is that associated with light amplification, or laser action. ("Laser" is an

acronym for "light amplification by stimulated emission of radiation.") A molecular system containing stored energy may radiate this energy spontaneously in a spectral line at frequency ν, or it can be stimulated to emit the energy by applying weak radiation of frequency ν to the system. Molecular amplification of radiation was first observed by J. P. Gordon, H. J. Zeiger, and C. H. Townes (1955) for a characteristic microwave frequency of ammonia. T. H. Maiman (1960) demonstrated that the same process occurs with visible light, the 6940 Å line of chromium in ruby. Since then, many systems—gaseous, liquid, and solid—have been found which act as lasers. To produce laser action, energy is "pumped" into the storage atoms or molecules with a high-intensity flash lamp; the exciting light contains a rather broad spectrum of frequencies. Then, in a properly designed and tuned system, the slightest stimulus will cause most of the stored energy to be radiated in a single narrow spectral line. From a photochemical standpoint, the process depends on the existence of a set of energy levels which make it possible for a system to absorb large amounts of light and then release it in a single line without reabsorbing it. The resulting beam of light can be made virtually nondivergent, so that it can be propagated for astronomical distances; it can be produced with extremely high intensity, so that it can produce harmonics or overtones of its own frequency when it passes through an appropriate material; or it can be focused to a point where the field is intense enough to explode air or to be a surgical tool for exceedingly delicate operations. (R. S. Be.)

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PHOTOELECTRICITY (literally, "light electricity") is the study of certain changes of an electrical nature induced in matter by light and other forms of radiation. When the primary result of the absorption of electromagnetic radiation by matter is the dissociation of the matter into electrically charged particles, the process is designated a photoelectric effect. As commonly investigated, with radiation lying between the X-ray and infrared limits of the electromagnetic spectrum, the photoelectric effect results in the ejection of electrons from the atoms of which matter is composed. The γ rays whose energy exceeds 1 Mev (million electron volts) may create pairs of positive and negative electrons. The γ rays whose energy is very large ($\sim$ 300 Mev) may create π mesons (*see* Particles, Elementary).

The study of the photoelectric effect was of major importance for the development of physical theory during the first two decades of the 20th century. The role played by the photoelectric effect during this period was largely due to the unambiguous manner in which it displayed the quantum properties of radiation which are not describable by the electromagnetic wave theory of James Clerk Maxwell. (*See* Electricity; Electromagnetic Waves.)

In addition, observation of the behaviour of photoelectrons was of the greatest aid in solving the riddle of atomic structure. For these reasons a brief survey will be given of the early history of the photoelectric effect, after which the photoelectric effect of high-frequency radiation and of low-frequency radiation, applications of the photoelectric effect, and nuclear photoeffects are discussed. This article, therefore, is divided into the following sections:

I. Historical Survey
II. Photoelectric Effect of High-Frequency Radiation
  1. Direction of Emission
  2. Compton Effect
  3. Auger Effect
III. Photoelectric Effect of Low-Frequency Radiation
  1. Metals
  2. Insulators
  3. Gases
  4. Photovoltaic Effects
IV. Applications of the Photoelectric Effect
V. Nuclear Photoeffects

I. HISTORICAL SURVEY

E. Becquerel, in 1839, reported that the illumination of one of a pair of metal plates immersed in a dilute acid solution altered the electromotive force of the cell. The decrease in the electrical resistance of selenium on illumination was discovered by Willoughby Smith in 1873. These photoelectric phenomena attracted great interest at the time of their announcement but remained unexplained and isolated observations.

In 1887 Heinrich Hertz observed that the behaviour of a spark gap was affected by illumination of the electrodes. W. Hallwachs investigated Hertz's observation and in the following year reported that a clean, insulated zinc plate acquired a positive charge on illumination with ultraviolet light. A negatively charged plate could be made to lose its charge by illumination. The effect was found to persist if the metal was placed in a vacuum.

In 1900, three years after the discovery of the fundamental particle of negative electricity, the electron, Philipp Lenard proved that the effects observed by Hallwachs were due to the ejection of electrons from the metal under the stimulus of radiation. It was found that the effect was a common property of metals but that only a few (*i.e.*, the alkali metals and some alkaline earth metals) were sensitive to visible light. In general, it was necessary to use ultraviolet radiation to provoke the effect.

J. Elster and H. Geitel discovered in 1900 that the number of photoelectrons emitted per second from the surface of a metal is proportional to the intensity of the incident radiation. Lenard established in 1902 the important fact that the maximum kinetic energy of a photoelectron depends only on the frequency of the incident radiation and is independent of its intensity.

According to Maxwell's theory, radiation consists of an electric and a magnetic field propagated through space in the form of a transverse wave. The constant velocity c of propagation in a vacuum is the product of the wavelength of the wave and the frequency of vibration of the electric and magnetic vectors. The energy transferred by the wave across unit area perpendicular to the direction of propagation in unit time is the intensity of the radiation and is proportional to the square of the amplitude of the electric vector.

It was believed that the electric field of the radiation exerted a force upon the electron which freed it from the atom to which it was bound. It was difficult to understand from the theory of Maxwell how the kinetic energy of the electron can be independent of the intensity of the radiation, which is fixed by the magnitude of the electric field.

This difficulty was ascribed by A. Einstein to a fundamental incompleteness of the Maxwellian wave theory of radiant energy. Einstein proposed that radiation possessed many of the properties commonly associated with material particles. In particular, he suggested that in a beam of radiation of frequency ν, the energy exists in the form of units of magnitude $h\nu$. The names photon and quantum are given interchangeably to these units of radiant energy. Einstein viewed the photoelectric process as one in which an electron absorbs a photon. The kinetic energy of the free photoelectron is the difference between the energy it has absorbed and the work it has performed in its escape from the forces binding it to the atom. Einstein proposed in 1905 the simple relation

$$T = h\nu - w \qquad (1)$$

between the maximum kinetic energy, T, of the free photoelectron and the frequency, ν, of the radiation. The constant w is the mini-

mum work which the electron must perform to escape from the material to which it is bound. Einstein predicted that the constant h would be found to be the same constant which Max Planck had previously introduced into theoretical physics in discussing the emission of radiation from matter.

The experimental data available in 1905 did no more than suggest the correctness of these conclusions, but by 1916 the validity of Einstein's relation between the maximum kinetic energy of a photoelectron and the frequency of the absorbed radiation had been fully confirmed. This was largely the result of the beautiful experimental work of Robert Millikan, whose measurements also determined Planck's constant, h, with great precision.

Photoelectric phenomena present another major difficulty to Maxwell's theory of radiation. It was estimated by Lord Rayleigh in 1916 that according to Maxwell's theory it would take a time of the order of several hours for an electron to absorb sufficient energy from a beam of radiation to escape from an atom. But Elster and Geitel had noted that the appearance of photoelectrons occurred simultaneously with the illumination of a metal surface. In fact, E. O. Lawrence and J. W. Beams, in 1928, found that the time lag between the incidence of radiation and the appearance of photoelectrons was less than 3×10^{-9} seconds. The experiments of A. T. Forrester and his co-workers established in 1955 that the interval between illumination and photoemission is less than 10^{-10} sec. If the photoelectric effect is initiated by the collision of two corpuscles, the electron and the photon, then there is no difficulty in understanding the instantaneous character of the emission.

The success of the photon hypothesis in yielding the Einstein equation (1) and in interpreting other photoelectric phenomena stands in sharp contrast to the successful application of the wave theory of radiation to the field of interference and diffraction effects. (*See* LIGHT.) It appears that a dual character must be ascribed to radiation and that a complete description of its interaction with matter cannot be obtained by the consistent use of either a wave or a corpuscular theory. (*See* QUANTUM MECHANICS.)

II. PHOTOELECTRIC EFFECT OF HIGH-FREQUENCY RADIATION

Radiations whose wave lengths lie between 100 and 0.01 angstroms are termed X-rays. The angstrom unit of length, named in honour of the Swedish spectroscopist A. Ångström, is equal to a hundred millionth of a centimetre (1×10^{-10} m.). X-rays are commonly produced by the impact of fast electrons upon matter (*see* X-RAYS); γ rays are of even shorter wave length and are emitted by the nuclei of radioactive atoms.

The photoelectric effect of high-frequency radiation in gases is easily demonstrated with an instrument known as an ionization chamber. This consists of a closed box filled with the gas. A thin window of metal foil or mica allows entrance of the X-ray beam. Inside the chamber are a pair of metal electrodes. By connecting the electrodes to the terminals of a battery an electric field is established between them. A gas under normal conditions is a good electrical insulator and no current will pass between the electrodes.

When X-rays enter the chamber, the photoelectrons and the positive ions formed from the atoms which have lost electrons are swept by the electric field to the electrodes and an electric current may be readily detected. The fast photoelectrons collide with the atoms of the gas and dislodge electrons from them so that the total number of electrons and positive ions is many times the number produced photoelectrically.

The photoelectrons produced by X and γ radiation possess very large kinetic energies and, therefore, very high velocities. The velocities commonly approach the speed of light and necessitate the use of relativistic equations in the discussion of their motion. The kinetic energies correspond to those acquired by electrons which have been accelerated by potentials of many thousands of volts.

With an instrument known as a β-ray spectrograph, H. Robinson and his co-workers performed some very informative experiments. This device, the use of which was introduced by O. Hahn, L. Meitner and C. D. Ellis, is illustrated in fig. 1. Robinson allowed X-rays of known frequency to impinge upon a solid placed in the position indicated. A fraction of the photoelectrons emitted by the solid pass through the slit and enter the evacuated chamber.

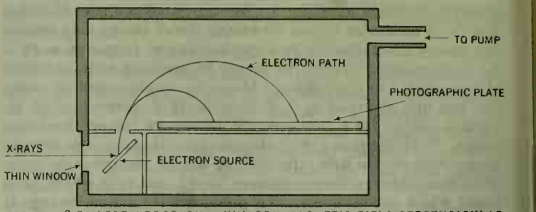

FIG. 1.—β-RAY SPECTROGRAPH. UNIFORM MAGNETIC FIELD PERPENDICULAR TO PLANE OF PAPER

Here they are bent in arcs of circles by a uniform magnetic field of known magnitude. The photoelectrons then fall upon the photographic plate leaving developable traces. The position of the traces and the dimensions of the apparatus determine the radii of the circular arcs traversed by the electrons. A knowledge of these radii and of the magnitude of the magnetic field makes calculable the velocities of the electrons.

Robinson tested Einstein's equation with X-rays of known frequency. The energy lost by a photoelectron in escaping from an atom of a given chemical element (the quantity w) was found to assume several sharply defined values. This behaviour was direct evidence for the existence of atomic energy levels.

If radiation of unknown frequency is allowed to eject electrons from an element whose atomic energy levels have been determined, the unknown frequency may be determined by the use of Einstein's equation after measurement of the kinetic energies of the photoelectrons with the β-ray spectrograph. In this manner, Ellis and M. de Broglie examined the γ rays emitted by many radioactive elements and established the very important fact that γ-ray spectra are discontinuous as are the atomic spectra of the elements. This important work was the beginning of a spectroscopy of the nucleus and the establishment of nuclear energy levels.

1. Direction of Emission.—An important problem connected with the photoelectric effect is the direction of emission of the electron by the radiation. According to Maxwell's theory, radiation consists of a transverse wave, and the direction of emission should be the direction of the force exerted upon the electron by the electric vector which lies in a plane perpendicular to the direction of propagation of the radiation. This problem may be investigated by using the photoelectric effect of X-rays upon a gas in a Wilson cloud chamber. (*See* CLOUD CHAMBERS.)

The Wilson chamber is a vessel in which a gas may be supersaturated with water vapour by a sudden expansion. A fast electron ejected from an atom by the radiation strikes other atoms in its passage through the gas. In this manner it ejects electrons from the atoms of the gas leaving the atoms positively charged. Water droplets condense upon the ions thus formed and render visible the path of the high-energy photoelectron.

If X-rays of long wave length (*i.e.*, low frequency) are used to produce the photoelectrons it is found that the most probable direction of emission is in the plane perpendicular to the direction of propagation of the X-rays. As the frequency of the X-rays is increased, the majority of the photoelectrons are emitted in a direction which makes an angle less than 90° with the direction of propagation of the wave. This effect is explained by the fact that in the photoelectric process the electron receives not only the energy, $h\nu$, but also the momentum, $h\nu/c$, of the photon. It is only when the frequency of the radiation is greater than that of soft X-rays that the momentum of the quantum is large enough to have a discernible effect upon the direction of emission of the electron.

Neither Maxwell's theory nor the simple photon hypothesis of Einstein is entirely successful in its description of the experi-

mental results. Maxwell's theory demands that all the electrons be ejected in the plane perpendicular to the direction of propagation of the radiation. The photon hypothesis predicts a definite angle between the perpendicular plane and the direction of emission which is approximately half that observed between the most probable direction of emission and the perpendicular plane. The quantum-mechanical treatment of the problem has met with considerable success. The observed variation in the direction of emission is correctly described and the effect of the quantum momentum upon the direction of emission is greater than predicted by the photon hypothesis.

2. Compton Effect.—A most unusual type of photoelectric effect is that in which in the act of absorption of the photon its full energy is not given to the photoelectron but a fraction is scattered as a quantum of smaller energy. (*See* COMPTON EFFECT.)

This phenomenon was originally observed in experiments upon the scattering of monochromatic X-rays by solids. Among the scattered X-rays there is radiation of the same wave length as that of the primary X-rays and two types of modified X-rays of longer wave length. Atoms which have absorbed quanta may reradiate energy as fluorescent radiation.

This fluorescent radiation contains wave lengths which are characteristic of the absorbing atoms and independent of the wave length of the primary X-rays and of the angle of observation. There is also present a scattered radiation whose wave length is dependent upon the wave length of the incident radiation and upon the angle which the direction of observation makes with the direction of the primary radiation.

The existence of this last-mentioned type of scattered radiation was established and a simple explanation of its origin was given by A. H. Compton in 1923. Compton suggested that, if radiation has the corpuscular character ascribed to it by Einstein, a quantum of energy $h\nu$ and momentum $h\nu/c$ might be conceived as making an elastic collision with a free electron whose kinetic energy before the collision is negligible by comparison with that of the quantum. The laws of conservation of energy and momentum, when applied to the collision, give at once a relation between the energy of the scattered quantum and the angle at which it is scattered. Expressed in terms of the difference in wave length between the scattered and incident quanta the relation is

$$\Delta\lambda = \left(\frac{h}{mc}\right)(1 - \cos\theta), \qquad (2)$$

where $\Delta\lambda$ is the difference in wave length, and θ is the angle of scattering. The constants h, m and c which enter the equation are Planck's constant, the electron mass and the velocity of light, respectively.

This equation agrees very closely with the results of experiment. Observation with Wilson cloud chambers has made possible the detection of the recoil electrons. The simultaneous appearance of the scattered quantum and the recoil electron at the predicted angles has been observed by experiments in gases with Geiger counters.

3. Auger Effect.—It was observed by C. T. R. Wilson in 1923 that the absorption of an X-ray quantum by an atom is accompanied occasionally by the emission of two or more electrons. In such a case, only one of the electrons has a kinetic energy which depends upon the frequency of the quantum in the manner described by Einstein's equation. The kinetic energy of the other electrons is characteristic of the type of atom. These facts were established by P. Auger in an extensive investigation of the phenomenon.

The explanation of the Auger effect is as follows. A tightly bound electron is first ejected from the atom by the usual photoelectric process. Such an electron is one for which the constant w in Einstein's equation is large. After the act of photoelectric emission the atom is left with the excess energy, w. The atom can decrease its energy by transferring an electron from a higher energy level to the one vacated by the photoelectron. In the course of this transition the atom loses energy, usually by the emission of a quantum of radiation. Occasionally the energy freed by the transition is given to one of the electrons of the atom which is ejected.

Such an Auger electron will appear outside the atom with a kinetic energy which is the difference between that given to it by the atom and the energy lost in escaping from the atom. Since each of these energies is determined by the atom, the kinetic energy of the Auger electron is characteristic of the atomic species.

In stripping itself of its excess energy the atom may emit more than one quantum and several Auger electrons. The total energy so lost cannot be greater than w, the excess energy with which the atom was left as a result of the initial photoelectric act.

III. PHOTOELECTRIC EFFECT OF LOW-FREQUENCY RADIATION

The wave-length region from 2,000 to 10,000 angstroms (Å) is of primary importance for photoelectric studies. The opacity of air and most optical materials has severely limited work in the region below 2,000 Å. The quanta of infrared radiation of wave lengths longer than 10,000 Å possess so little energy that they produce photoelectric effects in few substances. Visible radiation, or light, includes the wave-length region from about 4,000 to 7,000 Å.

1. Metals.—The most important topic of investigation with low-frequency radiation has been emission from the surfaces of metals. In this case, the constant w of Einstein's equation is known as the work function of the metallic surface. A brief discussion of the structure of a metal is necessary in order to understand the significance of the work function.

The large electrical conductivity of metals is attributed to the presence of electrons which are not bound to particular atoms but are free to roam the interior of the metal. At the surface the electrons are subject to forces which prevent them from leaving the metal. The number of free electrons is of the same order of magnitude as the number of atoms. The minimum work which must be performed against the surface forces to extract an electron from the metal is the work function.

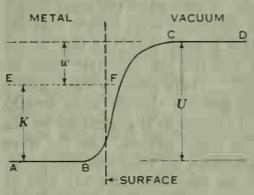

FIG. 2.—ENERGY DIAGRAM FOR AN ELECTRON AT THE SURFACE OF A METAL

This discussion may be amplified by reference to fig. 2. The heavy solid line, ABCD, represents the potential energy of an electron in the neighbourhood of the surface. It is assumed that inside the metal the potential is constant as indicated by the horizontal part, AB, of the line. In passing through the surface the potential energy increases suddenly as shown by the portion, BC, of the line.

Outside the metal the potential energy is again constant along the line CD. To extract an electron, initially at rest inside the metal, would demand the work U. The electrons in the metal, however, have kinetic as well as potential energy. The kinetic energies vary between zero and a maximum value as indicated by the horizontal line, EF. The maximum kinetic energy of an electron inside the metal is K. The work necessary to extract the fastest electron and leave it with zero kinetic energy outside the metal is the difference between U and K (or w), the work function. The equation

$$h\nu = w \qquad (3)$$

determines the photoelectric threshold frequency. Radiation of smaller frequency is incapable of ejecting electrons. Equation (3) is the Einstein equation (1) with the kinetic energy T of the photoelectron set equal to zero. For most metals the photoelectric threshold is in the ultraviolet. Tungsten has a work function of 4.53 electron volts (ev) which corresponds to a threshold wave length of 2,730 Å. This is well into the ultraviolet. Sodium has a work function of 2.28 ev or a threshold wave length of 5,400 Å, which is in the green of the visible spectrum. The electron volt is a common unit of work or energy in photoelectric studies and is the work necessary to move an electron through a potential difference of one volt.

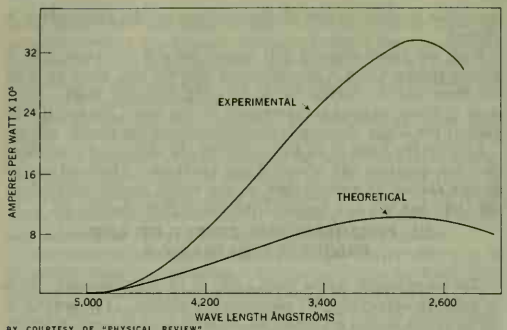

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FIG. 3.—PHOTOELECTRIC YIELD OF BARIUM AS A FUNCTION OF WAVE LENGTH EXPRESSED IN AMPERES PER WATT OF INCIDENT RADIATION. THE EFFECT OF REFLECTION IS INCLUDED IN THE THEORETICAL CURVE

It has been found that the work function is extremely sensitive to the presence of traces of impurities upon the surface of the metal. If the characteristic work function of a metal is to be measured it is necessary to remove all traces of absorbed gas from the surface, preferably by prolonged heating at as high a temperature as possible in a very good vacuum.

If monochromatic radiation is incident upon the surface of a metal, the photoelectric yield (*i.e.*, the number of electrons emitted for each quantum absorbed) is zero when the wave length of the radiation is longer than the threshold wave length. As the wave length of the incident radiation is made less than the threshold wave length, emission begins and the photoelectric yield increases with decreasing wave length. There exists a wave length for which the yield is a maximum and for shorter wave lengths than this the yield decreases. This behaviour is illustrated by the experimental curve of fig. 3 for the metal barium. As the wave length of the incident radiation decreases, its quantum energy increases and a greater fraction of the photoelectrons are able to escape from the metal. The existence of a maximum in the yield curve is not so immediately understandable. It results from the fact that the probability of absorption of a quantum by an electron decreases rapidly with increase of the frequency or decrease of wave length. This is a general feature of photoelectric absorption by electrons under all conditions.

The maximum in the photoelectric yield curve is then the result of a superposition of two effects. The shorter the wave length of the radiation the greater is the fraction of the electrons which will escape from the metal after the act of absorption. But the shorter the wave length, the smaller is the probability that any individual electron will absorb a quantum. For wave lengths less than that which corresponds to the maximum in the yield curve, the second effect is more important than the first.

Radiation incident upon the surface of a metal and not reflected is absorbed in a thin layer approximately a hundred thousandth of a centimetre in depth. The photoelectrons must come from this layer. I. Tamm and S. Schubin suggested that the majority of the photoelectrons are produced in a much thinner layer at the immediate surface of the metal. If the potential energy of an electron inside a metal is constant as drawn in fig. 2, it is easily demonstrated that only at the surface can photoelectric absorption occur. In the act of absorption the electron increases its energy by the amount $h\nu$ but its momentum increases by the negligible amount $h\nu/c$.

As a result, a free electron, which is one moving in a region of constant potential, cannot satisfy simultaneously the laws of conservation of energy and momentum during the act of photoelectric absorption of a quantum. The surface of the metal where the potential is rapidly changing may act as a third body and enable the conservation laws to be obeyed.

In actuality, the potential energy of an electron inside a metal is not constant and the possibility of photoelectric absorption by the electrons in the interior exists. Only photoelectrons produced in a thin layer approximately a ten millionth of a centimetre thick will have an appreciable probability of escape, however, since this is the order of magnitude of the distance traveled by an excited electron before making a collision with another electron in which it loses a substantial fraction of its energy.

Tamm and Schubin pointed out, however, that the threshold wave length for the emission of photoelectrons produced in the interior will be shorter than the threshold of the surface photoelectrons. Electrons at the surface can absorb quanta of any frequency and the work function of the metal determines the threshold. Selection rules, determined by momentum considerations, set a lower limit to the frequency of the quanta which may be absorbed by interior electrons. This lower limit of frequency varies from metal to metal but is always greater than the threshold frequency set by the work function for the surface photoelectric effect.

The theoretical curve of fig. 3 for barium was calculated according to the quantum-mechanical theory of K. Mitchell, who assumed that photoelectrons are produced only at the surface of the metal. It is not known to what extent the neglect of photoelectrons from the interior of the metal affects the divergence between the calculated and experimental curves. It is probable that the discrepancies are primarily due to an inadequate treatment of the behaviour of the radiation near the surface of the metal, where it is reflected and refracted.

The work function depends slightly upon the temperature of the metal. The most important reason for this effect is the variation of the kinetic energies of the electrons in the metal with temperature. At the absolute zero of temperature there is a definite upper limit to the kinetic energy of an electron as indicated in fig. 2.

At any finite temperature, the upper limit is not sharply defined but the probability that any electron possesses more than a definite amount of kinetic energy is small. An effect of this indefiniteness in the upper limit of the kinetic energy is that the photoelectric threshold is not well defined. R. Fowler and L. A. DuBridge developed approximate theories of the photoelectric effect which permit the determination of the work function that the metal would possess if the electrons were at the absolute zero of temperature. It is this fictitious work function which is usually tabulated and discussed.

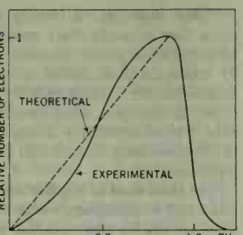
If a metal is heated to a high temperature, an observable number of electrons obtain sufficient kinetic energy to escape. This is known as the thermionic effect. From the variation in the number of thermionic electrons with the temperature it is possible to determine the work function w. It is highly gratifying that work functions measured in this manner agree with the photoelectric work functions. This is especially true in so far as it affords a confirmation of the theory of Tamm and Schubin that, at least near the threshold, the photoelectrons are produced at the immediate surface of the metal (*see* THERMIONICS).

It has been mentioned that the photoelectrons produced by a given wave length of radiation emerge with a distribution of kinetic energies and velocities. At one time it was thought that the electrons inside a metal were practically at rest and that the distribution of energies among the photoelectrons was the result of collisions of the electrons with atoms of the solid in their escape. If the photoelectrons originate at the surface, another reason for their distribution of kinetic energies must be found.

According to the model pictured in fig. 2 the reason for a distribution of energies is the fact that before photoelectric absorption takes place the electrons possess different kinetic energies. If all electrons absorb the same energy, $h\nu$, and if all suffer the same energy loss, w, in escaping from the metal, then the distribution of kinetic energies of the photoelectrons is an accurate replica of the distribution of the kinetic energies of the electrons in the metal.

A comparison of the theoretical and experimental energy distributions of the photoelectrons from a sodium surface is shown in fig. 4. The agreement between the curves is particularly good for the most energetic electrons and provides a direct test of the

Fermi-Dirac distribution function which is used to describe the variation with temperature of the kinetic energy of the electrons in metals. The differences between the experimental and theoretical curves at low energies may be due to a slight velocity-dependent reflection of the escaping electrons by the surface potential.



BY COURTESY OF "PHYSICAL REVIEW"

FIG. 4.—ENERGY DISTRIBUTION OF THE PHOTOELECTRONS FROM SODIUM. THE WAVE LENGTH OF THE RADIATION IS 3,650 Å; TEMPERATURE OF THE SURFACE, 25° C.

The photoelectric effect of contaminated metal surfaces has been studied in great detail. Many of these surfaces have high yields and very low work functions. They are, therefore, of great importance in the manufacture of commercial photocells. The properties of a surface which is widely used, known as the cesium-on-silver oxide surface, are almost entirely unexplained. The threshold is in the infrared near 12,000 Å and the yield is extremely large over the visible and near ultraviolet regions of the spectrum. An antimony-cesium alloy is also used for commercial photocells because of its high and stable sensitivity to visible and ultraviolet radiation.

2. Insulators.—The topics of interest in the investigation of the photoelectric effect with dielectric solids are somewhat different from those with metals. Little work has been done upon the emission of photoelectrons from surfaces of insulators. The loss of electrons leaves the surface with a positive charge which prevents the establishment of a steady photocurrent. (*See* also INSULATING MATERIAL [ELECTRICAL].)

Whereas the photoelectrons produced in the interior of a metal cause an unobservable change in its conductivity, the decrease in resistance of an insulator due to the presence of photoelectrons is readily detected. This phenomenon is referred to as photoconduction.

Typical insulating crystals, such as the alkali halides and the oxides of the light metals are quite transparent to visible and near ultraviolet radiation. Absorption by the electrons starts somewhere in the ultraviolet. The typical absorption spectrum begins with a series of overlapping bands which are absorption lines broadened by the interaction of the electrons with the vibrating ions of the crystal lattice. Following these bands and overlapping them is a region of continuous absorption resulting from the photoelectric production of free electrons. In this region of the spectrum the absorption is so large that the radiation penetrates only a thin layer of material as in a metal. Experiments with photoconduction are usually performed with radiation absorbed in the long wave-length tail of the first absorption band.

In this case one cannot predict unambiguously whether photoconduction will result.

The reason for this statement is that absorption in the bands which precede the region of continuous absorption does not lead directly to the production of a free electron in the interior of the solid.

The electron is raised by the absorbed quantum to an excited state in which it is still bound to the positive charge left on the atom from which the electron originated. The electron and positive "hole" are not bound to an individual atom of the crystal but may move as a pair throughout the volume of the solid. The movement of this pair, or exciton, as it has been called, cannot lead to a shift of electrical charge and photoconduction. The exciton may obtain sufficient energy from the vibrating ions of the lattice, however, to enable it to dissociate into a free electron and a free positive charge.

In an electric field they may then move in opposite directions giving rise to a photocurrent. The temperature of the crystal determines the average energy of the vibrating ions and it is to be expected that if photoconductivity occurs because of thermal dissociation of excitons, it will disappear at a sufficiently low temperature.

Absorption of radiation in the long wave-length tail of the absorption band of an alkali halide crystal such as sodium chloride does not produce photoconductivity. Presumably the excitons are not thermally dissociated. Under the same conditions, photoconductivity is produced in the silver and thallous halides. In this case the question has been raised as to whether the absorption is not due to foreign impurity atoms.

Large quantum yields, approaching one electron freed for each quantum absorbed, are quite common. In the region of true continuous absorption and the direct production of photoelectrons, the measured yield becomes small. In the cases of diamond and zinc sulfide the photoconductivity disappears entirely. The reason for this is not understood but may, in some cases, be due to the two following effects. When the absorption coefficient becomes large the reflectivity of the crystal surface becomes large. The major fraction of the radiation does not enter the crystal, an effect which has been commonly overlooked. In addition, since the radiation is absorbed in a very thin layer at the surface, the concentration of photoelectrons is large and recombination is promoted.

The fate of a photoelectron in a crystal is a matter of interest. Through collisions with the lattice ions it rapidly loses the energy gained from the absorbed quantum and comes into thermal equilibrium with the lattice. Finally, it will recombine with an atom which has lost an electron or will be trapped at an impurity atom, a crack, or other imperfection of the lattice.

It appears to be the rule rather than the exception that the photoelectrons in the interior of the crystal initiate secondary reactions. These may be of the most diverse types and have complicated enormously the study of the primary photoeffect. It is commonly observed that the primary photocurrent produces a more or less permanent decrease in the resistance of the crystal. In a few cases it has been possible to study this secondary current independently of the photocurrent proper.

The problem is further increased in complexity by the unavoidable presence of minute amounts of impurities. Concentrations of impurities of a few parts per 1,000,000 may determine completely the observed effects, either by acting as sources of photoelectrons or by trapping them and giving rise to secondary reactions.

An example of the last-mentioned effect is found in the silver halides. The formation of the latent image in photographic emulsions is the result of the production of photoelectrons in the interior of the small crystals of silver halide which are dispersed throughout the gelatin of the emulsion. The photoelectrons are trapped at specks of silver sulfide which are present as impurities on the surfaces of the crystals. The silver halide has a small number of positively charged silver ions wandering throughout the interstices of the crystal lattice and these are attracted to the trapped electrons.

The electrons and silver ions unite to form silver atoms. Submicroscopic clumps of silver atoms form the latent image which makes the silver salt susceptible to development by the proper chemical reagents.

Photoconductivity is a general property of semiconducting solids. Semiconductors have a feeble, temperature-dependent, electronic conductivity which disappears at low temperatures where they become good insulators. The photoconductive properties of selenium and cuprous oxide have been known and used for many years. The pure elements silicon and germanium are semiconductors that exhibit photoconductivity when exposed to radiation whose wave length is less than 1.2 microns (μ) and 2 μ, respectively. One micron equals 10,000 Å. These threshold wave lengths correspond to the onset of strong optical absorption by the elements. The semiconducting compounds lead sulfide, lead selenide and lead telluride are extraordinarily sensitive to near infrared radiation when properly prepared in the form of thin films. Lead sulfide films are formed by vacuum evaporation followed by sensitization with oxygen or by chemical deposition from solution. Lead sulfide is a useful photoconductor for wave lengths less than about four microns, while the threshold wave lengths of lead tel-

luride and lead selenide are near six microns and eight microns, respectively. Lead sulfide cells are commercially available and have numerous industrial and military applications. The military applications include not only infrared signaling but also the location of vehicles and personnel in the dark.

Trucks, tanks, ships, planes and missiles can be detected at long ranges by means of the infrared radiation emitted by heated parts or exhaust gases. Infrared radiation in the form of body heat of soldiers has been used in their detection at night. Infrared search systems offer better optical resolution and less susceptibility to enemy jamming than do radar systems.

Cadmium sulfide is commercially important for the manufacture of photographic light meters and similar devices because of its stable characteristics and high sensitivity to visible radiation.

3. Gases.—The photoelectric effect in gases is of particular interest because the ejection of an electron from a free atom represents the simplest photoelectric process. Unfortunately, experimentation in this field is very difficult. The work necessary for the removal of the most weakly bound electron from the atoms or molecules of the simple gases is large enough to place the photoelectric threshold in the neighbourhood of 1,000 Å. In this region of the spectrum there are available neither convenient high-intensity radiation sources nor simple optical instruments. Common difficulties are the emission of electrons from the walls of the reaction vessel by scattered radiation, and the occurrence of secondary chemical reactions which are induced by the primary photoelectric effect.

The photoelectric threshold frequency can be predicted very precisely from spectroscopic observations. Photoelectric emission of electrons from atoms or molecules which have been previously excited by absorption of a quantum frequently gives an apparent threshold at a lower frequency than the predicted one. While the available data are in qualitative agreement with the theoretical prediction that one electron is emitted for each quantum absorbed, a precision test of this point is lacking because of the experimental difficulties. (*See* also LUMINESCENCE.)

4. Photovoltaic Effects.—The photovoltaic effect consists in the generation of an electromotive force in a material on illumination. An electromotive force (e.m.f.) is the source of the electric field which produces a current in a closed circuit of conductors. The discovery of the phenomenon by Becquerel is mentioned in the *Historical Survey* section of this article. A similar effect was noted in 1876 by W. Adams and R. Day, who observed the generation of an e.m.f. on illumination of a junction of selenium and platinum.

The junctions of semiconductors and metals which exhibit a photovoltaic effect usually possess the property of being rectifiers. That is, the resistance of the junction depends upon the direction in which current is passed through the junction. Two of the most important junctions of this type are the selenium-metal junction and that between cuprous oxide and copper.

A theory of the photovoltaic effect at such junctions given by N. Mott appears to be at least qualitatively successful. In the case of the cuprous oxide unit there is a film, termed the blocking layer, of pure oxide of the order of a ten thousandth of a centimetre in thickness separating the copper and the impure bulk oxide.

The bulk oxide owes its semiconducting properties to the presence of an impurity which is an excess of oxygen. When radiation is absorbed in the oxide near the blocking layer, electrons are ejected from the oxide into the blocking layer. Within the blocking layer, there exists an electric field which drives the electrons to the metal. This results, in a closed circuit, in the production of a steady current. The field in the blocking layer exists because of the trapping of electrons from the copper by the impurities of the cuprous oxide, giving the oxide a negative charge with respect to the metal.

The cuprous oxide-copper photocell has a threshold in the neighbourhood of 14,000 Å and a maximum sensitivity near 6,000 Å. Another commercially important photovoltaic cell is that formed from the junction of a metal and selenium. Its characteristics are much like those of the cuprous oxide cell (*see* SELENIUM CELL). These cells are extremely convenient for many applications since they generate their own power and operate without the use of batteries or power supplies. The electromotive force generated by moderate illumination is sufficient to operate a low-resistance microammeter. Their stability is inferior to that of vacuum photocells. In addition, when amplification of the small e.m.f. is necessary it is an extremely difficult matter. The response to changes in illumination is slow so that the cells cannot be used for many applications.

The chief field of application is the qualitative detection of radiation and measurements where high precision is unnecessary, as in light meters for photographic work. In photometric work of this type, the fact that the relative sensitivity of these cells to light of different colours is similar to that of the human eye is of particular importance.

A photovoltaic effect is produced when radiation is absorbed near a P-N junction (*see* TRANSISTOR) in a semiconductor. Excellent photovoltaic cells have been constructed with silicon, germanium or indium antimonide as the semiconductor. The P-N junction is formed by adding to the pure semiconductor carefully selected impurities with the proper spatial distribution. Arsenic and boron are typical impurities used with silicon. The silicon crystal is prepared so that there is an abrupt transition from a region in which boron is the dominant impurity to an adjacent region in which arsenic is the dominant impurity. At the junction of the two regions there is a large electric field that accelerates free electrons produced by absorption of radiation. Silicon photovoltaic cells have an output voltage of approximately 0.5 and a threshold wave length near 1.2 μ. They are efficient converters of solar energy to electrical energy. Their conversion efficiency is about 10%, approximately half their theoretical efficiency. Silicon solar cells provided electrical power for a radio transmitter of the first U.S. earth satellite, launched March 17, 1958. The Mariner 2 probe used 10,700 solar cells to operate its instrumentation and transmit data a distance of 36,000,000 mi. to earth as it passed Venus on Dec. 14, 1962.

P–N junctions in germanium are used to make photodiodes and phototransistors which (because of their fast response, high sensitivity and tiny size) have important applications for the automatic control of machinery, the sorting and counting of manufactured articles and the operation of high-speed computers.

IV. APPLICATIONS OF THE PHOTOELECTRIC EFFECT

The applications of the photoelectric effect are numerous and diverse. The ionization chamber which has been described is a standard instrument for the determination of X- and γ-ray intensities. The determination of X-ray dosage in medical therapeutic work is performed in this manner.

The photoelectric cell illustrated in fig. 5 (A) makes use of the emission from a metal surface. Frequently the metal surface is present in the form of a thin film which is deposited upon a portion of the inner surface of the glass envelope. The photoelectrons are drawn to the collector by an electric field and the resulting electric current measured with a galvanometer. Some photocells are not evacuated but are filled with a relatively inactive gas such as argon. The photoelectrons on being accelerated to the collector dislodge electrons from the argon atoms. In this manner the total current set up in the photocell may be 10 to 100 times the initial photocurrent. Since the photoelectric cell is inherently a high-resistance device, it is adapted for use with vacuum tube amplifying circuits. This is fortunate since the maximum current ob-

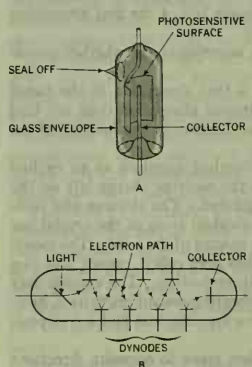


FIG. 5.—(A) PHOTOCELL. (B) DIAGRAMMATIC SKETCH OF PHOTOMULTIPLIER TUBE

tainable from a typical photocell is only of the order of a microampere.

To avoid the use of amplifying circuits the photomultiplier tube has been developed. This tube is illustrated in fig. 5 (B). In this device the photoelectrons are accelerated to the first of a set of auxiliary electrodes called the dynodes. The surfaces of the dynodes have the property of liberating several electrons for each electron which strikes them. In this manner the initial photocurrent is amplified as it passes from dynode to dynode. Such a device may have as many as ten dynodes and the current to the collector may be 100,000 times the primary photocurrent. The photomultiplier tube is manufactured in a size no larger than the ordinary photocell.

The scintillation counter is a device for the detection of γ rays or high-energy nuclear particles. A γ-ray photon or particle strikes a luminescent crystal and produces a brief flash of luminescence. A typical crystal is sodium iodide containing a trace of thallium as impurity. The photons of the luminescent radiation strike the cathode of a photomultiplier tube and eject photoelectrons that are amplified by the tube. If, as is commonly the case, the nuclear particle loses all its energy within the luminescent crystal, the number of luminescent photons and the magnitude of the output pulse of charge from the photomultiplier are a measure of the energy of the particle. The scintillation counter not only can detect and measure the energy of individual nuclear particles and γ-ray photons but does so in an incredibly short time. The speed of response of the counter is usually less than a microsecond and with crystals such as trans-stilbene may be as short as 0.006 microseconds.

The fundamental use of a photocell is to convert a change in the intensity of the incident radiation into a change in an electric current. This change in electric current may then be used to operate control or measuring devices. For example, a person approaching a doorway may interrupt a light beam which is incident upon a photocell. The abrupt decrease in photocurrent may be used to start a motor which opens the door or rings an alarm. The variations upon this usage are endless. In the manufacture or processing of materials photocells are used to detect imperfect articles and to actuate mechanisms which reject them. The speed and accuracy of such control is far greater than possible with a human operator.

In the production of sound motion pictures, a strip of variable density upon the photographic film is converted by a beam of light and a photocell into a fluctuating electric current which after amplification operates the loud-speakers. (*See* MOTION PICTURES.)

In television production the photoelectric effect is used to convert the light reflected from the object to be televised into an electric current. The electric current is reconverted by the radio transmitter into the long wave-length radiation termed radio waves. These are picked up by the receiver, transformed into electrical impulses and finally appear as a picture upon the fluorescent screen of a cathode-ray tube. (*See* TELEVISION.)

In scientific work photocells are used whenever it is desired to measure the intensity of a light beam with precision. They are, therefore, much used in the construction of photometric instruments. (*See* PHOTOMETRY.)

Finally, it should be noted that the photographic film, whose importance need not be reviewed, owes its light-sensitive properties to the production of photoelectrons by light in the interior of the silver halide crystals of the emulsion (*see* PHOTOGRAPHY).

V. NUCLEAR PHOTOEFFECTS

J. Chadwick and M. Goldhaber discovered in 1934 that the deuteron, the nucleus of the deuterium atom, will absorb a γ-ray quantum and disintegrate. The disintegration products are a proton and a neutron. The proton is the nucleus of the hydrogen atom of which deuterium is an isotope. The neutron is an uncharged particle of approximately the same mass as the proton. A minimum quantum energy of 2,170,000 ev (2.17 Mev) is necessary to produce the photoelectric disintegration of the deuteron. The nuclei of many other atoms have been shown to exhibit a similar reaction. In all cases the photoelectric effect results in the ejection of a neutron.

A second important nuclear photoeffect is pair production. A γ-ray quantum in traversing the neighbourhood of a nucleus may be annihilated and a positive and a negative electron created. This is a direct conversion of radiant energy into matter in which energy and mass are related by an equation due to Einstein:

$$E = mc^2, \qquad (4)$$

where E represents the energy converted into the mass m, and c is the velocity of light. With m taken as the sum of the masses of the positive and negative electrons, the minimum quantum energy E which is necessary for pair production is calculated as 1,020,000 ev. A quantum of greater energy will impart kinetic energy to the created electrons. This process is one of the most important mechanisms by which high-energy quanta interact with matter. The positive electron is unstable and soon after its creation combines with a negative electron, the pair being annihilated with the creation of one or two γ-ray quanta.

The γ-ray photons whose energy exceeds 150 Mev interact with protons and neutrons to create positively charged (π^+), negatively charged (π^-) and neutral (π^0) mesons. The charged π mesons have the same charge as that of an electron but have a mass that is 273 times that of the electron mass. They are unstable particles that decay into μ mesons and neutrinos with a lifetime of 2.6×10^{-8} seconds. The neutral π meson has a mass that is 264 times the electron mass and disintegrates into a pair of γ-ray photons in about 10^{-15} seconds.

The interaction of a γ-ray photon with a proton may either transform the proton into a neutron with the creation of a π^+ meson or create a neutral π^0 meson and leave the proton unchanged. Similarly, the interaction of a γ-ray photon with a neutron may produce a proton and a π^- meson or create a π^0 meson without transformation of the neutron into another particle.

Pairs of π mesons and of μ mesons are also created by the interaction of γ-ray photons of sufficient energy with nuclear particles. Since it is believed that mesons are responsible for the forces between nuclear particles, they are the subject of intensive research.

See ATOM; NUCLEUS; *see* also references under "Photoelectricity" in the Index.

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(R. J. MR.)

PHOTOENGRAVING, the photomechanical procedures by which an illustration with a relief printing surface is produced for use in the letterpress printing process. Although the term was originally applied exclusively to etched metal printing plates on which an image was obtained by photomechanical methods, photoengraving has come to be applied broadly to the making of letterpress relief printing surfaces in zinc, magnesium, and copper or in plastic or photopolymeric materials (photosensitive plastics), and to printing plates made by one of the electromechanical platemaking machines. Many of the physical and optical bases for photoengraving are identical with those employed in the offset lithographic or gravure platemaking operations. (*See* also PRINTING; LITHOGRAPHY; GRAVURE.) This article is arranged in the following sections:

I. Historical Development
  1. Halftone Screens
  2. Special Effects
  3. Process Developments
II. Modern Engraving Techniques
  A. Basic Production Processes
    1. Camera and Darkroom Equipment
    2. Plate Coating and Printing
    3. Etching and Finishing
    4. Blocking and Proofing

B. Colour Plate Production
1. Colour Separation
2. Elimination of Moiré
3. Colour Scanners
C. Production Specifications
1. Line Plates
2. Halftone Specifications
3. Combination Line and Halftone Plates

I. HISTORICAL DEVELOPMENT

The use of illustrations is as old as printed and written text. Photoengraving is the oldest of the engraving techniques employing photomechanical methods, since the printing process it serves, letterpress, was in existence for more than 300 years before other processes were developed.

Although printed illustrations appeared as early as the 15th century, the first engraving made by the action of light on a photosensitive plate is reported to have been that of Joseph Niepce (1826), a Frenchman, who coated a metal plate (either pewter or copper) with photosensitive asphalt, and under bright sunlight printed the image of Cardinal Georges d'Amboise from an etching which he used as a positive image. He then developed and etched a relief image on the metal surface. Niepce's discovery may have been of historical importance, but it did not bring an immediate use of photoengravings for printed images. Many other experimenters in Europe and the United States made further attempts at producing engravings, but the origin of the modern engraving process rested in the discovery by Mungo Ponton (1839) of the light sensitivity of chromium salts. However, Ponton was not an engraver and apparently was not interested in this field. The work of Firmin Gillot in Paris appears to have given the greatest impetus to engraving on zinc, although none of the early experimenters employed photography to produce the printing surfaces. In fact, much of the work antedated photography.

The discovery of the wet-collodion process for photography provided the means for producing the photographic negative as the basic element in photoengraving. Frederick Scott Archer introduced this process about 1850. The technique also provided a method of stripping or removing the image from the glass photographic plate. The wet-collodion process was used extensively by process photoengravers until the introduction of commercially coated stripping film in the 1930s. Thereafter, its use gradually declined because of the greater convenience and lower cost of the ready-made stripping films.

W. H. Fox Talbot, in England, appears to have been responsible for the direct application of the dichromated colloid to photoengraving (1852). He was interested in gravure images, but he learned of the light-hardening effect of dichromated gelatin in this work, and use of this information in other applications followed naturally.

It was obvious to Talbot and other experimenters that, if the reproduction process was to succeed, a means of breaking up the continuous-tone images in photographs or drawings, and reproducing them in quarter, half, and three-quarter tones, had to be found. Since the letterpress printing machine provides a uniform coating of ink on the printing surfaces, no provision can be made for reproducing intermediate tones between black and white in an illustration by varying the thickness of the ink film laid down by the press. Therefore, some other means of producing this effect had to be found. The answer, of course, lay in the halftone process, in which grays are obtained by varying the size of halftone dots and thus controlling the amount of ink laid down in a given area. However, as in the case of so many developments, credit for the invention of the halftone technique cannot be attributed to any individual; the work was evolutionary.

A single-direction line screen in which parallel lines were scratched in an opaque background is described in a French patent of 1857. As early as 1869, William A. Leggo, a Canadian, produced an image with a crossline halftone in the *Canadian Illustrated News*. Later, in 1882, Georg Meisenbach, using a single-direction screen, produced a crossline halftone by making half the exposure with the screen in one position and half with the screen rotated 90°.

Frederic E. Ives, who in 1885 prepared a mechanically ruled crossline screen on film, was responsible for the optical explanation that led to modern screens. There were others who made screens by various means, but the brothers Max and Louis Levy (1893) were the first to succeed in producing commercial grades of screens. The Levy brothers coated selected plates of high-quality optical glass with an etch-resistant base in which parallel lines were cut by a ruling machine. The ruled lines were etched with hydrofluoric acid and filled with an opaque material, after which they appeared in sharp contrast with the unetched glass. Two ruled glass plates were then cemented face to face with the lines at 90°, sealed, and bound in a metal frame.

1. Halftone Screens.—In principle, at least, there has been no significant change in the making of glass halftone screens from the methods used by the Levy brothers. Other screen patterns, such as the grainlike mezzograph screen, have been tried but none has produced such consistently good results as the halftone process. Halftone screens may be obtained with line frequencies of from 40 to 400 lines per inch. The coarser screens are used for illustrations printed on rough papers and the finer ones for illustrations of higher quality on high-finish and coated papers. The 50-, 60-, 65-, and sometimes 85-line halftones are generally used in newspaper reproduction, while 100-, 110-, and 120-line halftones are suitable for supercalendered papers and for the text papers used in some magazines; they find wide application for single-colour illustrations and for some multicolour work on these papers. The 120-, 133-, and 150-line halftones are usually used for colour illustrations in magazines and books printed on coated papers where picture detail is important. The 175- and 200-line photoengravings are seldom used because of the difficulties in keeping ink from filling in the plates during the press run. These fine rulings do, however, find some application in offset lithographic printing.

Although the production of glass screens has not changed greatly since the initial work of the Levys, there have been many other changes in the application of the halftone screen to photoengraving. Among the most important was the introduction of the contact screen. This is a film material containing an image of the pattern produced by a glass halftone screen. In use, it is held in contact at the focal plane of the camera or enlarger, directly over the film onto which the image is printed, and the exposure is made while contact is maintained. This eliminates certain diffraction effects inherent in glass screens, frees the operator from some of the lens diaphragm restrictions imposed by glass screens, and eliminates the necessity that lens opening, screen distance from the focal plane, and screen ruling be in proper relationship.

Contact screens are made with a silver (gray) screen image and with a magenta dye image; the dyed screen gives some additional control over halftone negative quality through the use of colour filters on the camera.

2. Special Effects.—Such techniques as dropping out the highlights from the halftone negative (*i.e.*, eliminating the dots in these areas) in order to achieve increased contrast in illustrations were studied and introduced by several individuals. F. J. M. Garland patented such a method in 1883, and in 1925 Laurent Bassani introduced a camera attachment that made it possible to impart a slight motion to the image on the film and thus reduce exposure to the point where small highlight halftone dots were not printed or developed. However, the most successful of the highlighting methods were those employing fluorescence phenomena. Walter Marx in 1938 patented his fluorographic process, in which fluorescing materials were incorporated in the artist's pigments. Alexander Murray patented similar pigments in 1935 and 1938 designed for colour correction in water-colour illustrations. The Kemart process, introduced shortly thereafter, utilized a fluorescing paper board. All of these processes were based on the same procedure: making an exposure under normal lighting for over-all reproduction, and then making an additional correcting exposure under ultraviolet light. The fluorescence produced by the ultraviolet illumination provided additional exposure in the affected areas that gave the necessary correction for highlighting or colour correction.

3. Process Developments.—The discovery of the halftone

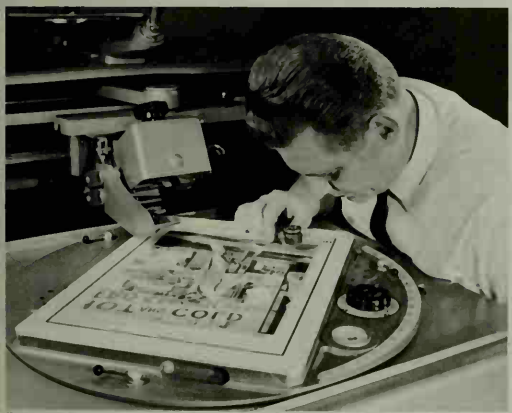
In producing a photo-engraving plate, the subject is first photographed through a halftone screen so that the image is divided into a great number of small "dots." Here the cameraman is positioning copy in a pressure frame that will be tilted so that the copy is held vertically when it is photographed by the process camera in the background

PLATE MAKING

An engraver adjusts an exposed plate in an etching machine holder. The plate will then be splashed with an etching bath. The modern technique of etching produces good plates without the use of dragon's blood etching powder, once generally used to prevent undercutting the printing surface

A power router is used to cut out nonprinting areas of the plate. The router does not disturb fine edges already cut by hand tooling

To make colour proofs, the finished yellow, red, blue and black plates are placed on a high-speed power proof press which prints the four colours "wet" in rapid succession



The halftone plate is inspected to determine if the plate has been etched to the proper depth. If the depth is too little, the space around the dots will fill up with ink during printing. This plate is shown on an engraving machine called the Vario-Klischograph, which can be adjusted to enlarge or reduce the copy and to select a variety of halftone screens. This machine eliminates camera work, etching and hand finishing

The PDI scanner, an electronic machine made by Printing Developments, Inc., a subsidiary of Time, Inc., makes colour-separation negatives from a colour transparency in one operation. Here the operator inserts a photographic transparency of a colour subject into the scanner

PHOTOGRAPHED ESPECIALLY FOR ENCYCLOPÆDIA BRITANNICA, INC.

PHOTOENGRAVING

COLOUR PRINTING BY FOUR COLOUR PROCESS

PHOTOGRAPH, ENAT FROM THREE LIONS

Reproduction of a painting, a photographic transparency or such subjects as wood grain and fabric is accomplished by the halftone colour process—a photomechanical technique which has replaced tedious and expensive hand engraving. The reproduction may be either larger or smaller than the original. The first step in making four-colour printing plates from the Ektachrome transparency at left above is to make colour-separation negatives by means of colour filters on the camera, as indicated in the diagram. When the transparency is photographed through a blue-violet filter, only the complementary colour—yellow—is reproduced in the negative. Green, orange-red and pale yellow filters are used to photograph the images of the red, blue and black values in the transparency. When printing plates (metal positives) are made from the photographically-produced separation negatives, each contains the image of the single colour it represents. The plates are printed in the sequence shown (top to bottom) above. The final black "key plate" provides sharp detail

screen was primarily responsible for the development and growth of photoengraving, and this growth was directly affected by other developments related to the printing industry. The introduction of the first practical colour film for amateur and professional use, Kodachrome, in 1935 probably did more to accelerate printing developments than any single invention. It made a colour studio out of the entire world and greatly increased the use of coloured illustrations. At approximately the same time, the commercial production of on-the-machine coated paper and heat-drying printing inks for letterpress printing began. Many colour developments related to films, printing processes, and materials followed.

Electrolytic and Powderless Etching.—Although the etching of metals by chemicals was the obvious method of producing printing plates, Henry Mawicke of Chicago was among the first (1912) to apply the electrolytic principle, utilizing the plate being etched as the anode in an electrolytic bath. The electrolytic etching machine is still used for specialty work, but it never found widespread acceptance.

Early methods of etching zinc and copper—methods that are still in use in many areas—were tedious, inexact, and could be learned only by trial-and-error training. The principal difficulty lay in achieving sufficient vertical etching depth without encountering undue lateral etching, which would undercut the edges of the halftone dots and lead to their collapse on the printing press. Some success in overcoming this problem was achieved through "powdering," in which an etch-resistant resin was deposited around the sides of the dots, permitting further etching in depth. The method did not, however, give consistently satisfactory results. A major step toward solving the problem—in fact, the most important development in the field of etching since photoengraving was invented—came in the Dow-Etch method, a means of etching a magnesium plate without the use of powder, introduced in the U.S. by the Dow Chemical Company. Experimenters found that by adding an oily material and a surface-active (wetting) agent to the nitric acid bath, and controlling the conditions under which the plate was etched, they could produce characters in relief with adequate etching depth and virtually no printing area loss during the etching. The process was later adapted to the etching of zinc, and was quickly adopted by engravers in all parts of the world.

With this major hurdle overcome in the etching of zinc and magnesium, attention turned to copper. Rexford Jones, working for a group of photoengravers carrying on developments under the name Photoengravers' Research Institute, found that a powderless etching process for copper was possible when thiourea was added to the iron chloride etching bath. He obtained a patent in 1956. His work was followed by further refinements in the process and the introduction of new compounds to add to the etching bath.

Electromechanical Platemaking.—While these developments in chemical etching were taking place, other experiments were conducted to assess the feasibility of replacing traditional methods with the techniques of electronics, optics, and mechanics. The first successful result of these efforts was the Scan-A-Graver, introduced in 1947, which optically scanned a picture and simultaneously reproduced it as a relief printing plate on a plastic sheet. The Scan-A-Graver found wide application, particularly in newspaper plants where photoengraving procedures were time-consuming and therefore costly. Within a short time, machines were developed that were capable of making etched plates in metals.

Meanwhile, investigators at the du Pont laboratories in the U.S. discovered about 1950 that some methacrylate compounds could be quickly polymerized by exposure to light. Nylon was also found to have photosensitive properties, and by 1958 both materials were being offered for use in printing plates.

Wraparound Plates.—A significant improvement in letterpress printing techniques came with the development of the wraparound plate, a thin metal or plastic sheet on which an entire printing form is photoprinted and etched. In appearance and in use the wraparound plate is much like an offset lithographic plate. Because it permitted letterpress printing with a relatively inexpensive but high-speed rotary press, the wraparound plate was particularly advantageous for smaller printing plants, which previously had to rely on slower flat-bed presses for letterpress work.

The term wraparound is generally associated with the thinner flexible metal or plastic-coated metal plates affixed to the press cylinder by clamping devices. A second type of photoengraved printing plate is prepared by etching an image on heavier precurved materials, varying in size from single page forms to several pages on a single plate.

Wraparound plates require an etching depth of approximately 0.01 to 0.015 in. on plate material 0.025 in. in thickness. The precurved printing plates have thicknesses of 0.032 to 0.040 in. and etching depths up to 0.020 in. Rigid plates are affixed to press cylinders by small clips. Therefore, plates of this thickness, as well as some wraparound plates, are completely engraved in curved form, a procedure that also insures accurate colour register and image length.

II. MODERN ENGRAVING TECHNIQUES

Plates made by the photoengraving process are all relief letterpress printing plates, but they may be further classified into groups on the basis of the materials from which they are made or the types of images they are to reproduce. Photoengravers classify them as zinc, magnesium, copper, or plastic plates; the plastic plates may be those produced either from the photopolymeric plastics or by one of the electromechanical engraving machines.

Buyers of printing commonly classify engravings in terms of cost, and such a grouping includes, in ascending order of costs: line engravings, halftone engravings, combination line and halftone engravings, single-colour, two-colour, and duotone engravings, and process colour plates. Each of these types may be produced in any of the customary metals or plastics. Process colour plates are usually made of copper in the U.S. and U.K., and of zinc elsewhere.

A. Basic Production Processes

The essential operations for the production of all types of photoengravings are similar. They include photography, photomechanical operations, etching, finishing, routing, blocking, and proofing.

1. Camera and Darkroom Equipment.—The engraver's camera, called a process camera, is a rigidly built machine designed to allow precise positioning of the lens and copyboard so as to provide control over the enlargement or reduction in size of the copy. It has a colour-corrected lens designed to give the sharpest possible image when focused on a plane surface, without the distortions commonly found (though usually unnoticed) in the average portrait or amateur camera lens. Process cameras are designated as gallery or darkroom types. The gallery camera may be installed in any convenient location, but all film must be removed in a light-tight cassette and processed in a separate darkroom. The darkroom camera is installed with its film holder as an integral part of the darkroom wall, giving easy access to the darkroom facilities.

Virtually all photographic work is done on film coated with high-contrast emulsions especially developed for graphic arts work. The introduction of dimensionally stable film bases has nearly eliminated the use of glass plates. The film emulsions used for halftones are of the "lith" type, giving the extremely high contrast needed for halftone or line reproduction. Stripping film, a laminar film with a soft adhesive layer between the base film and the emulsion layer, is widely used to permit images to be removed from the base film and properly oriented on the glass or film flat through which the metal plate will be exposed.

2. Plate Coating and Printing.—Photomechanical operations include cleaning the metal plate surfaces, coating them with a light-sensitive solution, drying the coating (known as the top or enamel), and making the exposure on this coating through the negative prepared in the earlier photographic step. Care is required throughout these operations to prevent imperfections such as bubbles, dirt, or scratches in the light-sensitive coating. The zinc, magnesium, or copper is prepared for coating by a careful cleaning with pumice and water. The light-sensitive coatings are usually poured over the surface and then the plate, held flat, is whirled to insure uniform coverage by the solution.

The light-sensitive coatings are usually a dichromated colloid

material, but light-sensitive resins are also used. The most common are called hot top and cold top enamels. Cold top enamels are used on zinc and magnesium, which cannot be heated because of their low recrystallizing temperatures. They are usually slightly alkaline solutions of shellac or polyvinyl alcohol to which a dichromate is added. Hot top enamels nearly always contain fish glue, as well as some egg albumin, to which is added a dichromate sensitizer. The mixtures of glue and albumin are used when it is necessary to control the etch-resistance and the ease with which the edges of the enamel break away during the etching process. Hot top enamels must be set at temperatures of 400°–600° F and therefore are used mainly on copper.

The tops are high-contrast materials that, when exposed to strong light, harden where the light strikes them and lose their solubility in water. Development in water then removes the coating from the unwanted areas of metal, exposing the metal to the etchant in the etching process. Photosensitive resinous materials find wide application in electronic circuit printing, an operation analogous to photoengraving (*see* PRINTED CIRCUIT). They have more limited applications in the making of photoengraved letterpress plates. These resinous materials are developed in organic solvents.

3. Etching and Finishing.—Nitric acid is commonly used in etching zinc and magnesium, the strength varying from 6 to 15% depending on the metal. Copper is attacked by some acids, but it is more readily attacked by ferric chloride (iron chloride) and this is the most common material used in photoengraving, usually in concentrations of 30° to 44° Baumé.

The etching may be done in an open tub or tray, but this method does not give the control needed for economical operation and is employed only where control is not critical. Most quality work is carried out in etching machines provided with agitators that break up the etchant into a spray and force it against the plate.

In the conventional etching processes, the acid or iron chloride is used without modification, although great care is needed to prevent overetching. In many cases, especially when making line plates, the etcher resorts to powdering to protect the upper printing areas from attack while he continues to etch in depth, but it is becoming more common to etch these plates by one of the powderless etching processes described earlier. Line plates are usually etched to depths of 0.010 to 0.045 in. Halftones may be etched to depths of 0.0023 to 0.009 in. depending on the fineness of the screen. Coarser screens are etched deeper.

The photosensitive plastic plates are not etched in the ordinary sense. They are washed out with either dilute alkali or alcohol. Overetching is not a problem with this type of plate.

Finishing includes hand operations to remove imperfections in the image area of the plate, and to improve its outward appearance. In colour plates, finishing also includes colour correction, a process of further etching or burnishing selected areas to improve fidelity of reproduction. Finally, unwanted metal in the nonprinting areas of the plate is removed by a mechanical routing machine.

4. Blocking and Proofing.—Blocking consists in adhering the plates to cherry-wood blocks to bring the printing surface to type height, 0.918 in. Until the development of thermoplastic adhesives in the 1940s, blocking was always done by nailing the plates to the wood blocks. This tedious and costly operation was largely replaced by hot-mounting of the metal plate. First the plate is placed on a block of wood precoated with adhesive and then this sandwich is subjected to heat and pressure. Upon cooling, the plate sticks firmly to the block without need for nails.

Proofing consists in placing the plates on a precision press and taking sample impressions or proofs that will show how the plates will print during a regular press run.

B. Colour Plate Production

The first colour work in printed matter was produced manually —artists painted in the necessary colours on the black-and-white printed sheets. Later, stencils were used to speed this work and, in a further development, colours were printed—either as solids or tints—from hand-engraved plates. All of this work, however, was crude by modern standards, and nothing approaching four-colour process printing was possible.

Modern colour printing, done with either three or four plates, each using a different colour of ink and overprinting the others, is based on the subtractive system of colours; *i.e.*, any intermediate hue can be obtained by some combination of two or more of the subtractive or secondary colours. The best colour printing is usually done with four colours: yellow, magenta (blue-red), cyan (blue-green), and black. The black plate is used to provide added uniformity of colour rendition and to maintain the detail in the picture. In theory, black should result whenever the three subtractive colours are superimposed. Thus, it should be possible to produce black wherever all three of the secondary colours are present without affecting reproduction. Further, any reproduction theoretically could be obtained by using only black plus the proper two of the secondary colours. However, this has not been found practical because of the nature of printing ink pigments and the lack of complete precision in the printing operation. Consequently, it is common practice to use the black plate to supplement the colour plates, portions of which are allowed to print in all except pure white areas of an illustration. The colour plates and the black plate must be printed in register; *i.e.*, they must be superimposed so that identical portions of the image in each plate colour overprint each other.

1. Colour Separation.—In manufacture, the production of an individual colour plate involves the same steps used to produce an ordinary black-and-white engraving, once the image is printed on the metal. Prior to this, the only differences lie in the use of colour filters on the engraver's camera and in steps to reduce the contrast range of the copy (the contrast range of a photographic transparency may be as great as 300:1, while limitations in the printing process reduce the attainable range with paper and ink to about 20:1). The camera filters are the red, green, and blue filters for the colour negatives, and the yellow filter for the black negative. The blue filter produces the yellow negative, the green filter the magenta negative, and the red filter the cyan negative. Masking procedures such as those employed in other forms of colour print reproduction are followed to remove yellow values and magenta values from the blue and red negatives and thus correct for deficiencies in the printing inks and in the colours of the copy.

Colour plates are made by two general methods, the indirect and direct. The indirect method produces continuous-tone negative separations from which positive continuous-tone separations are prepared. These are film or plate transparencies. After the masking and other tone correction work has been done on them, the positive image is placed in a process camera with a halftone screen, and the screen negatives are produced. In the direct method, the screen negatives are prepared direct from the copy through the colour separation filters and a halftone screen onto a high-contrast panchromatic film or plate to produce a negative ready for transfer to the metal plate.

The proofing of halftone colour plates for wet printing on high-speed presses (when one colour does not have time to dry before the next is laid down) is a critical operation, for the proofing must be carried out under conditions simulating as closely as possible those that will be encountered on the production press. Specially built proof presses make this possible. In appearance they resemble four conventional units placed end to end, and the sheet of paper is passed in turn over the four plates. However, because the production press employs not the original flat plates but curved duplicates made from them, and because ink and paper specifications are highly variable, exact duplication of production results in a proofing operation is difficult.

2. Elimination of Moiré.—A serious problem in colour reproduction is the occurrence of an interference pattern or moiré caused by the overprinting of the screens in the colour plates (a similar effect can be obtained by superimposing two pieces of window screening or fine net cloth). Because it is impossible to maintain printing register within the degree necessary to avoid such an effect, it is common practice to rotate the halftone screen when making the negatives so that each of the four plates has its

screen pattern in a different position. The screens are placed so as to provide maximum separation in rotation between the black, magenta, and cyan screen angles, with the yellow screen positioned between two of the least troublesome colours. For example, the yellow screen may be set at 90°, the magenta at 105°, black at 45°, and cyan at 75°; here it will be noted that the lightest colour, yellow, is at the angle of maximum disturbance to the eye and the darkest colour, black, is at the angle of minimum disturbance. In three-colour reproduction, when black is not used, the cyan screen would generally be placed at the 45° angle.

A moiré pattern may also occur during wet colour printing if the inks are not performing properly. One expedient used to avoid this is to make the yellow plate with one screen ruling and the rest of the plates at another ruling; *e.g.*, the yellow plate with a 133-line screen and the magenta, black, and cyan plates with 120-line screens.

3. Colour Scanners.—Paralleling the development of the electromechanical engraving machine, experimenters in the U.S. and Europe produced several machines that automatically made corrected colour-separation negatives. In one of these, developed for Time, Inc., in the U.S., a photographic transparency wrapped around a transparent cylinder was scanned by a beam of light which then passed through a colour splitter and into a bank of photoelectric cells. Energy from these cells activated lamps that produced the colour-separation negatives on another drum attached to the same shaft.

C. Production Specifications

1. Line Plates.—In line illustrations all of the image areas are either black or white, and hence no halftone screen is required to copy them for use in making a printing plate. The negative is suitable as it comes from the camera to transfer the line image onto the metal.

Plate preparation, coating, burning-in, etching, and finishing are essentially the same as for halftone plates. However, certain specifications must be met. The nonprinting areas must be etched sufficiently deep to prevent the ink rollers from touching them on the press, and to prevent them from rubbing on the surface of colour sheets during wet colour printing. For presses with accurately adjustable ink rollers, the etch depth may be as little as 0.01 in., and the same depth is permissible in thin, wraparound press plates. For conventional printing presses, the minimum etch depth is about 0.02 in. Plates that are to be duplicated by electrotype or stereotype processes may require slightly greater depths, although normal etching ordinarily is sufficient to produce good duplicates. Plates from which rubber duplicates are to be made will require etch depths as great as 0.045 in.

2. Halftone Specifications.—Etch depths in halftone plates need not be as great as those in line plates, but the contour of the halftone dot and the depth of the etched areas are very important. Etch depth in highlight areas, the most critical portions of halftones, varies from 0.006 in. in a 65-line halftone to 0.002 in. in a 133-line engraving.

3. Combination Line and Halftone Plates.—These plates must be prepared by assembling, in the negative form, the halftone and the line portions of the illustration, and then, after transferring them onto the metal, etching them in two operations so as to attain the best results for both portions. Some workers have been successful in simultaneous etching of both parts of combination plates, but these are special cases and usually require a high degree of skill. However, the powderless etching processes permit easier etching of coarse-screen combination plates for use in newspapers. Combination line and halftone plates may also be produced by making two plates in separate operations and mounting them on a single block in proper position with respect to each other.

See also references under "Photoengraving" in the Index.

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PHOTOGRAMMETRY is the use of photographs for measurements to be applied in such fields as map making and surveying (*see* Geodesy). In 1851 the Frenchman Aimé Laussedat first compiled map data based on measurements from photographs. Handicapped by the narrow field and imperfections of the photographic lenses of his time, Laussedat (known as the father of photogrammetry) and other workers made little practical progress.

Nearly 50 years after Laussedat's original conception of photogrammetry the first practical work was done by E. Deville, a Canadian who constructed maps by plotting intersections from phototheodolite pictures (*i.e.*, those taken from tripods on the ground). Deville also invented a simple machine for drawing maps from a stereoscopic pair of pictures. In the 20th century progress in photogrammetry was much more rapid. Practically all the development prior to World War I contemplated the use of apparatus for automatic plotting from phototheodolite pictures. Many machines of European origin were made for this purpose; these use a pair of pictures taken from the extremities of a measured base line. They mechanically plot the intersection of the light rays that formed the common images of the two pictures.

This terrestrial method was very successful and economical, especially in such mountainous regions as the Alps and in Alaska where the steep terrain afforded camera stations overlooking an extensive area. But photogrammetry changed abruptly with the introduction of practical aerial photography in World War I. The airplane afforded a superlative camera platform and flew rapidly from one exposure station to the next. Large areas could be covered in a single overlapping pair of photographs and blind areas (a serious handicap in the terrestrial method) were minimized.

Aerial photography also produced complications; in terrestrial work the length of the base subtending the two pictures is known, but not so in aerial photography. Other unknowns in aerial photography are the precise elevation from which the pictures are taken, and, especially, the difference in elevation between an overlapping pair of pictures and the angle of inclination of the camera at the instant of exposure. The stereoscopic plotting machines developed for terrestrial photography were replaced by universal plotting machines that used terrestrial or aerial photographs, and dominated most of the period between World Wars I and II. By 1945 terrestrial photogrammetry was used very little. Even large-scale maps of dam sites (for example, at 1:240) were produced by aerial methods. The quality was excellent, and the method proved economical. Emerging from World War II were aerial stereophotogrammetric processes, mosaics, and a once widely used reconnaissance mapping technique, the Tri-Metrogon system.

Ordinary aerial photographs have a wide variety of uses aside from photogrammetry; the airview (oblique photograph) employed for many illustrative purposes is the simplest and most widely understood application of aerial photography. Uncorrected vertical contact prints are extensively used, especially in petroleum geology. Hundreds of thousands of square miles of territory have been photographed for this purpose, to produce complete sets of stereoscopic, overlapping, vertical prints; usually with an index map that relates each print to the survey as a whole.

GEOMETRY OF THE PICTURE

Early users of aerial photography discovered that a picture taken with the camera axis vertical was truly a map only if the ground was flat and horizontal. Aerial pictures in those days were said to be distorted, partly from defects in the lenses used. The major trouble, however, was displacement; *i.e.*, the picture was a conic projection. Thus, vertical objects (such as telegraph poles) not at the exact centre of the picture appeared as radial images with base toward the centre and top displaced outward (fig. 1 and 2, *see* next page). The picture is a perspective with all vertical lines disappearing at a vanishing point at the centre. If there is a hill the same height as the pole (fig. 1), the top of the hill also will be displaced. However, since these displacements lie along radial lines, the angle subtended by any two images at the centre (the nadir point of the picture) is a true angle. Thus while this displacement is troublesome in trying to use an uncorrected contact print of mountainous terrain, it is the essence of photogrammetry. Actually photogrammetry measures this displacement, and all elevation data are derived from these measurements.

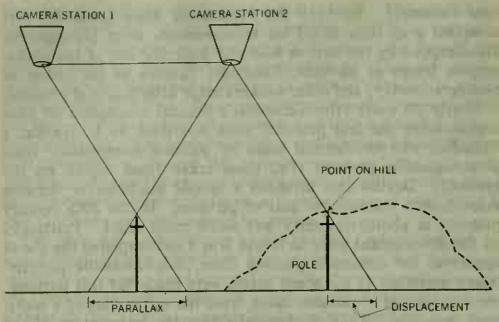

FIG. 1.—DISPLACEMENT IN OVERLAPPING PHOTOGRAPHS BECAUSE OF DIFFERENCE IN OBJECT HEIGHT AND PARALLAX (DISTANCE BETWEEN DISPLACED POINTS MEASURED PARALLEL TO AIR BASE)

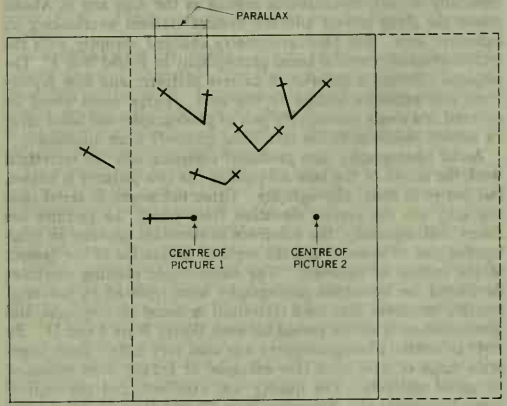

FIG. 2.—RADIAL IMAGES OF POLES OF SAME HEIGHT. PARALLAX THE SAME FOR THE SAME ELEVATION

The simplest form of stereoscopic plotting instrument measures the so-called parallax of the picture; *i.e.*, the measured difference between conjugate image points of objects at different elevations. Thus, if the two overlapping images of the base of a pole are placed in registry the images of the tops will be in two radially disposed positions. Their separation, measured parallel to a line connecting the picture centres, is the parallax of the top of the pole in relation to the base (fig. 2).

SYSTEMS OF CONTROL

All photogrammetric processes depend on ground control or office control. In ground control, positions or elevations (or both) are established independently of the aerial photography and the laboratory. Most ground control is by conventional survey on the ground, the most common methods being astronomical determination of position, triangulation, traverse and leveling (either by spirit level or trigonometric leveling), or radar (*q.v.*). Office operations are done in the laboratory by radial control methods, aerial triangulation, and mathematical solution.

Radar Control.—Horizontal and vertical radar control were in general use before the 1960s. Horizontal systems such as Hiran and Decca (*see* AIRWAYS; NAVIGATION) locate the airplane at the instant each photograph is taken. A radar signal is timed in transit between a ground station and the aircraft; this is translated as distance on dials carried aboard. The dials are photographed at the instant the main aerial camera is triggered. These systems work to extreme accuracy at distances of 100 mi. and often much farther. This method is, however, often unjustifiable because of its considerable cost. Vertical control is supplied by APR (airborne profile recorder), in which an impulse is reflected by the ground back to the aircraft. The altitude above the earth's surface is automatically plotted on graph paper; elevation is measured down from the barometric datum of the aircraft. Good accuracy may be obtained with this method of vertical control.

Aerial Triangulation and Bridging.—Aerial triangulation involves starting from some known ground control and extending by laboratory processes through a series of pictures. These processes are known as carrying forward control, or bridging. Control is carried forward by the successive adjustment of adjacent stereoscopic models upon each other. The stereoscopic model, for example, consisting of pictures 1 and 2, is adjusted to known ground control. Picture 1 is then replaced by picture 3, and while 2 remains unmoved in the plotting machine, 3 is adjusted to 2 until perfect stereoscopic correspondence is achieved. Then 2 is replaced by picture 4, and the process continues indefinitely. Closure errors that build up toward the end of a long series of pictures have to be adjusted.

Bridging is an office process of extending control between separated clusters of ground control and may be understood by examining how it is done with the multiplex (fig. 5). The multiplex is set up with as many as 20 projectors, each of which projects the image of one picture in the series. The first pair of projectors is adjusted to known ground control, and each subsequent projector carrying the next picture in the series is adjusted successively until control at the far end of the series is reached. The error of closure is distributed by formulae that consider the method, lens distortion, curvature of the earth, and similar factors.

Analytic Aerotriangulation.—In the early 1960s the graphical and machine bridging methods of control began to give way to mathematical analysis. By 1965 the best and most economical results were being obtained by measuring the picture and putting these measurements and other variables such as lens distortion, curvature of the earth, atmospheric refraction, and film distortion into a program for computer solution.

The Slotted-Template Method of Horizontal Control.—The most universally used method of office control was originally known as the Arundel method in England and the Bagley method in the U.S. A modern evolution, generally called radial control, is widely practised with both slotted cardboard templates and slotted metal arms. The slotted-template (templet) method, widely used in World War II for compiling maps when insufficient ground control existed, is a means of graphical triangulation. By this method (most easily explained in the cardboard version) a template is made from each individual photograph. The principal (nadir) point and at least eight office selected radial points around the edges are pricked through from the picture to the cardboard (fig. 3). A hole is punched at the centre prick mark of the template, and a radial slot is cut through each of the outlying points. Because of the conventional 60 × 30% overlap, each of these points is common to several pictures—sometimes as many as six. The templates are then "buttoned up" with connecting posts (studs) through the intersecting slots, so that all slots representing a common point from the pictures are assembled over a single post. Each post resembles a flatheaded rivet with a hole through the stem. The known ground-control points are shown on the photographs and on the templates representing these photographs. The

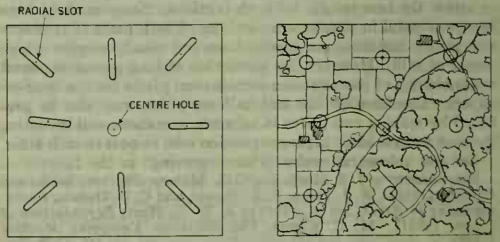

FIG. 3.—A SLOTTED TEMPLATE IS MADE FROM EACH PHOTOGRAPH. THE ASSEMBLED OVERLAPPING TEMPLATES CONFORM IN A GRAPHICAL TRIANGULATION NET

positions of these points are plotted on the assembly board in their true position at the desired scale and a post immovably nailed there. With these posts fixed and all others free at the intersection of the slots, the entire template assembly expands or contracts to conform to the fixed ground-control points to establish a uniform scale.

When the entire area is covered by the templates the posts at the radial slot intersections represent the true positions of many points. These are pricked through the hole in the post to the compilation board underneath the template assembly, affording an intensive control pattern.

The slotted-template method affords excellent horizontal control for mosaics, planimetric maps, and small-scale contour maps. It is not quite accurate enough to control the setup of the plotting machine, which is usually controlled by a proper balance between ground control and aerial triangulation (bridging).

PHOTOGRAMMETRIC MAPS

Mosaics.—Mosaics have evolved from an uncontrolled and often misleading conglomerate assembly of pictures to a map of predictable accuracy and widely accepted usage. Most mosaics are compiled through the following steps:

1. Scattered ground control.
2. Nine points per picture, established by radial control (slotted template).
3. Comparison of the contact print with the control to determine what restitution is required.
4. Restitution, consisting of:

a. Enlargement or reduction of the picture as a whole, to compensate for altitude changes of the airplane and different elevations of the ground.

b. Tilt correction, to compensate for averticality of picture at the instant of exposure, and for average ground slope.

c. Fractional treatment: the breaking up of the picture into small parts to compensate for irregular ground.

d. Pyramiding (where the utmost in precision is required): roughly contouring the picture and making a series of ratio prints, one for each tier of elevation, all from the same negative. The pictures are then cut on these approximate contours, and reassembled, with the picture for each higher contour being pasted over the lower one. Thus, the error may be reduced to plus or minus half the interval of the pyramiding.

5. Stick-up and editing; *i.e.*, superimposing on the mosaic such items as grids, geographical lines and names, and marginal data.
6. Copying by quadrangles, on large plates or films.
7. Reproducing by quadrangles:

a. Photographically.

b. Lithographically, and so on.

Photo-Contour Maps.—A photo-contour map is quite similar to the pyramidal mosaic. It is made by projecting onto a single sheet of sensitized paper each photographic band between adjacent contours at its mean scale. A contour line is made to show between each pair of strips, yielding a very accurate photomap (mosaic) that also shows contours. Such maps are especially desirable for highway location. They are more expensive than topographic maps or ordinary mosaics.

Line Maps.—Line maps as distinguished from photographic maps may be planimetric or topographic. Planimetric maps delineate horizontal information as do topographic maps, which add contour lines. Both may show such features as roads, railroads, buildings, drainage, lakes, shorelines, swamps, and cadastral data including latitude and longitude, rectangular coordinates, political and geographical boundaries, property lines, and any special data, such as land classification, crop classification, and soil types.

Cadastral maps and other precise planimetric types are compiled by stereoplotting. Planimetric maps are often controlled on a slotted-template base. From this point on the methods of compilation depend on the character of the aerial photography and the preferences of the compiler. One method is by projecting from a contact print onto a base compiled by slotted template. The image is enlarged or reduced to conform to the control on the compilation board, and the detail is then traced. Some prefer, especially in country of steep relief, to establish radial intersections at intervals along all the principal features that are to be shown. These intersections guide a draftsman who fills in the features by hand.

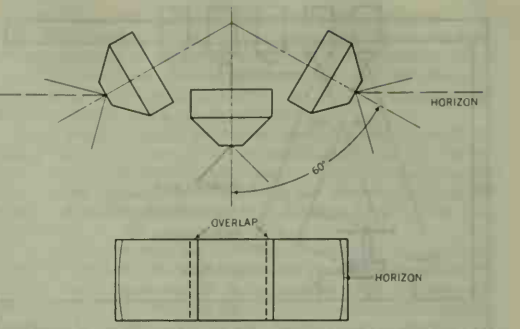

FIG. 4.—TRI-METROGON CAMERA ARRANGEMENT, SHOWING THE ONE VERTICAL AND THE TWO WING PICTURES

Planimetric maps are also compiled from oblique photography with such instruments as photo alidades in which a contact print or glass diapositive is observed in front of a transit, the centre of rotation of which is placed in the position occupied by the rear node of the taking lens. Attached below the vertical axis of this transit is a blade (similar to a conventional alidade) that plots the horizontal projection of the rays to the points sighted through the telescope. The true position of these points is determined by intersections developed by observing overlapping pictures.

Another extensively used device for placing planimetric detail from the photograph on the map is the sketchmaster, which is based on the camera lucida (*q.v.*). Through a half-silvered mirror or split prism the picture and the compilation sheet are seen simultaneously. After a good empirical registry is established between picture and compilation sheet, the detail is traced. Sketchmasters have been of three types; one plots from vertical pictures only, another draws maps from oblique pictures, while universal sketchmasters will draw from either type of photography.

Tri-Metrogon System.—The system derives its name from three K-17 cameras equipped with six-inch Metrogon lenses used as a unit. It was widely used in World War II, and since millions of square miles of Tri-Metrogon photography are in existence, the method is of interest, although it was substantially obsolete by the 1960s. The cameras are mounted with one axis vertical and the other two axes at 60° to the vertical and extending to the sides. Thus, the camera covers 7° or 8° above the horizon (fig. 4). This is important because the position of the horizon in the pictures is used to determine tilt. Since the horizon shows in each wing picture, two tilt determinations can be used as a check. If one or both wing pictures show a clean-cut water horizon or a horizon on fairly flat, low land, the tilt can be determined with good accuracy. If the terrain is mountainous, considerable estimating enters into the determination. Constants which should be known for satisfactory planimetric work are the focal length of each camera and the exact angular relationship among the three cameras.

In charting work the Tri-Metrogon photographs are assembled by slotted template. The template of the vertical picture is made in conventional manner. Probably the photo alidade is best for laying out oblique picture templates although such simplified apparatus as the rectoblique plotter and photoangulator were extensively used. The accuracy of the final result largely depends on the success in determining the tilt of the various pictures and the interlocking angles of the cameras. When the radial control plot has been completed the detail is put on the map with such devices as sketchmasters. Small-scale charts covering a large part of the world have been made this way.

Tri-Metrogon photography has also been used for topographic maps, but few existing plotting machines get effective production from it. The depth of focus of the multiplex is inadequate for the great range of the oblique photographs, and the excessive enlarge-

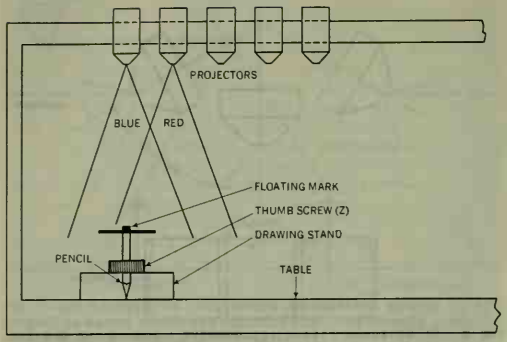

FIG. 5.—MULTIPLEX

The multiplex projects an overlapping pair or series of pictures in correct three-dimensional relationship. The images of complementary colours are viewed stereoscopically through spectacles with complementary coloured lenses. Drawing is accomplished by moving the drawing stand while keeping the floating mark in exact registry with the stereoscopic image

ment coupled with bad definition makes multiplex work fairly unsatisfactory. The stereoplanigraph has been best for mapping at scales for publishing at 1:25,000 from Tri-Metrogon photography. In this instrument the enlarging factor becomes so great and definition so poor beyond the centres of the wing pictures (25°± below the horizon) that accuracy is seriously impaired. The stereoplanigraph has, however, done the most effective job of contouring from Tri-Metrogon photography.

Tri-Metrogon equipment has been used at elevations up to 40,000 ft. The practical separation between flight strips is limited by atmospheric haze, topographical relief, and ground cover. It is generally usable to a total subtended angle of 110°; under favourable conditions to 135° or 140°. Practically, the principal point of the wing pictures is about the limit of successful coverage in terrain with considerable planimetric detail. Farther out than this such details as buildings and roads become very indistinct.

Wide-Angle Photography.—By 1960 the need to minimize flying and reduce photographic and control effort had moved interest away from Tri-Metrogon to the Wild system, composed of the RC9 camera (covering 120° with a single lens) and the A9 plotter. This camera of 9 × 9 in. format has a lens of 3.5-in. focal length; with it strips can be flown more than 12 mi. apart at 30,000 ft. altitude. One model will cover more than 80 sq.mi., and major clusters of horizontal and vertical control used with aerial triangulation may be held to one cluster of four points for each 500 sq.mi. Military aircraft at 50,000 ft. can fly strips more than 20 mi. apart with the RC9 camera, and a control cluster will satisfy about 1,300 sq.mi. or more. A good map could be plotted from this photography at a scale of 1:50,000 with 50-ft. contours.

Topography.—Topography is developed from aerial photography by two-dimensional and three-dimensional processes. All stereoscopic measuring uses a stereoscopic pair of pictures compared with a reference known as a floating mark. The floating mark may be placed at the intersection of the two projected rays of a common image as in the multiplex (fig. 5), or two marks may be fused just as the stereoscopic pictures are fused into one (fig. 6). When two marks are superimposed on the pictures and correspond exactly with conjugate images of any point, they appear to touch the ground at that point. If the eyes must converge more to see the mark than to see the image, the mark will appear closer to the observer (higher) than the image of the ground. If the eyes diverge to see the mark in relation to the image, the mark seems below the surface of the ground. In either system, this reference mark may be physically in contact with the pictures, or optically in contact with the image of the pictures in the more elaborate machines, and may be set for any desired ground elevation.

Parallax measurement applies very aptly to the two-dimensional processes. In principle, it also applies to the three-dimensional processes but not quite so obviously.

Two-Dimensional Processes.—The two-dimensional processes are simplest for deriving elevation data from a stereoscopic pair of aerial photographs. A pair of stereoscopic pictures is used in a stereoscope (*see* BINOCULAR INSTRUMENT) that has a pair of marks in contact with the pictures. The separation of the marks is set in accordance with the parallax of the desired elevation; the fused mark is moved along the exact ground surface of the stereoscopic image; and a contour is drawn. All points of the same elevation have the same parallax in vertical photography. The parallax is set once only for each contour. In drawing planimetry, a road that goes up- and downhill will require that the parallax be continuously changed. Maps drawn by the two-dimensional process emerge from the stereoscopic plotting instrument as conic projections (fig. 7). The map is a true conic projection only if the pictures of the stereoscopic pair were rectified (corrected for tilt) prior to their use. Stereocomparagraphs are the best-known type of equipment for this process. Acceptable maps can be made by the method even without rectified photographs if enough ground control is available. Unrectified pictures will give reasonably good results with one point of known elevation for approximately every two square inches of photograph. The same pictures, properly rectified, will give an excellent map with four known control points per stereoscopic model.

After the contours and planimetry have been traced off, the conic projection must be corrected. This means that each contour (which is at a different scale in accordance with the distance from the taking camera to the ground) and each planimetric detail (which is similarly displaced) must be proportionately corrected, elevation by elevation, to yield an orthographic map. This may be accomplished by tracing the detail off by pantograph (*see* LINKAGES), or similar device, changing the ratio for each change of contour; or it may be done in a projector by changing the projection ratio from contour to contour and tracing the orthographic map off on the projection screen.

Two-dimensional plotters go by such names as stereocomparagraph, contour finder, stereometer, and parallaxer.

Three-Dimensional Processes.—The three-dimensional process differs from the two-dimensional in that the light rays that originally formed the image are reprojected from the image in miniature back to the ground (its mechanical representation).

If the aerial camera were to remain in space in the same position in which the picture was taken and the film after development were replaced in the camera, the camera being used as a projector, each ray would return to the source from which it originated. Thus, if two cameras are retained in their spatial stereoscopic relationship, the conjugate rays from the two images of the common ground point when reprojected will fall back and intersect at that common ground point. Also if the cameras were moved to reduce their separation by half, the rays now would intersect at a distance halfway between the cameras and the ground. In other words, the scale of the entire system would be cut in half. If the cameras are only $\frac{1}{20,000}$ the distance at which they were separated in the air, a map can be drawn at precisely $\frac{1}{20,000}$ of the original scale.

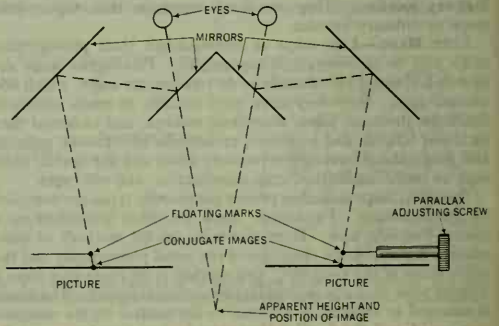

FIG. 6.—SIMPLE PARALLAX-MEASURING STEREOSCOPE

Similarly, the survey can produce a map at any desired scale.

The simplest example of the three-dimensional process is the multiplex. The original air pictures, which may have been 9×9 in., are reduced for multiplex use to $\frac{1}{4}$ original size. This permits use of very small projectors that can be brought close enough together to get the desired scale. Full-scale projectors using a 9×9 in. picture could not be placed close enough. For example, if a scale of 1:10,000 is desired, and the pictures were taken 3,000 ft. apart, the nodal points of the two projection lenses will be separated only $\frac{3,000}{10,000} = 0.3$ ft. or 3.6 in. Obviously, big projectors carrying 9×9 in. pictures could not be put this close together; the multiplex with its $2\frac{1}{4} \times 2\frac{1}{4}$ in. pictures can.

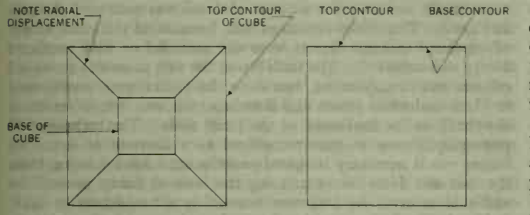

FIG. 7.—CORRECTION OF ORIGINAL PHOTOGRAPH. (LEFT) THE PHOTOGRAPH IS A CONIC PROJECTION. (RIGHT) THE MAP MUST BE ORTHOGRAPHIC. THIS CORRECTION IS MADE AUTOMATICALLY IN THREE-DIMENSIONAL PROCESSES, BUT IS AN ADDITIONAL OPERATION IN MOST TWO-DIMENSIONAL PROCESSES

The multiplex projectors have lenses of about 1.5-in. focal length, stopped down to a tiny aperture. Thus, at the focal plane of these lenses definition is sharp, and for a considerable distance on both sides of this plane the circle of confusion is small enough to be tolerable. In other words, the lenses have great depth of focus. This feature tends toward simplification of the multiplex system since the focus is sharp enough to draw a substantial band above and below the plane of most critical definition. Thus, without providing for any change of focus the multiplex operates effectively through a wide range of ground elevation.

Stereoscopic vision in the multiplex is by the anaglyph method: the two projectors (or, if more than two are used, alternate projectors) carry filters of complementary colours; *i.e.*, red and blue. The observer wears a red filter over one eye and a blue filter over the other to separate the two images and permit stereoscopic vision. The projected images are received on a drawing stand that can move over the compilation sheet, which is secured to a very flat table usually of slate or hand-scraped metal. The drawing stand carries a screen (parallel to the surface of the paper) that can be raised or lowered by a thumbscrew. In the middle of this screen a tiny point of light serves as the floating mark; directly beneath, a pencil draws on the compilation sheet as the stand is moved. In drawing contours the screen is set at the desired elevation, and the stand is then pushed around by hand. The operator observes the floating mark in relation to the plastic stereoscopic image and moves the stand so that the floating mark always follows the surface of the ground. In drawing planimetry, the floating mark is made to follow the feature; *e.g.*, a road. The operator works the thumbscrew of the screen, making it and the floating mark move up and down to follow the undulations of the feature.

Other three-dimensional processes use so-called universal equipment such as the Nistri, Poivilliers, Santoni, and Wild devices, and the Zeiss-aerotopograph. The word universal means that the machine will draw a map from vertical, oblique, and phototheodolite pictures.

All operate in a somewhat similar manner, except that the Porro principle is the basis of the Zeiss device. In the Porro system projection in the plotting machine is through a lens set at infinity focus and having identical optical characteristics with the lens of the aerial camera that took the pictures. Since projection through this lens is at infinity focus and the image on such a stereoplanigraph must focus in the plane of the floating mark, an automatic focusing lens is interposed between the projection lens and the floating mark. This is a telephoto lens that is constantly accommodating for the changing distance between the projection lens of the picture holder and the floating mark.

The Wild autograph has a ray rod passing through the mechanical representation of the nodal point. This rod actuates an optical system that scans the photograph in such a manner that the point viewed is always the point formed by a ray of light passing through the lens at the same angle as the ray rod.

These machines have a mechanical base by means of which the scale is set. In the case of the stereoplanigraph (fig. 8), the distance between the two floating marks is varied by changing this base, and on other types of machines the distance between the ground extremities of the ray rods is determined by the base adjustment.

The extensively used Kelsh plotter is similar to the multiplex except that it uses full-scale diapositives projected through lenses of focal length comparable to the air camera. This anaglyph system draws at about five times the scale of the original photographic negative. It compensates for lens distortion, although this is a minimal problem with modern air cameras.

In most three-dimensional plotters the picture holders (plateholders) are arranged so that they can be given X tilt and Y tilt around the nodal point. After the stereoscopic model has been perfected the two plateholders together can be made horizontal by the application of common X tilt and common Y tilt. The bases of these machines also carry BY and BZ adjustments. BY is an adjustment at right angles to the main base adjustment BX. BY is the equivalent of rotating the base in a horizontal plane. BZ is the adjustment for difference in the airplane elevation at the instant of exposure of the two pictures.

Stereoscopic pictures in a three-dimensional plotting machine can be put into perfect relative adjustment or correspondence without reference to the true horizontal. This is accomplished by a trial-and-error system that reveals imperfections of adjustment by vertical parallax. This is a splitting of the floating mark so that one mark appears above the other. When the adjustment is perfect no vertical parallax is present any place in the model. The subsequent process (known as horizontalizing) consists of moving the stereoscopic pair as a unit so that it bears the proper relationship to the base movements of the machine. Thus, before horizontalizing, the cameras (plateholders) will probably lie in some false inclined plane relative to the X and Y tracks of the base or the plotting table of the anaglyph plotters (Multiplex, Kelsh, etc.). The scale will also generally need adjusting. Horizontalizing is accomplished by measuring the distance between known ground control points and adjusting BX to get the proper scale, and by measuring the elevation of known points in the model and adjusting common X tilt and common Y tilt.

Drawing is accomplished by turning handwheels that actuate the X and Y movements and a footwheel controlling Z. The X and Y motion of the handwheels is transferred to a pencil on a plotting table. This table is connected to the stereoscopic machine through a gear box so that different ratios may be established between the two. It is not unusual to draw the map on the plotting table at six times the picture scale; frequently the scale is en-

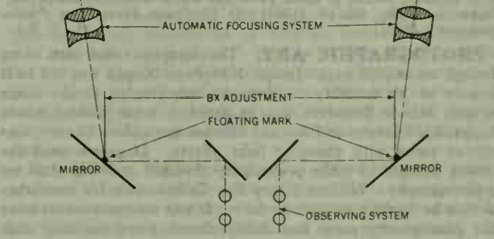

FIG. 8.—ELEMENTS OF STEREOPLANIGRAPH

larged as much as ten times horizontally.

This is related to a major criterion used in planning a stereoscopic survey. There is little relationship in most stereoscopic systems between the horizontal scale and flight altitude, because the horizontal scale can be enlarged or reduced. The determining factor of the flight altitude is the accuracy required of the contours. Thus the best plotting machines permit flying at 2,500 or more times the permissible contour tolerance. From this elevation a map can be drawn in which at least 90% of all points tested will check out within ½ the contour interval.

The wide choice of plotting scales gives universal plotting equipment an advantage over the multiplex when the plotting scale is restricted by the depth of focus of the projectors. One of the principal differences between these plotting machines is that, with the multiplex, drawing is accomplished by pushing the stand around over the compilation sheet, the elevation being changed by a thumbscrew. On the universal machine, drawing is accomplished by turning handwheels, the left hand controlling the X motion of the machine, and the right hand controlling the Y motion. On such universal machines the elevation of the floating mark is controlled by a footwheel. Thus, when contours are drawn, the footwheel sets the proper elevation. At this setting the floating mark, like that of the multiplex, is restrained to move in a given horizontal plane. For drawing planimetry with the universal machine, the operator looking through the stereoscope makes the handwheels follow the ground feature and with the footwheel keeps the floating mark moving up and down to conform with the elevation of the ground surface.

By the 1960s an extensive demand had developed for large-scale cross sections fed by stereoplotters into electronic computers and tabulators. Instead of drawing a map the plotter reads elevations at intervals along a cross section. These and readings of distance on either side of the centre line are fed to a tabulating typewriter and punched on a computer card. The process is extensively used for computing quantities of earth in highway design.

Summary.—Aerial photography and photogrammetry augment but in no way eliminate ground surveying. In all photogrammetry some, and often considerable, ground surveying is required for control. Many areas to be mapped are too small to justify the cost of flying to them or are too remote to absorb this cost. Areas obscured by vegetation will probably continue to be mapped with the traditional plane table.

It is not possible to drive a stake in the ground from an airplane; and the construction project must be laid out by conventional survey processes. Aerial photography greatly enriches visual information available about the surface of the ground. It frequently provides a more complete visual inventory more rapidly and cheaply than could be obtained any other way.

Photogrammetry usually minimizes the more costly phases of conventional ground surveys. Which will be more practical depends on such factors as purpose of the survey, scale of map, contour interval, size of area, distance from operating base, character of ground cover, data to be shown on the map, and character of the terrain. A study of the individual project will determine whether the survey should be by photogrammetric methods, by conventional ground methods, or by a combination of both. *See* also SURVEYING; MAP.

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PHOTOGRAPHIC ART. Photography came into being through an artistic urge: Joseph Nicéphore Niepce was led to it because of his inability to draw on lithographic stone; Louis Jacques Mandé Daguerre was an artist, a scene painter whose illusionistic Diorama in Paris and London was a show of enormous painted views with changing light effects. Daguerre used the camera obscura to make preliminary sketches and was thus led to photography. William Henry Fox Talbot made his researches because he found it difficult to draw. It was not mere coincidence that photography came into being almost simultaneously with means of multiplying pictures in great quantities (lithography) and with semimechanical means of picturemaking (the silhouette and the physionotrace). The underlying chemical and optical principles had long been known, but the idea of using the light-sensitive property of silver salts to record the optical image of the camera did not occur until there was a demand for pictures following the rise of the *bourgeoisie* after the French Revolution.

The first criticism of photography was necessarily based on a comparison of it with painting or drawing, since no other standards of picturemaking existed. The Parisian painter Hippolyte (Paul) Delaroche, when questioned about the value of the daguerreotype to artists, went so far as to say that the "process completely satisfies art's every need." Photography's remarkable ability to record a seemingly inexhaustible amount of detail was marveled at again and again. The critics regretted that, because of the great length of exposure, moving objects were not recorded or were rendered blurry and indistinct. The inability of the first processes to record colours was disappointing, but since the critics were conditioned to black-and-white prints and drawings, this was not so serious a drawback as the harshness of the tonal scale. The technique of photography was at once recognized as a shortcut to art. No longer was it necessary to spend years in art school drawing from the cast and from life, mastering the laws of linear perspective and chiaroscuro. As Daguerre boasted in a broadsheet in 1838, "with this technique, without any knowledge of chemistry or physics, one will be able to make in a few minutes the most detailed views. . . ." But formal art education had a purpose over and above the mastery of technique. The discipline taught the student to observe, and it gave him a feeling for the significant moments of time and an intuitive sense of composition. Already Leonardo da Vinci in his "treatise on painting" had warned against the use of the camera obscura as a shortcut to picturemaking, because it often led to superficial results, lacking in the qualities that distinguish a work of art from an illustration.

D. O. Hill and R. Adamson.—In the hands of artists, photography quickly showed its artistic possibilities. David Octavius Hill, a Scottish landscape painter, became interested in Talbot's calotype process. In 1843 he decided to paint a group portrait of the Church of Scotland ministers who in that year resigned their benefices and formed the Free Church of Scotland. There were 474 figures to be painted, and in order to simplify this enormous task, Hill turned to photography. He enlisted the aid of Robert Adamson, an Edinburgh photographer, and together they made hundreds of portraits. They did not confine themselves to the members of the church meeting, but included people from all walks of life. In view of the fact that they posed their sitters out-of-doors, in strong sunlight and with exposures of about one minute, it is hard to understand how Hill and Adamson managed to retain that spontaneity which is so essential to the success of a photographic portrait. They photographed the fishermen and their wives at Newhaven, Scot., posing them in groups reminiscent of paintings, and some of their landscape photographs show a startling affinity to watercolour drawings. The work of Hill and Adamson was forgotten after the 1860s but was revived in the early 1890s when J. Craig Annan made modern prints from the original paper negatives.

Daguerreotypes in the U.S.—By universal consent, the United States led the world in the production of daguerreotypes. It has been claimed that the first portraits made by photography were produced in the United States. By the late 1840s photography was a big business. Every city of size had its "daguerrean artist," and ingenuity led to the use of machinery and production line processing and though the work of the Boston, Mass., firm of Albert Sands Southworth and Josiah J. Hawes cannot claim to rival the artistic quality of Hill and Adamson, these two daguerreotypists had a fine perception of the individual. Instead of the stereotyped lighting and posing formulas of the average daguerreotypist, they showed the greatest variety, and they did not hesitate to present their sitters unprettified and "as they were." Lemuel Shaw stands with crumpled coat and unruly locks of hair under a glare of sunshine; John Quincy Adams sits in his living room; Lola Montez lolls over the back of a chair.

Formulation of an Aesthetic Theory.—In England the hey-

day of photography followed Frederick Scott Archer's invention of the wet collodion process in 1851. This new technique rapidly displaced and made obsolete the daguerreotype and calotype. Professionals had found the need of banding together; and the new process, which was free from all patent restriction, attracted countless amateurs. Rallying points sprang up: in 1853 the Photographic Society (renamed, in 1897, the Royal Photographic Society) was formed in London; and in the next year the Société Française de Photographie was founded in Paris.

Up to that time there had been little conscious effort to impose artistic rules on the production of photographs. No particular distinction seems to have been made between photographs produced for an aesthetic intent and those made for documentary purposes. An exhibition of photographs, including examples of the work of Hill and Adamson, was shown at the Crystal Palace in London, 1851, in the section "Philosophical Instruments." In the preceding year Gustave le Gray, a French professional, had sent eight photographs to a competitive art exhibition in Paris. They were accepted by the jury and catalogued as lithographs. When it became known that they were photographs, they were withdrawn by the organizing committee.

Photographic societies undertook to remedy this situation and began to examine the position of artistic photography in relation to scientific photography. At the first meeting of the Photographic Society the president, Sir Charles Eastlake, who was at the same time president of the Royal Academy, invited Sir William Newton, a miniature painter by profession, to read a paper "Upon Photography in an Artistic View" (*Journal of the Photographic Society*, i, 1853). His argument was that, to be useful to the painter, photography should depict natural objects "in accordance (as far as it is possible) with the acknowledged principles of Fine Art." One way in which the photographer could make his results "more like works of art," Sir William pointed out, was to throw the subject slightly out of focus. The extreme blue-sensitivity of wet collodion plates rendered the sky areas so dense that they appeared as blank paper on the print. To overcome this failure of the photographic process he recommended liberal retouching and free use of handwork on the negative.

Combination Printing.—An outcome of the urge to create photographs which would fit a priori concepts of art was the technique of making one print from several different negatives. The most famous example was made by O. G. Rejlander, a Swedish painter, who had received an art education in Rome and was practising photography in England. It was a painterly composition, 31 × 16 in. in size, printed from no fewer than 30 separate negatives. The picture was entitled "The Two Ways of Life," and showed, in allegory as obvious as it was sentimental, that the way of the blessed led through good works and the way of the damned through vice. Rejlander, who described the technique in photographic journals, stated that his purpose was to prove to artists the artistic possibilities of photography, which they had denied. The photograph was shown in the Manchester Art Treasures Exhibition of 1857 and was purchased by Queen Victoria for Prince Albert.

H. P. Robinson.—This technique stimulated Henry Peach Robinson, a professional photographer who had studied art as a young man. He became famous with a five-negative combination print, "Fading Away," in 1858. The subject depicted a dying girl, and this was considered by critics as too painful a subject to be represented by art. Perhaps the implied authenticity of photography bothered them, because painters had long presented subjects of far more painful nature. Robinson became a most articulate member of the Photographic Society, and his teaching was even more influential than his photography. In 1869 appeared the first of many editions and translations of his book, *Pictorial Effect in Photography*. Robinson went a step further than Newton; he offered photographers a set of rules. From a then outmoded handbook on painting, he borrowed compositional formulas the use of which, he claimed, would bring artistic success. The student was instructed to arrange his models in pyramidal compositions, and examples from the work of Sir David Wilkie, a popular painter of genre scenes, were given to show how this artist used the triangular form of composition. The importance of balance was stressed, and the opposition of light against dark was made clear. The fault of the book lay not only in the assumption that rules set up for one art form can be applied to another, but also in its intellectual and academic approach to art.

Robinson's work is, by modern standards of taste, weak and artificial. Not only did he practise photomontage, but he preferred to work in the studio, against painted backdrops and with props of natural objects, even foliage, mounted on casters. When he did photograph in the country, he took models with him, dressing them up to play the part of country girls, instead of turning to the genuine thing.

J. M. Cameron.—Using a lens of 30-in. focal length requiring exposure of several minutes and a definition rapidly falling off from the centre, Julia Margaret Cameron produced a remarkable series of portraits between 1864 and 1874. The success of these portraits, representing friends prominent in literary and artistic circles, cannot be laid to technique, however, because her genre studies, too obviously based on Pre-Raphaelite paintings, were weak and sentimental. The key to the success of the portraits lies in their artistic intensity. "When I had these men before my camera," she related in her "Annals of My Glass-house" (*Photographic Journal*, lxvii, pp. 296–301, 1927), "my whole soul has endeavoured to do its duty toward them in recording faithfully the greatness of the inner man as well as the features of the outer man. The photograph thus obtained has been almost the embodiment of a prayer."

Adam-Salomon and Retouching.—While the Parisian caricaturists and portrait photographers Nadar and E. Carjat produced great portraits in a simple and straightforward technique reminiscent of early daguerreotypists, the sculptor A. S. Adam-Salomon introduced a false note into photographic portraiture by retouching. Arguments were frequent in the 1860s over the legitimacy of retouching, particularly of portraits. Some prints of Salomon's were tested by the Edinburgh Photographic Society in 1868 to ascertain "whether they were pure photographs or indebted to retouching for their beauty." It was found that they were retouched.

O. W. Holmes on Photography.—There was one form of photography in which retouching or any other form of handwork was virtually excluded, and that was stereographic work. The paired images which, when viewed properly, produce the most astonishing illusion of three dimension, depend upon the most minute and exact differences in detail to render their startling effect, and this precision cannot be imitated satisfactorily by hand. Love of stereographs led the U.S. physician and writer Oliver Wendell Holmes to write three articles in the *Atlantic Monthly* in which he put down the basis of a functional aesthetic which was almost diametrically opposed to what Newton had recommended in London. To Holmes the photograph had characteristics which no other art could rival. Far from regretting that the camera had not been used in accordance with the accepted rules of art, Holmes praised what appeared to some the defects of the process. "The very things which an artist would leave out, or render imperfectly, the photograph takes infinite care with, and so renders its illusions perfect. What is the picture of a drum without the marks on its head where the beating of the sticks has darkened the parchment?" (*Atlantic Monthly*, iii, p. 746, 1859.) "In a perfect photograph," he added, "there will be as many beauties lurking, unobserved, as there are flowers that blush unseen in forests and meadows." Holmes was but one voice against the many. The aesthetic value of straight photography was not generally recognized, and the work of those who recorded the battlefields of the Crimean War and the American Civil War and who traveled throughout the world was overlooked by the aestheticians.

Naturalistic Photography.—The introduction of factory-produced dry plates in the 1880s attracted an increasing number of amateurs to photography. In comparison with the messy and awkward wet plates, the dry emulsions were revolutionary. The photographer could buy ready-made plates and process them at

his convenience. Small hand cameras freed him of his tripod, just as the dry plate had freed him of the necessity for taking a dark tent on his travels.

Peter Henry Emerson felt the artificiality of the Robinson school, and he set against the latter's theories another viewpoint which he named naturalism, and which he described in his *Naturalistic Photography,* first published in 1889. He believed that photography was potentially a great creative art, and that it did not need to be bound down to rules set up for painting. "Naturalism," he wrote, "is an impersonal method of expression, a more or less correct reflection of nature wherein (1) truth of sentiment, (2) illusion of truth of appearance (so far as is possible) and (3) decoration are of first and supreme importance."

Emerson sought a scientific basis for pictorial photography. He analyzed the physiology of vision in order to find out how the camera can simulate human perception. He reasoned that since the eye sees distinctly only a small part of what lies before it, while the surrounding area appears indistinct, it should be possible to reproduce this phenomenon by control of focusing. Only a small part of the photograph should be sharp; the rest should be just slightly out of focus. Today we recognize that this theory of vision is fallacious, because the eye, unlike the lens of a camera, is a living organism, which scans the field of view constantly so that the mind receives a composite report and the impression of full detail. The naturalistic theory was an advance over Newton's, for Emerson believed that the photographer should rely entirely on controls which were themselves part of the photographic process. In addition to control through differential focusing, he advised the careful use of developing and printing methods.

Emerson took a large number of photographs of the amphibious life of the simple country folk on the Norfolk Broads, which were far removed from the artificial genre studies of Robinson and very close to the graphic work of J. F. Millet which Emerson greatly admired. Imbued with a deep artistic feeling, Emerson's photographs fired a number of other amateurs to seek inspiration in nature as the first generation of photographers had done. He published his photographs in limited editions in handsome folio volumes as original platinum prints or as photogravures and photoetchings.

The scientific findings of Hurter and Driffield led Emerson in 1891 to renounce the art claims he had made for photography. A great artist, he said, had shown him that the mere reproduction or translation of nature was not art. The fallacy of this argument lay, of course, in the definition of art. It appears that "art" and "painting" were almost synonymous to Emerson when he wrote his retraction. What really happened was that Emerson's preaching on differential focusing led to the use of soft focusing lenses and other blurring effects such as the use of very coarse paper. Emerson dramatically announced his views in a black-bordered pamphlet "The Death of Naturalistic Photography."

The Linked Ring.—In his book Emerson had a good deal to say about photographic exhibitions. He felt that they were poorly organized. He recommended that photographs be framed in simple white moulding and that they be exhibited on one line in galleries, not plastered over the wall with the frames practically touching. He rightly felt that pictorial photographs should be isolated, instead of being lumped together with work done for scientific, technical, and other nonaesthetic purposes.

Dissatisfaction with the scientific bias of the Photographic Society under the presidency of Sir William Abney caused a split in the society in 1892. A group of pictorially minded members, under the leadership of H. P. Robinson and George Davison, formed a society for the exclusive purpose of furthering "the development of the highest form of art of which photography is capable." (*Camera Notes,* p. 119, the Camera Club of New York, 1901.) The society was named the Linked Ring. They held annual exhibitions which they referred to as *salons,* a name borrowed from the painting world, and which demonstrated their artistic motivation. By 1901 it was their proud boast that "through the *Salon* the Linked Ring has clearly demonstrated that pictorial photography is able to stand alone and that it has a future quite apart from that which is purely mechanical." (*Camera Notes,* p. 119, the Camera Club of New York, 1901.)

Stieglitz and the U.S. School.—In 1887 Emerson, judging a competition for the *Amateur Photographer,* had awarded a prize to Alfred Stieglitz, a young American who was studying in Germany. It was the first award which Stieglitz had received; the first recognition of one who was to carry pictorial photography to a high level, not only with his own work, but in his constant championship of all that has been progressive in photography and other forms of modern art.

When Stieglitz returned to the U.S. he found that photography was a passing craze, and that the New York Society of Amateur Photographers threatened to change their organization into a bicycling club. After serving as editor of the *American Amateur Photographer* for a number of years he organized a sympathetic group in the Camera Club, New York City, and founded a handsome periodical, *Camera Notes,* which, devoted exclusively to pictorial photography, was outstanding for the unusually high quality of its illustrations. Stieglitz was one of the first to demonstrate the pictorial possibilities of the hand camera with his straightforward photographs of New York under all weather conditions.

In 1900 F. Holland Day brought to England a collection of the work of the new photographers who had emerged largely because of the guidance and the example of Stieglitz. The showing, although not fully representative, included the work of A. L. Coburn, Frank Eugene, Gertrud Käsebier, Edward Steichen, and Clarence White. It was characterized by an emphasis upon aesthetic intent, by a variety of printing techniques, and by subtle presentation. Day, addressing the Royal Photographic Society, where the exhibition was held, referred to the exhibitors as the new school which "holds tenaciously that photography may be, if it is not yet, a fine art." (F. Holland Day, *Photographic Journal,* Royal Photographic Society, October 1900.)

The Photo-Secession.—Stieglitz and his friends, disturbed by the lack of standards and the general conduct of photographic exhibitions in the U.S., formed in 1902 the Photo-Secession. They chose the word "secession" to show their split with the *status quo,* just as the German and Austrian painters had used the same word to make manifest their independence of officialdom. The record of the Photo-Secession is contained in the 50 issues of *Camera Work* which were published by Stieglitz between 1903 and 1917. The society had a gallery, known as "291" from the street number of Fifth Avenue, New York City, where it was located, and there Stieglitz showed not only pictorial photographs, from Europe and the U.S., but also (in later years increasingly more than photographs) European *avant-garde* art selected by Steichen in Paris. *Camera Work* contains reviews of these exhibitions, photogravures, and other reproductions of the highest quality, and stimulating essays.

The Photo-Secessionists were much concerned over the recognition of photography as a fine art. The independence of pictorial photography had been proved, but as yet little interest had been shown officially by art museums. In 1910 the group organized an exhibition of about 500 prints by leading pictorial photographers from all over the world in the Albright Art Gallery, Buffalo, N.Y. The show created a sensation. Some of the exhibited prints were purchased by the gallery; for the first time in the U.S., photographs were admitted to an art museum on an equal footing with paintings and drawings as they had been at the Manchester Art Treasures Exhibition in England in 1857, and by Alfred Lichtwark, director of the Hamburg Kunsthalle from 1893 to 1903.

Transition.—The last issues of *Camera Work* contained photographs by Paul Strand which showed a new approach. There were views looking down from unusual angles; there were bowls in quasi-abstract arrangement; there were striking unposed open-air portraits of a type which 20 years later were to be called candid. One of the first Photo-Secessionists, A. L. Coburn, made a series of photographs looking down from a tall building, which he published as *New York from Its Pinnacles,* noteworthy for the way in which emphasis was thrown on form. He also made the first completely abstract photographs called Vortographs, which he contributed to *Photograms of the Year* in 1917.

There was other evidence that new trends were coming to the surface at the close of World War I. Edward Steichen renounced both his painting and his Impressionistic photography, which had been characterized by broad, simple effects, often rendered by gum prints, a process which was readily adaptable to manipulation. He turned to a precise, clean-cut way of working, which he applied to illustration work. The painter Charles Sheeler used the camera to record the stark beauty of Pennsylvania barns and the forms of industrial structures. Edward Weston in 1925 gave up the soft focus, often sentimental landscapes, and figure pieces which had brought him fame and discovered the beauty of close-up details and isolated form, which he recorded in full detail and with brilliant contrasts. Alfred Stieglitz carried his work further; in 1924 he began the "Equivalents" series in which the ability of the camera to record nature gives way to its use as a creative instrument, capable of imparting the most intense emotional reactions. He found in the photographic series a powerful means of expression. A portrait, for example, consisted of many separate yet mutually related photographs.

Influence of Abstract Art.—In Germany, a similar revaluation of the photographic medium had taken place in the mid-1920s, largely under the influence of Albert Renger-Patzsch, pioneer of the NeueSachlichkeit (New Objectivity) movement in photography which ran parallel to similar intentions of realistic, objective representation in painting and the cinema (*Potemkin, The Joyless Street*). Under W. Gropius' leadership, much of the modern idiom of architecture and industrial design originated at the Bauhaus, the famous experimental art school, where from 1923 to 1928 L. Moholy-Nagy, an abstract painter, directed a class of experimental photography in order to find out what the other art and craft subjects could learn from photography and to extend the boundaries of photographic image making. They discovered that there was a photographic vision which in itself was aesthetically stimulating. Instead of deploring the distortions caused by the use of lenses of abnormally short or long focal length, they delighted in the new forms thus created. They tipped the camera up and pointed it down. Christian Schad in 1918, Man Ray and Moholy-Nagy at later dates made highly complex abstract compositions by placing objects directly on sensitized paper, which was then exposed to light. The objects not only left negative images of their profiles, but also, if they were translucent, gradations of light modulated by them. Aesthetically, these "photograms" or "rayographs" were the photographic equivalents of abstract paintings of the period; technically, they were revivals of Talbot's photogenic drawing process.

Contemporary Photographic Art.—The experimental work of the 1920s served to break down the barriers of conservatism and to reveal that photography is an artistic medium with its own special characteristics. After 1930, three closely related trends became increasingly important: (1) a return to the use of large cameras and large negatives from which are made contact prints, rich in detail and brilliant in tonal gradations, that interpret in the most vivid way the subject before the camera; (2) the exploitation to the utmost of new technological developments in lenses, films, and lighting equipment to capture the fleeting moment and to photograph things and places never before recorded upon film; and (3) the shaping of photography to metamorphize subject matter so that all sense of reality is seemingly lost in an abstract form which, it is claimed, has an independent aesthetic existence.

Apart from Albert Renger-Patzsch, the German pioneer of "New Objectivity," the masters of the first group are largely American: Alfred Stieglitz (d. 1946), Edward Weston (d. 1958), Paul Strand, and Ansel Adams. Their work is distinguished by an impeccable classic technique and a deep respect for subject. They prefer in general to photograph by natural light, and have found their richest subject matter in the natural scene, architecture, and out-of-door portraiture. Their attitude toward the final photograph is comparable to that of an etcher to his print. The photograph is an entity, to be mounted with the greatest of care upon a white card, and to be preserved and respected as a work of art.

The second group has found one of its greatest exponents in Henri Cartier-Bresson. This French photographer found that the powerful lenses which can be used with miniature camera and high-speed film gave him an opportunity to photograph "on the run" and to find compositions which exist for a brief interval of time. To him the camera is "an extension of the eye," and his photographs—mostly of people—are characterized by their immediacy and by their unusual form.

Advances in lighting equipment, especially the development of the electric flash and the yet more powerful electronic flash, gave the photographer an extension of the medium. Steichen pioneered in the use of theatrical lighting in his portraits of celebrities; Barbara Morgan captured the essence of the dance in her remarkable action photographs. Reportage photographers consider themselves primarily journalists with a camera and many have pushed their work beyond that of topical records. These photographers intend their photographs to be presented upon the printed page. They seldom are interested in the single, mounted print as an aesthetic unit. (*See* also PHOTOJOURNALISM.)

More recently, some photographers in almost every country have used photography in a seemingly abstract manner. But where the abstractionists of the 1920s were, like the Cubist painters, content to present their work as nonrepresentational and of value for its challenging and stimulating form and colour, the new nonrepresentational photographers challenge us to find hidden meanings in their photographs. Deliberately choosing unlikely subject matter—peeling paint, crumbling walls, rock formations—they invite us to overcome subject association in the discovery through their images of forms never before perceived. In Germany a short-lived movement led by Otto Steinert proposed the founding of a school of "Subjective Photography," based somewhat obviously on the pre-World War II work of the Bauhaus. In the U.S., the chief exponent of the theory of "Equivalents" is Minor White, through his sensitive photographs, his teachings and his editing of the quarterly *Aperture*. The bold vision of Aaron Siskind and others has brought to its highest point the metamorphosis of insignificant detail to a seemingly abstract image which, to the perceptive, is yet rooted in reality.

There have also been remarkable developments in the use of books and exhibitions as vehicles for photographic art. The exhibition "The Family of Man" (1955), organized by Edward Steichen for the Museum of Modern Art, New York, used photographs in a spectacular way to convey a theme of universal appeal. The United States Information Agency, to inaugurate the Congresshalle in Berlin (1957), held an exhibition, "A Nation of Nations," of work by leading American photographers, selected by Nancy Newhall.

Collections of Art Photography.—There exist extensive collections of equipment and photographs as specimens of processes in a number of official technical and scientific institutions. Foremost among them are: the Science Museum, London; the Kodak Museum, Harrow, England; the Smithsonian Institution, Washington, D.C.; the Musée du Conservatoire National des Arts et Métiers, Paris; the Musée de l'Histoire des Sciences, Brussels; and the National Technical Museum, Prague. The building of collections of artistic photographs, however, has been slow in comparison with the collecting of other forms of art, and up to the 1960s very few art museums have taken an interest in the subject.

The most complete collections showing the development of the art of photography in many countries from its origin to the present day are those at George Eastman House, Rochester, N.Y., and the Gernsheim Collection, London. Both the Royal Photographic Society in London and the Société Française de Photographie in Paris possess notable material relating chiefly to the period before World War I, but since these collections rely entirely on gifts, they are rather sporadic and largely on a national basis. The Metropolitan Museum of Art, New York, also relying mainly on gifts, has a small and representative collection, chiefly relating to the period before 1914, whereas the Museum of Modern Art, New York, which formed an active department of photography in 1940, is particularly strong in contemporary work. The print departments at the Library of Congress and at the Bibliothèque Nationale in Paris have very large though haphazard collections

acquired originally through their function as national depositories of copyright material. The Library of Congress has the most extensive collection of photographs of the American scene, including Civil War photographs, and all the negatives taken for the Farm Security Administration. A beginning was made in 1947 to sift and catalogue the material which had been neglected for generations, and it is hoped that through a similar reorganization and cataloguing at the Bibliothèque Nationale both these great storehouses of photographs will eventually become readily available to the public.

Some other art museums have small collections of either old or contemporary photography, for example, the Victoria and Albert Museum, London, the Art Institute of Chicago, and the Staatliche Landesbildstelle, Hamburg, Ger. Several European museums, stimulated by exhibitions arranged from the Gernsheim Collection on the aesthetic development of photography, are in the process of building up collections; *e.g.*, the Museum of Modern Art in Stockholm, Sweden; the Stedelijk Museum, Amsterdam, the print department at the University of Leyden, Netherlands; the Folkwang Museum, Essen, and the City Museum, Munich, Ger.

(B. N.; H. Ge.)

TECHNIQUES OF PHOTOGRAPHIC ART

Anyone who has mastered a few simple instructions can make printable negatives with a pocket camera. Because it is impossible for the untrained beginner to achieve such acceptable results in any other medium, photography has sometimes been called the easy art. But to bridge the gulf between the taking of such casual snapshots and the production of photographs that can be classed as art is certainly no easy task. To the mastering of his tools and the perfecting of his technique, the photographer must devote just as much time and effort as does the musician or the painter. Since the nature of the photographic process determines the artist's approach, we must have some knowledge of the inherent characteristics of the medium in order to understand what constitutes the aesthetic basis of photographic art.

Photography must always deal with things—it can not record abstract ideas—but far from being restricted to copying nature, as many suppose, the photographer has ample facilities for presenting his subject in any manner he chooses. First, an infinite number of compositions can be achieved with a single stationary subject by varying the position of the camera, the camera angle, or the focal length of the lens. Second, any or all values can be altered by change of light on the subject, or the use of a colour filter. Third, the registering of relative values in the negative can be controlled by length of exposure, kind of emulsion used, and method of developing. And finally, the relative values in the negative can be further modified by allowing more or less light to affect certain parts of the image in printing. The photographer is restricted to representing objects of the real world, but in the manner of portraying those objects he has vast discretionary powers; he can depart from literal recording to whatever extent he chooses without resorting to any method of control that is not of a photographic (*i.e.*, optical or chemical) nature.

But the artist's use of these controlling powers must be conditioned by two factors: (1) the nature of his recording process, and (2) the nature of his image. There is a frequent cause of mistaken understanding in the belief that the camera's image reproduces nature as the human eye sees it. On the contrary, its ability to record things as the unaided human eye can never see them is one of the most important attributes of photography. The human eye can focus on but one small area at a time; consequently, we observe an object or a scene only by letting our eyes rove over it in a series of short jumps. The assortment of images thus recorded are flashed to the brain which sorts and edits them, automatically discarding some as of no importance and emphasizing others, according to its individual conditioning. The impersonal camera eye makes no such distinctions; every detail within its field of vision can be recorded instantly and with great clarity. In the time the eye takes to report an impression of houses and a street the camera can record them completely, from their structure, spacing, and relative sizes, to the grain of the wood, the mortar between the bricks, the dents in the pavement. The image that is thus registered has certain characteristics that at once distinguish it from the products of all other graphic processes. In its ability to register fine detail and in its ability to render an unbroken sequence of infinitely subtle gradations, the photograph cannot be equaled by any work of the human hand. For this reason any manual interference with the image at once destroys those very qualities that give the true photograph value as an art form. From these two facts we may draw an obvious deduction: if the recording process is instantaneous and the nature of the image such that it cannot survive corrective handwork, then it is clear that the artist must be able to visualize his final result in advance. His finished print must be created in full before he makes his exposure, and the controlling powers enumerated above must be used, not as correctives, but as predetermined means of carrying out that original visualization. As in the mastery of any other graphic form, years of experience are necessary in photography before technical considerations can be made entirely subordinate to artistic aims. The ability to prevision the finished print is the photographer's most important qualification and in order to attain it he must concentrate on learning to see in terms of his tools and processes. Having chosen the simplest possible equipment (so as not to complicate his task needlessly) he first learns by experiment the potentialities and limitations of each instrument and process. He must learn the field of his lens, the tone scale of his film and paper emulsions; he must learn to judge the strength and quality of light; he must learn to translate colours into their relative monochrome values and know how those values are affected by the use of different filters.

He must learn the kind of negative necessary to produce a given kind of print, and then learn what kind of exposure and development will produce that negative; then, having learned how those needs are fulfilled for one kind of print, he must discover how to vary the process to get other kinds of prints. Gradually, with experience, this knowledge becomes intuitive; the photographer sees a scene or object in terms of his finished print without having to think of these processes any more than a musician playing a piece thinks of the whereabouts of the next note he will sound or how much pressure he will use in sounding it.

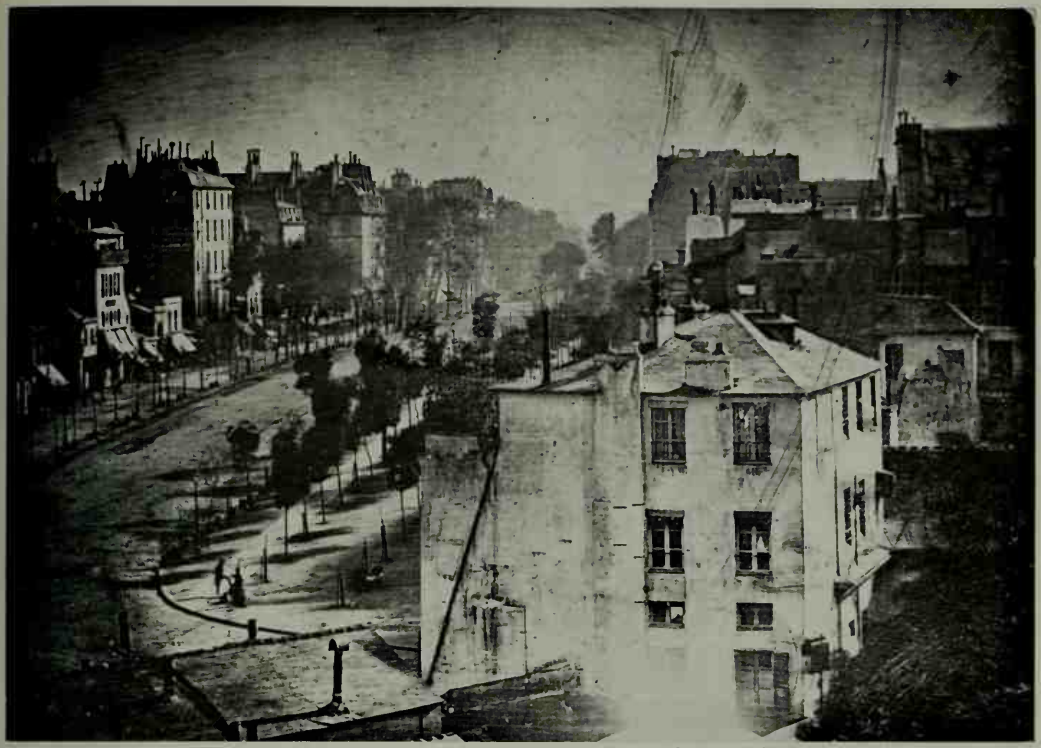
The Print.—The value of the photograph as a work of art depends primarily on the photographer's seeing before exposure, but its artistic value can be determined only by an examination of the finished print.

Exposure records the photographer's seeing; developing and printing execute it; so no matter how fine the original vision, if it has not been faithfully carried out in subsequent procedures, the resulting print will suffer. The clarity of image and delicacy of gradation that characterize a fine photograph demand a special kind of surface for their best presentation. A rough surface destroys the integrity of the image; a smooth surface retains it. A shiny or reflecting surface enhances the beauty of image quality, while a dull or absorbing surface tends to obscure it.

For beautiful image quality, the best of the old daguerreotypes can hardly be matched. The positives were made directly on the metal base and the small pictures were esteemed for their exquisite rendering of fine detail. The photo-painters, who did away with all things characteristically photographic, often used papers of independently beautiful surface texture for their prints. The result of such a combination is that the paper competes with the image instead of becoming a part of it.

Among modern processes the nearest approach to the fine image quality of daguerreotypes is a glossy print. Unfortunately, glossy paper is still held in general disfavour among creative photographers. It is said to be harsh and cold and only suitable for commercial work.

These erroneous beliefs are partly a hangover from the heyday of photo-painting and partly a result of the difficulty of making good glossy prints. The glossy surface reveals the image with such clarity that minor blunders, which might escape detection on the more veiled, dull-surface papers, are at once exposed. However, the glossy surface has the advantage of a longer scale which makes it possible to reproduce more of the negative and allows



COLLECTION OF THE BAVARIAN NATIONAL MUSEUM, MUNICH

"Paris Boulevard," daguerreotype by Louis J. M. Daguerre, 1839. On the corner at lower left is visible the first human form ever photographed. Though blurred, it is a man having his boots brushed. The street appears empty because the early daguerreotype process was so slow that only stationary objects could be captured on the plate

GEORGE EASTMAN HOUSE

"The Castle Ruins at St. Andrews, Scotland," calotype by D. O. Hill and R. Adamsen, taken between 1843 and 1848. An early attempt at photographing landscape which resembles a watercolour

NOTE—THE PHOTOGRAPHS ON THIS AND THE FOLLOWING PLATES ARE MARRED BUT HAVE BEEN LEFT UNRETOUCHED FOR REASONS OF HISTORICAL ACCURACY

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART. GIFT OF EDWARD S. HAWES, ALICE MARY HAWES, MARION A. HAWES, 1938

"Chief Justice Lemuel Shaw," daguerreotype by A. S. Southworth and J. J. Hawes, 1851. An early portrait of an eminent Massachusetts jurist

PHOTOGRAPHIC ART

GEORGE EASTMAN HOUSE

"The Two Ways of Life, or Hope in Repentance," a composite photograph made from 30 negatives and measuring 31 x 16 in. taken and assembled by Oscar Rejlander in 1857. The elaborate tableau is allegorical, showing a young man torn between a life of debauchery (left portion of picture) and virtue (shown at right)

COMBINATION PRINTS

GEORGE EASTMAN HOUSE

"Fading Away," a composite photograph made from 5 negatives by Henry P. Robinson in 1858. Robinson, like Rejlander, wished to convey the didactic allegories of Victorian painting through the new techniques of photography

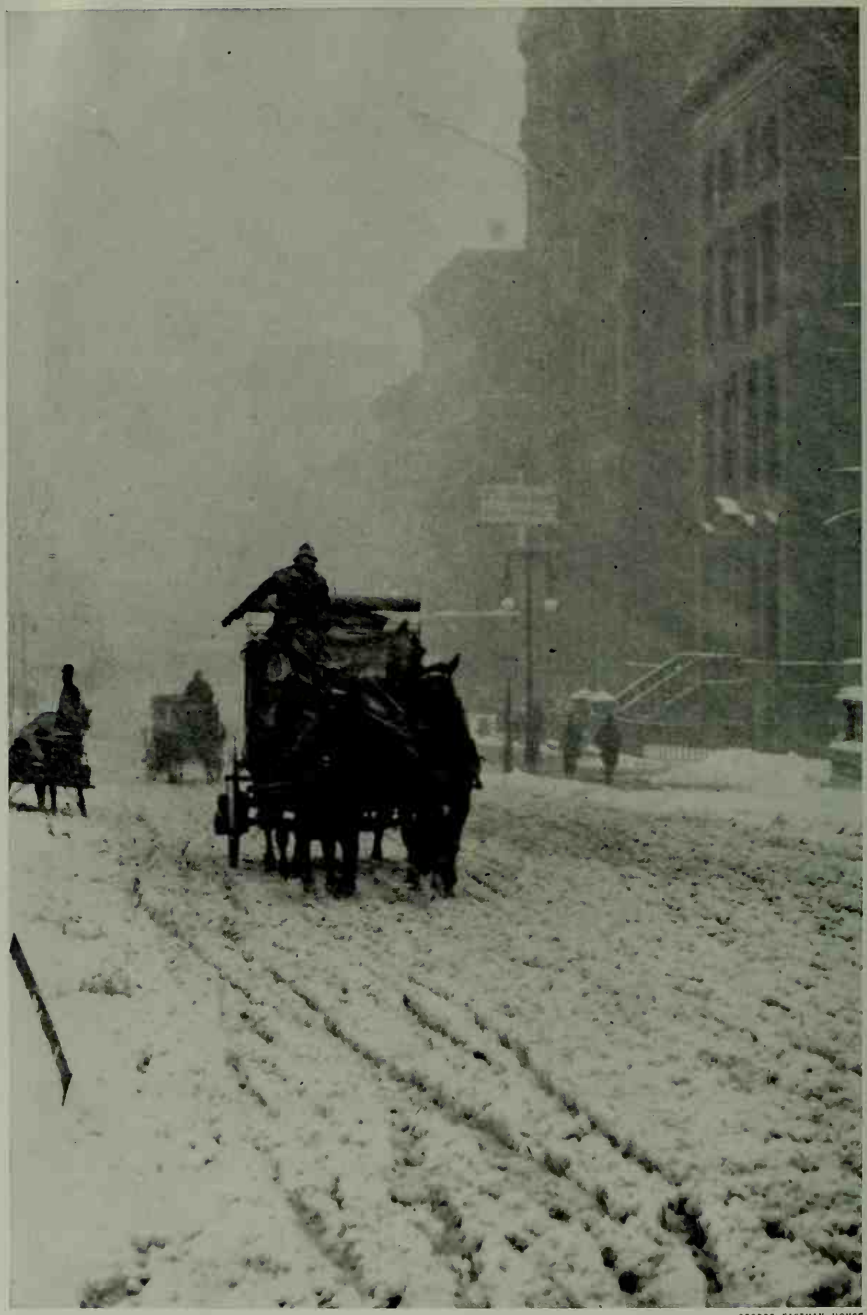
GEORGE EASTMAN HOUSE

"Gathering Water Lilies," a platinum print made in 1886 by Peter H. Emerson, the founder of the naturalistic school; one of his many pictures of life on the East Anglia marshes. Emerson strove to prove that photographers could produce valid works of art without merely copying conventions used in painting

GEORGE EASTMAN HOUSE

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, BEQUEST OF ALFRED STIEGLITZ, 1949. ALFRED STIEGLITZ COLLECTION

Two portraits by Julia M. Cameron: (left), Sir John Herschel, the astronomer, in 1867, and Ellen Terry, the actress



GEORGE EASTMAN HOUSE

"Winter on Fifth Avenue, New York," 1893, by Alfred Stieglitz, a pioneer in the use of the hand camera and one of the founders of the influential Photo-Secession group

GEORGE EASTMAN HOUSE

"The Octopus, New York" by Alvin L. Coburn, 1912, an early abstraction taken from atop a tall building

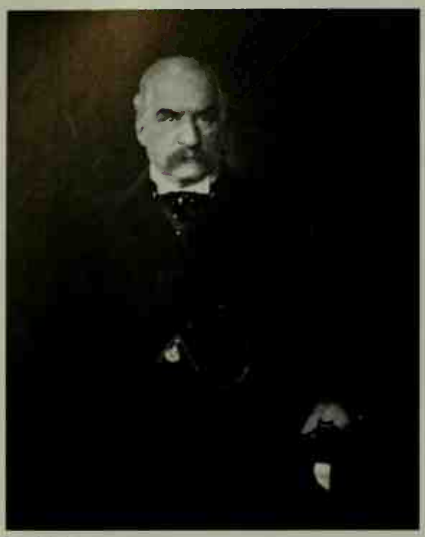
"Photogram" by László Moholy-Nagy, about 1940, an abstract photograph made by placing objects directly on sensitized paper and exposing the paper to light

GEORGE EASTMAN HOUSE

PAUL STRAND

"The Family" by Paul Strand, 1953, one of a book-length series of photographs comprising a profile of the small Italian town of Luzzara

PHOTOGRAPHIC ART

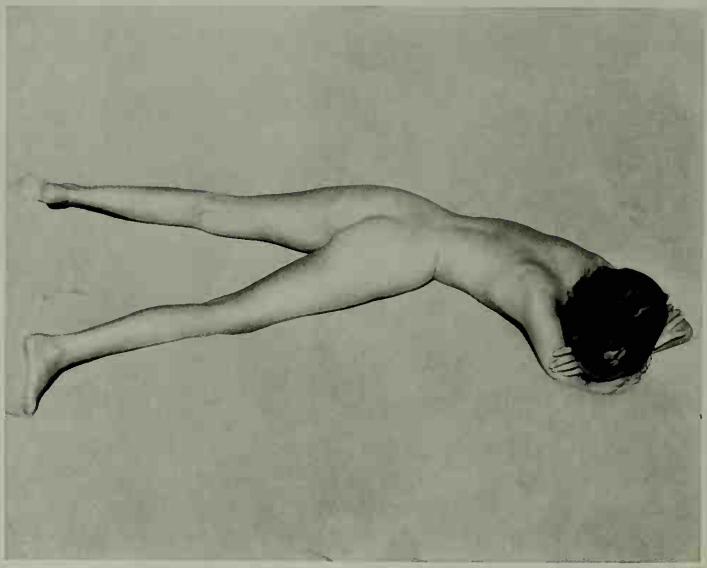


EDWARD STEICHEN

"Portrait of J. P. Morgan," platinum print by Edward Steichen, 1903

BERENICE ABBOT

"The Organ Grinder" by Eugène Atget, a long-neglected French photographer who recorded the look of Paris and its people during the early years of the 20th century



COLE WESTON

"Nude on Beach, California" by Edward Weston, 1936

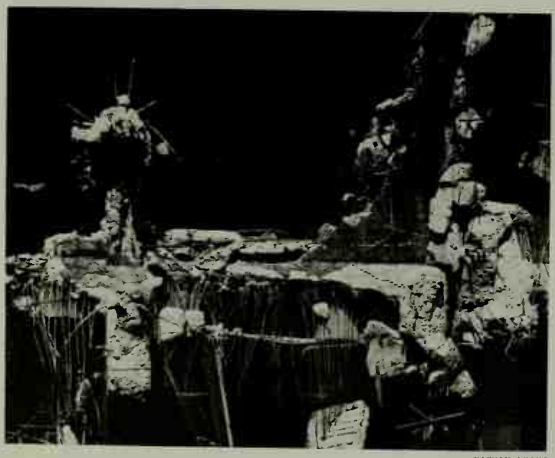
ANSEL ADAMS

"Moonrise, Hernandez, New Mexico" by Ansel Adams, 1941

PHOTOGRAPHIC ART

HENRI CARTIER-BRESSON—MAGNUM

"Children Playing in the Ruins, Spain" by Henri Cartier-Bresson, 1933



NATHAN LYONS

AARON SISKIND

Two contemporary abstract photographs: (above) "Demolition, Rochester, 1956" by Nathan Lyons and "Rome 50" by Aaron Siskind, 1963

a greater latitude in reproducing extremes of tone from the strongest to the most subtle and delicate. When a photographer speaks of the warm or cold tone of a print, he is usually referring to its colour—a cold blue-black as opposed to a warm green-black. But to use such variations of colour to emphasize the feeling of his picture is to misuse his medium. If he prints a snow scene blue-black so that it will look cold and a forest scene green-black so that it will appear warm, he is introducing a foreign element into his monochromatic process just as surely as if he coloured the print by hand. In black-and-white photography the effect of warmth or coldness should be communicated by the values in the print, whose colour should—at the extremes of the scale—be as nearly pure black and pure white as possible (use of obvious colour tone belongs in the province of colour photography). Obviously then, the longer scale of glossy paper gives greater opportunity of producing through the values in the print whatever effect is desired. And lastly, the luminous surface of the glossy paper, by making the image light-giving, comes nearer to rendering the effect of the original scene and so heightens the illusion of reality. A good glossy print reveals the delicacy of subtle gradation, the lucidity of tone, and the brilliant clarity of image that are unique characteristics of the photographic process.

Subject Matter.—It is impossible to make any sharp distinction between the subject matter appropriate to one graphic medium and that more suitable to another. But in the case of photography we can at least draw a few general conclusions, based on an examination of the work of the past and our knowledge of the special properties of the medium. From the wet plate era we may draw two contrasting examples that serve to indicate a field of endeavour in which the photographer is least likely to be successful. On the one hand is the work of O. G. Rejlander and Henry Peach Robinson, two men who achieved prominence for their photographic work in England during the 1850s and 60s. In their best-known pictures (Rejlander's "Two Ways of Life," and Robinson's "Fading Away") they attempted to depict allegorical and dramatic situations by combining a number of negatives of posed and costumed figures into composite prints. On the other hand is the work of Roger Fenton, Mathew Brady, Alexander Gardner, and many anonymous photographers who documented wars. These men were bound by no artistic purpose; their sole aim was to record to the best of their ability every phase and aspect of the hostilities that their clumsy and limited equipment could encompass. Yet it is in these straightforward records that we perceive true photographic quality: here is the tremendous power and appeal of the camera's realism, the intensity of its vision undiluted; and these documents of the past still move us profoundly with their clear, objective picture of the horror and pathos of war. Beside these photographs the artistic efforts of Rejlander and Robinson appear self-conscious, stilted, and artificial. Their carefully posed and costumed figures look absurd and unreal.

Now this comparison makes one fact apparent: the camera lens sees too clearly to be used successfully for recording the superficial aspects of a subject. It searches out the actor behind the makeup and exposes the contrived, the trivial, the artificial for what they really are.

But if the camera's innate honesty works any hardship on the photographer by limiting his subject matter in one direction, the loss is slight when weighed against the advantages it provides. For it is that quality that makes the camera expressly fitted for examining deeply into the meaning of things. The discriminating photographer can direct its penetrating vision so as to present his subject—whatever it may be—in terms of its basic reality. He can reveal the essence of what lies before his lens in a close-up with such clear insight that the beholder will find the recreated image more real and comprehensible than the actual object.

The photograph isolates and perpetuates a moment of time: an important and revealing moment, or an unimportant and meaningless one, depending upon the photographer's understanding of his subject and mastery of his process. The lens does not reveal a subject significantly of its own accord. On the contrary, its vision is completely impartial and undiscriminating. It makes no distinction between important detail and meaningless detail. Selection, emphasis, and meaning must be provided by the photographer in his composition. Nowhere has the painter's influence had a more lasting hold on photography than in the field of composition. Photographers who have put to use every other resource of their medium still try to emulate the work of painters in this respect. They consider composition as a thing apart, having no relation to a specific medium, but consisting of a set of tested rules and conventions that must not be contravened. To compose a subject well means no more than to see and present it in the strongest manner possible. The painter and the photographer will have two different ways of doing this because of the basic differences between their mediums. Its capacity for rendering fine detail and tone makes photography excel in recording form and texture. Its subtlety of gradation makes it admirably suited to recording qualities of light or shadow, and its ability to record sharply everything within the angle of lens vision from the immediate foreground to the distant horizon carries it far beyond the painter's province. The photographer cannot depend on rules deduced from finished work in another medium. He must learn to see things through his own eyes and his own camera; only then can he present his subject in a way that will transmit his feeling for it to others.

An intuitive knowledge of composition in terms of the capacities of his process enables the photographer to record his subject at the moment of deepest perception; to capture the fleeting instant when the light on a landscape, the form of a cloud, the gesture of a hand, or the expression of a face momentarily presents a profound revelation of life.

The appeal to our emotions manifest in such a record is largely due to the quality of authenticity in the photograph. The spectator accepts its authority and, in viewing it, perforce believes that he would have seen that scene or object exactly so if he had been there. We know that the human eye is capable of no such feat, and furthermore that the photographer has not reproduced the scene exactly; quite possibly we would not even be able to identify the original scene from having seen the photograph. Yet it is this belief in the reality of the photograph that calls up a strong response in the spectator and enables him to participate directly in the artist's experience.

Conception and execution so nearly coincide in this direct medium that an artist with great vision can produce a tremendous volume of work without sacrifice of quality. But the camera demands for its successful use a trained eye, a sure, disciplined technique, keen perception, and swift creative judgment. The artist who would use his photographic powers to the full must have all these, plus the first requisite for the artist in any medium—something to say.

(E. WN.)

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PHOTOGRAPHY is the process or art of producing visible images (photographs) on sensitive surfaces directly or indirectly by the action of light or other form of radiant energy. Classical photography depends on the action of light in bringing about changes in compounds of silver, usually the silver halides (*e.g.*, silver bromide, silver iodide, and silver chloride). These changes may be a directly visible darkening (print-out) or, more generally, may be invisible (latent image); in the latter case a developer must be applied to reveal the image. The act of permitting the light to fall on the sensitive layer is known as exposure. The developer is a chemical reducing solution that converts the exposed silver halide to dark, metallic silver.

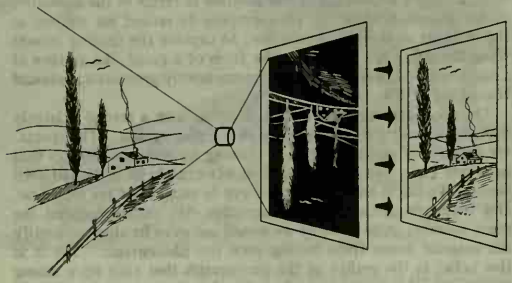
Usually, the brighter the subject is the darker the photograph is, so that a negative picture results. In order to obtain a positive picture, in which the light and dark parts correspond to those of the original scene, the negative is printed onto another sheet of sensitive material that basically resembles the negative material, so that the tones are reversed on the second sheet. If the positive is made in the original negative material by developing the negative, removing the negative silver by chemical means (bleaching),

and then developing the remaining material, the procedure is called the reversal process. Positives may be produced directly in the originally exposed material by using special effects such as solarization and the Herschel effect.

The sensitive layer usually consists of tiny particles of compounds of silver dispersed in gelatin and coated in a layer (usually less than $\frac{1}{1,000}$ in. thick) on a support consisting of rigid glass, flexible film, or paper. An example of a sensitive layer is silver bromide in gelatin. After it is exposed to light it can be developed to black silver, the degree of blackening depending on the extent of exposure. Treatment with a solution that dissolves the remaining silver bromide but does not attack the silver fixes the negative or positive and renders it stable against further exposure, after it has been washed in water.

The operations required to produce a photograph are these:

1. Preparation of the sensitive negative material.
2. Exposure.
3. Development, followed by fixation, washing, and drying.
4. Preparation of the sensitive positive material.
5. Printing.
6. Development, fixation, washing, and drying of the print.



BY COURTESY OF KODAK RESEARCH LABORATORIES

FIG. 1.—STEPS IN THE PRODUCTION OF A PHOTOGRAPH

In the early days of photography all of these operations were carried out individually by the photographer himself, but at the present time the sensitive materials, both negative and positive, are almost always made by manufacturing companies, and much of the developing and printing is done by commercial organizations.

A wide variety of negative materials, cameras, and printing processes are used in photographic operations, their selection depending upon the particular branch of photography under consideration.

This article discusses the fundamental principles and methods involved in the production of photographs. For other aspects and special applications of photography, the reader should *see* such articles as MOTION PICTURES; PHOTOGRAPHIC ART; PHOTOGRAPHY, CELESTIAL; PHOTOGRAPHY, SPARK; and PHOTOJOURNALISM. For a detailed listing of articles on this subject, *see* the references under "Photography" in the Index.

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I. HISTORY

Discovered by no one man, photography is the outcome of the early observations by physicists of the formation of images in the camera obscura and by chemists of the action of light, sub-

jects that in truth belong to the domain of photo-optics and photochemistry (*q.v.*). Although the blackening of silver salts was known in 1565, it was not until 1725, when J. H. Schulze used a mixture of silver nitrate and chalk under stenciled letters, that it was definitely recognized that this darkening action was caused by light and not by heat. The experiments were repeated by William Lewis in 1763 and Joseph Priestley in 1772 and were greatly extended by C. W. Scheele in 1777. Their work led to Thomas Wedgwood's experiments with silver nitrate on paper and leather, the results of which were published in 1802. Humphry Davy suggested that silver chloride would be more sensitive to light, but all early efforts to make pictures with the camera obscura failed because of the very long exposures required, and because no means were known by which to remove the unaffected material and thus stabilize or "fix" the image against light.

1. Camera.—The camera was the outcome of the old camera obscura, originally a darkened room with a tiny hole in the window shutter for viewing natural scenes, the invention of which has been incorrectly ascribed to Giovanni Battista della Porta, who in his *Magia naturalis* (1558) published a long and clear description of it. The principle had, however, been known to Alhazen (*c.* 1000), Roger Bacon (*c.* 1267), and others; and the camera obscura itself had been described by Leonardo da Vinci (d. 1519) in his notebooks, which remained unpublished until 1797. In 1550 Geronimo Cardano proposed the addition of a biconvex lens to obtain a brighter image. Daniello Barbaro in 1568 suggested the use of a diaphragm to secure greater sharpness. Ignazio Danti in 1573 corrected the reversed image by means of a concave mirror behind the lens, a device still in use. Friedrich Risner (d. 1580) described in his works (published 1606) methods of enlarging and reducing the image, and proposed that a portable box be used in lieu of the room in use until then. Della Porta, in his greatly enlarged second edition of the *Magia naturalis* (1589), included all the improvements of others as his own. Johannes Kepler in his work on optical astronomy, 1604–11, described the use of a concave lens behind the convex to obtain larger images, and thus anticipated the telephoto lenses of the present day. In a book published in 1685–86 Johann Zahn described a portable camera obscura with two or three lenses mounted in a tube to secure a more brilliant image on a ground glass, and side wings to shield it from extraneous light. At the beginning of the 18th century the portable camera obscura had become a regular article of commerce and was used to obtain sketches from nature. Its use was stimulated by the growth in the number of amateur artists, who also used other optical devices, such as the camera lucida and the Claude glass, as aids in sketching.

The ineptitude of the artists led to an interest in letting light from the scenes create its own record, particularly through the medium of the camera obscura. Photography thus grew from attempts to apply to the interests of picturemakers observations on the action of light in producing visible changes.

BY COURTESY OF THE GERNSHEIM COLLECTION, LONDON

EARLIEST EXTANT PHOTOGRAPH BY J. NICÉPHORE NIEPCE OF THE VIEW FROM HIS WINDOW AT GRAS, NEAR CHALON-SUR-SAÔNE, FRANCE. FIXED ON A PEWTER PLATE IN 1826

2. The Beginnings of Photography.—Toward the end of the 18th century there grew a demand for inexpensive naturalistic pictures, particularly portraits. A simple way of producing pictures was the silhouette, made by tracing the outline of a projected image of the face and filling it in with black. In 1786 G. L. Chrétien invented the "physionotrace" in which the projected image of a head was traced by a stylus, and by a pantograph arrangement an engraving tool cut a copper plate which could be inked and printed. Aloys Senefelder invented lithography in 1798; but, though it was introduced in Paris in 1802, it was not until 1813 that it became a success and a fashionable hobby. From that date until 1817 Joseph Nicéphore Niepce was engaged in an examination of natural stones to find one suitable for lithography. Since he was unable to draw, his son, Isidore, undertook this work, and when the latter was called for military service, Niepce was impelled to produce the images automatically. In conjunction with his brother Claude, Niepce first tried photography with silver chloride on paper. The light sensitiveness of iron, manganese, acids, and other compounds was tested, stone, metal, and paper being used as supports. Finally, guaiacum resin was tried and then asphalt, or bitumen of Judea, which had been in common use as an etching ground since the days of Rembrandt. This, becoming insoluble in its usual solvents by the action of light, gave not only a resist for the etching of metal plates but also transparent images on glass. A successful result—a photographic copy of an engraving without use of the camera—was obtained in 1822, and thus it may be said that the first permanent photograph was made in that year by Niepce. Prior to that, in 1816, Niepce had obtained in the camera a positive on paper.

BY COURTESY OF THE GERNSHEIM COLLECTION, LONDON

DAGUERREOTYPE OF L. J. M. DAGUERRE TAKEN IN 1848 BY J. E. MAYALL

Three years were required to perfect the process of heliography, as it was called, by the simple superposition of waxed engravings; and in 1826 an etched pewter plate was sent to G. Lemaître, of Paris, to be printed. In order that the pictures should be more distinct, they were exposed to the vapours of iodine. The highlights of the plates consisted of hardened bitumen; the shadows, of the bare metal; thus, the contrasts were very poor. This led to the use of pewter instead of copper. Lemaître suggested silvering copper plates. Between 1816 and 1829 Niepce also fixed the image in the camera several times using silver compounds and the bitumen process. In 1827 he submitted to the Royal Society, London, his first successful view from nature, taken in the camera obscura with an exposure of over eight hours, together with a memoir on heliography.

3. Daguerreotype.—In 1826 L. J. M. Daguerre, a painter who had experimented with silver salts, heard of Niepce's work and approached him to form a partnership. This was consummated in December 1829. The work that Daguerre had done with Niepce had drawn their attention to the light sensitiveness of silver iodide, and Daguerre discovered that the effect produced by exposing an iodized silver plate in a camera would result in an image if the plate were fumed with mercury vapour and fixed in a solution of common salt. The inventions of Niepce and Daguerre were published simultaneously by the French home minister in a bill presented to the Chamber of Deputies proposing a national reward to the inventors. A full description of their methods was presented by François Aragn on Aug. 19, 1839, at a joint meeting of the Académie des Sciences and of the Académie des Beaux Arts.

The daguerreotype process was a complete success. In its operation, a silvered copper plate was buffed and burnished to a high polish. It was then iodized by fuming with iodine, and exposed in a camera for 20–30 minutes, which excluded portraiture. After various optical and chemical improvements by American, English, and Austrian investigators, from 1841 onward exposures were secured in a few seconds under favourable light conditions. The development was effected by placing the exposed plate over a cup of mercury heated to about 75° C. The image was then fixed with a solution of thiosulfate of soda and strengthened by treatment with gold chloride. The daguerreotype was viewed by reflected light and was laterally reversed, and copies could only be obtained by copying the original picture. The process flourished, especially for portraiture, until about 1860. England was the only country in which it had been patented.

4. Calotype.—A preliminary notice of Daguerre's success was made by Arago on Jan. 7, 1839. This caused W. H. Fox Talbot,

BY COURTESY OF MATILDA TALBOT AND HAROLD WHITE

FOX TALBOT'S CALOTYPE ESTABLISHMENT AT READING, ENG., ABOUT 1845

Assistants photographing a painting and making a portrait

an Englishman, to claim priority in obtaining a picture in the camera and rendering it permanent. Talbot had begun his experiments in 1834, using the camera obscura with silver chloride on paper and common salt or potassium iodide as fixing agents. A communication was made to the Royal Society on Jan. 31, 1839. But not until a month later did he disclose his working method of "photogenic drawing," which then involved silver iodide with an excess of the nitrate, and fixation with sodium thiosulfate. The solvent action of this for silver salts had been discovered by Sir J. F. W. Herschel in 1819. Exposures were 30 minutes to one hour in the camera until June 1841, when Talbot announced the much faster, patented, calotype process in which the latent image was developed with gallic acid, the accelerating action of which had been discovered independently by the Rev. J. B. Reade.

The developed image on calotype paper was the exact reverse, as far as light and shade were concerned, of the original image. Such a picture was termed by Herschel in 1840 a "negative." The transparency of paper can be increased by waxing or oiling, and so Talbot was able to obtain true copies, or positives, of any negative by simple contact printing upon another piece of sensitized paper. Talbot's process is the first step in the real line of photographic development, the inventions of Daguerre and Niepce being bypaths whose chief importance was the stimulus they gave to photographic evolution. The disadvantages of calotype were the long time required for printing and the structure of the paper.

Herschel in September 1839 took a photograph on glass coated with carbonate of silver. In 1848 Abel Niepce de Saint-Victor suggested albumen as the vehicle for silver iodide. This albumen-on-glass process was very slow but held its own until 1851, when Frederick Scott Archer, an English sculptor, published a description of his wet collodion process.

5. Collodion Process.—To a solution of cellulose nitrate (collodion) in ether and alcohol, Archer added a soluble iodide, usually with the addition of a little bromide, and coated a glass plate with it. In the darkroom, the iodized collodion was sensitized by immersion in a bath of silver nitrate and formed silver iodide with an excess of silver nitrate. The plate was exposed wet in the camera, developed by pouring on a solution of pyrogallol containing acetic acid, and fixed with a strong solution of thiosulfate of soda for which potassium cyanide was later substituted. Archer's collodion process was not patented, and as it was the fastest photographic process it displaced by the mid-1850s both calotype and daguerreotype. For portraiture, a modification of the process was devised by Archer and P. W. Fry. An underexposed negative backed with black paper or velvet appeared as a positive and was very popular for cheap portraiture under the name Ambrotype.

BY COURTESY OF GEORGE EASTMAN HOUSE

AMBROTYPE WITH BLACK BACKING ON ONE HALF TO SHOW ITS NEGATIVE-POSITIVE CHARACTER

The necessity for preparing the plates immediately before exposure and developing them immediately after considerably limited the practice of photography. John Spiller and William Crookes suggested bathing the prepared plates in a solution of a hygroscopic salt so that they could be kept some time both before and after exposure. This was followed by the use of hygroscopic substances of all kinds. They greatly reduced the speed of the plate, however, and were of little practical value.

6. Collodion Emulsion.—In 1864 B. J. Sayce and W. B. Bolton described the preparation of an emulsion of silver bromide in collodion. In 1874 Bolton washed the emulsion in bulk to remove the soluble salts formed in precipitating the silver bromide, and his methods are still followed.

Collodion emulsion, though it was no more sensitive, was a practical advance over wet collodion. A considerable increase of sensitiveness was obtained when C. Russell introduced alkaline development in 1862, but the full fruit of this was reaped only with the introduction of gelatino-silver bromide dry plates.

7. Gelatin Emulsion.—In 1871 R. L. Maddox made an emul-

BY COURTESY OF GEORGE EASTMAN HOUSE

"SEASCAPE," WET-COLLODION PHOTOGRAPH BY GUSTAVE LE GRAY, 1856. FOR THE FIRST TIME, MOTION WAS STOPPED WITH "INSTANTANEOUS" PHOTOGRAPHY

sion of silver bromide in essentially the same manner as that used for making collodion emulsions but he substituted gelatin for collodion. The matter was followed up by other experimenters, who greatly improved and speeded up the emulsion. Among them must be mentioned John Burgess, Richard Kennett, and Charles Bennett. Kennett placed on the market a dry, washed emulsion which photographers could dissolve in warm water and use as a coating on glass and thus produce their own plates.

A great amount of experimental work was at once commenced on gelatin emulsions, the records of which filled the photographic journals between 1873 and 1885. The by-product salts were removed by washing. William Abney recommended the use of iodide in small quantity with the bromide and found that this made it possible to obtain faster emulsions with less fog. Digestion, or "ripening," as it was called, came into use in 1878, and in 1879 Désiré van Monckhoven employed precipitation in ammoniacal solution as the basis of manufacturing dry plates. In 1877 the commercial plates of the Liverpool Dry Plate and Photographic Printing Company, Wratten and Wainwright, and B. J. Edwards were introduced. By 1879 comparatively rapid dry plates were available on the market.

After this period, amateurs gradually ceased their researches, and mass manufacture became general. Considerable increases in sensitiveness were made by improved emulsion-making techniques which resulted in further advances in sensitivity without the undesirable qualities which previously had accompanied attempts to increase speed.

8. Colour Sensitivity.—The silver halides are sensitive chiefly to the blue, violet, and ultraviolet rays; hence, all other colours are reproduced as dark grays or blacks. In 1873 H. W. Vogel of Berlin discovered that the addition of certain dyes to the emulsion, or immersion of the coated plates in a solution of dye, increased the sensitiveness to other colours.

Following this, J. Waterhouse found that eosin sensitized collodion emulsion, and shortly afterward John Clayton and P. A. Attout found that eosin would sensitize gelatin emulsions. They obtained a patent for its use in England and France, and their plates were placed on the market under the name of "isochromatic" plates. In 1884 eosin was replaced by erythrosine, which was found by Joseph M. Eder to be a better sensitizer, and for 50 years erythrosine was used almost exclusively for the so-called "isochromatic" or "orthochromatic" materials. In 1903 Adolf Miethe and Arthur Traube found that ethyl red, an isocyanine dye, gave strong colour sensitiveness as far as the orange of the spectrum, and in 1905 B. Homolka discovered Pinacyanol, a dye of structure somewhat similar to ethyl red but which sensitizes very powerfully throughout the red. It thus became possible to make "panchromatic" plates, which would photograph the entire visible spectrum without difficulty. Such plates were placed on the market in 1906 by the English firm Wratten and Wainwright.

The early dyes were largely of the cyanine and isocyanine types. In 1920 W. H. Mills and F. M. Hamer found Pinacyanol to be a carbocyanine dye. After that time there was much activity in the study of sensitizing dyes, resulting in the present great variety which achieve high sensitivity in all parts of the visible spectrum and out into the infrared. Most of the new dyes were found after 1929 in England, Germany, and the United States, and the most important types are modifications of the carbocyanines and the merocyanines.

The first panchromatic film was made by the Eastman Kodak Company in 1914, but it was not generally used for motion-picture work until 1925. In 1931 a new supersensitive type of panchromatic film was introduced. The progress in sensitizing dyes made possible the great advance in colour photography after 1930 and the introduction of plates and films of high speed and low graininess.

9. Film.—The weight and fragility of the glass support led to attempts to replace it by lighter and flexible substitutes. In 1875 Leon Warnerke introduced a roller slide containing a spool of stripping film for 100 exposures. Ten years later the roll film system of photography was popularized through mass manufacture by George Eastman and W. H. Walker. A machine for continuously coating photographic paper in long rolls was patented by Eastman in 1884. The sensitized paper was loaded into a roll holder which could be attached to the back of a camera in the same position as a plateholder. At first, the paper was greased to reduce the printing time, but later a stripping film was used. This consisted of a temporary paper base coated with soluble gelatin, which in turn was coated with a gelatin emulsion.

This stripping film was used in the first portable roll film camera, the No. 1 Kodak, marketed in 1888. The pictures were circular, about $2\frac{1}{2}$ in. in diameter. When the film was used up, the camera was returned to the manufacturer, who developed and printed the pictures and reloaded the camera. This was the origin of modern photofinishing.

Eastman conducted experiments to produce a flexible film from collodion, but the ether-alcohol solutions would give only films that were too thin to be of practical use. Finally, the use of wood alcohol as a solvent for nitrocellulose was discovered, and a flexible film was marketed in rolls in 1889. In the previous year J. Carbutt had introduced emulsion coated on sheets of plastic nitrocellulose cut from blocks. The new flexible Eastman film was utilized immediately by Thomas A. Edison. The film had been independently invented, and a patent applied for in 1887, by the Rev. Hannibal Goodwin.

In 1891 daylight loading film was made. The film was wound on a wooden core inside a light-tight box and black cloth leaders were attached to the ends of the film. Later, the film was wound inside a protective sheet of black paper; sufficient overlength was left to permit loading of the camera without fogging the sensitive film. In 1903, a noncurling film was produced by coating the back of the film with plain gelatin.

AMERICAN PIONEERS IN PHOTOGRAPHY

(Below) Wagon used by Mathew B. Brady to carry his photographic equipment to the Civil War battlefields. Brady worked with wet plates, which necessitated transporting chemicals to prepare and process the plates. (Right) W. H. Jackson photographed in 1873 atop Observation Point in Yosemite Valley. Jackson's photographs were among the first depicting the American West

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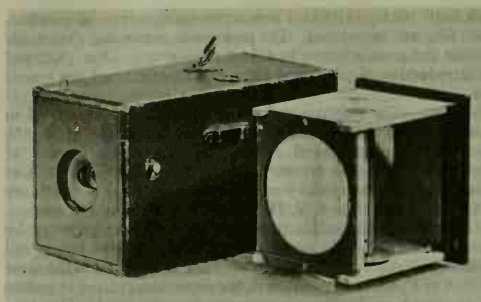


BY COURTESY OF EASTMAN KODAK COMPANY

THE ORIGINAL NO. 1 KODAK, PERFECTED IN 1888

In 1895 positive film was introduced for printing motion pictures. In 1909 slow-burning motion-picture film was first made by the substitution of cellulose acetate for cellulose nitrate as the plastic used in the preparation of the base.

A method of packing films, invented in 1903, was introduced on the market under the name of "film packs." These are now used mostly in cameras of the type originally designed for plates and sheet film. Flat sheet films have taken the place of plates to a considerable extent, especially in professional photography.

In 1917 X-ray films coated on both sides with emulsion were introduced. Because of the transparency of the material to the X-rays, this doubled the density to be obtained.

The year 1923 marked the introduction of 16-mm. cellulose acetate motion-picture film packed in such a manner that it could be loaded into small motion-picture cameras without the use of a darkroom. This film was designed for finishing by a reversal process, in which the first negative is removed by a bleaching bath and a positive is then developed in the remaining silver bromide. In 1932 a similar film 8-mm. wide was introduced. The use of these films led to a great advance in amateur cinematography.

10. Developing Agents.—In the calotype process gallic acid was used as the developer, but in 1851 H. V. Regnault of Paris and Justus von Liebig simultaneously discovered the more energetic pyrogallol, which allowed shorter exposures to be given. This was used also at first for wet collodion, though it was later replaced by an iron salt, and for dry collodion plates. Until 1861 free silver nitrate was an important ingredient of developers; but in that year G. Wardley proved that pyrogallol alone could be used. C. Russell and Thomas Leahy independently announced alkaline pyrogallol development, the former suggesting also an alkaline bromide as restrainer. Even after the introduction of the gelatin dry plate, pyroammonia was the only developer used until 1884, when the alkaline carbonates came into general use. In 1880 Abney discovered the developing properties of hydroquinone. C. Égli and Arnold Spiller recommended the use of hydroxylamine in 1884. In 1888 M. Andresen of Berlin patented the use of para-phenylenediamine, para-toluidinediamine, and xylidenediamine as developers. In 1891 he patented the use of para-aminophenol and its derivatives, especially para-methylaminophenol sulfate (Metol, Elon). In 1951 W. B. Kendall and Ilford Ltd. announced a new kind of developing agent, 1-phenyl-3-pyrazolidone, under the trade name of Phenidone. It can be used to replace a great part of the Metol in Metol-hydroquinone developers.

11. Printing Processes.—The first printing process, *i.e.*, Talbot's, employed silver chloride and excess silver nitrate on plain paper, the image being more or less buried in the fibres of the paper. Furthermore, many hours of daylight were essential for printing. Louis Désiré Blanquart-Evrard in 1847 suggested the use of albumen to keep the sensitive salt more on the surface. A few years later the first coat of albumen was coagulated and a second applied, which gave a more brilliant glossy surface. The colour of prints obtained on this printing-out paper was yellow and to darken the colour to a deep sepia Gustave le Gray in 1850 proposed toning the print with chloride of gold which had been the standard practice with daguerreotypes since 1841. Albumenized paper toned with gold remained the standard photographic printing medium until about 1900. It was too slow for enlarging purposes.

Alexis Gaudin had suggested an emulsion of silver chloride in collodion for printing-out. This was revived by George Wharton Simpson in 1864. Paper thus prepared was introduced commercially by J. B. Obernetter four years later. Humbert de Molard, 1855, proposed to precipitate silver chloride, wash and suspend it in a solution of starch or gelatin, and paint the mixture onto paper. The same process was revived by W. H. Smith and J. E. Palmer in 1865 and by Abney in 1882. From that date gelatinochloride, or printing-out, paper came into general use and eventually completely displaced albumen. Printing-out papers are little used now except for proofs.

Gelatin silver bromide paper was invented and first produced in 1873 by Peter Mawdsley, founder of the Liverpool Dry Plate & Photographic Printing Company. Six years later J. W. Swan of Newcastle patented it and by 1880 several firms had begun its manufacture in England. In 1881 J. M. Eder and G. Pizzighelli published a paper on gelatinochloride of silver with development, and the former, two years later, described a chlorobromide emulsion. Chloride developing paper was introduced by Marion and Co. in England under the name of Alpha in 1884 and by the Nepera Chemical Co. in the United States as Velox nine years later. Since then the use of this paper has increased, special types, including a great variety of surfaces, being used for amateur and professional work. Modern papers are of the chloride type for contact printing, and of the bromide and chlorobromide types mainly for enlargements. Special papers are made for industrial and scientific use, document reproduction, graphic arts, and photofinishing.

12. Nonsilver Printing Processes.—The gradual fading of silver prints led many experimenters to the investigation of different light-sensitive substances promising permanence. Robert Hunt utilized the light sensitiveness of ferric oxalate in combination with a platinum salt in the hopes of obtaining images in that metal, but the process was a failure because he did not recognize that the ferrous salt, formed by the action of light, must form a complex in order to reduce the platinum salt to the metal. William Willis of London in 1873 patented a workable platinum process, but it was not until 1879 that platinum paper was put on the market. The pictures are permanent but the high cost of platinum and the ease with which development papers are worked resulted in neglect of the process after World War I.

Louis Vauquelin in 1798 had discovered the light sensitiveness of silver chromate; G. I. Suckow in 1832 observed that the bichromates were reduced by light in the presence of organic matter. Mungo Ponton in 1839 used paper treated with potassium bichromate. Edmond Becquerel in 1840 and Robert Hunt in 1843 made improvements; but Talbot first pointed out in 1852 that bichromated gelatin became insoluble on exposure to light, and this was patented as a resist for photogravure, for which it is still used.

Paul Pretsch, Alphonse Poitevin, Testud de Beauregard, Henri Garnier, and A. Salmon and John Pouncy devised carbon processes in which carbon in a finely divided state was used as the pigment in bichromated gelatin. But they failed to recognize the important point that, as the light acted first on the outer surface of the gelatin, those parts underlying the middletones and highlights would still be soluble; hence, on developing with warm water, they would have no anchorage to the support and would be washed away. J. W. Swan in 1864 patented the production of carbon, or pigment, prints by transfer of the exposed pigmented tissue to a temporary support on which it was developed from the back. A few months later Walter Bentley Woodbury of London patented a photorelief printing process, called Woodburytype, which produced very similar permanent photographs to the carbon process.

Working on principles published by Alphonse Poitevin in 1855, A. Rouillé-Ladêveze in 1894 introduced the gum print process

which after further improvement by R. Demachy the following year became the favourite medium of pictorial photographers until the 1920s. T. Manly in 1905 patented Ozobrome, a pigment process in which a developed silver print was squeegeed into contact with pigmented tissue saturated with potassium ferricyanide and bichromate. A modification of this, known as Carbro, was introduced later.

In 1905 G. E. Rawlins reverted to an old process suggested by E. Mariot in 1866. Gelatinized paper is sensitized with bichromate, dried, exposed under a negative, freed from excess salt, and inked up with a greasy ink, which adheres only to the light-affected parts. Somewhat similar is the bromoil process, first suggested in 1907 by E. J. Wall and worked out by Welborne Piper. This utilizes the principle, stated by Howard Farmer in 1889, that finely divided silver imbedded in gelatin reacts with bichromates and renders the contiguous colloid insoluble. A bromide print is treated with a hardening and bleaching solution, fixed, washed, and dried, then soaked in water and inked up with a greasy ink, which takes only on those parts where there was silver.

A number of printing processes have depended upon the light sensitivity of salts of iron. The most used until after World War II was the blueprint process for copying drawings, introduced by Herschel in 1842. Paper is sensitized with a mixture of potassium ferricyanide and ferric ammonium citrate. On exposure to light the latter is changed to the ferrous compound which, on wetting the paper, combines with the ferricyanide to form Prussian blue. In the ferrogallic process the exposed iron salts are developed in gallic acid to give a positive image in dark ink. The ferrous salts formed by exposing ferric compounds to light can reduce other metal salts to the metal. Platinotype depends essentially on this reaction, but in the argentotype (Herschel, 1842) and kallitype (1889) and the more recent Vandyke processes, a silver image is formed by reduction of silver nitrate by the ferrous salt. In the ferrogelatin process (A. Tellkampf and Arthur Traube, 1905; also known as fotol, Ordoverax, fulgar) an unwashed blueprint is squeegeed in contact with a moist gelatin surface, then removed, and the surface rolled with greasy ink, which gives a positive image that can be transferred to paper.

Light-sensitive organic compounds have formed the basis of many printing processes, the most used being the diazotype process for copying drawings (G. Kögel, 1917, 1920). In it, paper is coated with diazo compounds that are destroyed on exposure to light, development being with a "coupler" that combines with the unexposed diazo compound to form a dye.

In the metal-diazonium process, higher sensitivity is obtained than in the normal diazo process. On exposure to ultraviolet, certain diazo compounds give decomposition products that can reduce some metal salts, *e.g.,* mercurous nitrate, to the metal if the compounds are coated together. The small particles of metal formed, *e.g.,* mercury, can be physically developed in a solution of silver salts and a reducing agent to give a dense image of high contrast and high resolving power.

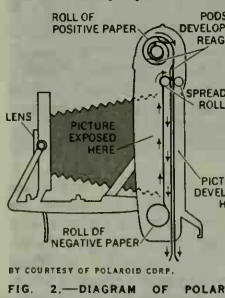
Photosensitive glass was described by S. D. Stookey and the Corning Glass Works in 1947. Coloured images can be produced in special glasses by exposure to ultraviolet followed by heating. Silicate glass is used, but it contains ultraviolet absorbers, optical sensitizers, and photosensitive metals such as gold, silver, and copper. In 1951 a new photosensitive glass was announced in which exposure to ultraviolet followed by heat treatment increased very greatly the solubility of the glass in hydrofluoric acid so that relief patterns could be etched into the glass.

Photothermography provides a dry method of copying documents relying on reactions initiated by heat and giving a directly-visible image. In the Thermo-Fax process, documents are copied by reflex, using a source of infrared radiation. The rays absorbed by the dark image areas of the original document are converted into heat which affects locally the coating of a sheet of material in contact with it. Originally, a layer of wax was used and was caused to melt into a paper supporting layer having a coloured opaque backing. Later a chemical reaction between colour-forming components in the coating was initiated imagewise by the local heating. In 1950 there was introduced on the American market equipment for an electrophotographic process—xerography—which is a dry, indirect process of photographic reproduction. It depends on the action of light in discharging a uniformly charged photoconductive insulating layer on a conductive support, such as selenium on a sheet of aluminum. The resulting electrostatic image is "developed" by applying a finely divided dark pigment on a charged carrier so that the pigment will adhere to the charged areas on the layer. This pigment can then be transferred to a receiving sheet, such as paper or a lithographic plate, and fused on by heating. In the Electrofax process, announced in 1954, a photo-conductive layer consists of zinc oxide in an insulating resin binder, on a paper base. The sheet is uniformly charged electrically, discharged imagewise by exposure to the document to be copied, powdered with a pigment which adheres to the remaining charged areas, and fused directly onto the zinc oxide-coated paper.

Some processes have been devised in which the image is produced in a transparent layer by releasing bubbles of gas which scatter light and so give a white image by reflected light and an image of appreciable optical density by transmitted light. Such a system is the Kalfax or Kalvar process, in which diazo compounds are incorporated in a transparent resin layer. On exposure to ultraviolet radiation, nitrogen is released, and when the layer is then heated the gas bubbles expand and form a scattering "bubble" image. Other processes depending on the release of gas have been proposed for producing a relief for braille and for relief printing plates.

Photosensitive polymers have been used, mainly to make "resists" for printing plates, printed circuits, and chemical etching systems. These materials can be coated on metal and other surfaces, using specific solvents, and on exposing the coatings they "polymerize" to become insoluble in the normal solvents. The unexposed areas may thus be dissolved out leaving an "image" in the insoluble polymer which can act as an ink-carrying area in lithography, or as a "resist" against the etching of the metals on which it is left, to provide the relief printing plates in photoengraving, printed circuits, and so on.

Image Transfer Processes.—Image transfer processes have assumed much importance for document reproduction and for continuous-tone photography in the camera. Basically there are two systems, which can be distinguished as diffusion transfer and physical transfer. The diffusion transfer process appears to have been described almost simultaneously in Europe by A. Rott of the Gevaert Company and E. Weyde of the Agfa Company, in 1944, and papers under the names of Geva-copy and Copyrapid respectively appeared on the market for document copying. In the United States, E. H. Land in 1947 adapted a diffusion transfer process for obtaining paper prints rapidly in the Polaroid Land camera. The physical transfer processes are represented commercially by the Verifax system introduced by the Eastman Kodak Company in 1952.



BY COURTESY OF POLAROID CORP.

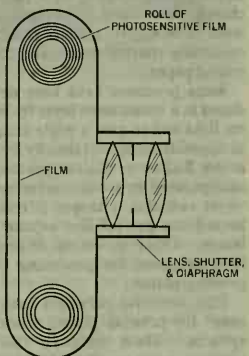
FIG. 2.—DIAGRAM OF POLAROID LAND CAMERA IN WHICH THE DEVELOPMENT IS PERFORMED AND PRINT PRODUCED BY SOLVENT TRANSFER

In the diffusion transfer process, the negative is developed in the presence of a solvent for silver halide. This not only develops the negative, but also dissolves the nondeveloped silver halides. In contact with the negative layer is another sheet coated with a material such as gelatin containing nuclei for physical development. The silver halides dissolved out of the negative sheet are physically developed onto the adjacent sheet to give a positive image in silver. Many variations are possible, for instance, the developing agent may be in the emulsion of the negative layer and the silver halide solvent in the receiving layer. In the Polaroid Land camera, the combined developing-fixing solution is contained in a "pod" which bursts under pressure in the camera and spreads

the processing chemicals in a thin layer between the exposed negative material and the receiving paper (or film) as they are wound on together. This principle has been applied to colour photography.

The diffusion transfer method is used in the Kodak Bimat system introduced in 1963. A film (Bimat) coated with a colloid layer containing nuclei and soaked in solvent-developer is wound in contact with the camera film after exposure. A negative is developed, with a corresponding positive transparency in the Bimat web.

In the Verifax system using physical transfer, the material exposed in the printer is of paper coated with an unhardened emulsion containing the developing agent. It is exposed in a special printing box by reflex to the document to be copied, and is immersed in an "activator" which initiates development of the negative. The negative sheet is then pulled out of the apparatus in contact with a receiving sheet to which some of the nondeveloped, unhardened positive image adheres. Dye-forming components may be present to enhance the density. (W. Ck.; H. Ge.)



BY COURTESY OF KODAK RESEARCH LABORATORIES

FIG. 3.—ELEMENTS OF A CAMERA

II. MATERIALS OF PHOTOGRAPHY

Negative materials are made by preparing a precipitate of silver bromide containing a small amount of silver iodide in a medium containing enough gelatin to enable it to be set to a jelly when cooled. This suspension is termed the emulsion. The melted emulsion is coated upon a support that may consist either of glass, in which case plates are produced, or a flexible polymeric sheet material, in which case the product is termed film. After the emulsion is set by chilling and then dried, the material is cut to suitable sizes and packed in light-tight containers. Films are packed as sheet films for use in holders similar to those used for glass plates, roll films protected with paper in special spools or cassettes to make them suitable for loading in daylight, film packs, and long rolls for taking motion pictures.

Cameras are of many varieties, the essentials being a lens to form the image, a shutter to regulate the duration of the exposure, a material holder to carry sensitive plates or film, and a connecting shield to protect the sensitive material from exposure to light other than that which comes through the lens. This is sometimes extensible and then takes the form of a bellows.

The cameras used for various purposes are discussed in the section *Apparatus,* below.

Positive materials may be used for transparencies, in which case they are lantern slides on glass or positive films (especially for motion-picture photography). They are prepared in the same way as negative materials, the emulsion being modified to give the results desired. Usually, however, negatives are printed on sensitized paper. Printing papers are generally coated with a sensitive emulsion prepared either with silver bromide, giving bromide papers, with silver chloride, giving chloride papers, or with a mixture of chloride and bromide to give chlorobromide papers.

At one time, most types of paper were prepared with an emulsion containing free soluble silver compounds and were printed under the negative in strong light until the image was visible; such papers are called printing-out papers. No development was required with these papers. They are now used in trace-recording instruments and for the preparation of proofs submitted by professional photographers to customers.

Many other varieties of printing processes are known and some are used to a large extent in the reproduction of drawings; *e.g.,* the blueprint, diazotype, and Vandyke processes. Others use specially sensitized gelatin or other colloid layers containing pigments, *e.g.,* the carbon and Carbro processes, or gelatin to which pigments may be applied; *e.g.,* bromoil. A high percentage of prints are made by special colour processes.

III. SCIENTIFIC AND APPLIED PHOTOGRAPHY

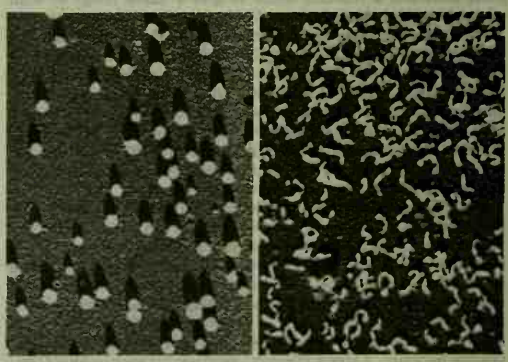
The advantages of photography for scientific and technical recording are that it can record visible images in black and white or colour; it can record radiations of wavelengths invisible to the eye; it can integrate faint radiation and build up a record that can be seen, whereas the eye does not possess this property; it can be used to measure the intensity of radiation; and it can give glimpses of actions that are too fast to be studied in detail by the eye. Moreover, it gives a reasonably permanent record that can be studied at leisure when the original subjects are no longer at hand. Photography thus extends the range of vision, permitting records to be made of things the eye cannot see because they are too faint, are too small, move too fast, or are associated with radiation to which the eye cannot respond.

Photographs themselves are sometimes used as part of a manufactured object (*e.g.,* in the decoration of ceramic articles), as nameplates, instrument dials, electrical wiring diagrams, reticles, and scales. Their most important role, however, is in recording information.

1. Photomicrography.—Photography through the microscope is important in chemical, biological, and geological instruction, but it is especially important in biological research and study; in medicine, criminology, metallography, and petrography; in agriculture, industrial studies, and production control; and in a great variety of fields in which the examination and identification of minute objects or structures is desired. If a slightly enlarged picture, up to about 50 diameters, is adequate, a photomacrograph is made, *e.g.,* of the weave of cloth, of insects or plant stems, or of metal corrosion, using a simple microscope or a single lens with a lens-to-film distance greater than twice the focal length of the lens.

Most photomicrography is done by using the compound microscope with a camera arranged opposite the eyepiece so that the image can be focused on a film or plate. The ordinary hand camera can be used, but photomicrography is best done with a camera without a lens, the microscope and camera being mounted on a rigid bed, vertically or horizontally. Photomicrographs may be made by light transmitted by the specimen or reflected from its surface. The resolution of microscopes will not in general permit the photography of detail finer than 0.2 mμ, although the resolution is increased by using short wavelength radiation; *e.g.,* the ultraviolet. For higher resolution, resort must be to the electron microscope (*see* Microscope).

The usual sources of illumination in photomicrography are carbon arc lamps and incandescent tungsten filament lamps, but for



BY COURTESY OF KODAK RESEARCH LABORATORIES

ELECTRON MICROGRAPHS OF GRAINS IN A "GRAINLESS" LIPPMANN PLATE: (LEFT) UNEXPOSED AND (RIGHT) DEVELOPED

ED HOIS

INFRARED PHOTOGRAPH OF OUTDOOR SCENE

Infrared rays in photography yield peculiar results. They intensify the definition of distant objects, heighten the contrast between light and dark areas, and cause green plants to photograph white, as in the foreground, left.

special purposes flashbulbs, electronic discharge lamps, tungsten and zirconium arcs, mercury-vapour lamps, and sodium lamps are used.

Contrast in photography by transmitted light of stained specimens, such as biological sections or bacteria, is controlled by the use of light filters, maximum contrast being given by filters that transmit light of a colour complementary to that of the stain. Maximum rendering of detail is given by a filter that transmits light of the colour of the stain.

The ultraviolet is used to give maximum rendering of detail. On the other hand, the longer wavelength infrared may be used because some materials are transparent to the infrared while they are opaque to the shorter wavelength. The subjects lie in such fields as histology, cytology, embryology, organic remains in fossils, botanical specimens, and the structure of textile fabrics. Polarized light is used in the photomicrography of birefringent substances, especially in colour. When detail is not rendered satisfactorily by the usual techniques, phase contrast photomicrography may be used with certain subjects. High-magnification motion pictures are often made, using the motion-picture camera in conjunction with the microscope.

Colour photography is important, especially in metallography, polarized-light photography, and the photography of stained sections. Most colour films are suitable, but special attention must be paid to the proper determination of exposure and to the use of filters to ensure correct colour rendering, which is a function of the colour film used, the colour quality of the light source, and colour that is usually present in the optical system of the microscope.

2. Spectrography.—The bulk of spectroscopic observation is done by attaching a camera to the spectroscope and photographing the spectrum. The visual spectrum can be photographed on panchromatic materials and the near ultraviolet on ordinary blue-sensitive plates or films. For wavelengths shorter than 2,800 Å the absorption by the gelatin of the emulsion is too strong to permit photographs to be made, and in this region spectrography is done by coating the plate with a thin layer of material that fluoresces in the short wavelength ultraviolet, fluorescent light being used to make the photograph. In the Schumann method practically all of the gelatin is removed from the emulsion. For the infrared, emulsions containing special infrared sensitizing dyes are used and photographic records have been obtained to beyond 12,000 Å. Plates and films are available having especially high sensitivity in rather narrow wavelength bands spaced all through the visible and near infrared.

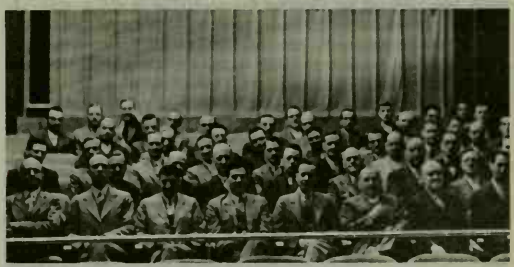
In spectrographic analysis, photographs of spectra are used to detect the presence of elements and to obtain an estimate of the proportions in which they are present. The analyses, qualitative and quantitative, are based upon measurements of the positions and relative intensities of the spectral lines. The method is particularly useful for identifying materials and for determining very small percentages that might be missed or measured inaccurately by chemical methods. (*See* also SPECTROSCOPY.)

The spectrograph has been particularly useful in astronomy since it provides the only means of determining the composition of the celestial bodies. (See *Astronomical Photography*, below.)

3. Infrared Photography.—Plates and films can be made to respond to radiations beyond the red end of the visible spectrum, out to about 13,000 Å, by using special sensitizing dyes. This permits records to be made of subjects that are associated with radiation in the near infrared (spectra, stars, hot objects, etc.) and of subjects that are more transparent to infrared than to visible radiation, or which reflect it differently; *e.g.*, chlorophyll in green vegetation, and hazy atmospheres.

It would not be possible by direct photography to photograph using radiation beyond about 13,000 Å, partly because the atmosphere absorbs strongly in a band just beyond that wavelength and partly because of "dark space radiation," which would affect the films and perhaps even interfere with making the sensitizing dyes.

Infrared photographs over long distances may show greater clarity of far detail, partly because the atmospheric haze may selectively transmit the infrared, and partly because the contrast of the distant objects may be higher as a result of their different reflectivities in the infrared. Chlorophyll is transparent to infrared, and grass and foliage appear white in infrared photographs. Many green paints that match foliage in colour absorb the infrared strongly, so that infrared photography can be used in camouflage detection. The skin is somewhat transparent to infrared and



BY COURTESY OF KODAK RESEARCH LABORATORIES

FIRST GROUP PHOTOGRAPH TAKEN IN TOTAL DARKNESS USING INFRARED FILM, 1931

infrared photography is sometimes of value in medicine in showing the appearance of veins just beneath the skin. It is also of use in dermatology, ophthalmology, and the photography of gross specimens and biological sections. Other applications include photography in total darkness, determination of temperature distribution at the surface of heated bodies, deciphering of altered documents, study of falsified or deteriorated works of art and of textiles, particularly where dark dyes interfere with visual examination, and many applications in botany, paleontology, the graphic arts, criminology, and technology.

4. Ultraviolet Photography.—The invisible ultraviolet rays, shorter in wavelength than visible light, can be used for special photography because the ultraviolet passes through some objects in a manner different from light, and also because it can cause fluorescence in some materials, thus frequently causing photographs made by fluorescent light to reveal details not normally

seen. It is an important tool in the hands of museums and art galleries, police departments, examiners of questioned documents, analytical laboratories, food manufacturers, and mineralogists. In the printing field, original water-colour paintings can be made in fluorescent paints, providing a means of reducing the amount of hand work in the colour separations if a fluorescent photograph is made by ultraviolet.

There are two different methods of ultraviolet photography: (1) the reflected ultraviolet method, which is analogous to ordinary photography except that a filter is used to allow only ultraviolet to reach the film; (2) the fluorescence method, in which the subject is illuminated by ultraviolet and the camera is provided with a filter that absorbs ultraviolet and allows only the visible fluorescent light to reach the film. Normal, orthochromatic, and panchromatic films are used. Colour photography by the fluorescent-light method can be done with ordinary colour films, the choice of film depending on the fluorescing colour it is desired to emphasize.

5. High-Speed Photography.—Photographs made at high speed are very important in science and technology, because they record a phase of a fast event, or photograph a rapid sequence of events that can be slowed down for study. It is necessary to use a very bright light and very short exposure times so that sharp records can be obtained.

The first high-speed photograph was taken by Fox Talbot, using a spark from a Leyden jar. In the 1870s Eadweard Muybridge began his photographic studies of a horse in motion, using successive exposures of short duration in a series of cameras. E. J. Marey, in 1882, perfected a "photographic rifle" in which 12 photographs were taken in one second on a revolving plate. This was called chronophotography, and in 1890 he devised the photochronograph, using film. Similar experiments were made by O. Anschütz in the 1880s. (*See* also Motion Pictures.)

The earliest photographs of projectiles in flight were attempted about the middle of the 19th century at the Woolwich Arsenal in England, by Marey in Paris, and by Anschütz in Germany. A cannonball in flight was photographed at Woolwich in 1866, but the best ballistic pictures were obtained after 1884, when E. Mach, in Prague, introduced the electric spark as the light source. The spark was released by allowing the projectile to cut a wire. L. Bull, Marey's successor in Paris, applied Mach's principle in such a way that he obtained a rate of 2,000 pictures per second. In 1909 C. Cranz made a ballistic cinematograph giving exposures at time intervals of $\frac{1}{5,000}$ sec., for a total time of $\frac{1}{10}$ sec.

Among the early studies of extremely high-speed photography are the photographs of ripples by J. H. Vincent, of splashes by A. M. Worthington, the shadow photography of bullets in flight by C. V. Boys, the analysis of the propagation of flame by Mallard and Henry le Châtelier, and T. E. Stanton's studies of the pressure of gases ejected from nozzles. P. P. Quayle later made improved studies of the flight of projectiles and R. W. Wood of sound waves, outlines of which had accompanied the ballistic pictures of Boys. With a high-speed camera devised by W. Heape and H. B. Grylls, and taking 10,000 pictures a second, studies were made of the penetration of shells into hardened steel targets. Other cameras designed by C. F. Jenkins, Baron Shiba and J. H. Waddell, and the Eastman Kodak and the Bell Telephone laboratories have yielded results of much value in the study of high-speed phenomena. During World War II, high-speed photography was developed and applied to a wide range of studies of military interest, and a great many special high-speed cameras came into use.

The modern methods of high-speed photography may be classed as follows:

Single, Instantaneous Photographs.—(1) Steady illumination and short shutter exposure: the best mechanical shutter will not permit shorter exposures than about $\frac{1}{1,000}$ sec. Special nonmechanical shutters have been developed to give very short exposures in still photography. They include magneto-optical shutters using the Faraday effect; electro-optical shutters using the Kerr effect; electronic shutters using the image-converter tube or the iconoscope.

(2) Light flash of short duration: (*a*) shadow or silhouette, (*b*) reflected light, and (*c*) stroboscopic.

(*a*) In shadow photography, used for objects moving as fast as bullets, the shadow of the object may be cast directly on the film or plate. An electric spark is generally the source, since it is bright, of short duration, and small, thus producing sharp shadows on a film at a fair distance from the spark, if the subject is near the film. Exposures of the order of $\frac{1}{1,000,000}$ sec. may be obtained. Alternatively, a condenser may be used between the spark and the object, the photograph being made in a camera with a lens. A development of this is the Schlieren method, originally used by Léon Foucault and applied by August Toepler, which depends on slight differences of refractive index in the air, or inhomogeneities in glass and other transparent solids. It will show sound waves accompanying the flight of projectiles, convection streams from heated bodies, vortex rings formed in warm air, or vapours of different densities.

(*b*) In the reflected light method, the source is a spark or a lamp of the type of the Edgerton gaseous discharge lamp, the latter with its large area source being preferred on the basis of illumination. A camera is used, as in ordinary photography. This method requires more energy and longer exposure time than the shadow method, but exposures as short as $\frac{1}{50,000}$ sec. can be attained, which is satisfactory for practically all high-speed photography other than ballistics photography.

(*c*) In the stroboscope, a series of light flashes is made to agree with the speed of rotation of a steadily rotating object, so producing a stationary appearance of the object. This can be photographed in an ordinary still camera with long exposures if necessary to record the aspects of the object at any part of its cycle.

Series Photographs.—(1) Motion pictures: The ordinary slow-motion camera takes photographs at 64 frames per second, and some at 128 frames per second. These cameras produce intermittent motion of the film. For higher speeds, up to 5,000 or more frames per second, the film moves continuously and there is compensation for image movement by some optical device such as a rotating plane-parallel glass block, or rings of lenses or prisms. If films made in this way are projected at normal speed, the movement is slowed down to the extent of the ratio of the taking to the projection speeds.

(2) Series of photographs can be made of short duration and at closely successive intervals. In one method, successive photographs are made on one sheet of film by using a rapid series of flashes from a gaseous condenser discharge lamp, or from a series of flashbulbs. In the early studies of animal locomotion by Muybridge, 24 separate cameras, operated in rapid succession, were used.

(3) A special high-speed camera was developed by the Bell laboratories as the ribbon-frame camera, primarily to study the behaviour of rockets in the early part of their flight. The shutter consists of two concentric drums, the outer of which has five slots and the inner four. They are rotated in the same direction, but the outer at 24 revolutions per second and the inner at 30. Glass plates are used to compensate for image movement, and the photograph appears as a series of narrow adjacent strips across the film. A camera developed by F. E. Tuttle is capable of taking 1,000,000 pictures a second; a parallel-line grid is moved in the focal plane in front of the film, and the picture is viewed through a similar grid moving more slowly.

(4) In some cases, as in explosions, the subject is self-luminous, moving fast, and of short duration, and a rapid sequence of photographs of it permits a study of its development. Several methods are used for the study of flame in explosions. In one, short snapshots are made through a rapidly rotating shutter onto a stationary film or plate. If the flame is moving along a transparent tube, a series of such photographs in rapid succession shows the consecutive phases of its propagation. In a second method, the film or plate is moved. If the explosion occurs in a horizontal glass tube, and if it is photographed by a lens on a plate falling vertically or on a film wrapped about a rotating drum, an envelope showing the changing shape of the flame will be obtained, and its velocity can be calculated. In some cameras, rapidly rotating mirrors are used

in the moving film camera to give what amounts to a series of separate snapshots, or the film is held still and a single rotating mirror is used. Exposures shorter than $\frac{1}{50,000}$ sec. can be obtained in this way. Continuous-trace photographs on continuously moving film were used in the study of the initial stages of the explosion of atomic bombs. High-speed X-ray pictures have been taken by discharging a high potential of short duration through an X-ray tube.

6. Astronomical Photography.—Visual observation in astronomy has been replaced almost entirely by photography through the telescope. By using long exposures, photographs can be made of stars that are much fainter than those that can be seen. Many stars can be photographed simultaneously, thereby providing a record of relative positions that may be compared with records made later. Wavelengths not visible to the eye may be used in photography, and careful choice of wavelength may reduce the limitations imposed on penetration into space by the luminosity of the earth's atmosphere. In order to photograph extended areas of the sky, lenses of the type used in ordinary photography or Schmidt lenses are employed. In these, high apertures and short focal lengths are obtained by using a correcting plate in conjunction with a spherical mirror. The small-scale photographs so obtained are valuable for position measurements and surveys, and if the aperture is high enough, faint nebulae, the Milky Way, and meteors may be recorded.

For photographing positions more precisely, or for separating close stars, objectives of longer focal length are used. They are either refractors or reflectors. Refractors suffer from chromatic aberration and are corrected to give their best focus in the green, and the best photographic focus is therefore obtained by using orthochromatic plates and yellow filters. Reflectors do not have this disadvantage. The fastest available photographic plates are used, and the lower definition given by plates of highest speed is not serious since "seeing" limits the sharpness of image the telescope will give. The plates are made so that they have the minimum reciprocity failure for long exposure times.

In addition to direct photography, the other great branch of astronomical photography is spectrography. The chemical and physical constitution of the stars may be determined by the light they emit. Spectra of many stars may be recorded, simultaneously, by placing a prism or grating over the camera objective. Spectral types of many stars may thus be determined in a short time. For more detailed study, the image of the star produced by the telescope is directed to the slit of a spectrograph, and long exposures may be given.

The nearer planets are bright and exposures are relatively short, although fixed by the short time of good observation. Telescopes of short focal length give small bright images, and slow plates may be used. In long-focus telescopes the image is larger but less bright and fast plates must be used. Information about the atmospheres of the planets has been obtained by using plates of different colour sensitivities, relying on the different opacities of the atmospheres to different wavelengths.

Detail of the surface of the sun, the nearest star, is much studied. Direct photography records the positions and areas of sunspots, and the prominences and the corona during eclipses. In times when there is no eclipse, the corona can be photographed by means of the coronagraph. Much information about the sun is obtained from instruments that enable photographs to be made with narrow wavelength bands, in particular the spectroheliograph which uses the red light of the Hα line of hydrogen, or the blue light of the H and K lines of calcium. Birefringent filters transmitting extremely narrow bands of radiation were developed for the same purpose. Motion pictures, speeding up motion, have been made of the moon and the planets, and are regularly made of the sun.

Flare, or the luminous veil resulting from scattered light in the earth's atmosphere, is an important factor in astronomical photography because it tends to obscure faint detail. The intense diffuse light from the sun scattered in the atmosphere prevents the stars from being seen in daytime, but even on moonless nights there is much scattered light and also light emitted by atoms that have been "excited" by sunlight. Observatories are therefore usually on high ground, and as far as possible from cities. In order to avoid the effects of the earth's atmosphere as much as possible, astronomical photography has been done from "platforms," such as balloons, at very high altitudes.

Great advances in astronomy are attributable to improvements in speed and colour sensitizing of photographic plates, and to improvements in fine grain, resolution, and reciprocity failure characteristics. (*See* PHOTOGRAPHY, CELESTIAL.)

7. Criminological Photography.—Photography is one of the most important tools of the criminologist. Its usefulness ranges from straightforward photography of, for example, car accidents and sites of crimes to specialized detective work in deciphering things that cannot be seen. Its scope includes identification records and security passes, fingerprint photography, and photographs in crimes of violence, arson cases, burglaries, and forgeries. Special photographic techniques, such as ultraviolet and infrared photography, aid in detecting stains, invisible writing, and alterations on documents; photography with illumination at glancing incidence may reveal slight depressions or elevations in paper surfaces; multiple printing may be used to enhance very faint contrasts; combination of photography by reflected and transmitted light may yield more information than either alone; spectrographic analysis and radiography are much used; cinematography is used to record criminal operations; photography through the microscope is very important, a special case being the examination of bullets. (*See* also INVESTIGATION, CRIMINAL: *Photography.*)

8. Photoelastic Analysis.—A study may be made of stresses in structures by making models of them in transparent plastics that are isotropic and have large optical stress coefficients. If a stressed model is photographed in polarized monochromatic light, a pattern of light and dark bands results, and from these the distribution of stress may be calculated. The method has been applied successfully to such things as test bars, hooks and chain links, structural foundations, bridge trusses, expansion joints, machine details, and the action of cutting tools. (*See* LIGHT: *Polarization and Electromagnetic Theory.*)

9. Records of Physical Measurements.—Recording in physical measuring instruments can be done by photography where an external spot of light is deflected, for instance, by a galvanometer mirror and falls on a dropping photographic plate or on a moving band of paper or film and records a trace of its path. There are many such devices; *e.g.*, oscillographs, electrocardiographs, seismographs, magnetometers, optical gas engine indicators, and other devices recording variations in pressure, electrical characteristics, optical transmission and reflectance, thickness variations, and so forth. The most-used photographic recording of this type is sound recording, by variable-density or variable-width trace, on motion-picture film.

In trace-recording instruments (other than the cathode-ray oscilloscope), the string galvanometer and the moving-mirror galvanometer are generally used. A much-used type of recording is photography of the trace on a cathode-ray tube. The problems are simple if the trace is recurrent, but if the trace is in the form of a rapid transit that does not repeat, or if the image does not persist, very fast lenses and high-speed films must be used. The films are sensitized to green or have inherent sensitivity to blue, depending on the colour of the phosphor glow. A special adaptation of cathode-ray photography is used to record images on the screens of radar equipment.

10. Photo Layout.—Photographic methods are used for transferring drawings to metal for making templates, precision dials, scales, and wiring diagrams, and for laying out designs for the engineering, aircraft, and shipbuilding industries. Bichromated colloids may be coated on the sheet and developed and the lines darkened by ink or dye. A variation used a sensitive colloid containing the pigment but gave a direct positive image from a positive. In the strictly photographic method, the sheet on which the drawing is to be printed is sensitized by a silver halide emulsion applied by spraying, or by a stripping layer transferred from a temporary support. The drawings can be prepared on sheet material coated with a white layer that fluoresces or phosphoresces in

ultraviolet or under X-rays. The sheet on which the glow is obscured where there are opaque lines drawn is used to print on the sensitized sheet. Alternatively, the fluorescent layer may be overcoated by a photographically opaque layer through which the drawing is scribed, exposing the lines in white fluorescent pigment that can be excited and printed. Copies can also be made by reflex copying to give negatives for contact printing, or by using a camera to give reduced negatives that can be printed by enlargement onto the sensitized sheet.

Photosensitive polymers are used to provide images on metal for subsequent etching to remove unwanted metal, to make printed circuits for electrical equipment, for nameplates, and a variety of purposes.

11. Underwater Photography.—Photographs can be taken of underwater objects such as swimmers and divers, fish, the bottom of the sea, ships' bottoms, and the corrosion of structures. Water absorbs red and blue light strongly, and the dominant colour is blue-green. At depths to 15–20 ft., pictures can be taken with reasonable exposures by using the light penetrating from outside. At greater depths, special lighting equipment has to be lowered into the water. Strong lights are required, particularly for study of the behaviour of fast missiles dropped into water or launched under it. Special cameras in water- and pressure-proof cases have been designed for still and motion-picture photography with flat glass pressure plates in front of the lens. Some attempts have been made to design lenses that can be used with the front surface in contact with the water. There are few special problems involved in photographing underwater through windows, provided the water is clear, the light intensity is adequate, and proper account is taken of reflections and refractions. Surface reflections must be avoided by shielding. Colour photographs will tend to appear blue-green, but compensation at moderate depths may be achieved with daylight-type film with the appropriate colour-correcting filter. During World War II, black-and-white and colour photographs were obtained from aircraft to determine water depths off enemy coasts. A great importance was given to underwater photography through the development of "frogman" equipment during and after World War II, and after the war it became a popular hobby in addition to being of scientific and military importance.

12. Medical Photography.—Among the most important applications of photography in medicine are radiography and photomicrography, which are dealt with as special subdivisions. In the form of the motion picture, medical photography is important for recording and teaching. In still photography its scope has three main aspects; *i.e.*, photography of the living person, photography of surgical operations or methods of treatment, and photography of pathological specimens. Special lighting techniques may be necessary in some cases, but in general the technique is that used in good ordinary photography, but under the supervision of the medical expert. Colour photography is of increasing value. Special techniques in medical photography include infrared and ultraviolet photography, use of special equipment for photographing the eye, and study of body cavities by endoscopic photography in which pictures can be made of the interior of the stomach, larynx, bladder, thorax, and nearly all other body cavities.

13. Document Reproduction.—The reproduction of documents is an important part of applied photography. Its significance lies in its importance for reproducing accurately, for effectively increasing the life of perishable documents, for permitting multiple copies to be stored in different places as a security against disaster, for reducing the storage space of documents, and for retrieving the information in them rapidly, accurately, effectively, and cheaply. Processes are available in which documents may be copied by contact to the same size as the original or copied optically at a reduced scale, giving reproductions that can be read in special viewing devices or that can be enlarged to give photographic prints.

Direct copies on paper of the same size as the original are used for business papers, printed material in general, notes for research, musical scores and parts, drawings, insurance policies, etc. They may appear as positives (dark on a light ground) or as negatives (light copy on a dark ground). Reduced-size copies are usually made on film, generally 16, 35, 70, or 102 mm., or in certain cases on sheet film, and a fair percentage of document reproduction to reduced size is done on cards. Enormous quantities of a great variety of documents are copied on film (microfilming)—for instance, bank, business, and insurance records, official documents, military documents, books and periodicals from libraries, engineering drawings, etc. Reproduction on cards is widely used for books, periodicals, and abstracts of literature. Combinations of microfilming and cards have been used in which the film transparency is inserted in a hole in the card, which also carries reference information and can be filed and punched for use in sorting machines.

Reproductions on paper to the same size as the original, or to approximately the same size as the original, can be done by contact printing through the document onto photographic paper if the original is printed on one side only; thus is produced a negative from which prints can be made, or a negative print in which the type matter is not reversed if the back of the document is placed in contact with the sensitized paper in printing. In the case of double-sided or opaque originals, reflex copy negatives can be made as intermediates for obtaining prints. Image-transfer processes are widely used for this purpose to give positive copies directly. If large production is involved or if the copy is to be changed in size, special cameras for photographing onto paper are used, among the best known being the Photostat, Rectigraph, Haloid Foto-Flo, Dexigraph, and Rutherstat machines.

The earliest large-scale commercial use of greatly reduced-size copying onto narrow rolls of film resulted from the introduction of the Recordak system by the Eastman Kodak Company in 1928. Continuous, automatic cameras photographed documents on 16-mm. film and the first large use was for copying checks in bank transit or clearing work, but it soon spread to a great variety of applications and to use of 35-mm. film as well as 16-mm. film. A special use of the method, known in England as Airgraph and in the United States as V-mail, was developed in 1941 for distributing mail to and from the armed forces overseas. Storage of engineering drawings is greatly facilitated by copying onto narrow roll or small sheet films, and paper reproductions can readily be made. Many libraries have document copying services and when the volume is large automatic and continuously operating systems based on intermediate microfilms are used.

In the drawing office, copies of tracings are made by blueprint, iron-silver, ferric-gelatin, and diazotype processes, and by special types of paper that give ordinary silver images and can be handled in room light. When a great many reproductions of a single original are required, it is often convenient to print from lithographic printing plates, and simplified ways of putting the image on the plate are available.

14. Recording Cameras.—Among the uses of cameras for special recording purposes may be mentioned the following: gun cameras, used for training in aerial gunnery and for recording the effectiveness of gunfire in combat; phototheodolites for survey from the ground and for plotting the position of shell bursts; submarine periscope cameras for photographing through the periscope the results of torpedo fire and enemy coast lines; cameras provided with enclosed lights for photographing fingerprints and instrument panels; special cameras frequently using invisible rays for photographing aircraft instrument panels; cameras for photographing inside tubular cavities such as gun barrels and oil well bore holes; endoscopic cameras for photographing inside body cavities, radarscope and other cathode-ray tube cameras.

15. Photographic Photometry.—The intensity of radiation can be measured by photography. The radiation whose intensity is to be measured is compared with that from a standard source by matching the densities of photographic images produced by both. A number of conditions have to be met, and they are described in the publications on the subject. (*See* also PHOTOMETRY.)

16. Phototopography.—Col. Aimé Laussedat of the French Army pioneered the application of photography to surveying, especially in the Alpine regions, and it was applied extensively in Canada, especially by E. Deville. Practically all photographic

survey is done from the air. In ground phototopography, special cameras (phototheodolites) are used after the manner of theodolites, and photographs are taken in pairs from the ends of measured base lines, in such a way that the subject can be identified in both photographs. The cameras have means for orienting them precisely in relation to the subject, levels for setting them true to the perpendicular, and means for properly orienting the image inside the camera. Plates are usually used unless easy portability is important; and exposures may be long, so the plates may be relatively slow and of high resolving power. Special phototheodolites have been used for determining the position of antiaircraft shell bursts and to follow the course of space vehicles and similar distant objects. (*See* also PHOTOGAMMETRY.)

17. Aerial Photography.—The first aerial photographs of the ground were made from captive balloons (Nadar, 1858; S. A. King and J. W. Black, 1860) using wet collodion plates. The principal early development of aerial photography came after the advent of the airplane, particularly during World War I. In the last year of that war, thousands of photographs were taken each day for intelligence purposes. During World War II, millions of photographs were made from the air and more than 80% of the knowledge of the enemy was derived from them; the same was true during the Korean War.

The chief uses of aerial photography are: (1) in military intelligence, for recording troop movements, positions, defenses, supply facilities, bridges, railways, docks, industrial establishments, shipping, etc., orientation of bombers and bomb damage assessment (in the military field, aerial photography may sometimes be done indirectly by photographing the face of the radar tube and by using "unaccompanied" cameras in missiles and drones); (2) in mapping, military and civilian, to provide the basis for making new maps and filling in detail or revising existing maps; (3) for mosaics, which are composite aerial photographs made by joining a number of separate photographs of the ground; (4) in making survey photographs for purposes of forestry, oil, geology, crops, soil erosion, archaeology, traffic distribution, real estate, exploration, city planning, and such studies.

Aerial photographs are made in cameras specially mounted in airplanes so as to minimize vibration; the photographs are called vertical or oblique according to the orientation of the camera to the ground. Early aerial cameras were modifications of existing plate cameras but they were provided with magazines permitting exposure of a number of plates in rapid succession. With the exception of a few special survey cameras that use plates, aerial cameras now use rolls of film that can be moved intermittently by hand or generally by an electric motor controlled by an intervalometer in order to make series of photographs of the ground along the line of flight. These photographs are usually arranged to overlap about 60% so that they can be viewed stereoscopically when maps are being plotted from them, or when it is desired to study ground detail.

Film for general aerial photography is of the high-speed panchromatic type, with extra red sensitivity to permit short exposures through filters. Special fine-grain films giving high resolution are used where the maximum information is required from the photograph. Infrared film is used for long-distance and high-altitude photography, for camouflage detection, and for forestry survey. Colour film was first used in aerial photography in World War II. The colour contrasts aid identification of objects, show up underwater features, and permit night photography of coloured flares.

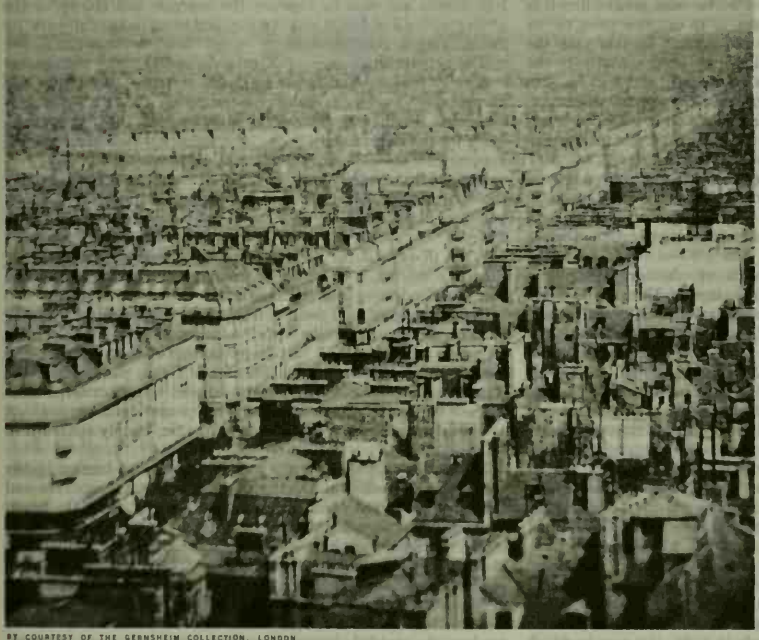
Aerial films range in width up to 20 in. and up to 400 ft. in length. The film support for aerial photography is mainly of the topographic variety, which undergoes little dimensional change in processing or with change in humidity and so reduces the errors that must be corrected in plotting maps from the photographs.

A wide variety of lenses is used, ranging in focal length from about 3 to 100 in., and in aperture from *f*/8 to *f*/1.5. (See *Photographic Lenses*, below.)

In aerial photography the camera is moving in relation to the subject photographed, and exposure times must be very short or the picture will be blurred. Use is therefore made of high-speed shutters of the focal-plane, louvre, and between-the-lens types. For night photography using flash bombs, special shutters are operated by a photocell circuit activated by the light of the flash.

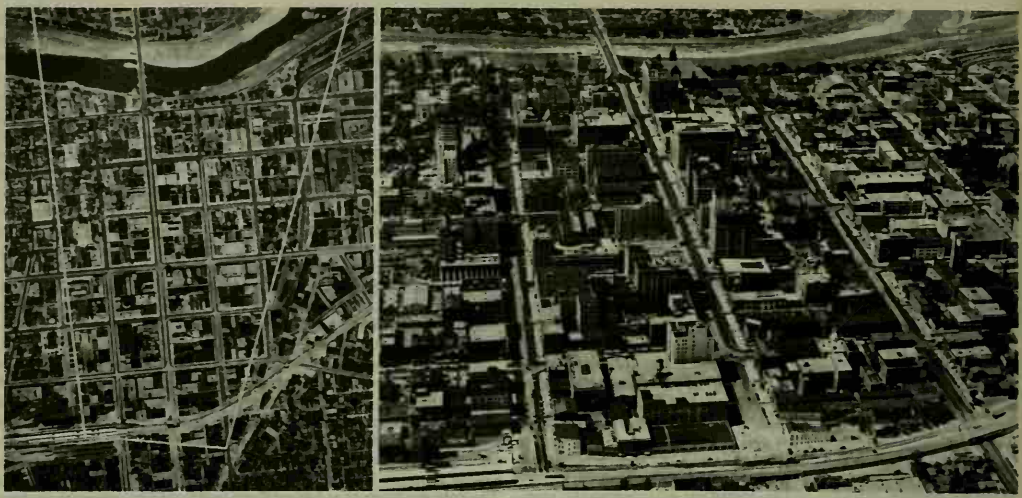
Instead of, or in addition to, using high-speed shutters, compensation for movement of the image can be effected by moving the lens during exposure, moving the film continuously through its magazine at the same rate the image moves, the exposure being made continuously through a narrow slit in the focal plane, or by moving the film in its magazine but exposing the full picture area intermittently as in ordinary photography.

In order to photograph large areas of ground at one time, wide-angle and short-focus lenses, or multiple-lens cameras, or groups of separate cameras may be used. Multiple-lens cameras having three, four, five, and nine lenses have been developed. In the Tri-Metrogon system developed for rapid survey during World



BY COURTESY OF THE GERNSHEIM COLLECTION, LONDON

VIEW OF PARIS IN 1862 TAKEN FROM A BALLOON BY F. T. NADAR. PRINT MADE FROM A WET-PLATE NEGATIVE



BY COURTESY OF THE U.S. AIR FORCE

AERIAL VIEWS OF THE SAME PORTION OF A CITY: (LEFT) VERTICAL AND (RIGHT) OBLIQUE

War II, three cameras are used, one vertically and two obliquely, one on each side of it, the photographs being made to overlap somewhat to cover the entire ground from horizon to horizon on each side.

Atmospheric haze presents a serious problem for aerial photography since it tends to lower the contrast of or to obscure ground detail. Haze scatters blue light preferentially and transmits the longer wavelengths. Its effects can be largely eliminated by using panchromatic film and filters that absorb blue light. The commonly used filters are yellow, but for better haze penetration it is sometimes necessary to use red filters, or in extreme cases to use infrared-sensitive film and a deep red filter. In this case the apparent increase in haze penetration may be due partly to the selective penetration of the infrared and partly to an increase in the contrast of the ground resulting from the special reflectance characteristics in the infrared of the objects on it. Special filters also are used for other particular purposes, for instance, green filters for distinguishing certain kinds of vegetation.

Film for aerial photography is developed in the roll on special machines in which it moves continuously through a series of tanks, or back and forth from one reel to another in single tanks, or on spiral reels or racks that can be immersed in the solutions for the desired times.

18. Radiography.—In this branch of photography, photographs are produced on film by the passage of X-rays or gamma rays through an object. There are several aspects: medical and dental radiography, which is by far the widest use; industrial radiography for examination of the interior condition of solid objects, especially castings, welds, and structures, usually of metal; gamma radiography, for examination of the interior state of solid objects, but using gamma rays from radium or radioactive isotopes; X-ray diffraction for the analysis of the atomic and molecular structure of materials. In autoradiography the specimen emits radiation and is placed in direct contact with the film.

Radiographs, other than diffraction photographs and autoradiographs, are shadow photographs obtained by passing a beam of the rays directly through the object, which absorbs them to an extent depending on its atomic nature and thickness. Photographic films are sensitive to X-rays and gamma rays, as they are to light, and when the exposed film is developed, the image varies in density according to the extent to which the rays were absorbed. The invisible internal structure is thus revealed.

The earliest radiographs were made in 1896, the year in which Wilhelm Röntgen discovered X-rays, and the glass plates then available were used. Modern radiography is done on film coated with a special emulsion, and usually on both sides to give maximum speed and contrast. Only a very small percentage of the X-ray beam is absorbed by the emulsion, and in order to increase the effectiveness of the exposure the film is usually put between two "intensifying screens," which are coated with a layer of material such as calcium tungstate that fluoresces under the action of the X-rays; the fluorescent light augments the exposure caused by the X-rays. For some classes of industrial radiography, thin lead foil screens are used to improve the contrast and clarity of the photograph. For dental radiography and some industrial work, no intensifying screens are used.

The penetrating power of X-rays depends on the voltage between the filament and target in the X-ray tube; the higher this voltage, the "harder" or more penetrating are the rays. For general medical radiography 40–80 kv. may be used, the higher values being for the thicker body parts. For industrial radiography, voltages ranging up to several million may be employed. X-rays generated at high voltage for radiography of metals are so penetrating that materials such as cloth, paper, and leather appear quite transparent to them, and low voltages of 4–20 kv. must be used with them.

When X-rays strike an object, a considerable percentage of them is scattered, in much the same way light is scattered by fog. The scattered rays tend to cause a veil over the radiograph and so reduce contrast and detail. This effect can be offset by using a Potter-Bucky diaphragm, which consists of a grid of alternate strips of lead and wood that is moved between the object and the film during the exposure. The direct X-rays pass through the wooden strips, while the lead strips absorb those scattered sideways. The grid is moved to prevent its casting a shadow but sometimes a stationary Lysholm grid of thin, closely spaced lead strips is used.

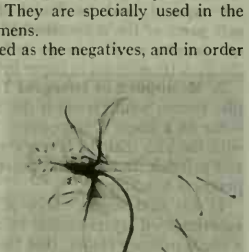
Medical uses of radiography include location of foreign bodies and cavities; studies of fractures; diagnosis of tuberculosis and abnormal conditions of the digestive and urinary tracts, the heart, the spinal column, and the sinuses; and in the case of dental radiography, studies of cavities, abscesses, unerupted teeth, pyorrhea, and many other conditions.

The widest use of industrial radiography is in the examination of interior structures for hidden faults, without involving damage to the object, for instance, in castings and welds, assembled mechanisms, molded plastics, munitions, and a vast range of manufactured products.

Among special radiography techniques may be mentioned: body-section radiography in which only one plane of the body gives a distinct image, nearer and farther parts being blurred, the result being obtained by moving the film and X-ray tube in opposite directions about a pivot point in the plane that is to appear sharp; roentgenkymography, used for study of moving parts, such as the heart, by moving between the patient and the film during exposure a lead plate with a series of horizontal slits; microradiography, usually for thin specimens of low X-ray absorption, with very fine detail, in which the radiograph is made on fine-grain film and subsequently enlarged; high-speed radiographs have been made in $\frac{1}{1,000,000}$ sec. for ballistic and other high-speed studies.

There developed, particularly during World War II, a need for radiography on a large scale, particularly for making X-ray photographs of the chests of people being examined for induction in the armed forces. Mass miniature radiography was introduced. In Europe, photographs of the fluorescent screen image were made on 35-mm. film, using lenses of very high aperture. In the United States, the preferred size was 4×5 in., stereo pairs being made on film 4×10 in. in size. In motion-picture radiography, or cineradiography, motion pictures are made of the image on the fluorescent screen, or, less frequently, series of natural-size radiographs are made in quick succession. Usually one cycle of movement of a part is photographed, and in projection it is viewed in repeated succession. The chief limitation in this work was that lenses of extremely high aperture were required in order to keep the X-ray dosage to the patient at the minimum. However, image amplifiers came into use, so that low exposures to X-rays could be given the patient and low exposure to the film. In gamma radiography, the gamma rays from radium or radioactive isotopes are used. They are of shorter wavelength than X-rays and thus have greater penetrating power. They are specially used in the radiography of thick metal specimens.

Radiographs are usually examined as the negatives, and in order to give the impression of depth they are frequently made in pairs, using two positions of the X-ray tube, and viewed in the stereoscope. In X-ray diffraction methods, the internal structure of crystals may be determined by the diffraction pattern photographed on passing a beam of X-rays through a single crystal or a sample of the material in powder form. Autoradiography is a procedure that originated when radioactive isotopes became available. It is known that when isotopes are introduced into an organism, they localize in certain tissues and, in some cases, in specific portions of the living cell. These concentrations of the radioactive substances can be detected by placing thin sections of the tissues in close contact with special photographic plates. Upon development of the plate, black specks identify the location of the concentrations of the radioactive materials. By using fine-grain materials and magnifying the resultant image microstudies are possible. (*See* RADIOLOGY; X-RAYS.)



ALBERT G. RICHARDS

RADIOGRAPH OF A COLUMBINE BLOSSOM

19. Nuclear Particle Recording.—Direct recording of charged atomic particles by photographic emulsions provides an important adjunct to the ionization chamber, the Geiger counter, and the Wilson cloud chamber in atomic physics. The effects were first found with alpha particles, which produce a track of silver grains in the developed emulsion. It was later discovered that the paths of protons could also be recorded and that the tracks had a different grain spacing than alpha particles. Cosmic ray particles give nuclear disintegrations on collision with the atoms in the emulsion, and star patterns arise, consisting of the tracks made by the particles from the atomic nuclei. Tracks of electrons, and effectively any charged particle of any energy, can be recorded on special thick emulsions with a high silver bromide content, small grains, low fog, and of a speed designed for use with the particle concerned. The tracks are caused by grains being made developable by ionizations within them resulting from impact of the particle. The tracks are examined and measured by special microscopic techniques.

BY COURTESY OF DRS. BERNARD PETERS AND HELMUT BRADT

COMPOSITE NUCLEAR TRACK PHOTOGRAPH

Nuclear explosion initiated by a heavy, energetic cosmic ray particle. One particle causes a record nuclear event (A)

IV. COLOUR PHOTOGRAPHY

In 1810 J. T. Seebeck, in 1840 Sir J. F. W. Herschel, and later Edmond Becquerel and Abel Niepce de Saint-Victor observed that silver chloride darkened by exposure can record the spectrum of the sun by its direct action, in colours similar to those of the spectrum itself. The colours cannot be fixed and the method has no practical value.

The first fixed colour photographs from nature were made by G. Lippmann in 1891, using the interference principle, the possibility of which had been pointed out by W. Zenker (1868), Lord Rayleigh (1887), and O. Wiener (1890). Beautiful colour reproductions can be obtained, but the plates are insensitive, the viewing is not convenient, and only one photograph can be obtained.

The basic principles of modern colour photography are derived from an experiment made in 1861 by James Clerk Maxwell in a study of the theory of colour vision. He photographed coloured ribbons through red, green, and blue filters, from the negatives made three positive black-and-white transparencies, and projected these in register onto a screen using three lanterns, each transparency being projected by light of the colour by which its negative was taken. The image on the screen was a colour reproduction of the ribbons.

In 1869 Louis Ducos du Hauron published a book in which he laid down the principles that provide the basis for modern processes of three-colour photography. At about the same time Charles Cros published an article with much the same conclusions. Ducos du Hauron's book gives a clear account of the two fundamental processes of colour photography, the additive and the subtractive, with suggestions for carrying them out. The practical development of the processes was delayed until panchromatic plates became available through the introduction of colour sensitizing by Vogel in 1873 and the introduction of isocyanine and carbocyanine sensitizers early in the 20th century.

The additive process, which was almost entirely replaced by the subtractive processes after 1935, is used only for transparencies for projection and direct viewing; the subtractive processes can be used for transparencies and for paper prints to be viewed by reflected light. In both cases the first step is to make three separation negatives of the subject by the red, green, and blue light from it. It is also possible to make colour photographs by the two-colour process, in which the separation negatives are made by half the spectrum, blue-green and orange, but the best colour rendering is obtained by the three-colour process.

1. Additive Processes.—In the additive processes, the colours are produced by adding together varying amounts of red, green, and blue light. There are three main processes of additive colour photography: triple projection, screen unit, and lenticular film.

In the triple projection process, black-and-white positives made from negatives exposed through red, green, and blue filters are projected through similar filters in register on a screen, as in the original Maxwell experiment. Special equipment for making the three negatives in succession or simultaneously were put on the market, together with lanterns for projection. Ducos du Hauron,

Cros, and F. E. Ives invented devices for viewing the three pictures directly rather than by projection. In the photography of stationary objects, the three negatives can be exposed in succession. In the case of moving objects, however, the three negatives must be made simultaneously, otherwise colour fringing will occur. For simultaneous exposure of the three negatives, use is made of groups of lenses or of beam splitters consisting of a group of mirrors or prisms. Another system for making these three negatives, originally invented by Ducos du Hauron, is the so-called tripack in which three separate films are arranged behind each other, with filters to ensure that the red, blue, and green records are obtained separately, one on each film.

In the triple projection process good colour quality can be obtained, but the system is complicated and has never been a commercial success.

2. The Screen Unit Process.—The first commercially successful colour process, the Lumière Autochrome plate, brought out in 1907, utilized the screen unit process. This was a modification of one form of additive process suggested by Ducos du Hauron. Instead of making three separate negatives through filters, a single plate was covered with minute blue, green, and red filter elements. A panchromatic emulsion was coated over this layer. The exposure was made through the filter layer so that the image obtained was broken up into tiny units representing blue, red, and green components of the colours of the subject. The emulsion was developed by the reversal process to give a direct positive in black and white, which, on direct viewing or projection, gave a reproduction of the subject in colour. Alternatively, if the filter elements were uniformly arranged, the plate or film could be developed to a negative and printed to give a positive transparency that could be registered in contact with a plate carrying minute filter elements to give a positive colour transparency.

The first successful use of the screen unit process was made by J. Joly and by J. W. MacDonough in 1892, the filter elements being on a plate separate from the negative. This arrangement was later employed in the Finlay plate. In the Lumière Autochrome process, the filter layer consisted of dyed starch grains with the spaces between filled with carbon black. The plates gave good colour quality and were on the market as plates and later as films for 30 years. Other screen unit processes were later introduced: in particular, the Finlay process mentioned above, in which the screen was printed in bichromated colloids; the Agfacolor plates and film, in which the filter layer consisted of dyed resin particles rolled flat; and the Dufaycolor process, in which the emulsion was coated on a regular dyed screen pattern prepared on the film support. The Agfacolor and Dufaycolor materials were developed by reversal and were sold as roll, sheet, and motion-picture film.

The screen unit process gave transparencies of good colour quality, but the plates and films were difficult and costly to manufacture. They were dense, so that it was difficult to get enough light in projection, and the screen pattern was frequently very evident.

3. The Lenticular Film Process.—This was invented by R. Berthon in 1908 and developed by A. Keller-Dorian and particularly by J. G. Capstaff and the Eastman Kodak Company; it was made available commercially in 1928 as the Kodacolor process for amateur motion-picture photography in colour. In this process, the film support is embossed with minute cylindrical lenses on the side opposite the emulsion. A three-colour banded filter is used over the lens; during exposure, the embossed side of the film faces the lens. Somewhat as in the screen unit process, the lens forms a full image of the subject on the film, but it is broken up into minute elements that are images of the banded filter formed by the embossed lenses on the film. The film is developed by the reversal method and projected through a three-colour banded filter.

The quality of the results given by the lenticular film was excellent, but disadvantages were encountered in projection, which involved a great loss of light because of the filters, making special projection optical systems necessary, and the lenticular pattern was often very much in evidence.

4. Subtractive Processes.—The subtractive processes are the important practical processes of colour photography. Their principle was first described by Ducos du Hauron, and they are now used practically exclusively for colour prints on paper and transparencies for still and motion-picture projection. In the subtractive process, three separation negatives are first made by red, green, and blue light. From these, positives are made in colours complementary to those by which the negatives were made, and the three are superimposed in register on white paper to give a colour print or on film to give a transparency.

The negative made by red light is printed to give a cyan (blue-green) picture; that made by blue light is used to give a yellow picture, while that exposed by green light is printed in magenta. When these partial images are superimposed, a good colour reproduction can result.

The three separation negatives can be made: (1) separately by successive exposures through the three filters on three plates or films; (2) simultaneously on three plates or films using a one-exposure (one-shot) camera provided with a beam splitter of partially reflecting prisms or thin pellicles or split lenses; (3) simultaneously on a tripack of three films or plates superimposed and so sensitized and provided with filter layers that each records only one of the primary colours; (4) simultaneously on an integral tripack or monopack.

In the first three cases the three negatives are generally used to print three positives, which can be superimposed on paper or film. Various processes have been used, in particular carbon, Ozobrome or Carbro, bromoil, and dye-mordant methods, and differential tanning of a gelatin layer. There are two principal forms of the last-named—the Pinatype process, in which dye is taken up in an amount dependent on the softness of the gelatin, and is allowed to stay in the layer if a transparency is required, or is transferred to gelatin-coated paper by imbibition if paper prints are required; and the Kodak dye transfer process, in which the soft parts of the differentially hardened gelatin layer are washed out, leaving a relief image in hard gelatin that can be dyed and the dyes transferred to paper or film.

5. Monopack or Integral Tripacks.—It is evident that a simpler system would result if the three layers were coated over each other on a single film support. This proposal was first suggested with the idea that the layers should be separated for development and printing, but the manipulation proved to be too difficult for practical handling.

It was next suggested, by K. Schinzel in 1905, that the three superimposed layers should be arranged so that each responds to a single primary colour, that the layers should be inseparable, and that a coloured image should be developed in each. In Schinzel's proposal, dyes of colour complementary to the spectral region of sensitivity were incorporated in the layers, which were to be developed and then treated in such a way that the dyes were bleached, to an extent proportional to the amount of silver developed. C. Christensen in 1918 proposed a similar arrangement, in which the dyes in the layers were destroyed by reduction by hydrosulfite in the presence of the silver image. The silver-dye bleach method was applied by B. Gaspar, in whose process the dyes were catalytically bleached in the presence of the silver, and by CIBA in 1964, as the Cilchrome process for making colour prints from positive colour transparencies.

Most of the modern processes of colour photography depend on the formation of dyes to an extent depending on the exposure and thus the amount of silver developed in the layers inseparably coated one over the other. The colour of the dye in each of the three layers is complementary to the spectral region to which the layer is selectively sensitive. The basic method for producing the colours depends on a discovery made by B. Homolka and worked out by R. Fischer in 1911; they found that when certain developers react with silver halide to form silver, in the presence of a compound known as a coupler, there is formed along with the silver image a dye image in proportion to the amount of silver formed. The developers used are of the type known as diamines, in particular derivatives of *p*-phenylenediamine; by proper selection of the coupler and developer a great variety of colours can be developed, the final dyes usually being of the indoaniline or azomethine types. The couplers that form cyan dyes are usually phenols; nitriles or

pyrazolones are used for magenta dyes; esters, ketones, or amides may be used to form yellow dyes. After the films are developed, the silver is bleached out, leaving the dye images.

Various arrangements of the three basic coatings on the film have been proposed, as well as various ways of introducing the colours. In 1912 Fischer proposed a process using a film with three layers of emulsion coated over each other, each layer containing couplers so that appropriate colours could be developed in them. Fischer was not able to make the process work because he could not prevent the couplers and sensitizing dyes from wandering from the layers to which they applied. It was not until 1935 that the first commercially successful colour process using coupler development was marketed. It was worked out by L. D. Mannes and L. Godowsky and the Eastman Kodak Company, and was called the Kodachrome process.

In the Kodachrome system, three emulsions responding selectively to blue, green, and red light were coated over each other, the blue-sensitive layer being on top and beneath it a yellow-dyed layer to prevent blue light from reaching the two lower layers.

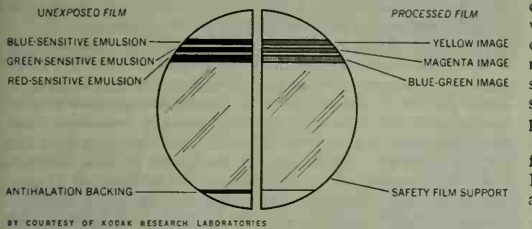


FIG. 4.—CROSS SECTION OF KODACHROME FILM

(By about 1931, nonwandering sensitizing dyes had been developed.) The process was designed to give a direct positive colour transparency. The significant features of the process were that the dye-forming couplers were used in the developer solutions and not in the emulsions, and that the dye images in each of the layers were developed successively in separate solutions using the stages of development, controlled diffusion bleaching, and colour redevelopment, the final step being the removal of the silver to leave the images in the dye alone. Kodachrome film was first made available as 16-mm. film for motion pictures and later was produced as 35-mm. film for slide transparencies, 8-mm. motion-picture film, sheet film, and as reflection prints by coating on a white support (Minicolor, Kotavachrome, and later Kodachrome prints).

The processing of Kodachrome by controlled diffusion was clumsy and toward the end of 1938 was replaced by a selective method in which the assigning of the dyes to their proper layers was determined by the sensitivity of the layers. In this, the film is first developed to give a negative in all three emulsion layers. It is then exposed through the base to red light, which affects the undeveloped parts of the bottom red-sensitive layer, and is then developed in a developer containing a cyan coupler, so that a positive cyan dye image is formed in the bottom layer. By exposing through the front to blue light, an image in yellow dye can be developed in the top layer, and the middle layer can then be made developable and give a magenta image. If the silver in all three layers is bleached out, the dyes alone remain to give the colour picture. The success of the Kodachrome processing depends largely upon using sensitizing dyes that will not wander from their appropriate layers and will withstand processing solutions.

Some time after the introduction of Kodachrome film, Agfacolor-Neu film became available in Germany and later Ansco Color film was introduced in the United States. (After World War II, similar products were put out by Gevaert and Ferrania, among others.) These films differed from Kodachrome film in that the colour-forming couplers were incorporated in the three emulsion coatings rather than in the developer solution, thus permitting simultaneous formation of the three dye images in a single colour-developing step. The couplers were attached to heavy molecular chains that prevented them from diffusing through the gelatin, so that each dye was formed exclusively in its proper layer. These films were also intended to give direct-positive colour transparencies, and processing consisted essentially of (1) developing a black-and-white negative in all three layers, (2) exposing thoroughly to white light, and (3) developing the residual silver halide in all three layers simultaneously in a colour developer, the couplers in each layer forming the proper dyes. Finally, the negative and positive silver images were bleached out, leaving the dyes. Similar materials were later made available on a white base to provide prints for viewing by reflection.

Other systems, known as the Kodacolor, Ektacolor, and Ektachrome processes, also used nondiffusing couplers in the emulsion layers. In these cases, however, the weighted couplers were not dispersed directly in the emulsions but were dissolved in an oily liquid that was dispersed in the emulsion in the form of very fine droplets. The first material of this type was made in 1940 as Kodacolor Aero Reversal film for aerial photography by the U.S. Army Air Corps. It gave direct-positive colour transparencies and could be developed in the field. In 1942, a new Kodacolor film was made available for direct colour development to give negative colour pictures (in colours complementary to those of the original subject) by direct colour development and bleaching out the silver. This negative could be printed onto paper coated with a similar set of emulsions and developed in the same way to give paper prints in colour.

In 1946 the Eastman Kodak Company introduced Ektachrome film, which was a reversal film generally similar to the earlier Kodacolor Aero Reversal film; however, it was of lower contrast and of longer scale, and in sheet film and later in roll film form.

Late in 1946 the discovery of coloured couplers was disclosed by the Eastman Kodak Company. In the early Kodacolor process, a positive silver mask was incorporated in the colour negative to improve the colour reproduction. In the new process, first used in Ektacolor sheet film in 1948, couplers incorporated in the emulsion are coloured red and yellow, and their colour is destroyed in development in proportion to the amount of image dye that is developed. The negative dye image is thus associated with positive images in red and yellow, and these positive images counteract the effects of the lack of purity of the negative image dyes and so lead to greatly improved colour reproduction in subsequent prints.

Films and printing materials of the types mentioned have been put out by a number of manufacturers in a variety of forms, including narrow-gauge negative and reversal motion-picture films, negative and positive professional motion-picture films, sheet films, roll films for amateur and professional still cameras, and 35-mm. cassettes for miniature cameras, as well as reversal and negative-positive printing papers.

6. Colour Printing Processes.—Prints on paper have been made by the screen unit process, but they are unsatisfactory because of the high density of gray with which they must be associated. All satisfactory colour prints are made by subtractive processes, in which positive images in yellow, magenta, and cyan pigment or dye are combined in register. Methods of obtaining the coloured positives are: (1) chemical toning, in which the black-and-white silver images are converted into coloured compounds, for instance, lead chromate for yellow, nickel dimethyl-glyoxime for magenta, and an iron blue for cyan (Chromatone of Defender Co., Snyder and Rimbach); (2) dye mordanting, in which the silver images are converted into compounds known as mordants that have an affinity for basic dyes, among the best known being silver iodide (Traube's Diachrome), copper ferrocyanide (Traube's Uvachrome), and copper thiocyanate (Christensen); (3) imbibition or transfer processes, in which differentially hardened gelatin layers are formed by tanning development or tanning bleach in the pattern of the positive image of the subject, and dyed directly to give a picture in which the dye is taken up to an extent depending on the hardness of the gelatin (Pinatype), or washed out with hot water to give a gelatin relief image, which can be dyed. In either case the dyes can be transferred to gelatin-coated paper to give a print on paper, and if the three-colour images are so transferred, a colour print results (Kodak Dye Transfer process).

7. Pigment Processes.—In the pigment processes, the gelatin contains pigments and can be differentially hardened by the direct action of light if bichromated, or indirectly by a tanning developer, or by indirect action from a bromide print and a special bleach, to give positives that can be washed out with hot water to give pigment-gelatin images.

In the carbon process, originally devised in a practical form by J. W. Swan in 1864, the gelatin containing the pigment is bichromated and exposed and developed in hot water, leaving an image of hardened gelatin containing pigment. In the Carbro process, which was developed from processes devised by A. Marion (1873) and T. Manly (1898), a bromide print treated with a special bleach is placed in contact with a pigmented gelatin coating and differential hardening of the gelatin occurs. The soft gelatin can be washed out in hot water, and three positives so prepared can be transferred to a common support to give a colour picture.

In the Duxachrome process, silver bromide emulsions containing pigments were coated on supports from which the images could later be stripped. The exposed layers were developed in tanning developers and washed out in hot water, the silver was bleached out, and the remaining pigment images transferred to a final support.

The dye-destruction printing processes were typified by Gasparcolor prints, in which three superimposed layers of emulsion contain subtractive pigments. On exposure and development a special solution is used to bleach the pigment image to a degree depending on the amount of silver developed. In 1964, CIBA introduced a silver-azo dye bleach process called Cilchrome.

The dye-bleaching processes typified by the Utocolor paper of J. H. Smith (1910) relied on direct bleaching of dyes by light. The sensitivity of the dyes to bleaching was enhanced by thiosinamine, and the stability of the image was determined mainly by rendering the sensitizer ineffective.

8. Dye-Coupling Processes.—These provide almost all of the modern materials for making colour prints. They are of the subtractive, integral tripack type, basically resembling the various coupler-developed films described earlier, although they are coated on a white reflecting support of paper or a white-pigmented plastic sheet. The materials are made to give direct-positive colour prints by reversal processing from positive transparencies, or positive prints from colour negatives made directly, or as intermediates from positive transparencies, or from black-and-white colour-separation negatives. Examples of the reversal printing processes are Kodachrome prints (earlier known as Minicolor and Kotavachrome prints), Kodak Ektachrome prints (earlier called Kodak color prints, Type R), and Ilford colour prints. The printing materials for reproduction from colour negatives are typified by Agfacolor, Kodacolor, and Ektacolor printing papers, and Ferraniacolor, Pakolor, and Gevacolor papers, which basically resemble the Agfacolor materials. Special materials are available for making positive colour transparency duplicates from original colour transparencies and also for making positive transparencies from colour negatives.

In 1963, there was introduced the Polaroid-Land colour film, Polacolor. It employs the diffusion-transfer principle, giving a positive paper colour print in the camera in 50 seconds. The film is a multilayer-silver halide material. Each layer of emulsion is sensitive to one of the primary colours and is adjacent to a layer containing a developer linked to a dye of colour complementary to the spectral sensitivity of the emulsion. After exposure, alkali is squeezed between the film and a paper receiving sheet. Development is initiated and the dyes are anchored in the exposed (negative) parts. In the undeveloped parts, the dye-developer molecules migrate to the receiving sheet to give a positive colour image. An acid stabilizing layer is present here.

9. Colour Motion Pictures.—The earliest colour motion pictures employed the additive processes: Kinemacolor, a two-colour process using successive projection of separate positives through a rotating pair of filters; the Friese-Green process of successive projection through filters, or with the frames on the film themselves dyed; the Gaumont simultaneous additive process using three lenses in taking and projection. Later, the Dufaycolor screen-unit process was used and methods of printing the film for theatre release were worked out. The lenticular process, which was developed commercially as 16-mm. Kodacolor, was not used to any great extent in theatres. The additive processes, although giving excellent colour quality, are difficult to print, give low screen brightness and difficulty of registration, or undesirable patterns, and therefore are surpassed by the subtractive processes from the practical point of view.

The earliest subtractive processes used chemical toning, dye toning, or dye-mordant methods, especially as two-colour processes; the separate colour positives were printed on the opposite sides of a single support. The earliest Technicolor process was a two-colour relief process, but about 1928 it was changed to a two-colour, and later to a three-colour, imbibition process. For the three-colour process a special camera was used in which separation negatives were made on a single film and a bipack, using a special type of beam splitter. The three negatives were printed onto special films to give matrices from which prints were made by imbibition. Later, three-layer coupler-developed films were used in the cameras, and separation negatives were made from them for printing by the normal imbibition process.

Practically all amateur colour motion pictures are now made on 8- and 16-mm. reversal film using the coupler development processes. A high percentage of professional motion-picture films in colour for theatre use are made by the negative-positive coupler development processes, using materials basically resembling those described before as Kodacolor, Ektacolor, and Agfacolor films and printing materials. In the case of the Kodak process, Eastman Color negative and print films are used for professional 35-mm. motion pictures. Processes resembling the Agfacolor negative-positive system later appeared as the Gevacolor and Ferraniacolor processes.

V. THEORY OF PHOTOGRAPHY

1. The Sensitive Material.—Under the high-power microscope, the image on a photographic negative is seen to consist of large numbers of small, dark grains of silver. They are derived from the structure of the original emulsion, which consists of crystals of silver halide distributed in the gelatin. These crystals may be round, flat, triangular, or hexagonal in shape, with an occasional rod shape. They are of various sizes, ranging up to about $\frac{1}{10,000}$ in. across, depending on the type of emulsion. In a normal film, there are several thousand million in a square inch. Examination by X-rays shows that the silver halide is all in the crystalline form, even though the separate particles may have a lumpy appearance.

If solutions of silver nitrate and potassium bromide in water are mixed, the silver bromide formed settles out in flocks; but if gelatin is present, the silver bromide remains suspended in a much finer form. Gelatin is used in emulsion making, partly to keep the silver bromide suspended as fine crystals. In the ripening stage of emulsion making, the crystals grow in size, but they are of low sensitivity. After the addition of the bulk of the gelatin, washing, and digestion, there is little increase in crystal size, but there is a growth of sensitivity to light to an extent that depends largely on the kind of gelatin.

The sizes and distribution of sizes of the crystals or grains in the emulsion are determined by the way in which the emulsion was precipitated, and the sizes are related to the photographic properties of the emulsion. If they cover a wide range of sizes the emulsion usually has high speed and low contrast and is used for making negatives. If they are small and uniform, the emulsion has low speed and high contrast, and might be used for motion-picture printing film or lantern slides.

When an emulsion is exposed to light, an invisible change known as the latent image is produced in it, and the effect of the exposure is not apparent until the emulsion is developed by treating it in a chemical reducing solution, the properties of which will be discussed later. On development, the emulsion blackens to a degree that depends on the extent of development and on the exposure. In the case of a film exposed in a camera, a negative is produced, in which the brighter parts of the subject are reproduced as dark, and the darker parts as light. The degree of blackening of the

A colour negative (above) and positive (below): note that the negative shows complementary rather than natural colours

An autochrome portrait made by Alfred Stieglitz about 1907. The Lumière Autochrome process, the first colour process to be commercially successful, was introduced in 1907

COLOUR PHOTOGRAPHY

Since the first crude attempts at making colour photographs, colour photography has become an increasingly important pictorial medium, enabling even amateurs to take fast, accurate, and pleasing pictures. Colour photographs are now used in a wide variety of fields, ranging from almost pure abstraction (see below) to the most complex and exacting rendering of concrete likenesses, as shown on the following plate

"Bullfight" by Ernst Haas, a photographer who emphasized light, colour, and movement rather than naturalistic rendering

BY COURTESY OF (TOP LEFT, CENTRE LEFT) EASTMAN KODAK CO., (TOP RIGHT) GEORGIA O'KEEFFE FOR THE ALFRED STIEGLITZ ESTATE, COPIED BY ROBERT KAFKA PHOTOGRAPH, (BOTTOM) ERNST HAAS —MAGNUM

PHOTOGRAPHY

Exploration photograph: Edmund Hillary atop Mt. Everest, May 29, 1953

Colour photomicrograph: section of white pine magnified 120 times

Astronomical photograph: sunspots (dark spots at right of centre) on sun's face

Underwater photograph: diver approaching an exploration vehicle on the floor of the Red Sea

Motion-study photograph: picture of a man in motion lit by repetitive strobe lights and taken through concurrently changing filters so that tapes attached to the man appear to change colour with each exposure. Thus, scientists could trace the flow of muscular movement as the subject bent to pick up an object

Nature photograph: head of an edible frog (*Rana esculenta*) photographed at the instant it emerged from a pond

PHOTOGRAPHS, (TOP LEFT) "LONDON DAILY EXPRESS"—PICTORIAL PARADE, INC., (TOP RIGHT) ERIC GRAVÉ—PHOTO RESEARCHERS, INC., (CENTRE RIGHT) RUSS KINNE—PHOTO RESEARCHERS, INC., (CENTRE LEFT) "PARIS MATCH"—PICTORIAL PARADE, INC., (BOTTOM LEFT) YALE JOEL, "LIFE," © 1957, TIME, INC., (BOTTOM RIGHT) HERMANN EISENDEISS—PHOTO RESEARCHERS, INC.

film is called density (see *Sensitometry*, below). When a print is made from a negative, the light parts again appear dark and vice versa, so that in the print the tones are in the same order as in the subject.

The density in the negative results from the presence of the developed silver grains—the more silver in a particular area, the higher is the density. The silver grains have their origin in the silver halide crystals originally present, so that higher density means that a higher percentage of these crystals was made developable by exposure. On the average, the larger crystals in an emulsion are more sensitive to light than the smaller crystals. This is not due exclusively to the fact that they are bigger and therefore contribute more silver than a small grain, for it is possible by chemical treatment to make a fast emulsion practically insensitive without changing the size of grain.

When an exposed grain starts to develop, it does so at a limited number of isolated points on its surface. These points are distributed according to the laws of chance, and it appears that they coincide with points on the crystals that were preferentially affected by light; *i.e.*, the latent image is concentrated at certain centres. This indicates that the crystals had extra-high sensitivity at these centres; in other words, there are sensitivity centres on the original emulsion grains. Evidence indicates that they are specks of silver sulfide in the crystal surface. The most important support for this view comes from the study by S. E. Sheppard of the function of gelatin in determining emulsion sensitivity. He isolated the sensitivity-promoting substance from gelatin and found it to consist of sulfur compounds, especially allyl isothiocyanate. This material forms allyl thiocarbamide in the presence of alkali, and this substance can form a complex compound with silver bromide. In the presence of alkali, the complex can give rise to silver sulfide, and apparently this is the sequence of reactions occurring in the manufacture of a high-speed emulsion. The sensitivity can be increased by treatment with gold compounds and by reducing agents. Silver itself also plays some part in the formation of sensitivity centres. In addition to the sensitizing material, gelatin can also contain desensitizing materials, and the net sensitivity will be the result of a balance of properties.

There have been many theories as to how the sensitizing specks act during exposure to give rise to the latent image. After Sheppard found the specks to be silver sulfide, he and A. P. H. Trivelli and R. P. Loveland propounded the "concentration speck" theory. According to this, the silver sulfide speck was able to cause the light energy absorbed by the crystal to be concentrated about a speck, and there to liberate silver by decomposition of the silver bromide. There is considerable evidence showing that the latent image consists mainly of metallic silver accumulated about the sensitivity specks. A silver speck can initiate development when it has grown to a certain size.

The concentration speck theory still forms the basis of latent image theory, but the mechanism by which the concentration is effected is now explained on the basis of atomic physics. Although it cannot be assumed that the whole mechanism of latent image formation is understood, the modern theory based on photoconductivity and electrolytic conductivity can correlate much existing data and predict new effects. When light is absorbed by silver bromide, the ability of the material to conduct electricity is greatly increased because electrons become available. J. H. Webb suggested that these electrons could move through the crystal freely, but that they would become trapped at the sensitivity specks of silver sulfide. In addition to this conductivity, there is also a small conductivity of silver bromide that is caused by the movement of some silver ions within the crystal.

R. W. Gurney and N. F. Mott visualized a combination of these two conductivity processes in explaining latent image formation as follows: On exposure to light, the photoconductivity electrons move freely in the crystal until they by chance impinge on the sensitivity specks, where they are trapped and build up a negative charge. This negative charge attracts the positively charged silver ions, which migrate to the specks and there are neutralized by the electrons to form neutral silver atoms. The specks will thus grow by accumulation of silver atoms until they are big enough to act as nuclei in the development process.

2. Development.—In development, the emulsion is treated with a solution that converts the exposed silver halide to black silver. The developer acts much more quickly on exposed than on unexposed grains. There are two kinds of development—physical and chemical. A physical developer contains chemical reducing agents and silver compounds in solution that deposit silver on the latent image from solution. A chemical developer does not contain any silver and is essentially a solution of chemical reducing agents that will distinguish between exposed and unexposed silver halide in an emulsion and thus convert the exposed silver halide to metallic silver. Chemical developers are the basic developers of photography.

When a silver halide crystal in an emulsion starts to develop, it does so at a limited number of points, from which development spreads outward until the whole crystal is converted to silver. A grain ultimately develops completely or not at all. The development is initiated at the latent-image centres where silver was deposited during exposure, and the development of the silver bromide starts about these silver centres. It was felt for a long time that the latent-image nuclei played no part in development except to act as a centre on which silver formed by reduction of dissolved silver halide could deposit. It is now clear that such a process does not play a major part in development. The more likely explanations involve a mechanism by which there is direct reduction of the silver halide at the boundary of the silver latent-image speck, and that the speck itself in some way accelerates this. The shape and size of the silver particles vary with the kind of developer and other factors. Studies made with the electron microscope show that the silver does not have a compact cokelike structure, as might appear from examining it in an ordinary microscope, but that it has a filamentary structure.

Only a limited number of types of chemical compounds are used as developers. A few inorganic compounds, particularly ferrous oxalate, have been used, but the developers used in usual photographic practice are organic reducing agents largely of the classes known as phenols or amines. A rule established by A. and L. Lumière and by M. Andresen in 1891 stated that developers must contain at least two hydroxyl groups, or two amino groups, or one hydroxyl group and one amino group, attached to a benzene nucleus in the ortho (neighbouring) or para (opposite) positions to each other. Meta (midway position) compounds do not develop. It has also been pointed out that many developers form quinones or quinonoid compounds when they are oxidized. J. D. Kendall formulated a rule stating that hydroxy and amino compounds could be developers if they had the basic structure $a-(C=C)_n-b$, where C = C represents two carbon atoms joined by a double bond, n is zero or an integer, and a and b are hydroxyl or amino or substituted amino groups. There are, however, some developing agents that do not follow these rules.

The most common developers have been hydroquinone and paramethylaminophenol sulfate (known by the trade names Elon, Metol, and others). A popular developer in the past was pyrogallol. Diaminophenol hydrochloride (Amidol) has been used as a paper developer, and there is a wide range of developing agents on the market for special purposes. Fine-grain and colour developers have been frequently based on para-phenylenediamine.

In 1951 Ilford, Ltd., marketed Phenidone (1-phenyl-3-pyrazolidone), an important developer patented by Kendall. It can replace Metol in many Metol-hydroquinone developers and generally is effective in much smaller quantity than Metol.

The essential constituents of most practical developing solutions are: (1) the developing agent; (2) an alkali, sometimes called the accelerator; (3) sodium sulfite, sometimes called the preservative; and (4) potassium bromide, the restrainer.

The common alkalis used are sodium carbonate, sodium hydroxide, and some borates, particularly sodium metaborate (Kodalk) and tetraborate (borax). The function of the alkali is to make the developer active, and it does this by adjusting the alkalinity (or pH) to a suitable value and holding it there. This applies to developers containing hydroxyl groups, but the pH also seems to determine the activity of developers that do not contain such

groups. Amidol does not require an alkali to make it effective. On the other hand, the rate of development can sometimes be increased by adding accelerators, of which certain quaternary salts are examples.

Sulfite plays two important parts in a developer mixture. It acts as a preservative by decreasing the tendency of the developer to be oxidized by the oxygen of the air: in general the oxidation products of developing agents have an undesirable influence on the course of development. It also combines with the oxidation products of the developer that are formed when the developer reduces the silver bromide to silver, so preventing them from interfering with the progress of development and from staining the photograph, for they may be highly coloured.

Potassium bromide is frequently added to a developer to restrain the growth of fog (*i.e.*, development of unexposed grains) and to control the uniformity of development. It usually slows down the rate of development and may tend to make the photograph warm in colour. In addition to bromide, other antifoggants used in developers include benzotriazole and 6-nitrobenzimidazole.

The nonhomogeneous, coarse structure of a negative, seen as graininess, is a matter of the grain structure of the original emulsion and of the developed negative, the extent of development, and the nature of the developer. So-called fine-grain developers are made to reduce the apparent graininess. Generally, they are adjusted to be of low activity and therefore contain a solvent for silver bromide, which may consist of an increase in the sulfite or a special solvent such as potassium thiocyanate. Sometimes special developing agents are used, the best known being para-phenylenediamine, which in itself is a silver halide solvent. Fine-grain development is chemical development with enhanced physical development.

Modern colour photography relies on so-called coupler development, in which the oxidation products of the developer, usually a para-phenylenediamine derivative, combine with organic compounds known as couplers to form dyes. The couplers may be in the developer or in the emulsion. (See *Colour Photography*, above.)

Certain developers can be used for tanning, or hardening, the gelatin in the areas where development occurs, an effect that has been used for producing gelatin relief images for photomechanical reproduction and for imbibition colour printing. Pyrogallol and catechol developers with little or no sulfite are commonly used, the tanning effect being due to the oxidation products of the developer. In some materials, *e.g.*, the Verifax matrix material, the tanning developing agent is incorporated in the emulsion, development being initiated by external application of alkali, known as an activator.

The various developing agents differ in their behaviour. For instance, in a plain Metol developer development starts much more quickly than in a plain hydroquinone developer. The Metol gives detail first and slowly builds up density, while with hydroquinone the detail appears only after much density has been built up. In combination, the Metol and hydroquinone form a very satisfactory developer. In some instances a great part of the Metol in the combination may be replaced by Phenidone.

Developers are worked out for various special purposes, and they vary widely in their properties, depending not only on the material they are used to develop but also on differences inherent in themselves. In fact, the developer-emulsion combination is the determining factor, although very often the mechanical way in which development is carried out is of great significance. The developing rate increases with temperature but varies markedly with the nature of the developer. It also depends on the concentration of the components, and the effect of alkali in particular varies with the developing agent. Developers also vary in the way in which they keep when they are exposed to air, in the rate at which they become exhausted in use, in the rate at which they will develop fog, and in the effective emulsion speeds they produce.

When an exposed part of a film is developed, there is usually an initial period, known as the induction period, in which no visible effect appears. After this, the density increases, rapidly at first and then more slowly, and eventually further time in the developer produces no more density until fog starts. For the simplest case of a developer and emulsion in which there is no tendency to produce fog on prolonged development, and in absence of much free bromide, the relation between density and development time is

$$D = D_\infty (1 - e^{-kt})$$

in which D is the density that has been developed at a time t, D_∞ is the density ultimately developable and k is a constant—the velocity constant of development.

From this, the law of constant density ratios was deduced: if a film that has had a series of increasing exposures is developed, the ratio of the densities caused by any two exposures is constant and independent of development time. Other aspects of development are dealt with under *Sensitometry*, below.

For special purposes, monobaths, or combined developing and fixing solutions, have been devised. Basically they consist of a developing composition containing a fixing agent—in the past usually hypo, but other agents are available. They shorten processing times but are quite critical and specific in use, and if care is not exercised they may result in stain, fog, and loss of speed.

Usually, on development, some grains that have not been exposed to light are reduced to silver and the resulting density is known as fog. It may be ascribed to the emulsion or to the developer, some emulsions showing a greater tendency than others to produce fog, and some developers have a greater tendency than others. Generally, fog can be diminished by adding to the developer certain chemicals such as bromide and so-called antifoggants that have less effect on the development of exposed grains than on the development of fog.

3. Processes Following Development.—*Fixing.*—After development, the emulsion is "fixed" by dissolving out the unchanged silver halide. The commonest fixing baths are water solutions of sodium or ammonium thiosulfate (known respectively as hypo and ammonium hypo). Potassium cyanide is used in the wet collodion process in photomechanical reproduction, since it readily dissolves silver iodide, but it is extremely poisonous.

When a negative or print is transferred to the fixing bath, it carries some developer with it. This may oxidize and cause stain, which may be prevented by adding sulfite to the fixing bath. The alkali carried over in the developer may cause development to continue in the fixing bath and also may tend to assist oxidation of the developer. Acid is therefore added to neutralize the alkali. Thiosulfate, however, is unstable in the presence of acids and will deposit sulfur. This can be prevented if sulfite is present. A simple acid fixing bath, therefore, contains thiosulfate, sulfite, and a weak acid, such as acetic.

In order to prevent softening of the gelatin, hardeners may be added, and the result is an acid hardening fixing bath. The commonest hardeners are potassium and chrome alums, and their hardening ability is facilitated by the acidity of the bath. When the acidity of a potassium alum fixing bath becomes too low, a sludge of basic (*i.e.*, alkaline) aluminum sulfite forms; but this tendency can be diminished by adding boric acid.

Stop baths or rinse baths are sometimes used between development and fixing in order to neutralize the alkali carried over. A simple water rinse is better than nothing, but a weak acetic acid solution is preferred. Sometimes, a hardening bath containing chrome alum is used prior to fixing, especially in hot weather. In order to suppress swelling of the gelatin, sodium sulfate is sometimes added to the stop bath. As a special hardener for emulsions after fixing and before special later treatment, a bath containing formalin and carbonate is used.

The rate at which a fixing bath acts depends largely on the concentration of hypo and the temperature. It is most rapid at 20%–40% concentration. At higher concentrations the rate is slowed down because the extra salt content tends to suppress the swelling of the gelatin. The optimum temperature lies between 60° and 70° F (16°–21° C). Agitation also increases the rate of fixing somewhat. A practical rule for fixing film is that it should be continued to twice the time taken for the film to clear. Use of a second fresh bath is preferred. The rate of fixing can be increased by adding ammonium salts to the hypo bath, or by using ammonium

thiosulfate instead of the sodium salt.

Washing.—Negatives and prints are washed in water after fixing in order to remove products that might affect their appearance or stability, and in particular to eliminate the fixing salts and the compounds they formed in dissolving the silver halides. If the silver compounds are not removed, there will be stain in the highlights and unexposed areas, while if the thiosulfate and its products are not removed there will be eventual slow sulfurizing of the image.

In washing, the basic factor is the rate of diffusion of the hypo and other salts out of the film and into the water, provided the water in contact is continuously renewed. The removal is exponential; *i.e.*, the amount of salts remaining in the gelatin is halved for each unit of time. Removal of salts is increased by increasing the temperature, but the temperature is limited by the danger of softening the gelatin, and 60°–70° F (16°–21° C) is best unless specially hardened films are used. Washing is more rapid if no hardener is used than if a potassium alum hardening fixing bath is used, although chrome alum hardening has little effect.

Washing of prints is slower than the washing of negatives, because the paper fibres offer much resistance to the removal of the adsorbed silver-hypo complexes. It is very difficult to remove the last traces of hypo from paper by washing, and if in the interest of permanence the last traces must be eliminated, recourse must be had to chemical agents. Alkaline solutions will assist the removal, but it is preferable to use hypo eliminators that convert the last traces of hypo to sulfate. An effective solution contains hydrogen peroxide and ammonia. Various solutions of salts have been marketed as rinses for use between fixing and washing to accelerate removal of the fixing salts.

If negatives and prints are to be preserved for a long time, they must be thoroughly fixed and washed. On the other hand, where long life is not required, but results of fair stability must be obtained in a short time, "stabilization" may be used. Stabilizing agents produce complexes with the undeveloped silver halides in the negative or print that are relatively inert to heat, light, and humidity. Washing is avoided.

Drying.—After washing, negatives are usually dried in moving, warm air, after surface moisture is removed by blotting, wiping, or squeegeeing. Prints on paper can be dried at higher temperatures, and in large-scale photofinishing this is usually done on heated revolving metal drums, which may also give gloss to the prints if they are put emulsion side to the polished metal surface.

Reduction and Intensification.—"Reduction" in photography refers to methods of decreasing the density of an image by chemical means, while "intensification" involves processes for increasing density.

Reducers are oxidizers in the chemical sense, and they convert some of the silver into a soluble compound form. They are divided into three classes according to the way in which they affect density and therefore contrast: (1) Subtractive or cutting reducers remove equal amounts of silver from all densities. The proportion of silver removed is thus greater the lower the density, and the effect is that of increasing image contrast. (2) Proportional or true-scale reducers remove silver in proportion to the amount present, thus reducing the contrast of the negative. (3) Superproportional reducers remove a greater proportion of silver from the higher densities than from the lower, thus reducing the highlights without affecting the shadow detail. Typical reducers are: of the first kind, potassium ferricyanide and hypo; of the second, acid potassium permanganate; and of the third, acid persulfates.

Intensifiers increase the density of the image by deposition of some substance such as chromium, silver, or mercury on it, or by toning it. They may be divided into three classes: (1) Proportional intensifiers are the most common type. Best known are the chromium intensifier, in which the silver image is bleached in a solution of bichromate and hydrochloric acid and redeveloped in Metol-hydroquinone; the silver intensifier, in which silver is deposited on the image from a solution containing silver nitrate, sulfite, hypo, and Metol; and Monckhoven's mercury intensifier, in which the image is bleached with mercuric chloride and potassium bromide and then blackened with silver nitrate in cyanide solution. (2) Superproportional intensifiers have a solvent or other inhibiting action that tends to prevent increase in the lower densities. Examples are the Monckhoven intensifier with a slight excess of cyanide in the redeveloper, or a mercury bromide bleach with a sodium sulfide redeveloper. (3) Subproportional intensifiers do not fully intensify the intermediate and higher densities. Typical are the toner containing uranium nitrate and potassium ferricyanide, and the chromium intensifier in which bleaching or redevelopment is incomplete. An effective intensifier that gives the greatest known degree of intensification of very weak images on fast negative films contains quinone and hypo.

Toning.—The colour of the photographic image can be modified by toning. The normal colour is black or gray, but by modifying the size of the silver particles by special development or other treatment, the colour can be changed, usually to brownish, olive green, blue, or purple. If fine-grain silver images tend to have a "warm" tone, they can frequently be made "cold" by adding certain organic chemicals to the developer.

Toning can be effected by a change in the chemical composition of the silver image. In the days of print-out papers, it was customary to replace the silver of the image with gold by using a bath containing gold chloride and thiocyanate, and modern printing papers can be toned to brown by gold solutions.

Brown, purplish, and reddish tones may be obtained by converting the silver into silver sulfide, selenide, or telluride. Sulfide toning may be direct, in which case the photograph is converted by direct bathing in a solution containing colloidal sulfur or polysulfide, or indirectly, in which case it is first bleached to silver chloride or bromide, which is then acted upon by sodium sulfide solution. Selenium or tellurium dissolved in sulfite or sulfide will tone directly, or the indirect method may be used.

Many coloured metallic salts will be precipitated by the silver image and tone it. In conjunction with ferricyanide, copper and uranium salts give red and brown tones, and iron compounds give blue.

Dye images may be obtained by the methods of coupler development used in colour photography, in which an image of silver halide (obtained by bleaching a silver image if necessary) is developed with the special developer in presence of a coupler (see *Colour Photography*, above). They may also be formed by the methods of dye toning in which the silver image is converted into a mordant, such as silver iodide, silver ferrocyanide, or a mixture of silver and uranium ferrocyanides, to which the dyes attach themselves.

4. Sensitometry.—Sensitometry strictly refers to the measurement of the sensitivity of photographic materials, but in practice it includes the measurement of all the factors that go into the making of a photographic image. The first quantitative measurements of the action of light on photographic materials were made by W. de W. Abney in 1874. He measured the transparency of the image and demonstrated that within limits it varied inversely as the logarithm of the exposure.

In 1890 F. Hurter and V. C. Driffield published a paper, "Photo-Chemical Investigations and a New Method of Determination of the Sensitiveness of Photographic Plates," which laid the foundations of modern sensitometry. They studied the relation between exposure, development, and the silver deposit resulting and defined density, D, as the logarithm of the opacity, O, which was defined as the reciprocal of the transparency, T. Thus, if a light of intensity I falls on a photographic deposit, and I' is transmitted, then

$$T = I'/I;\ O = 1/T = I/I' \text{ and density } D = \log I/I' \text{ or } -\log I'/I$$

The following table shows the relation between a few values of transparency, opacity, and density:

Transparency	Opacity	Density
$\frac{1}{2}$	2	0.301
$\frac{1}{4}$	4	0.602
$\frac{1}{8}$	8	0.903
$\frac{1}{10}$	10	1.0
$\frac{1}{100}$	100	2.0
$\frac{1}{1.000}$	1,000	3.0

It was once thought that there was a fairly strict relation between density and the amount of silver per unit area—the photometric equivalent—a density of 1.0 being given by 0.1 mg. of silver per sq.cm. of area. The reciprocal of the photometric equivalent is called the covering power. The covering power varies greatly with the nature of the development, the emulsion, and the degree of hardening of the gelatin, and perhaps other factors.

The relationship between density and the logarithm of exposure was first shown by Hurter and Driffield in what they called the characteristic curve. As the light source they adopted first the standard candle and later the pentane lamp. Exposures were made in an increasing series of steps in a sensitometer using a rotating disk in which successively increasing angular apertures had been cut, and the density of the final plates was measured in a visual photometer. This curve is the basis of modern sensitometry. (*See* fig. 5.)

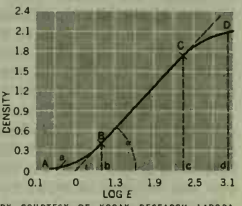


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FIG. 5.—CHARACTERISTIC CURVE OF AN EMULSION

The characteristic curve has three fairly well-defined portions: (1) a straight line (B to C); (2) a "toe" (A to B); and (3) a "shoulder" (C to D).

The chief use of the characteristic curve is in determining the sensitivity or speed of a film, plate, or paper; the contrast; the latitude of exposure; and the manner in which tones will be reproduced. The curve must be made under carefully controlled conditions involving: a source of light giving radiation of known intensity and spectral quality; a modulator by which a series of graded exposures of known values are produced; standard development conditions; a means of accurately measuring density; and a method of interpreting the results.

Many light sources have been proposed, but that adopted internationally in 1928 was a tungsten filament electric lamp operated at a colour temperature of 2,360° K and screened with a filter (Davis-Gibson) of specified composition to give light having approximately the spectral quality of mean noon sunlight in Washington (5,400° K). For special purposes appropriate light sources must be used to match the conditions of practical exposure; for instance, arc lamps for graphic arts products, high-intensity electronic flash lamps or flashbulbs for flash exposures, and infrared sources for infrared photography.

The light source and the exposure modulator constitute the sensitometer. Exposures are made on a strip of the material either in a continuously increasing manner or, more frequently, as a series of steps. The change in exposure through the series may be made by changing the intensity of light or the time of exposure, and sensitometers are therefore either intensity-scale or time-scale instruments. A typical intensity-scale sensitometer is a step tablet or optical wedge consisting of a series of areas having precisely known light transmissions, or a continuously graded transmission. A typical time-scale sensitometer consists of a series of slots of known lengths, cut in a plate that falls past or is rotated in front of the material being exposed.

The exposure may be intermittent, *i.e.*, in a series of short times that add up to the desired total time, or continuous. The early sector-wheel sensitometers gave intermittent exposures, for they were rapidly rotated in front of the material. Continuous exposures are preferred, however, because the photographic material does not add up the separate short exposures properly for normal frequency of intermittency. This is the so-called intermittency effect. Above a critical high frequency, however, the effect is that of a continuous exposure.

The best sensitometers should be of the continuous-exposure intensity-scale type, and the exposure time should be roughly equal to the time that would be given the material in use.

The exposed strips are developed in a standard developer, or in the developer recommended for use with the particular material, for the desired time, at a standard temperature, usually 68° F (20° C), and under conditions of agitation that will ensure uniformity and reproducibility.

Density is measured in a densitometer, and in accordance with the definition established by Hurter and Driffield. The early densitometers were of the optical-bench type using the inverse square law, but in later instruments the intensity was controlled by polarizing devices, as in the Martens photometer, or by variable apertures. Some densitometers are comparators in which the density is compared with one that has already been calibrated on another instrument. Many instruments use photoelectric cells in place of the eye for the measurement. A number of instruments are in use in which the characteristic curve is automatically traced, and for colour films there are densitometers that trace the curves for the three component colours.

When light passes through a developed film or plate, some of it is scattered or diffused, while some passes straight through and is said to be specular. If all the light, diffused and specular, that passes through is collected and used in the measurement, the density obtained is called the diffuse density. If only the light passing directly through is measured, the density is said to be specular. The diffuse density is lower and is related to the other by Callier's Q factor, which varies as the density is varied and also depends on the gamma (slope of line BC) and the type of emulsion. The value of Q may range from 1 to almost 2. Most densitometers have a diffusing glass in contact with the film or plate and the readings are of diffuse density. The most satisfactory and reproducible diffusing medium is an integrating sphere.

Developed materials generally show a very slight density (*i.e.*, fog) in parts that have not been exposed. Some fog is inherent in the emulsion, and some is caused by the development conditions and increases with time in the developer. Any density read also includes that caused by fog as well as the film support. In order to find the density caused by the exposure alone, it is customary to measure the density caused by fog and the support on an unexposed area and correct for it.

In the case of paper prints the densities must be measured by reflected light, and the definition of reflection density is analogous to that for transmission density. If D_R is the reflection density, and R is the ratio of light reflected by the paper to the light reflected by the image on it,

$$D_R = \log 1/R$$

Characteristic curves are drawn by plotting the densities against the logarithms of the exposures (E) that produced them (*see* fig. 5). If the straight line BC in the figure is extended to meet the exposure axis, it cuts it at a point i, which Hurter and Driffield called the inertia, and at an angle designated as α. This angle is of great importance; and its tangent, that is, the slope of the line BC, was called by Hurter and Driffield gamma (the Greek letter γ). It is frequently used as a means of expressing contrast, but it must be realized that it refers only to the straight-line portion of the curve.

The projection of the straight-line portion of the curve (BC) onto the exposure axis, at the points b and c, is called the latitude and is expressed in log E, or exposure, units. It represents the exposure range over which there is strict proportionality between density and log exposure. The total scale of a negative, on the other hand, represented roughly by the distance a to d on the log E axis of fig. 5, denotes the whole exposure range within which the material can represent a brightness difference in the subject by a density difference in the negative. In most negative materials the total scale is much larger than the brightness range of most scenes.

As the time of development increases, the slope of the characteristic curve increases. Hurter and Driffield found that with a bromide-free developer, the inertia points for curves for different development times coincided. In other words, inertia was independent of development time and was therefore a very significant constant. Hurter and Driffield, therefore, used the inertia as a basis for a method of expressing speed. So-called "H. and D. speeds" were obtained by dividing the exposure corresponding to the inertia point into 34, a value that was arrived at empirically.

Later, other people used other numerators, and the inertia method was used for many years. Unfortunately, it does not hold that with all emulsions and developers the straight-line parts of the curves will intersect at the inertia, and the inertia method has fallen into disfavour.

Some methods proposed for estimating speeds relied on estimating the exposure that corresponded to a just perceptible density—the threshold density. Such methods included those that used the Eder-Hecht wedge and the Scheiner method using a rotating sector wheel. A modification of the threshold method was the German DIN (Deutsche Industrie Norm) system, in which the speed was derived from the exposure required to give a density of 0.1 higher than the fog, development being carried to an extent that gave the highest speed figure. This particular requirement was later dropped, fixed development conditions being used.

The idea that speed systems should be based upon a gradient in the underexposure part of the curve, rather than upon a single point or density, was proposed by R. Luther and later was developed by L. A. Jones. It was applied first for Kodak speeds and later was adopted by the British and Americans as standard. In this system, it is assumed that negative film speed should be based on the least exposure to give a negative from which prints of excellent quality could be made. On the basis of a statistical study of print quality, the standard for measuring speeds was selected, based on the exposure, E, in the toe of the characteristic curve where the gradient is 0.3 of the average gradient over a log exposure range of 1.5. (*See* fig. 6.) Speed $= 1/E$.

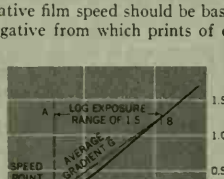

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FIG. 6.—ESTIMATION OF FILM SPEED BY FRACTIONAL GRADIENT METHOD

To determine camera settings for pictorial photography, "exposure indexes" equal to $\frac{1}{4}E$ were used instead of speed. A safety factor was incorporated in these exposure indexes for black-and-white negative materials, and when those film ratings were used with most exposure meters a factor of $2\frac{1}{2}$ was effective. It later was realized that in practice the extra-high exposure provided by use of these indexes was a disadvantage from some points of view and strong arguments were produced to reduce or eliminate the safety factor, which was effective when the indexes were used in conjunction with exposure meters calibrated according to the U.S. standard. Much evidence was also produced to show that a fixed density-above-fog criterion for measuring speed correlated well with fractional gradient speed when development was controlled so that a fixed average gradient was obtained.

The above factors had an important effect on the 1960 revision of the American standard method for determining speed of photographic negative materials.

The method used for determining speed in the revised standard is illustrated in fig. 7. In this figure, the point M is located at a density of 0.1 above fog-plus-base density on the density-log exposure curve. The point N lies 1.3 log exposure units from M in the direction of greater exposure. To fulfill the requirements of this standard, the developing time in the standard developer must be chosen so that the point N lies at a density 0.8 above the density at point M. When this condition is satisfied, the exposure E_m (expressed in meter-candle-seconds) corresponding to point M represents the sensitometric parameter from which ASA (American Standards Association) speed is computed by use of the formula:

$$\text{speed} = \frac{0.8}{E_m}$$

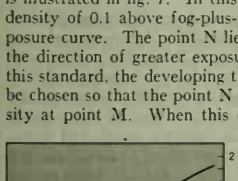

FIG. 7.—FORMULA FOR DETERMINING SPEED OF FILM FOLLOWING THE 1960 REVISION (*see* TEXT)

It has already been mentioned that as development time is increased, the slope of the characteristic curve, or the gamma, increases. A typical series of curves is shown in fig. 8. Ultimately, further increase in development time results in no further increase in contrast, and the maximum obtainable is known as gamma infinity (γ_∞). If gamma is plotted against time of development, a rate-of-development curve or a time-gamma curve is obtained similar to that in fig. 9. The curve describes the rate of change of development with time, showing that it increases rapidly at first and then at a slower rate until it reaches a limit. The limit reached depends on the developer and on the emulsion, being lowest for the high-speed materials and highest for the very slow materials such as those used for photomechanical reproduction.

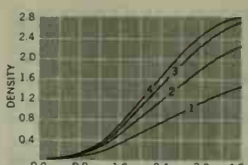

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FIG. 8.—CHARACTERISTIC CURVES OF FILM FOR FOUR TIMES OF DEVELOPMENT. THE TIMES INCREASE IN THE ORDER 1, 2, 3, 4

The sensitometric characteristics of printing papers can be described by a series of figures parallel to those used for negatives, and derived from characteristic curves obtained by plotting reflection densities against the logarithms of the exposures. The most important constants of a paper are the exposure scale, which is determined by limiting exposures in the high and low density regions of the curve, the density scale, which is the difference between the densities corresponding to these two limiting exposures; and the useful maximum density, which is the density corresponding to the upper limiting exposure. Speed values of photographic papers have been based on a gradient in the high density part of the curve, but speeds or "printing indexes" based on a fixed density of 0.6 are often used.

The contrast of a printing paper is a difficult thing to define, since it involves both psychological and physical considerations, but it has been expressed in terms of sensitometric characteristics.

Increasing the development time of papers mainly increases the effective speed in the case of chloride and chlorobromide papers, since gamma infinity is reached very rapidly, but with bromide papers increased development increases both average gradient and speed.

An important factor is the failure of the reciprocity law. The law itself, first enunciated for photochemical reactions, stated that the result of the action of light depends on the product of the light intensity (I) and the time of action (t), and not on the individual values of either. Abney found that it does not always hold in the case of photography that the density resulting from an exposure E is independent of the absolute values of I and t, where $E = It$. In many cases if I is very high or very low the resulting density is less than that normally obtained for the same value of It. The reciprocity failure varies greatly with the nature of the emulsion, but there are no definite rules by which it can be related to other attributes of the emulsion, such as speed, grain size, or spectral sensitivity. The failure is of special significance where very long exposures at very low intensities are involved, as in astronomical photography, or where very short, bright flashes are given. Closely related is the intermittency effect, in which the density given by a continuous exposure may be different from that given by the same total exposure made in a number of discrete installments. Its extent for a particular emulsion depends on the intensity level and the rate of interruption.

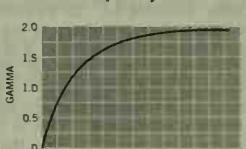

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FIG. 9.—CURVE SHOWING INCREASE OF GAMMA WITH TIME OF DEVELOPMENT

A very high-intensity exposure of short duration may desensitize an emulsion to a second lower-intensity exposure, a phenomenon known as the Clayden effect. In the case of many photographic materials, prolonged exposure may result in solarization, in which, after the maximum density in the negative has been obtained, fur-

ther exposure gives a lowering of density, so that a positive, rather than a negative, image may result. Solarization is markedly influenced by the composition of the developer, and by the presence of halogen acceptors during exposure. In a phenomenon called the Herschel effect, the effect of exposure of certain emulsions to blue light may be erased by subsequent exposure to red or infrared radiation before development.

Many factors determine the ability of a photograph to reproduce fine detail, and the most important are resolving power, graininess, sharpness, and acutance. Resolving power refers to the ability of an emulsion to separate fine detail; it is usually measured by photographing a parallel-line test object at great reduction and expressing the result in terms of lines per millimetre that are just recognizable separately. The values may range from below 50 to 1,000, although in the case of most negative films the image would resolve up to about 150 lines. Values depend on the type of emulsion, the contrast of the subject, the density of the negative, the colour of the light, the developer, and other factors.

Photographs usually have a nonhomogeneous, "grainy" appearance. If it is not directly visible, it usually is seen under magnification. The appearance is known as graininess and the objective aspect of it is called granularity. Emulsions of high sensitivity generally show more graininess than slower emulsions, and development and density have marked effects. Makers of emulsions are constantly striving to increase the speed/graininess ratio; *i.e.*, to get higher speed without correspondingly coarser grain. Graininess in prints increases as density of the negative increases.

Definition in a photograph is also dependent on the sharpness of the image; that is, on the appearance of the edges of well-resolved detail. Theoretically, if a film is exposed partly covered by an object having a sharp edge, such as a knife blade, development should produce an abrupt change from density to no density at the edge. In practice, however, the developed image is shaded at the edge, to an extent depending on the development, the agitation during development, and the turbidity of the emulsion. It is difficult to ascribe numerical values to sharpness, so the objective aspect of acutance has been worked out to describe by numbers the change in density at the boundary of a knife-edge image. The values agree with sharpness judgments made by observers.

The simplest emulsions respond only to ultraviolet, violet, and blue light, but by dye sensitizing they can be made to respond to other wavelengths. In measuring the spectral sensitivity of an emulsion it is customary to trace the curve showing its response to different wavelengths of a source of a particular spectral quality, or to an ideal source in which the energy is assumed to be the same at all wavelengths. The response to a particular source, such as a tungsten filament lamp, is frequently measured in a wedge spectrograph. This is a spectrograph having an optical wedge over the slit so that the photograph of the spectrum obtained will vary in height at any wavelength according to the response of the material to the light source at that wavelength. For equal-energy spectral sensitivity measurements, characteristic curves of the material are made for a series of narrow wavelength bands isolated in a spectroscope, and from the curves the sensitivity values for equal energies at all wavelengths are deduced and plotted against the wavelengths.

5. Tone Reproduction.—The basic problem of photography is to make a reproduction that will produce in the mind of the observer the sensations that were produced by viewing the original scene. At least, it is important to represent satisfactorily the brightness aspects of the original on a paper surface. There are two major aspects of the problem. One of these is the objective phase, in which by physical methods it is possible to determine the fidelity with which the brightness and brightness differences in the original subject are rendered in the reproduction. On the other hand, the faithfulness with which the appearance of the original is reproduced involves psychological factors, and this is the subjective phase of the problem.

The quality of the reproduction of tone obtained in a two-stage negative-positive process depends on a variety of factors, including the intensity of the light from the subject; flare light in the camera; the spectral sensitivity, exposure, development, and shape of the characteristic curve of the negative material; the type of printer or enlarger and flare light in the enlarger; the exposure, development, shape of the curve, and kind of positive printing material; and the method of viewing the final photograph. The tone reproduction problem has engaged the attention of many photographic workers, and complete studies have been made, mainly by L. A. Jones.

VI. PHOTOGRAPHIC MANUFACTURE

Before the introduction of the dry plate, photographers made their own materials. In 1873 there appeared in England the first advertisement for a gelatin emulsion ready for use, and the first coated plates were placed on the market in England. In 1880 George Eastman marketed plates in the U.S. and manufacture began on the continent of Europe.

The manufacture of photographic materials is now a very large industry, and the distribution of its products is one of the world's big businesses. Until 1900 small factories under the control of their founders produced most of the sensitive products, but modern manufacture is largely organized in factories operating on a big scale.

The chief photographic sensitive materials are plates, films, and papers, and in each case three main manufacturing operations are involved—preparation of the base or support, manufacture of the sensitive emulsion, and coating of the emulsion on the support. In addition, there is the cutting to shape and the packing.

1. Preparation of Glass Plates.—The support of plates is glass sheets that are selected for reasonable optical flatness and freedom from blemishes. The sheet is cleaned by brushing in alkaline solutions in special machines and is then coated with a substratum, *e.g.*, a weak solution of gelatin containing chrome alum, which will cause the gelatin emulsion to adhere to the glass. It is then dried, examined to reject defective sheets, and passed to the coating room. The thickness of glass for plates increases with the size, and ranges from about 0.05 to 0.125 in.

2. Film Support.—Film support, or film base, consists of a thin, flexible, transparent sheet. It was first made of cellulose nitrate, which was flammable and provided a hazard in storage and use. Since the early years of the 20th century, research has been conducted to find a slow-burning substitute, and cellulose acetate came into commercial use in the 1920s for narrow-gauge motion-picture film, X-ray film, and some professional films. In 1937, the Eastman Kodak Company introduced an improved "safety" base of cellulose acetate propionate, and in 1948 a new support of high acetyl content approaching cellulose triacetate was introduced. By 1950, all Kodak film was on safety support, and other manufacturers followed. Other polymeric materials came to be used as film supports, particularly where dimensional stability was needed for mapping and graphic arts purposes. Among these were polyvinylchloride and copolymers (Vinylite), polystyrene, polycarbonate, and polyesters, particularly those related to compounds prepared from ethylene glycol and esters of terephthalic acid (Estar, Cronar).

Film base usually ranges in thickness from 3½ thousandths of an inch for roll film, through 5½ thousandths for motion-picture film, to 7 to 8 thousandths for sheet and X-ray film. Film base made from cellulose esters is coated as a layer of viscous solution called dope onto a continuously moving smooth surface in the form of a large wheel or a belt on which it sets by evaporation of the solvents, and from which it is stripped, cured, and dried. In addition to the solvents, plasticizers are added to give flexibility to the final film, and for special films dyes or white diffusing agents may be added. Some of the later supports are made by extrusion rather than by coating from solvents, and are laterally and longitudinally stretched. Special coatings or treatments may be applied to the film support, for example to reduce curl, to reduce the tendency to build up static electric charges on handling, to change the colour, to provide antihalation protection, and particularly to enable the emulsion to stick to the support. In the U.S. the support is usually made 42 to 60 in. wide and continuously in rolls cut to lengths of about 2,000 ft. In Europe, where band machines rather than wheels are used, the width is usually about 26 in.

3. Paper Base.—Photographic paper base is generally made in mills that specialize in its manufacture from rag stock or specially refined wood pulp. The methods of manufacture are similar in general to those used for other papers, but extreme care is taken to exclude traces of impurities, especially of metals such as copper and iron from the paper stock. The composition of the paper and its treatment vary according to the purpose for which it is to be used. It is appropriately sized, and it must have high wet strength, for it has to undergo much handling while soaked with water and alkaline and acid solutions. Some papers are specially treated to lower the tendency to absorb water.

Before it is coated with emulsion, photographic paper is usually coated with baryta, *i.e.*, a suspension of barium sulfate in gelatin is coated over the surface; and if a high gloss or other special surface characteristics are needed, the paper may be calendered after coating with baryta.

4. Emulsions.—Emulsions are of three main types: for negatives, for positive printing materials, and for colour photography. Negative emulsions consist of suspensions in gelatin of silver bromide containing a small amount of silver iodide. The emulsions for printing papers may also consist of silver bromide in gelatin, but usually printing paper emulsions consist of silver chloride or a chloride and bromide mixture in gelatin.

In making negative emulsions, silver nitrate is run into a solution of potassium bromide containing a small percentage of potassium iodide, and a low percentage of gelatin. The temperature, rate of addition, and stirring are controlled, and the mixture is ripened in the presence of excess bromide at an elevated temperature, or of ammonia at a lower temperature, until the silver halide crystals have attained the required size and size distribution. More gelatin is then added, the emulsion is set to a jelly by cooling, cut into shreds, and the shreds washed in cold water. The washed emulsion is then melted again, more gelatin is added if necessary, and the whole is digested by maintaining it at a moderate temperature; during this digesting period contrast and speed are built up. Sensitizing dyes are added if required, and finally special additions are made to preserve the emulsion, to keep down fog, and to aid in coating.

In making paper emulsions, chloride or a mixture of chloride and bromide are most used, most of the gelatin is added before precipitation, and the emulsion is not washed. Some of the high-sensitivity bromide papers used for enlarging are made with washed emulsions similar to those made for slow negatives or for motion-picture positive film or lantern slides.

There is one type of paper which is now used for making proofs by directly printing-out the image in sunlight or mercury light, which is also unwashed, and in which the silver salts are a mixture of chloride and citrate. A similar paper is made for use in trace-recording instruments using galvanometers.

Certain paper emulsions are made to give direct positives from positive original subjects, using special photographic effects, and some papers are made, particularly for the documentary recording field, in which the developing agent is incorporated in the emulsion.

5. Coating.—Plates are coated with emulsion by passing the cleaned and prepared glass sheets, held on a horizontally moving belt, under a device that permits the melted emulsion to spread in a uniform layer on the glass. The coated plates pass to a cold moving belt or set of rollers where the gelatin sets, and at the end of the machine they are placed on racks and dried slowly and evenly in cabinets. When dry, they are cut to the required sizes and packed with specially prepared interleaving paper in boxes for the market. Sometimes a special antihalation coating is applied to the back of the glass.

A great variety of plates in a wide range of sizes is made. For most photography, sheet film has replaced glass plates, but plates are still used in the graphic arts, and for lantern slides, photomicrography, and in a great range of speeds, contrasts, and spectral sensitivities for astronomy and spectroscopy.

Film and paper may be coated on the same type of machine. The roll of support, usually 42 in. wide and about 2,000 ft. long, is led over a series of rollers and into a coating trough or other device where a layer of emulsion is applied to it, the thickness depending on the temperature, viscosity, and rate of travel. The coated base passes into a vertical runup, where the emulsion coating evens itself out, over a chill roll and finally into a cold chamber, where the emulsion is thoroughly set. The film or paper is then automatically looped into festoons varying from 5 to 20 ft. in length or carried flat, and is then moved slowly through drying tunnels supplied with cleaned air of adjusted temperature and relative humidity. The dried film or paper is continuously reeled up into rolls of appropriate length and is then sent to the finishing departments.

In the case of many films, the back is coated with a layer containing dyes, which are destroyed or removed in processing, to prevent halation and sometimes to prevent curl. Special coatings may be applied over the emulsion in films and papers to prevent scratching. Some motion-picture films are coated on a support carrying a nonremovable dye to reduce halation.

In films for colour photography, many separate coatings may have to be applied; for instance, there may be three emulsions responding to blue, green, and red, with separating or filter coatings between them, and in addition antihalation coatings on the back.

Motion-picture film is slit from the roll in 35-, 16-, or 8-mm. width and is perforated for camera or projector use with standard perforations. It is edge-printed with the maker's name and other marks in such a way that they become visible on development, and footage numbers are printed in the case of 35-mm. negative film to aid in editing. Professional motion-picture film is packed in a variety of lengths, but mostly in 100-, 200-, 400-, and 1,000-ft. lengths. The 16- and 8-mm. film is generally wound on metal spools, provided with leader for daylight loading, or placed in special magazines. Thirty-five-millimetre film for miniature cameras is spooled in special cassettes in lengths for 20 or 36 exposures.

Roll films are slit from the full coated rolls in the required widths and lengths, usually for 6, 8, or 12 exposures, and wound on metal spools with light-impermeable backing paper so that they may be handled in daylight. Sheet films are cut in sizes comparable with plates and packed in a similar manner. For X-ray photography, film is usually coated on both sides with emulsion, and individual sheets are put into special light-tight envelopes.

Photographic paper is cut from the roll into sheets, which are stacked and cut to the desired sizes, wrapped in black paper, and boxed.

All plates, films, and papers are inspected at various stages during manufacture to ensure the minimum of defects, and all wrapping and packaging materials are carefully selected so that they will not have any adverse effect on the emulsion. For the tropics, special packaging methods are used to prevent moisture from entering the containers.

VII. APPARATUS

The most important piece of photographic apparatus is the camera, in which the photograph is made. Next is the equipment for printing, enlarging, and viewing. The other important items are the apparatus for lighting the subject and for handling the material in processing. There are large numbers of accessory apparatus. Of these may be mentioned the supports for the camera, filters, range finders, exposure meters, the special equipment for darkrooms, and the devices for storing photographs. Lenses are dealt with later in this article. For detailed discussion of the historical development of photographic equipment, the reader should refer to some of the works listed in the bibliography of this article.

1. Cameras.—A camera consists of an image-forming device, which is a lens; a shutter that permits light to enter the camera for a desired time; a holder for the material on which the photograph is to be made; a light-tight enclosure that carries the lens and material holder in their proper positions and excludes all light except that passing through the lens; and a finder to show what is being photographed.

The first commercially available cameras for photography were made by Alphonse Giroux in Paris for Daguerre in 1839. They

consisted of two wooden boxes sliding one in the other for focusing, a Chevalier simple achromatic lens, a pivoted metal cover to act as shutter, a ground-glass back for focusing, and a holder for the plates. Other models of cameras were quickly introduced, and the tripod was used in 1839 by Baron P. A. Séguier, who also introduced the collapsible bellows to make the camera more portable. To the same end, Peter Voigtländer made a camera conical in shape. The first panoramic camera was invented by F. von Martens in 1845.

Talbot used simple cameras with telescopic boxes, and the construction was not much changed in the 1850s when the wet collodion process was introduced, except that special holders were used for wet plates and the bellows was in common use. Wet plate cameras ranged in size from miniatures taking plates about one inch square, to those taking very large plates of glass.

With the advent of the dry plates there was a demand for more portable cameras, since photography had become easier for the general public. Plates for these were loaded into special single or double holders for use in the backs of the cameras. Sometimes 12 plates could be loaded in the back, a special device being provided for dropping them in the bottom of the camera after exposure, or magazines containing a number of plates could be used in the position of a single plateholder.

When paper roll film was introduced by Eastman in 1885, it was loaded into roll holders that fitted on camera backs in place of the plateholders. In 1888 the Eastman Company introduced the Kodak, which was a simple box camera containing a 100-exposure roll of stripping film. This marked the introduction of modern amateur photography with roll film and the small hand camera. In 1889 the first transparent flexible roll film was marketed and many lightweight box and folding cameras were introduced for use with this type of film. In 1894 the roll film was packed with a roll of black paper to permit loading and unloading in daylight, and small cameras in box and folding form became popular. The first pocket Kodak was introduced in 1895 and the first of the collapsible cameras, the Folding Pocket Kodak, in 1898. The small, inexpensive Brownie camera, originally intended for use by children, appeared in 1900. Later, sheet film instead of plates began to be popular in certain cameras of the plate type and the film pack was also introduced to provide a convenient magazine of thin sheet films for this type of apparatus.

Large studio portrait cameras were introduced in the wet collodion days. They had long-focus lenses and from them were derived the later studio cameras using dry plates and sheet film. Sturdy stands were used; they were adjustable for height and inclination and were equipped with casters to permit moving easily. The cameras were generally of the square bellows type, with means for rapidly focusing by rack and pinion movements and with rising and falling fronts designed to carry heavy lenses.

The so-called field cameras were mainly intended for use outdoors on a tripod, for large groups, genre studies, landscape photographs, and so on. The cameras were rigidly constructed and had long bellows, rising and falling fronts, and swing backs. Some had parallel instead of conical bellows, and they are still used in studios for copying and commercial photography.

With improvement in plates and films and facilities for enlargement, the use of large cameras tended to decrease. The small-sized pocket cameras increased in popularity, but there was developed an important group known as hand-or-stand or view cameras. They used relatively small plates, sheet films, or film packs; they had ground-glass focusing as well as focusing scales; long-extension bellows; rising, cross, and swing movement for the front; swing, reversible, and revolving backs; and drop or swinging beds. They were the basic small cameras of great flexibility.

Some small cameras were developed in the second half of the 19th century as instantaneous hand cameras or detective cameras, and in general they used lenses of short focal length with good depth of focus. Even in the wet collodion days, some were small enough to fall into the class now known as miniature cameras. Some of them were of the "secret" type, which could be concealed from the subject, *e.g.*, in the hat, vest, or necktie, or had the form of some familiar object such as a book, satchel, or pair of binoculars. Some cameras took the form of pistols or revolvers and used very small plates. These were the forerunners of the modern miniature cameras.

Early in the 20th century very small roll-film cameras, such as the Vest Pocket Kodak, were introduced and in 1914 there were brought out the first still cameras using 35-mm. motion-picture film. The vogue in miniature photography did not develop until the 1920s, however, being given a great boost by the introduction of the Leica camera in 1924. This camera had been designed by O. Barnack for testing motion-picture film. A wide variety of such cameras followed, and in general they used 35-mm. film in 20- or 36-exposure cassettes and produced pictures twice the normal motion-picture frame size; *i.e.*, 24×36 mm. The cameras were characterized by compactness. They had high-aperture lenses of short focal length, and some had focal-plane shutters and provision for interchanging lenses, coupled range finders, and special viewfinders. Special processing, printing, and viewing equipment was made, films of fine grain permitted high enlargement of the small negatives, and special colour films and projectors were made for use with the cameras. In fact, the introduction of 35-mm. colour film gave a great boost to miniature camera photography. In the 1950s many "subminiature" cameras appeared, making use either of 16-mm. film or special films of narrower width.

Many modern cameras for amateurs are rigid models molded from plastic; they have simple lenses of small aperture and simple shutters synchronized with an attached flash unit. The Kodak Instamatic camera, introduced in 1963, was loaded with a special cassette that required no threading of the film.

Special cameras may be used for press photography, many of them being based on the German Goerz-Anschütz and the English Panros, which were introduced at the start of the 20th century. The most such popular type in the United States was the Speed Graphic. These cameras were designed for rapid use at eye level and generally had focal-plane shutters, large finders to permit rapid viewing, means for rapidly opening and focusing them, and, in modern models, range finders and flash attachments.

In reflex cameras, it is possible to compose and focus the image to be photographed up to the moment of exposure. There are three main forms. In that developed first (Sutton, 1860; Marco, 1883), a mirror inside the camera reflects the image to a ground glass on top, which is viewed through a collapsible vertical hood. When the lever is pressed to make the exposure, the mirror is first urged out of the light path. The cameras usually have focal-plane shutters, and folding types have been made. In the second type, called the twin-lens reflex camera, two similar cameras are in effect used, one above the other. The upper camera serves as the finder, while the lower carries the taking lens, shutter, and film. In older forms of the twin-lens camera the ground-glass focusing screen of the finder was in the rear, but in modern forms a reflex finder is used, a mirror reflecting the image of a focusing screen on top. In the third form, a special prism is used to present to the photographer an erect, full-frame-size view of the subject through the camera lens itself. When the exposure is made, pressure on the shutter release first flips a lightweight mirror out of the light path to the film. These cameras in general use 35-mm. film and frequently allow the use of interchangeable lenses, whether with focal-plane or behind-lens shutters. Often there is a device whereby focusing is done at full lens aperture; when the shutter is released for exposure, the lens diaphragm closes down to a predetermined value before the shutter operates.

For panoramic photography special cameras are used to cover the wide angles of view frequently involved. Panoramic photographs may be made with an ordinary camera by taking a series of pictures that are made to overlap slightly as a result of swinging the camera about the nodal point of the lens. In single cameras, the lens may be rotated about its optical centre while a curved film is scanned by a slit (Martens, 1845; Kodak), or the camera may be rotated about the centre point of the lens, the film being moved to compensate for the image movement. Such cameras are sometimes used for photographing large groups of people, or for wide landscape views.

Special cameras or attachments are used for stereoscopic photography. In principle, two photographs must be made from positions corresponding to the positions of the two eyes of an observer, and the prints must be viewed in such a manner that each eye sees only its appropriate view. Two successive views may be made from two camera positions, using a single-lens camera, but the most-used cameras are equipped with two lenses to make two photographs simultaneously. Alternatively, a single-lens camera may be provided with a beam splitter having two reflectors spaced at about the interocular distance apart, thereby giving two adjacent photographs on the normal picture area.

A great variety of cameras are made for special purposes, such as aerial photography, document copying, photographic survey, ballistic studies, photomicrography, metallography, oscillograph recording, medical studies, astronomy, and many other applications, the design being suited to the special needs.

2. Shutters and Diaphragms.—The exposure in a camera is made by a shutter that is opened and closed to permit light to pass through the lens. The earliest shutters were hinged or pivoted metal plates by which the front of the lens could be uncovered and covered by hand. These, and the removable lens cap, could be used only where the exposures were rather long. With faster plates and shorter exposure times quicker-acting shutters were needed. The simplest was the guillotine, or drop shutter, which consisted of a wooden or metal plate with a hole in it; it was allowed to drop freely or was urged by a spring or rubber band. In modifications of this, a second plate was provided to prevent light from passing through the lens while the shutter was being set, or two plates with holes moved in opposite directions, or the plates rotated rather than slid in a straight path. Modifications of these are used on some cameras. Varieties of the flap shutter consisted of one or two hinged flaps opening outward. The roller-blind shutter has a blind with a fixed slit aperture; it is mounted in a frame and used behind or before the lens. The blind can be wound so that when it is released the slit passes rapidly across the lens, the speed being varied by changing the tension.

Most-used types of shutters are the focal-plane and diaphragm or between-lens shutters. In the focal-plane type, a roller blind is used; it has a single adjustable slit or a series of slits of different widths, one of which travels across the film to expose it. The tension on the blind and the setting of the slit are adjusted from outside the camera. The shutter operates just in front of the film—practically in the focal plane—and is capable of exposures as short as $\frac{1}{1000}$ sec. The common types of diaphragm, or between-lens, shutters have their blades arranged near the diaphragm between the lens elements. They usually consist of three or more thin blades that open out from and close into the centre of the lens. They are made to give a range of exposure times, in some cases from 1 sec. to a nominal $\frac{1}{800}$ sec., in addition to "bulb," in which the shutter stays open as long as the release is pressed, and "time," in which the shutter is opened when the release is pressed and closed at any later time when it is again pressed. A spring provides the motive power to open and close the blades; and the time the shutter remains open is controlled pneumatically, or by gears and escapements. Still higher speeds are provided in a few lens shutters in which the blades, instead of opening and closing, execute a continuous rotary movement.

Diaphragms, or stops, are apertures that control the amount of light admitted through the lens. They are arranged in front of the lens or between the elements, depending on the lens type. There are three main forms: Waterhouse stops, which consist of a metal plate carrying a single hole and can be inserted in a slot in the lens barrel; rotating stops, which are circular plates carrying a series of holes of different diameters, any one of which can be brought into position in the lens; and iris diaphragms, which consist of a series of overlapping leaves of metal associated with a rotatable ring to form an approximately circular aperture whose size can be varied by turning the ring.

3. Viewfinders.—Finders are important in that they show what will be included in the photograph. In cameras that have a ground-glass focusing screen, the screen can be used to compose the picture as well as to focus it. In single-lens reflex cameras, in which the camera lens is used as the finder, the picture can be exactly composed on the ground glass to which the image is reflected by a mirror, or by direct viewing by a combination of a mirror and a roof prism. Most finders, however, are auxiliary to the camera. They are usually mounted on the top or side of the camera body, and they view the subject from a slightly different angle than does the lens. The errors introduced by this separation are reduced by putting the finder as close to the lens as possible, making the axes of the two intersect at about 15 ft. from the camera, and making the finder field smaller than the camera lens field. The errors will be apparent only in the case of very close subjects.

Finders can be divided into two general classes—reflecting finders and direct-vision finders. The simplest reflecting finder was a small camera with a simple lens, a mirror, and a ground glass to which the image was reflected, reversed left to right. In the "brilliant" finders more commonly used, the ground glass was replaced by a viewing lens. In twin-lens reflex cameras, the finder is essentially a duplicate of the camera, placed above it and having a mirror that reflects the image to a ground glass where it can be composed and focused, the focusing mechanism being connected with that of the camera lens so that when the finder is in focus the camera lens also is in focus. Direct-vision finders, which have largely superseded reflecting finders, are used close to the face. The simplest consists of a wire frame of the picture size mounted above the lens with a peep sight behind in the plane of the film. In a more compact form, the aperture of the front frame is reduced in size and placed nearer the peep sight, the angle included being that of the camera lens. Direct-vision optical finders consist essentially of a reversed telescope, with a strong negative lens in front and a weak positive lens at the eye.

4. Range Finders.—Range finders are used in photography to measure accurately the distance between the subject and the lens. They may be separate from or attached to the camera and are small versions of those originally designed for military use. They are of the split-field and coincidence types. In coupled range finders, the range finder is mechanically coupled to the camera lens so that when a distance is determined in the range finder, the camera lens is automatically focused for that distance. The field of the range finder sometimes forms part of the full field of the viewfinder, so that it is only necessary to look through one eye lens to focus and compose.

5. Focusing Scales.—Cameras that do not rely on ground-glass focusing or coupled range finders are equipped with focusing scales. When the whole front of the camera moves in focusing, the scale is attached to the camera bed. If focusing is by rotating part of the lens, the scale is on the lens mount or shutter face. If the camera is equipped with a focusing scale, the photographer must know the distance from the subject, either by estimation, measurement, or use of a range finder.

6. Depth-of-Field Indicators.—Many cameras carry a table or circular slide rule that shows the distance range in focus for various distances on which the camera may be focused, and for various lens apertures.

7. Flash Attachments.—In the early days, flash photographs were taken by burning magnesium ribbon, or by exploding a powder containing magnesium and an oxidizing agent, the camera shutter being opened before and closed after the burning time. Modern flash photographs are made with flashbulbs of glass containing wire or foil of magnesium and aluminum, or other combustible material, in an atmosphere of oxygen, or by condenser discharge lamps. They are fired electrically, usually from portable batteries, and the circuit is closed when the camera shutter is operated. In one form, operating the shutter brings into play a solenoid, which at the appropriate moment closes the battery circuit to the flashbulb. In the other form, the shutter itself is provided with a contact that closes the flashbulb circuit as the shutter operates. Various settings are used according to the delay in the firing of the flash after the circuit is closed. The condenser discharge lamps permit very short exposures (as short as $\frac{1}{1000}$ sec. with portable units) but the exposure time is determined by the electrical circuit used. Some flash lamps of this type are made to give a rapid succession of very short, bright flashes. Most

modern cameras are provided with flash attachments that fire the flash in synchronism with the operation of the shutter.

8. Exposure Estimation.—Experience can give photographers confidence in their unaided judgment of exposure, but for most people or in special circumstances some guide is required. Exposure tables are provided by most film manufactures. They give exposure times and lens apertures for the time of day, latitude, weather conditions, degree of light and shade, and for various types of subjects. Exposure calculators are forms of slide rule in which the exposure can be calculated from the data given in exposure tables; the first important calculator was the Hurter and Driffield Actinograph of 1888. A calculator was usually combined with the older chemical type of meter and is always included in the modern devices. Chemical exposure meters or actinometers (now obsolete) depended on measuring the light value by a photochemical change, usually the time taken for silver-chloride paper to darken to a standard tint. Visual, optical, and extinction exposure meters are photometers in which (1) the brightness of a scene is compared with a calibrated lamp, the light from which can be modulated in a known way; or (2) the scene is viewed through the instrument and a neutral density wedge is adjusted until shadow detail disappears; or (3) a numbered or lettered step wedge is moved across the integrated light from the scene and the dimmest number or letter is taken as the basis for calculating the exposure.

Photoelectric exposure meters, first introduced commercially in 1932 by the Weston Electrical Instrument Corporation as the Weston meter, measure the light by a barrier-layer type of photocell and a sensitive direct-current meter. In more recent designs a cadmium sulfide photocell, the resistance of which varies with the illumination falling upon it, is employed together with a miniature battery. The meter readings are translated into exposures by using a calculator. These meters are used as illumination meters, which measure the light falling on the subject, and as brightness meters, which measure the integrated light reflected by the scene, or the brightness of a particular part of it, the angle of view or acceptance angle being chosen to approximate that of the average camera lens. They are also used for determining exposures in contact printing and enlarging. The colour response of the photocell approximates that of the eye. In many camera designs of the mid-1960s a built-in photoelectric meter served either to control the exposure automatically or to control adjustments made by the user.

9. Light Filters.—Filters are sheets of dyed gelatin or other plastic, coloured glass or other medium, and in some instances materials giving selective transmission by light interference, specially designed to transmit particular regions of the spectrum and absorb others, or to absorb uniformly through the visible spectrum. There are many forms used in photography:

Correction (orthochromatic) filters are designed for use with panchromatic materials to ensure that the film-filter combination gives a photograph in which the tone values agree as closely as possible with those perceived by the eye. Contrast filters are used to enhance or subdue contrast in the reproduction of the subject, the principle being that to render a colour light in the print a filter is used that transmits that colour, and to render a colour dark in the print a filter is used that absorbs the colour. Colour compensating filters are used with colour films to correct for variations in the colour of the light source or the colour response of the film, and thus to ensure good colour balance in the photograph. Separation filters are intended for use in two- and three-colour photography and in photomechanical reproduction in order to make the separation negatives for the printing process. Monochromatic filters transmit a narrow spectral band and are usually used in conjunction with a gaseous discharge light source. Safelights are filters designed for use with a specified lamp in a darkroom to provide just enough light to see in handling plates, films, and papers without fogging them. Haze filters decrease or eliminate the flattening influence of atmospheric haze. Graduated filters are made in such a way that the transmission varies over the area of the filter, the most used being the sky filter, which is yellow in the top part and graduates into clear in the lower part, and the neutral wedges or tablets, in which the light transmission varies along the length of the filter either stepwise or gradually. Neutral-density filters reduce the photographic effectiveness equally at all wavelengths in the visible spectrum. Special filters include those used for infrared and ultraviolet photography. In addition to the common types of filters there are special polarizing sheet materials, which are used for subduing reflections and for special sky and other effects. Such filters are also made in combination with coloured filters.

Filters usually are used in making negatives, but they are also used in great variety in making colour prints, in black-and-white printing for contrast control, and in additive three-colour viewing.

Filters having the most precise spectral transmission and the best reproducibility are made from dyed gelatin sheet, which may be used alone, coated with a transparent lacquer, or cemented between glass or plastic sheets. Filters are also made of coloured glass, but they are not all easily reproducible. In addition, filters can be made from coloured liquids or gases in special glass cells, but they are used only for special purposes.

Most filters absorb some light, and in making photographs through them it is therefore necessary to increase the exposure by a ratio that is known as the filter factor.

10. Supports and Tripods.—When it is necessary to compose a photograph carefully, or when exposures longer than about $\frac{1}{25}$ sec. are to be given, it is necessary to use the camera on a rigid support. For commercial photography these supports may be of complex mechanical construction, permitting the camera to be used from near floor level to a great height above it, and to be tilted to any angle, and yet be quite steady. Portrait studio cameras are of sturdy pillar construction with means for rapidly raising and lowering the table on which the camera rests, and for moving rapidly about the studio floor. For general photography the tripod forms of stand are most used. They are made of wood or metal and frequently have adjustable legs to permit folding or telescoping to increase portability and to allow them to be used on uneven ground. The tripod top, or head, is generally flat and is provided with a screw that attaches the camera by a special socket in its body. In flexible models, a second raised head can be used to give extra height, and there are means for rotating and tilting the head.

11. Auxiliary Camera Equipment.—Lens hoods, or shades, are used on the front of the lens to prevent as much light as possible not coming from the subject from reaching the front of the lens. Devices for operating a shutter from a distance may make use of a Bowden wire or electric lead. Changing bags are used to load plate or film holders (or developing tanks) in daylight when a darkroom is not available.

Dark slides, or plate and sheet-film holders, are used to carry plates or sheet films and to position them in the plane occupied by the focusing screen. They are provided with a draw slide that makes them light-tight but which can be withdrawn in the camera before the exposure is made. They take one or two plates or films, in the latter case usually being back to back with a metal partition between. Film packs are used in special adapters that fit in the place otherwise used by dark slides and are provided with draw slides. Roll-film adapters make it possible to use roll films in cameras made for plates and sheet film, and alternatively some roll-film cameras have plate or sheet-film adapters. Plate or sheet-film magazines (now obsolescent) contain 12 or 18 thin metal septums, each carrying a plate or sheet of film. After the front one has been exposed, it is transferred to the back of the group, so revealing the next for exposure, the whole being done in the light-tight magazine. Some roll-film and miniature cameras have interchangeable backs in which the whole camera back carrying the roll of film is provided with a draw slide; the back can be removed in the light, permitting substitution of a second back with a different roll of film.

12. Special Cameras.—Special cameras are designed for many of the special applications of photography. They cannot all be described here, but the following are a few of the important ones.

For photomicrography the cameras are of the conventional type but they are arranged on special vertical stands or horizontal opti-

cal benches in conjunction with the microscope, filters, light source, and a variety of attachments and adjustments for ensuring alignment.

For colour photography special cameras were first devised to permit making three-colour separation negatives through three primary filters (see *Colour Photography*, above). In the simplest form, the negatives can be made by three successive exposures, changing the plateholder and filter three times. In repeating backs, the three filters were placed in a row in front of a long plate or three separate plates in one holder, which was moved through the camera back in three steps, one for each exposure. These gave way to one-exposure three-colour cameras in which an arrangement of reflectors permits the three exposures to be made simultaneously. These cameras were used primarily for commercial colour photography but are largely replaced by integral tripack films.

Cameras in which development may be performed have been known since wet-collodion days. In 1947, however, there was introduced by E. H. Land and the Polaroid Corporation a new approach to developing in the camera, resulting in the "picture-in-a-minute." It depended on the solvent-transfer process described earlier, would produce a paper print from the camera back in one minute or less, and became very popular for amateur photography; it was also adapted for press and commercial photography, aerial photography, radiography, reproduction of cathode-ray tube images, and a variety of other purposes where rapid production of a picture might be desired.

Cameras for copying in photomechanical reproduction are large and complex. They may have to handle dry plates and film and wet collodion plates; provision is made for photographing through halftone screens with means for varying the distance of the screen from the plate; precision lenses of long focal length are used and arrangements are made for changing filters. Some cameras have vacuum backs in which film is held flat by sucking it against a backplate. Provision is made for accurately arranging parallelism of the plate or film and the copy, and special supports are used to eliminate effects of vibration. In copying cameras used for mapping, provision may also be made for correcting distortions by tilting the plate- or film-holder or the copy. Photocomposing cameras are available in which, through the operation of a keyboard, negatives of type face can be photographed on a roll of film in rapid succession, the material thus being actually composed photographically to give a negative from which a printing plate can be made directly. Composing backs are made in which a series of photographs of a number of pieces of copy can be made on one film or plate, properly arranged in relation to each other, thus composing a page of varied subject matter.

A wide range of cameras is made for copying documents by microphotography on film. In the simple forms, negatives are made on 35-mm. film in miniature cameras, but for work where large numbers of negatives of all kinds and sizes of subject matter are required, special cameras, with film and paper-feeding devices, special framing means, and other refinements, are used. One of the most important developments in this field was the Recordak, originally brought out for use by banks in copying checks on 16-mm. film but later applied in both 16- and 35-mm. size to copying commercial documents, newspapers, drawings, large bound volumes, and similar materials.

In cameras for photocopying, documents are photographed directly onto rolls of paper without using an intermediate negative, as in the Rectigraph and Photostat machines introduced in the first decade of the 20th century. Various scales of enlargement and reduction can be used, and the lens carries a prism to invert the image. Automatic machines of this type are made in which the paper is processed. Automatic coin-operated portrait cameras are made, in which the subject is photographed on paper processed in the machine to give a direct positive picture.

13. Studio Arrangements and Lighting.—Photographic studios are provided with backgrounds, seats, and properties selected according to the whim of the photographer and the nature of the subject. The most important studio equipment is that concerned with lighting the subject. In the early days, daylight was used, controlled by drapes and reflectors. Mercury vapour lamps and carbon arcs were later employed; but since the introduction of fast panchromatic and colour films, incandescent tungsten filament lamps are used in the main. Some carbon arcs are employed, and some fluorescent lamps are used for broad lighting, but the greatest flexibility is obtained with tungsten lamps. The lamps are used in special lamphouses or reflectors, which vary in the extent to which they concentrate the beam of light. Although good pictures may be made with one lamp, for flexibility several are needed. The number and arrangement of lights depends on the subject and the desired effect, but a typical arrangement for portraits consists of a key light from the front, or partial front, a fill light to eliminate shadows, a backlight aimed at the back of the subject, and a background light to illuminate the background. Overrun lamps of the Photoflood type came to be much used, especially by amateurs; for colour photography, lamps operating at a colour temperature of 3,200° K are employed, and for general studio use high-efficiency lamps of up to 5,000 w. are employed. The choice of reflector is very important. A further development in tungsten filament lamps has been achieved in the quartz-iodine lamps; in these the inclusion of a small amount of iodine, which combines with tungsten at 250° C and dissociates again at above 2,000° C, avoids deposition of tungsten on the quartz envelope of the lamp and thus maintains the lumen output at a high value throughout an extended life.

For flash photography, flashbulbs are used in arrangements similar to the normal studio lights, although they are also much used at the camera position and at some distance from it by means of extension leads connected to the camera synchronizer. Gaseous condenser discharge lamps, introduced by H. E. Edgerton, can be used in the same manner as flashbulbs. All have a shorter flash duration, and some have a much greater light output.

14. Printing and Enlarging.—Prints are made from negatives by (1) contact, in which case they are the same size as the negative, or (2) by enlargement or projection printing, usually to produce bigger pictures. Contact prints are made in (*a*) printing frames, which press the negative and paper in close contact against a sheet of glass through which exposure can be made to a lamp, or (*b*) printing boxes or machines, which contain the printing lamps as well as the means for holding negative and paper in contact. The simplest printers contain one lamp and are made for small negatives. The professional printing devices are designed for larger negatives, frequently have many lamps, and provide means for "dodging," or controlling the exposure of different parts of a negative. Printers for photofinishing are designed to permit a large number of prints to be made from single negatives or rolls of negatives in a minimum of time. In some the exposing platen is operated by a foot treadle to leave both hands free for manipulating the negative and paper, and there are means for stamping identification numbers on the prints. In the more advanced types, the printing time for the negative may be measured photoelectrically and the appropriate exposure given automatically. Special automatic printers are made for use with colour negatives in which the exposure to the colour printing paper is made through three filters, the exposure through each filter being automatically determined photoelectrically, the net result of the three exposures being to give good colour reproduction. Reflex printing is contact printing, used mainly for document copying, in which the back of the sensitive paper is in contact with the original to be copied, the emulsion-coated side of the paper being toward the light source.

A projection printer or enlarger has a means for illuminating a negative, and a lens for projecting an image of it onto a sheet of photographic paper on a board or easel. It resembles a lantern-slide projector, or a camera in which the negative is the subject and the paper corresponds to the film. The best enlarger lenses are designed to operate at magnifications of a few times and are generally more satisfactory than camera lenses for enlargement.

Projection printers are distinguished mainly by the means by which the negative is illuminated, and are of three main types: (1) diffusion enlargers, in which there is a lamphouse or reflector containing a lamp, and, in front of this, a sheet of ground or opal

BY COURTESY OF EASTMAN KODAK COMPANY

EXAMPLES OF BLACK-AND-WHITE NEGATIVE AND POSITIVE PHOTOGRAPHIC PRINTS

(Left) Photographic negative after development. Light areas appear dark and vice versa; right side of picture appears left in camera. (Right) Positive print made from the negative

glass in front of which the negative is placed; (2) condenser enlargers, which contain a small light source and a condensing lens behind the negative; (3) the modern type of condenser enlarger, in which a lamp with a diffusing bulb or having a large area, such as a fluorescent lamp, is frequently used to lessen the degree to which grain and dirt on the negative are shown sharply in the print. Condenser enlargers give prints of higher contrast than diffusion enlargers.

Enlargers are usually arranged vertically. In the simplest forms, focusing is achieved by watching the projected image on a sheet of white paper, which temporarily takes the place of the printing paper, and adjusting the lens until the image is sharp. Some enlargers, however, focus automatically, the image remaining in focus on the paper over a wide range of magnifications.

15. Darkrooms and Processing.—Rooms for handling films, plates, and papers must be dark, or illuminated only by light to which the materials do not respond appreciably in a reasonable time. They are provided with running water, large sinks, and work surfaces on which operations can be carried out. Small darkrooms are used for loading, unloading, and developing negatives and for printing and developing prints. In larger installations the negative and printing rooms are separate. Negative rooms for handling panchromatic materials are completely dark or are illuminated by safelights that are dark green in colour, since the eye has its maximum sensitivity in the green, and a very low level of illumination may thus be used. For orthochromatic films, deep red safelights are used, while for slow noncolour-sensitized materials, such as positive or process films, orange or deep yellow safelights can be used. In printing rooms, the lighting is yellow, orange, or yellow-green, since most papers are not sensitive to red light.

Developing, fixing, and washing are done in dishes (trays), tanks, or special equipment; and all require sinks and plenty of water. Roll films are frequently developed in tanks on spiral reels on which they are wound, or hung vertically in tanks, and sheet films and plates are processed in special frames or hangers, so that many can be handled together. Paper prints are developed in dishes. Washing of negatives and prints must be done in such a way that there is frequent change of water over the entire surface, and special washers are made for use where large quantities of films or prints are handled. Drying of negatives can be done in the open air, or preferably in special drying cabinets through which warm air is blown. Prints can be dried flat in the open, on racks covered with muslin, between blotters, or by passing automatically around heated drums that can also be used for glazing the prints. Prints are commonly glazed by squeegeeing them onto metal plates having a lacquered or chromium-plated surface. Printing rooms contain the contact printers and enlargers.

Clocks or timers are necessary in all darkrooms to time the steps of processing accurately, and thermometers must be used in the control of processing temperatures. Sections of the rooms are devoted to storage and mixing chemicals. Adequate ventilation is important.

Special equipment is used in photofinishing establishments, especially for the automatic processing of large numbers of roll films. These films are hung vertically on special hangers, and pass continuously into a deep tank of developer and then into each successive solution and washing tank and finally through a drying cabinet. In smaller installations, the film hangers are used in deep tanks but are transferred manually.

Similarly, special apparatus is made for large-scale printing operations, in which the exposed papers pass with the minimum of attention through the solutions and are then dried, and glazed if necessary, on continuously rotating drum driers. Modern large-scale practice also involves the use of continuous paper processing machines through which long rolls of exposed paper pass continuously, sometimes in several strands, to be developed, fixed, washed, dried, and glazed, ready to be cut up.

Finished prints are frequently mounted on cards. A number of adhesives may be used, the most satisfactory being dry-mounting tissue, which is a sheet of tissue impregnated with shellac or other fusible plastic. If this is placed between the print and the mount and the whole is heated in a press, the shellac melts and sticks the print to the mount. (W. Ck.)

VIII. STROBOSCOPIC PHOTOGRAPHY

1. Electronic Flash.—The term "stroboscopic photography" should apply strictly to multiflash examples. However, the term has come to be used in the U.S. to describe single-flash photography, and the abbreviation "strobe" is very often heard when photographers are discussing single-flash electronic equipment and photographs taken with it. Before the theory and application of multiflash or stroboscopic photography are discussed, the theory of electronic flash photography will be reviewed.

Nearly all electronic photography systems of short flash duration rely upon the electrical capacitor to supply the high peak power needed to flash the lamp. The instantaneous power needs to be about 100,000 w., even for a small portable flash lamp. The important criterion for exposure of a photograph is the quantity of light produced, expressed in beam-candlepower-seconds (BCPS), which depends upon (1) the efficiency of conversion of electrical energy to useful light, (2) stored energy in the capacitor, and (3) the effectiveness of the reflection.

The electrical capacitor is the most important component in a flash unit, other than the flash lamp itself. The capacitor accounts for most of the weight, volume, and cost of the usual flash equipment. As mentioned before, the capacitor has the ability to ac-

cumulate energy at a slow rate and then suddenly discharge the energy into the flash lamp at a very high rate for a short interval of time. Many of the advances in modern electronic flash equipment design have been concerned with improved capacitors, such as the electrolytic type.

Electronic flashtubes are made in many sizes and forms, such as straight, U, or spiral shapes, as required for different applications. The pressure of the gas, usually xenon at $\frac{1}{10}$ atmosphere, and electrode spacing are arranged so that the lamp will not flash by itself in most cases. Starting is initiated when a voltage pulse is applied to an external starting wire, thereby causing internal ionization, and the tube flashes when the capacitor discharges.

Flash duration for a specific flashtube and circuit is best described by an oscillographic plot of the light as a function of time. Thus can be portrayed as a curve the initial delay, the rise, the peak, and the decay of the light intensity. From a practical standpoint, the entire duration may be a negligible amount of time, if the motion of the subject is effectively stopped. The duration can be defined as the time between instants when the light is one-third of the peak.

A large variety of electronic flashtubes is available for the equipment designer to consider, and new ones appear frequently. For any specific application important factors are:

1. *The Shape of the Tube.* The tube may be linear, spiral, U-shaped, etc. A concentrated lamp is most effective in a reflector, when control of the light is required, but some light may be lost by self-absorption.

2. *The Efficiency at the Required Energy Input.* Each lamp has its maximum efficiency for a particular input. The designer should attempt to use the lamp at or near this maximum efficiency point (about 5 candlepower per watt), although he usually cannot do this for other reasons, such as heating or life.

3. *The Flash Duration.* This is a function of the tube and the circuit. If a specific duration is required, the design voltage is usually fixed for a specified energy.

4. *The Voltage at Which the Flash Is Desired.* Factor (2) above needs to be reconsidered in terms of voltage, since the efficiency usually drops when the tube is used at low voltage.

5. *The Xenon Flash Lamp.* This lamp has a spectral output that is very similar to that of daylight except for an excess in the blue and near ultraviolet. It has been shown experimentally that a flash lamp with a large voltage per mean free path and high energy per unit volume will have a greater excess in the blue compared with the output of a lamp with small values. The differences, however, are small and difficult to detect with colour film. A long-flash lamp operated at low voltage has a larger relative proportion of infrared output.

Many times the most efficient flashtubes cannot be used because of heat storage and heat conductivity problems. This is the usual case with stroboscopic sources, and particularly with those that operate at high frequency and high power for extended times.

2. Applications.—The name "stroboscopic photography," as mentioned above, has come to mean multiple-flash exposed photographs. Some of the earliest users of this general system were Eadweard Muybridge, E. J. Marey, C. Cranz, H. Schardin, and Lucien Bull, whose excellent pictures of horses, people, and bullets are still used today as classic examples. The first multiexposure photographs were made with a slotted disc as a shutter or with a series of cameras. Electronically produced flashes of light at accurately controlled intervals of time are an excellent method of producing stroboscopic photographs.

Two practical problems arise when an electronic flashtube is required to operate as a stroboscopic source.

1. The flashtube becomes so hot that it does not function properly. For example, it may misfire, owing to not starting properly.

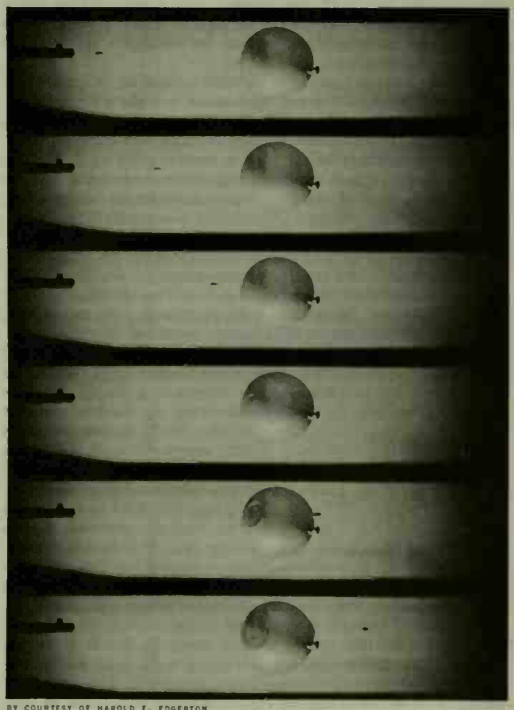
2. The flashtube fails to deionize, thus preventing the capacitor from building up a charge for the subsequent flash. The power unit, when it fails to deionize, supplies continuous current in the flash lamp; this condition of steady current is called hold-over.

A hot lamp may fail for several reasons; *e.g.*, electrical puncture of the glass by the external sparking circuit, short-circuiting of the triggering spark by the conduction of the hot glass, or collapse of the glass wall of the tube. Failure of a tube to deionize results, as mentioned, in the continuous arc holdover condition, where the capacitor charging current flows continuously into the lamp. A further difficulty may result when the tube self-flashes as the capacitor recharges, owing to the lowering of the hold-off voltage by residual ionization, temperature, or heated electrodes.

Any or several of these difficulties are soon experienced when a flashtube is operated at a fast rate of flashing with high energy per flash. Tubes of quartz are much more capable of operating at high power rates, since the quartz has a higher melting temperature.

Several special circuits have been used to operate flashtubes at high flash rates per second. Examples are the series mercury-arc rectifier of the pool type and the hydrogen thyratron used in radar modulators.

In the mercury-pool control tube circuit, the only new element added to the conventional electronic-flash-operating circuit is the mercury tube. This mercury tube is connected in series with the main discharge current path of the capacitor to the flashtube. Thus, the mercury tube must be designed to handle adequately these high-valued peak currents. Immediately after a discharge, the mercury tube deionizes quickly, owing to its low pressure, and thereby prevents the previously mentioned holdover current from flowing in the flashtube. The mercury tube is also beneficial in starting a flashtube, because the igniting spark circuit from the mercury cathode goes directly between the two main electrodes. This circuit makes it possible to start flashtubes at very low voltages on the flash capacitor. Operation at several thousand flashes per second with an input of a kilowatt is practical with a mercury-connectron tube six inches in length and one inch in diameter for



BY COURTESY OF HAROLD E. EDGERTON

MULTIFLASH PHOTOGRAPHS ON A MOVING FILM OF A 22-CALIBRE BULLET AS IT WAS SHOT FROM A GUN INTO A BALLOON. FREQUENCY IS 4,000 FLASHES PER SECOND AS CONTROLLED BY A THYRATRON CIRCUIT

bursts several seconds in duration.

In a second type of control circuit, a hydrogen-thyratron tube serves as a switch to discharge the capacitor energy into the flashtube. This thyratron has a very quick deionization time, thus enabling the starting of the flashtube to be controlled at high frequency, far above rates where the frequency is limited by the slowly deionized, high-pressure gas in the flashtube. High pressure (10 to 70 cm.) is required for efficient light production in the xenon flash lamp. The charging circuit of the capacitor in this circuit can be very efficient and, furthermore, doubles the source voltage across the flash capacitor, if the discharge circuit is nonoscillatory. An inductance is used in the charging circuit in series with a rectifier in place of the usual charging resistor. The circuit with the hydrogen thyratron is identical to that used in radar transmitters, except that the flashtube replaces a magnetron. In both applications, the function is the same: namely, to pulse the lamp or magnetron with high voltage and high-power energy. One of the properties of the hydrogen thyratron is the ability to supply large peak currents without damage to the thyratron cathode.

One stroboscopic unit that uses the hydrogen thyratron control tube operates at the following electrical conditions: lamp voltage, 8,000 v.; capacity, 0.01, 0.02, or 0.04 microfarads; frequency, 6,000 max. per sec. (0.01 microfarads); flash duration, 1 to 3 mμ sec.; energy per burst, 1,500 w. sec. (limit set by lamp heating).

The flashtube has been designed with high resistance to reduce the peak current requirement of the hydrogen thyratron. This is accomplished by the use of a small diameter (one millimetre) and a long arc length (four inches). A small percentage of hydrogen gas is mixed with the xenon to reduce the afterglow in the discharge.

The stroboscopic light also can be synchronized with the motion of the film to produce framed pictures for projection. This is commonly done with the 16-mm., high-speed, rotating-prism cameras. Magnetic pickups can be used to trigger the flash lamp at the correct instants of time so that the flashes are synchronized with the film position.

Another general type of multiflash equipment is capable of great speed and flexibility and can be used to make a limited number of photographs. Each flash for this method is powered by a separate capacitor into either separate lamps or a common lamp. Such circuits become bulky when a large number of flashes are desired, since each flash requires a separate storage system. There is a frequency limit set by trigger-tube deionization for these last two circuits. (H. E. Ed.)

IX. PHOTOGRAPHIC LENSES

A photographic lens must give crisp definition over a relatively wide flat field, and in this respect it differs from all other types of lenses. Moreover, for instantaneous photography the image must be bright, which implies a high relative aperture.

1. The Landscape Lens.—The first deliberately designed photographic objective was made in 1812, about 25 years prior to the introduction of photography. It was the simple meniscus landscape lens (*see* fig. 10A) proposed by the English physicist William H. Wollaston for use in the camera obscura. At first, a simple equiconvex lens was used but it was found that the image, although sharp in the middle, became blurred in the outer parts of the field. Wollaston's invention consisted in the use of a meniscus-shaped lens with a small stop on the front (concave) side, as in fig. 10B, the mirror being mounted between the stop and the lens.

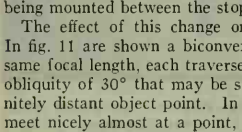


FIG. 10.—THE WOLLASTON LANDSCAPE LENS. A, IN A CAMERA, B, IN A CAMERA OBSCURA

The effect of this change on the image quality is profound. In fig. 11 are shown a biconvex lens and a meniscus lens of the same focal length, each traversed by a number of light rays at an obliquity of 30° that may be supposed to emanate from an infinitely distant object point. In the upper figure, the oblique rays meet nicely almost at a point, but the point is not at all on the desired flat field. In the second case, the oblique rays, passing through the lens do not meet at a point but suffer from all the properties of spherical aberration. Placing a small stop (about $f/11$) at B isolates a beam of light that comes to a focus exactly above the focus of the axial beam. Thus a flat field is produced by isolating only those rays that cross where it is desired that they cross.

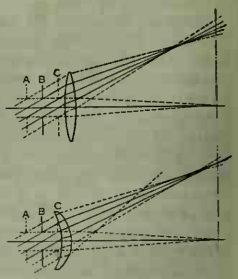


FIG. 11.—PATHS OF LIGHT RAYS THROUGH BICONVEX AND MENISCUS LENSES

Although the simple Wollaston landscape lens has been made and used by millions in simple box cameras, it suffers from several defects that can be corrected only by the addition of more lens elements. The defects are: (1) chromatic aberration, meaning that light of different colours comes to a focus at different distances from the lens; (2) spherical aberration, in which rays from different aperture zones come to a focus at different distances from the lens; (3) lateral colour, implying different-sized images in different colours; (4) astigmatism at field angles beyond about 20°, causing radial and tangential lines to come to a focus at different distances from the lens; and (5) distortion, indicated by a square object being reproduced as a barrel- or pincushion-shaped image.

The longitudinal and lateral chromatic defects were the first to be eliminated by achromatization. The lenses made by C. Chevalier for the first daguerreotype cameras were merely 16-in. telescope objectives, about $3\frac{1}{2}$ in. in diameter, used back-to-front with an $f/17$ diaphragm situated about 3 in. in front of the lens. Within a year or two, however, Chevalier had adopted the meniscus form advocated by Wollaston, thus introducing the so-called French or achromatic landscape lens (fig. 12). This lens was popular for use on the better grades of box cameras for 100 years, but after about 1930 only the simple Wollaston lens was manufactured.

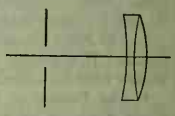


FIG. 12.—THE CHEVALIER ACHROMATIC LANDSCAPE LENS

2. The Petzval Portrait Lens.—Finding that the customary speed of landscape lenses ($f/15$) was slow for portraiture, J. Petzval of Vienna undertook the designing of a rapid lens. In 1841 he produced his portrait lens (fig. 13) which had a speed of $f/3.6$ and covered a half-field of 10° to 12°. Beyond that angle, the astigmatism and field curvature became so great as to soften the definition to a serious extent, but on the lens axis the definition was exceedingly sharp and clear-cut. The Petzval lens consists essentially of two modified telescope objectives spaced apart, each being achromatic and substantially spherically corrected. The lack of sharp definition in the outer parts of the field is not serious in portraiture; in fact, it is actually desirable to have the background somewhat out of focus.

FIG. 13.—THE ORIGINAL PETZVAL PORTRAIT LENS (1841)

Because of its high relative aperture and excellent central definition, this type of construction, suitably modified, has been used extensively for motion-picture photography and projection. The definition is very sharp to about 5° from the axis even at apertures as high as $f/1.6$, after which it begins to fall off abruptly. The semifield of projection lenses is often extended to 10° by means of a field flattener, a thin negative element close to the image plane that tends to overcorrect the astigmatism and thus flatten the field. This method of field flattening was first suggested by C. Piazzi Smythe, in 1865, who used it to make excellent miniature photographs in Egypt on wet collodion plates one inch square.

3. The Symmetrical Principle.—Early attempts to correct the distortion of landscape lenses soon indicated that a lens that is symmetrical about the stop is automatically free not only from distortion but also from lateral colour and coma. This is

not entirely correct except at unit magnification, but the improvement in these three aberrations resulting from the symmetrical construction is so marked that symmetry in lenses became almost a universal rule from 1865 to about 1910.

The first to appreciate the advantage of the automatic coma correction associated with symmetry were A. Steinheil in Munich and J. H. Dallmeyer in London about 1866. Prior to this time, landscape lenses had possessed spherical aberration; and, consequently, it was possible to choose a stop position that would simultaneously correct the coma and make the field as backward curving as possible. Dallmeyer and Steinheil realized that with the coma automatically eliminated by symmetry, it was no longer necessary to have a considerable residual of spherical aberration in the separate components. They therefore chose a symmetrical construction as indicated in fig. 14, in which the divergent cemented surfaces were used to correct the spherical aberration, and the outer shape of the lens was chosen so as to flatten the field. The coma of each component was bad, but it disappeared as a result of the symmetry. By this means, a simple, substantially distortionless lens could be constructed at an aperture of *f*/7 or *f*/8 with a flat field out to a half angle of 25°. There was some residual astigmatism at that obliquity, but the depth of focus at *f*/8 or *f*/11 covered it to a considerable extent. This was fundamentally the construction of the Steinheil Aplanat and the Dallmeyer Rapid Rectilinear lens. This type immediately became popular, and it was imitated by almost every manufacturer for nearly 50 years. A number of variants of these designs were tried, some of which were good, but no real progress was made until the introduction of barium glass in 1886, which brought about a revolution in the art of lens designing and ushered in a new era.

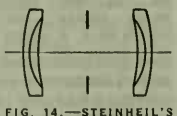


FIG. 14.—STEINHEIL'S APLANAT

4. Barium Glasses and the Anastigmat Lens.—In all the types so far discussed, the negative elements were of flint glass with a high refractive index and high dispersive power, while the positive elements were of crown glass with a low index and low dispersion. Thus, the cemented surfaces were generally divergent in action, and tended to overcorrect the spherical aberration and the astigmatism.

In 1881 E. Abbe and O. Schott in Jena began conducting experiments aimed at developing a crown glass having a high refractive index combined with a low dispersion. If such could be found, it would be possible to make achromats in which the cemented surface would be convergent instead of divergent. Thus, it would be possible to stop and even reverse the drastic overcorrection of astigmatism that occurred in the outer parts of the field of all lenses made up to that time. Their efforts were rewarded in 1886, when Schott announced the first barium crown glass having the desired properties.

By 1890 Paul Rudolph of the Zeiss Company had entirely redesigned the Rapid Rectilinear types of construction by replacing the divergent cemented surface in the rear component by a convergent surface (fig. 15). The new barium crown glass was used in one element of the rear component, thus making an objective in which one of the cemented surfaces was divergent and concave to the stop, leading to an increasingly overcorrected astigmatism and spherical aberration, while the other cemented surface was convergent and convex to the stop, leading to an increasingly undercorrected astigmatism. The result was a lens in which the astigmatism was everywhere small, and it actually became zero at one obliquity of the field. This lens was announced in 1890 as the Anastigmat, the name being changed to Protar after other firms took up the word anastigmat to imply any lens having a node of zero astigmatism somewhere in the field. Early designs of this type up to *f*/9 were produced, and even an *f*/4.5 lens was made with a cemented triplet in the rear. The Protar was still manufactured at mid-20th century as an *f*/12 or *f*/18 extreme wide-angle lens.

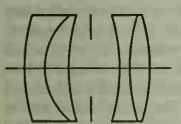


FIG. 15.—THE ZEISS PROTAR

5. The Dagor Type.—During the years immediately following Rudolph's invention of the Protar, many designers tried to develop symmetrical anastigmat lenses that would combine the virtues of the Rapid Rectilinear and the Anastigmat. Among the most successful was E. von Höegh, of Goerz, who developed a cemented triple lens comprising, in one component, a strong dispersive surface to correct the spherical aberration and a weaker collective surface to remove the astigmatism. A combination of two of these components then corrected three more aberrations automatically by symmetry, forming a highly successful objective, the *f*/6.3 Double Anastigmat Goerz, or Dagor (fig. 16). Lenses of this type cover a relatively wide field at a moderate aperture and are much used by commercial photographers. Some designs are convertible; *i.e.*, a front component of one focal length can be combined with a rear component of a different focal length to yield a combination having a third focal length, a variety of focal lengths being thus available to the user of the lens.

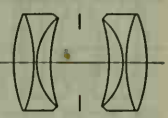


FIG. 16.—THE GOERZ DAGOR

6. The Airspaced Four-Element Lens.—In 1898 Von Höegh designed the Celor, an entirely new type of lens shown diagrammatically in fig. 17, which as first constructed covered a 28° half-field at *f*/8. The design may be regarded as a direct descendant of the Dagor. In each half of the Dagor lens there are two outer surfaces, both concave to the stop, an internal divergent cemented surface, and an internal convergent cemented face convex to the stop. Von Höegh argued that the airspaced construction shown in fig. 17 is essentially equivalent to the Dagor, since each half contains two outer surfaces concave to the stop, an internal divergent surface, and an internal convergent surface convex to the stop. The airspaced construction has an advantage over the cemented construction in that each surface separates glass from air, with a large index difference, and, thus, the internal surfaces in this lens become much weaker than the corresponding surfaces in the Dagor. Little difficulty was found in extending the new design to *f*/3.5 covering 21°, an achievement quite impossible with the cemented type. The field is, however, not so wide as in the Dagor type.

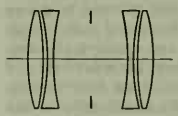


FIG. 17.—THE GOERZ CELOR

This airspaced four-element design was used by the Goerz Company in the Dogmar series, and was later adopted by A. Warmisham in the Aviar lens (1915). A. Steinheil used this design in his Unofocal of 1901, and a great many similar designs have appeared. All the Kodak anastigmats prior to about 1928 were of this form, and the type remains popular.

7. The Tessar.—The preceding paragraph traced the evolution of the Von Höegh quadruplet from the Dagor. At about the same time, Rudolph was following a parallel path. Whereas Von Höegh replaced the divergent and convergent cemented surfaces in his Dagor design by glass-air surfaces, Rudolph returned to his original Protar of 1890 and replaced the cemented surface in the front component by an air lens, remembering that a convex-shaped air lens has a diverging action. In this way he designed the famous Tessar lens in 1902, shown in fig. 18.. It was a successful lens, mainly as an *f*/4.5 universal objective covering a semifield of about 26°. By 1910, some *f*/3.5 designs had appeared, and in later years, the type was used universally in medium focal lengths for *f*/4.5, *f*/3.5, and even *f*/2.7 lenses of the better grade, and particularly for the *f*/2.8 lenses of miniature cameras.

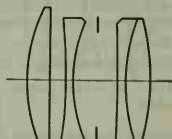


FIG. 18.—THE ZEISS TESSAR

8. The Gauss (Meniscus) Type.—In 1817, C. F. Gauss urged the use of a pair of positive and negative meniscus lenses in the design of a telescope objective. For various reasons, this scheme was never adopted, but in 1889 Alvan Clark patented (U.S. 399,499) a photographic objective composed of two Gauss objectives mounted symmetrically about a central stop. The same idea occurred independently to Rudolph, who in 1895 developed the

Planar lens (fig. 19). Rudolph found it impossible to achromatize a system of four single elements, so he introduced two "buried" surfaces separating glasses having the same refractive index but different dispersive powers. Other designers, however, were more fortunate and succeeded in making well-corrected four-element meniscus objectives such as the Ross Homocentric and the Kodak Wide-field Ektar, which enjoyed considerable popularity.

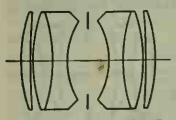


FIG. 19.—THE PLANAR

In 1920, H. W. Lee of the Taylor, Taylor and Hobson Company in England revived the original six-element Planar design, and by departing from strict symmetry and introducing a difference of refractive index between the two glasses used in the negative components, he succeeded in making the Opic lens, covering a semifield of about 24° at *f*/2. This combination of a high aperture and a wide field was completely revolutionary and ushered in the modern period of extreme lenses. The Opic type has been adopted extensively by the makers of "miniature" cameras using 35-mm. film, a typical example being the *f*/2 Schneider Xenon shown in fig. 20.

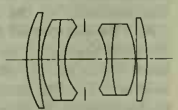


FIG. 20.—THE SCHNEIDER *f*/2 XENON LENS

9. The Topogon Lens.—In 1933 R. Richter of Zeiss sought to extend the field of the Gauss type of objective as widely as possible and adopted the construction in fig. 21, an *f*/6.3 lens capable of covering a half-field of 45°. This lens may be regarded as a modification of the Globe and Pantoskop lenses popular in the 1850s, with the negative elements separated from the positive elements and bent into a more extreme form. After about 1938, this lens was made in the U.S. by Bausch & Lomb as the Metrogon lens.

10. The Cooke Triplet Lens.—In 1893 H. Dennis Taylor decided to put aside all historical precedent and proceed to design the simplest possible photographic lens. He argued that a separated pair of approximately equal positive and negative elements will automatically satisfy the Petzval condition for a flat field and will also have some positive power by virtue of the finite separation. However, such a system will be badly unsymmetrical and will exhibit considerable distortion and lateral colour. He therefore divided the positive element into two parts and set the negative element between them. Thus, he had five degrees of freedom (three powers and two airspaces) with which to secure the desired overall power, the desired Petzval sum, to achromatize, and to correct the distortion and lateral colour. In addition, he could bend or alter the shape of each of the three elements to eliminate spherical aberration, coma, and astigmatism. In this way, Dennis Taylor produced the first modern triplet known as the Cooke lens (fig. 22). It was made in several series, including a narrow-angle *f*/4.5 design for portraiture, a wide-angle *f*/6.3 for landscapes, etc. Originally, no barium crown was employed, but its use greatly facilitates the design and shortens the overall length of the lens, thus improving the corner illumination.

FIG. 21.—THE RICHTER TOPOGON WIDE-ANGLE LENS

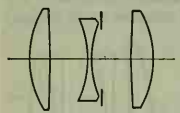


FIG. 22.—THE COOKE LENS

Since 1893 millions of lenses of this type have been made in apertures up to as high as *f*/1.9 in short focal lengths but mostly as a low-priced *f*/4.5 or *f*/6.3 anastigmat for ordinary folding cameras. Within its limitations, it is an excellent lens, although of course it can be improved by making it more elaborate.

11. Modifications of the Triplet Lens.—From some standpoints, the Tessar (fig. 18) may be regarded as a modified triplet in which the rear element has been replaced by a cemented doublet. In 1902 H. Harting, of Voigtländer, felt that if a convergent cemented face in the rear component is an improvement, then the insertion of a similar surface in the front component should be a still greater improvement, and in this way he developed the Heliar lens. This form has not been used extensively, in spite of its merits. Some typical modern examples are the Dallmeyer *f*/2.9 Pentac (fig. 23), covering out to 22°, and the Kodak *f*/3.5 Ektar, covering to 26°.

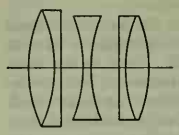


FIG. 23.—THE DALLMEYER PENTAC. DESIGNED BY L. B. BOOTH

12. The Sonnar Lens.—A much more profitable modification of the triplet was that suggested by C. C. Minor in 1916 and developed by L. J. Bertele of the Ernemann Company during the early 1920s. Bertele began by adding a meniscus element in the front airspace of a Cooke triplet (fig. 24) to raise the relative aperture without aggravating the aberrations. He then (1924) improved the system by using cemented doublets for each of the first two elements, and thus made the *f*/2 Ernostar lens, covering a field of ±19°. This type of construction has since been in active competition with the Opic lens, the most important developments (also by Bertele) being the series of Zeiss Sonnars. The most extreme member of this series, having an aperture of *f*/1.5, is shown in fig. 25.

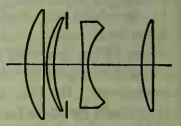


FIG. 24.—BERTELE'S TRIPLET WITH ADDITIONAL MENISCUS LENS IN THE FRONT AIRSPACE

13. The Telephoto Lens.—This type of lens was introduced into regular use about 1891, its particular property being a shortening of the total length of the lens from the front vertex to the focal plane. Indeed, in some telephotos the total length is as little as 60% of the focal length, in contrast to the Tessar or Cooke Triplet type, in which the total length may be about 115%, or to the Petzval Portrait lens, in which it may reach 140%.

The telephoto type of construction consists essentially of a positive front member separated widely from a negative rear member, the action of this combination being to move the rear principal point forward (fig. 26). Originally, a complete normal camera lens was used for the positive component, the rear member being a thin achromatic negative lens, the separation between the positive and negative systems being adjustable to give any desired magnification. These designs were unsatisfactory optically, had bad pincushion distortion, and worked at very low apertures.

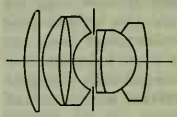


FIG. 25.—THE ZEISS SONNAR *f*/1.5

In 1905 the modern era of telephoto lenses was initiated by the Busch Bistelar, a fixed self-contained telephoto lens of *f*/8 aperture covering a half-field of about 15°. The two components were nothing but cemented doublets, yet, because the designer was released from the necessity of separately correcting the front component, the final result was superior to all previous telephoto lenses and was comparable in performance to the normal *f*/8 lenses of the day. However, when larger relative apertures were attempted, many difficulties were encountered, and it was not until the introduction of the Cooke and Dallmeyer *f*/5.6 anastigmatic telephoto lenses in 1919 and 1920 that this type could begin to compete with modern anastigmats. Nevertheless, in spite of all the efforts of lens designers, the aperture of an 80% telephoto lens cannot be raised much above *f*/3.5, nor the semifield much above 12° to 15°. Recent attempts to remove distortion have led to the use of either a strongly convergent cemented interface in the rear member or a separation of the two rear elements by an air

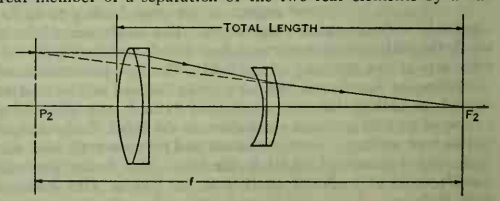


FIG. 26.—THE TELEPHOTO PRINCIPLE

gap. During World War II, many large telephoto lenses of focal lengths ranging from 12 to 60 in. were manufactured for use in aerial reconnaissance cameras, but since the corrections of a telephoto lens are not so good as those of the equivalent conventional lens, telephotos are never used unless compactness is an important factor.

14. The Reversed Telephoto Lens.—By reversing the construction of a telephoto lens and placing the negative member in front, it is possible to design a high-aperture, wide-angle lens having an exceptionally long back focus combined with a short focal length. This type became popular about 1945 for use on 16-mm. and 8-mm. motion-picture cameras, especially for lenses of very short focal length with wide-angle coverage. After 1950 a large number of reversed telephoto objectives, containing from 4 to 10 lens elements, appeared for use on single-lens reflex cameras, where the space between the rear lens surface and the film must often be greater than the focal length of the lens in order to accommodate the viewing mirror. The construction of a typical reversed telephoto lens is shown in fig. 27. If the components are made very powerful and a large amount of barrel distortion is deliberately introduced, the result is a so-called sky lens, or fish-eye lens, in which an entire hemisphere can be recorded as a circular picture on flat film. A number of lenses of this type appeared after 1957. A less extreme form, covering only part of the hemisphere, was the Zeiss Pleon lens used in World War II for aerial photography. Similar lenses were manufactured for military purposes where an exceptionally wide field is desired and distortion is not objectionable.

FIG. 27.—REVERSED TELEPHOTO LENS DESIGNED BY P. ANGÉNIEUX

15. The Aviogon and Biogon.—Beginning in 1950 an entirely new type of lens construction appeared on the market as a highly corrected and virtually distortionless wide-angle lens. This form resembles a double-ended telephoto system comprising a central positive member mounted between two large negative components. The arrangement was proposed originally in 1946 by the Russian M. M. Roosinov (U.S. patent 2,516,724), and it was developed by L. J. Bertele and others. The *f*/4 Biogon lens (1951) by Zeiss (fig. 28) represents a wide-angle lens covering a full 90° field with only a slight reduction in the illumination across the film from centre to edge. Because of its relatively great length and diameter, this type of construction is applicable only to the shorter focal lengths.

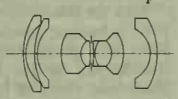


FIG. 28.—ZEISS BIOGON LENS

16. Apochromatic Process Lenses.—In photomechanical reproduction, it is frequently necessary to make colour-separation negatives of coloured original drawings or photographs, and the lenses used must be colour-corrected to a degree entirely beyond anything necessary in ordinary lenses. By using special types of glass and restricting the aperture to about *f*/10 or *f*/16, it has been found possible to design lenses, generally of a symmetrical type, in which all the colours of the spectrum are brought accurately to a common focus. It is further necessary in these lenses for all the coloured images to be of precisely the same size. Such lenses are called apochromatic process lenses to distinguish them from the ordinary achromatic lenses in common use.

17. Lens Attachments.—The familiar portrait attachment for fixed-focus cameras consists of a weak meniscus-shaped positive lens having a focal length approximately equal to the distance of the subject (four feet). Stronger positive lenses are sometimes used to photograph small objects, when the focusing scale of the camera will not go down to a sufficiently close distance. Negative lens attachments are also occasionally employed to lengthen the focus of a camera objective to give a magnified picture, but their use requires a considerable bellows extension. Small Galilean telescopes have been used as lens attachments to enlarge or minify the picture without any change in image position or relative aperture. After 1950, converter lenses of this type were used extensively on the turret of 8-mm. motion-picture cameras to provide a range of focal lengths. A basic 13.3-mm. lens can be raised to 25 mm. or reduced to 8.5 mm. by the use of telescopic attachments having a magnifying power of 1.9 or 0.63 respectively (fig. 29).

18. Anamorphic Attachments.—By the use of a Galilean telescopic attachment made entirely of cylindrical surfaces having parallel generating axes, it is possible to broaden a photographic image by as much as two times, in one direction only. It was suggested by E. Zollinger (U.S. patent 1,032,172) in 1910 that a system of this kind could be used on a motion-picture camera to compress a wide picture into a small film image, a similar cylindrical converter being used in reverse on the projector to expand the image back to its original proportions on the screen. After 1953 this proposal was adopted on a very extensive scale by the motion picture industry under such names as CinemaScope.

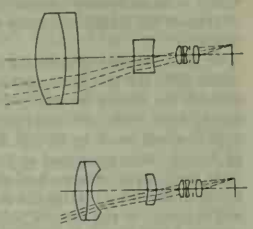


FIG. 29.—AFOCAL LENS ATTACHMENTS: (TOP) TELEPHOTO; (BOTTOM) WIDE-ANGLE

19. Zoom Lenses.—In the varifocal, or zoom, lens one or more of the components can be moved along the lens axis to vary the focal length, and the image is held in focus on the film by one of the following means: (1) providing a cam to move another lens component through the necessary distance; (2) coupling two or more lens components and moving them as a unit, the lens powers and spacings being chosen to achieve an optical compensation of the image motion; or (3) moving two or more of the lens components at rates bearing a linear relation to one another.

Zoom lenses were available for 35-mm. motion-picture cameras as early as 1932, although they were not much used until the 1950s, when a variety of these lenses was also introduced for 8- and 16-mm. cameras. The greatest use of zoom lenses, however, was in television cameras. Originally limited to a focal-length ratio of 3:1, zoom lenses with ratios of 10:1 were in use in the early 1960s (Taylor-Hobson, Angénieux), and in 1964 a model with a 20:1 ratio was announced.

A few zoom lenses for 35-mm. still cameras were made, but they tended to be large and heavy, and the focal-length range was generally small (2:1), the relative aperture low, and the field angles rather narrow. Nevertheless, such lenses proved convenient in framing and composing the picture. Zoom lenses for motion-picture and slide projectors were also becoming popular. (R. KE.)

X. THE BRANCHES OF PHOTOGRAPHY

1. Amateur Photography.—In the 19th century, when the photographer had to make his own materials, amateur photographers were responsible for many of the major advances in the art. Nowadays, however, photographic materials are made by manufacturers who can supply ready-to-use products in large quantities and of uniform quality. The amateur is now essentially a user and his opportunities for making basic advances are limited. He can and does, however, contribute much to advance practical

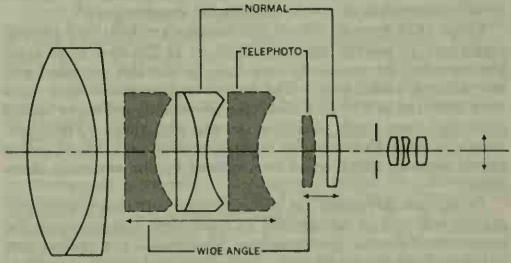


FIG. 30.—ZOOM LENS SHOWING POSITIONS OF ELEMENTS FOR WIDE-ANGLE, NORMAL, AND TELEPHOTO SETTINGS

techniques and pictorial qualities. The amateurs range from the millions who want personal photographic records with the minimum of effort, skill, and expense to the group to whom photography is an extremely serious matter and who will spare no pains to achieve the technical quality and aesthetic effect they personally desire.

In general, photography did not become a popular amateur interest until the roll-film camera was introduced in 1888. It then became the means by which uninstructed amateurs could record scenes from their own experience easily and faithfully. The first such cameras, made by George Eastman under the trademark name of Kodak, were preloaded at the factory with a roll of film sufficient for 100 pictures, each of which was round in shape and about $2\frac{1}{2}$ in. in diameter. After the roll was exposed, the loaded camera was returned to the factory, where the film was developed. With contact prints from all printable negatives and with a fresh loading of film, the camera was then returned to its owner.

Cameras and general photographic equipment for the amateur have evolved rapidly since the turn of the century. The inexpensive, fixed-focus, fixed-exposure, roll-film camera of the "box" type appeared in 1900. The box camera maintained its great popularity for more than half a century; its basic design, its simplicity, and its photographic capacity endeared it to millions who wanted to make photographs without concern over technicalities. With the advent of more sensitive films, both black and white and colour, from about 1940, the classic box camera tended to give way to a smaller format with improved optical and mechanical qualities.

Over the same period there were similar changes in cameras intended for more skilled use. For about 30 or 40 years the folding camera with adjustable focus, a range of shutter speeds from *T* (time exposure) to $\frac{1}{200}$ sec., and a lens rated at *f*/6.3 was a kind of classic norm. Some variations on this theme had precise range finders, $\frac{1}{500}$ shutters, an *f*/4.5 lens, and provision for flash exposures. Others were little more than box cameras—one speed, fixed focus, an aperture of about *f*/11. Picture size tended to decrease until the folding cameras became, essentially, miniatures.

In the mid-1920s, the miniature camera appeared. Originally designed as a means of testing 35-mm. film in professional motion-picture photography, the miniature camera soon assumed importance as a means of making small but excellent "still" negatives. Considerable precision was necessary to produce a clean, sharp, enlargeable image on an area about $1 \times 1\frac{1}{2}$ in. in size; this precision was implicit in the lens and in the adjustments for focusing, for exposure, and for film movement. Lenses for the miniature camera were, as a rule, considerably faster than lenses for larger cameras; lens ratings of *f*/2, *f*/2.8, and *f*/3.5 are common among miniature cameras, whereas larger cameras are seldom equipped with lenses rated faster than *f*/4.5.

Its fast lenses, highly sensitive films, and inconspicuous size threatened, for a time, to characterize the miniature as primarily a candid camera, but it survived this threat because serious-minded amateurs came to appreciate the wide capability of miniature equipment. These amateurs soon constituted a large and influential group. They organized themselves, forming enthusiastic and articulate units. They required, and ultimately received, improved equipment of all kinds—finer cameras, specialized lenses and films, and processing tanks and enlargers capable of producing clear and crisp enlargements of 10- or 20-diameter magnification.

About 1935 reversal colour film became available and photography was, in essence, reborn. Again, as at the start of amateur photography, the processing was done by the film manufacturer, and without added cost. The colour transparencies thus made were mounted as 2×2-in. slides for projection, and many optical projectors were made available for use with them. The transparencies were also used for making several varieties of colour prints, some of which could be produced by the amateurs themselves.

Techniques developed for the miniature enthusiasts were ultimately reflected in refinements of equipment and processes for conventional-format photography. Mechanical and optical precision of high degree became characteristic of larger as well as smaller cameras. Films that once were primarily for the miniature cameras were made available in larger sizes; and fine-grain developers, often necessary in miniature work, came into general use.

In the 1960s there was a tendency to make small cameras automatic in the sense that integral photocell meters evaluated the existing light and either set the appropriate lens and shutter adjustments or indicated them for the user's guidance. This emphasis on precise exposure was one result of the widespread acceptance of colour film; colour exposures offered much less latitude than monochrome and only experts safely departed from a scientifically determined optimum exposure.

Essential to the maintenance of photography as a popular amateur activity is the easy availability of film, and amateur roll film in standard sizes can be found in thousands of general merchandise shops as well as in those primarily concerned with photographic and optical goods. Black-and-white film for the simple camera usually permits 8 or 12 exposures and is provided in a variety of types. For general outdoor pictures there is medium-speed panchromatic film; for work in artificial or low-level light there are fast panchromatic films; for pictures destined for considerable enlargement there are fine-grain films. Negative and reversal colour films from which colour prints as well as slides for projection can be obtained are available in a variety of formats offering from 8 to 36 exposures per roll.

While roll film is by far the most commonly used sensitive material among amateurs, many serious workers prefer sheet film (for which special film holders must be used) or film packs. Most types of film put up in rolls are also provided in sheets, with a number of special types available in sheet film for the specialized requirements of many amateurs as well as professionals. Colour films are made in sheet and roll form.

The great majority of amateurs have their finishing (developing and printing) done for them by commercial photofinishers. For the amateurs who do their own monochrome developing and printing, there is a wide range of simple and inexpensive apparatus; and chemicals are put up in packaged form to eliminate the need for measuring quantities. Papers are provided in a great variety of surface and contrast either for enlarging or contact printing. It is also possible for the experienced amateur to process several types of colour film, and to produce colour prints.

With the introduction of the sensitive panchromatic films about 1930, it became possible for the amateur to take photographs indoors with simple artificial lighting equipment. This was aided considerably by the introduction of tbe overrun (overvolted) Photoflood types of lamps and simple stands and reflectors, and later by the flashbulbs and synchronizers that could be attached to amateur cameras. Nowadays many amateur cameras are provided with flash attachments or at least with special shutters having electrical contacts that permit their use with flashbulbs or with electronic discharge lamps. Colour films are made to give good-quality photographs with artificial lighting.

2. Professional Photography.—From the era of the daguerreotypes—the 1840s and early 1850s—down through the collodion and dry plate eras to the first or second decade of the 20th century, the professional photographer was almost invariably a portrait photographer. Indeed, photography was popularly accepted as primarily a means to personal portraits.

The photographic portrait establishments attempted to maintain something of the grand style. Furnishings and decoration were lavish, and the backgrounds against which patrons were posed were elaborate counterfeits of grandeur. Because the use of electricity became widespread only in the 20th century, most early portrait studios used daylight, which was provided by large banks of windows facing north, or away from direct rays of the sun. By the ingenious use of reflectors, diffuse light was used with considerable effect, but the intensity was relatively low. This fact, coupled with the slowness of the photographic plates then available, necessitated long exposures. To assure the rigidity of the sitter during exposure a head clamp was commonly used; such a device also tended to induce rigid facial expressions. However, because naturalness and informality were almost foreign to the manners of the late 19th century, portrait photographers flourished and few

respectable homes were without their albums in which portraits of the *carte de visite* size (2 × 3 in.) were elaborately presented, along with some of the larger "Cabinet" size (about 3 × 5 in.). By the 1860s, portrait photography had become so popular that cameras taking several portraits on one plate were used in order to speed up taking and developing.

In the United States particularly, the vogue of portrait photography was immense. "Artists of the lens" were established in every town, and itinerant portrait photographers toured the fringes of the frontier. The camera was invariably a bulky mechanism mounted on a heavy stand that was sometimes carved to comply with the standards of contemporary elegance. From beneath a black focusing cloth at the back of the camera, the photographer watched the ground glass image of his sitter, suggesting, cajoling, pleading for a pleasant expression.

Early in the 20th century, public taste turned from the formality and the artificiality of conventional portraiture. Thanks to the constant improvement in plates and to the growing use of artificial light, it became possible to make studio portraits with the sitter far more at ease. Exposures were shortened, the head clamp disappeared, and the rococo motif in furnishings and backgrounds gave way to simplicity, with all the interest falling on the sitter.

Modern professional portraiture is done almost exclusively on sheet film of the orthochromatic or panchromatic variety, one or the other being used according to the nature of the sitter. The negative sizes tend to be smaller than in earlier years, and modern types of long-focus lenses and shutters are used. The lighting is almost exclusively artificial, largely by tungsten filament electric lamps in special reflectors or as spotlights. Some fluorescent lighting is used for general lighting, and there is a growing use of flash, especially electronic.

Proofs of portraits are usually provided to the sitter, and they are made on print-out paper or special slow types of enlarging paper. Contact and enlarging papers are made for portraits, frequently giving warm tones.

Mass production methods have been introduced into portraiture, especially in automatic or semiautomatic "studios," and in coin-operated machines. The best portrait quality is, however, attained by the photographers who undertake each appointment seriously and carefully apply their time and skill to making good studies of the subjects. In recent years, colour photography has been introduced into portraiture.

3. Commercial Photography.—Photography is used very widely for commercial illustration and advertising, for technical illustration, and for a wide variety of special purposes. When the photographs are made by professional photographers on a commercial basis, the subject is called commercial photography; it is a very important branch of photography. The photographers are usually highly skilled in the art of lighting and the use of special techniques, particularly since advertising agencies demand much in the way of unusual subjects and dramatic effects. There is some tendency to specialization in commercial photography, one man doing primarily fashion photography with live models, another still photography of food subjects, another sporting events, and so on. The successful commercial photographer is adept in the use of all modern techniques, especially colour.

4. Photographic Art.—Over the years there has been almost continuous discussion as to photography's status as an art. During the first decade of the 20th century Alfred Stieglitz and Edward Steichen affirmed photography's artistic potential in the publication *Camera Work;* many of their published photographs appeared to confirm their claims. While the camera is not always regarded as an art medium, the discerning mind and perceptive eye of a skilled and sensitive photographer can produce—and have produced—stimulating and aesthetically meaningful compositions. Indeed, such photographs transcend much that is presented through traditionally accepted art forms. (*See* also PHOTOGRAPHIC ART.)

5. Polaroid Land Camera.—In the late 1940s a wholly new type of amateur camera was introduced—the picture-in-a-minute Polaroid Land camera. It was in most respects a fairly conventional folding camera of the larger size; it was loaded, however, with a most unconventional and complex package of sensitized material in which were incorporated pods of developer. After making an exposure, the user withdrew the film one picture length; in so doing the developer pods were broken and their contents spread evenly on the exposed material. Within a minute a positive image was fully developed on a sheet that could be torn from the camera. As the process was improved the time required for developing was reduced to ten seconds. In 1963 a colour material for these cameras was introduced; the resulting colour prints were relatively expensive but the novelty of full-colour prints produced on the spot and in about one minute compensated for the cost. *See* also references under "Photography" in the Index. (W. B. BT.)

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PHOTOGRAPHY, CELESTIAL. Celestial photography is the application of photography to objects in the sky and, in particular, to astronomical objects such as the sun, moon, planets, satellites, comets, stars and nebulae. Although pictures of clouds are not generally considered to be examples of celestial photography, pictures of meteors and of aurorae, which are also atmospheric phenomena, are considered within this subject. This article is divided into the following sections and subsections:

I. The Application of Photography to Astronomy
II. Photographic Telescopes
  1. Photographic Efficiency
  2. Limiting Magnitude
  3. Field
  4. Schmidt Telescope
  5. Other Modern Telescopes
  6. Photographic Plates and Films
III. Celestial Photographs
  1. Sun
  2. Moon and Planets
  3. Artificial Satellites
  4. Meteors
  5. Aurorae
  6. Charts of the Heavens

I. THE APPLICATION OF PHOTOGRAPHY TO ASTRONOMY

The invention of photography by Louis Daguerre in 1839 led to a great step in astronomical progress. The first application of the daguerreotype to astronomy was made by John William Draper of New York city, who photographed the moon on March 23, 1840, the exposure being 20 min. Experiments in the new method were made under the direction of W. C. and George P. Bond at the Harvard College observatory, with the assistance of John A. Whipple and his colleague Black, photographers of Boston, as operators; the first photograph of the moon was taken there on Dec. 18, 1849, with the 15-in. object glass. A daguerreotype picture of the moon shown in London by George Bond at the Great Exhibition of 1851 attracted much attention.

Having seen the Harvard pictures in England, Warren De la Rue took up the subject and presented to the Royal Astronomical society, in 1857, positive copies from a negative picture of the moon made by a collodion process that he had found practicable five years earlier. In 1864 Lewis M. Rutherfurd of New York city made a telescope with object glass of 11¼-in. aperture so corrected as to bring the photographic rays to focus. About the same time Henry Draper surpassed his father's efforts by taking photographs of the moon with a 15-in. reflector.

Probably the first photograph of a star was a daguerreotype of Vega taken at Harvard observatory on July 17, 1850, but want of sensitiveness made this process rather impracticable, and there was little success in stellar photography until the invention of the collodion plate that was used in the U.S. and England in 1852. In Nov. 1857 a photograph taken at Harvard of ζ Ursae Majoris (one of the stars of the Ursa Major cluster) with its companion Alcor was sent for exhibition at the Royal Astronomical society by W. C. Bond; an exposure of 80 sec. had been given to photograph the 6th-magnitude star with the 15-in. refractor. De la Rue at that time was making experiments on the actinic power of Jupiter and Saturn compared with that of the moon, but his photographs did not show any details of the planetary surfaces. Under De la Rue's direction, and to his design, a photoheliograph was made and set up at Kew observatory, Surrey, Eng., for the Royal society, and the work of taking daily photographs of the sun, that was later carried on successfully at Greenwich and elsewhere, began at Kew in March 1858. De la Rue did not succeed in his attempt to photograph Donati's comet of that year, but Usherwood of Walton Common, Surrey, Eng., photographed the comet in 7 sec. with a portrait lens of short focus.

Daguerreotypes of the sun taken by J. B. L. Foucault and Armand Fizeau in 1845 and photographs of the solar eclipses of 1851 and 1854 were interesting experiments, but the photographs taken by De la Rue and by Angelo Secchi of the total solar eclipse in 1860 were the first of their kind to have real scientific importance, since they established beyond doubt that the solar protuberances were really appendages of the sun and not of the moon. Ten years later, at the eclipse of Dec. 12, 1870, excellent photographs taken by A. Brothers at Syracuse, N.Y., supplied evidence that the corona was also of solar origin; from that time a photographic picture of the sun's surroundings remained an integral item in the program of eclipse observation.

In the years after 1870 many people were engaged in research and experiment in photography generally. Of particular relevance to astronomy were the studies of W. de W. Abney. It was decided, mainly at the instigation of De la Rue, that photography (in addition to visual observation) should be used by the British expeditions that were to study the transit of Venus in 1874, and the work, so far as the process was concerned, was put in Abney's charge. He realized that the circumstances of the occasion would make a wet-plate process inapplicable and, after experiments conducted at Chatham, Kent, Eng., recommended the adoption of an albumin dry process, using a highly bromized collodion and strong alkaline development.

The titles of two of Abney's papers—"On Dry Plate Processes for Solar Photography" and "On the Photographic Method of Mapping the Least Refrangible End of the Solar Spectrum"—indicate their bearing on astronomy. These papers represent a remarkable achievement in that Abney succeeded in producing a special photographic emulsion, sensitive to red light, which he used to map the solar spectrum far into the infrared.

It was pointed out by George Bond that photography might be successfully used to measure the relative positions of stars, of a group or of double stars; and in a letter to William Mitchell on July 6, 1857, he predicted, in effect, the application of photography to stellar astronomy on the magnificent scale that actually exists today. In 1864 Rutherfurd began a long series of photographs of star clusters and of the bright double stars; but apparently these measures were never completed. In 1870–84 B. A. Gould, in an expedition to the southern hemisphere, accumulated negatives of the principal double stars and clusters. Because the wet-plate process was used in making these photographs it was not possible to give an exposure long enough for faint stars to imprint themselves. With the invention of the gelatin dry plate, which had been used by William Huggins for spectrum photography in 1876 and which came into general use about 1880, this difficulty was removed and modern astronomical photography became possible. Circumstances connected with the comet of 1882, which was especially magnificent as seen from the southern hemisphere, led to new applications of celestial photography. A photograph, taken with a camera strapped, for the purpose, to the great equatorial of the Royal observatory of the Cape of Good Hope, showed not only the comet but great numbers of faint stars around it; this at once suggested to David Gill the possibility of making star charts by photography. Effects of various kinds followed upon Gill's idea. At Paris the brothers Paul and Prosper

Henry of the National observatory were engaged in the laborious task of plotting the positions of stars found by eye observation in order to make charts of the stars near the ecliptic; but they abandoned this work and devoted their efforts to making a telescopic object glass suitable for photography.

In England, Ainslie Common turned to the art and, with a three-foot silver-on-glass mirror, took a photograph of the Orion nebula on Jan. 30, 1883, with an exposure of 37 min. He earned the gold medal of the Royal Astronomical society in 1884 for this feat, which Abney called "epoch-marking" when presenting the medal to another nonprofessional astronomer for similar work 11 years later. An earlier photograph of this nebula, taken by Henry Draper of New York city on Sept. 30, 1880, is said to be the first obtained but it is agreed that this was not a satisfactory representation. The later recipient of the medal mentioned above was Isaac Roberts. In 1885 he had made a 20-in. silver-on-glass reflector of nearly 100-in. focal length for the purpose of making star charts by photography, but altered his plans and devoted the instrument to photographing star clusters and nebulae. The excellent pictures produced at his observatory at Crowborough, Sussex, are collected in two volumes published during his lifetime, supplemented by a third prepared and issued by his widow in 1928.

Common's photograph of the Orion nebula led, through Edward Holden, to the acquisition of a three-foot reflector in 1895 by the Lick observatory, Mt. Hamilton, Calif. Two mirrors made by Calver and formerly owned by Common, were presented to that institution by Edward Crossley of Halifax, Eng., and one of these, refigured by Sir Howard Grubb, forms the essential part of the instrument known by his name. In James Keeler's hands it yielded a superb series of photographs of nebulae which for the first time demonstrated the great advantages of the reflecting telescope for certain classes of astronomical photography and led to the construction of the great modern reflectors.

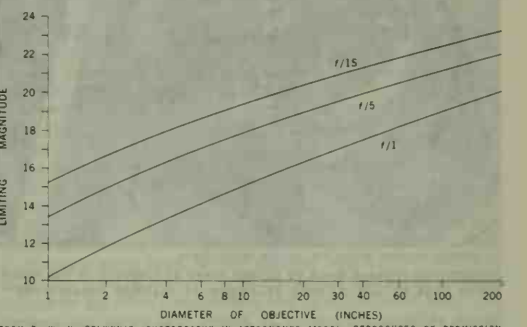
(H. P. H.; F. H. S.; D. E. O.)

II. PHOTOGRAPHIC TELESCOPES

The instruments used for celestial photography are telescopes of one or another kind, but without an eyepiece. Instead the light is brought to a focus at the photographic plate, as in a simple camera. Astronomical telescopes may be grouped into three classifications: (1) refractors, (2) reflectors and (3) catadioptric or composite systems (*see* TELESCOPE). In a refractor a lens collects and brings light to a focus; in a reflector a concave mirror, usually of glass aluminized on the curved surface, serves the same purpose; in a catadioptric system a light-transmitting plate and a mirror in combination have the same function. In addition refractors may be subdivided into two kinds: those designed for visual observations, and those for photographic purposes. Since the development of celestial photography and its almost universal application occurred after many of the larger refractors had been constructed, a number of observatories were in the position of having to use for photography instruments originally intended for visual work. In these cases the adaptation from visual to photographic use was accomplished in a variety of ways: by adding another lens to the objective; by reversing one of the elements in the objective; by placing a small correcting lens a few feet in front of the focus; or by using a yellow colour filter and an emulsion sensitive to visual light. The last two methods, because of their simplicity, are those in commonest use respectively for photography of spectra and of star fields by the largest refractors, such as the 40-in. telescope at Yerkes observatory, Williams Bay, Wis., and the 36-in. Lick telescope. In the case of reflectors, since their mirrors bring light of all colours to the same focus, photography over a wide spectral range is possible without focal compensation.

1. Photographic Efficiency.—The aperture, focal length and focal ratio of a telescope are usually chosen to make it as efficient as possible for a particular type of problem. The larger the focal length, the larger the scale or magnification of the image. For a particular focal length, the larger the aperture, the greater the amount of light collected and hence the brighter the image. For objects having extended surfaces like the sun, moon, planets and nebulae, the situation is similar to ordinary terrestrial photography. The photographic efficiency for surfaces is inversely proportional to the square of the focal ratio and is independent of the aperture; for a particular focal ratio the advantage of a large aperture is its great magnification and hence its ability to resolve small details.

For stars the situation is somewhat different. According to geometrical optics, star images are points; if diffraction is taken



FROM E. W. H. SELWYN'S "PHOTOGRAPHY IN ASTRONOMY" (1930); REPRODUCED BY PERMISSION OF EASTMAN KODAK COMPANY

PHOTOGRAPHY OF FAINT STARS

For a given focal ratio, the larger the telescope aperture the fainter the stars that can be photographed. For a given aperture, a larger focal ratio permits fainter stars to be recorded

into account, they are small disks whose linear size is proportional to the focal ratio. One might expect that the photographic efficiency would be proportional to the square of the aperture of the telescope. However, for telescopes with apertures larger than a few inches, the actual image size is determined by aberrations and imperfections in the optical elements and by the effects of disturbances in the earth's atmosphere (called "twinkling" or "seeing"). In larger telescopes, therefore, the star images are larger and the photographic efficiency does not increase as rapidly as the square of the aperture.

2. Limiting Magnitude.—For a given telescope it is impossible to photograph fainter and fainter stars merely by prolonging the exposure time. In order to record a perceptible image of a star there is required a certain minimum difference between the brightness of the stellar image and the sky background. The effect of sky illumination, the light of which is a faint and variable auroral glow produced in the earth's atmosphere by solar radiation, is determined by the focal ratio. For a given focal ratio, therefore, increase in linear dimensions does not affect the sky brightness in the focal plane of the telescope. From experience it is found that when the surface brightness of an object falls below one-sixth the sky illumination it becomes difficult to recognize the object on the emulsion. When this condition is approached the magnitude of the faintest star discernible on the photograph is termed the limiting magnitude. Because of its great practical importance, the limiting magnitude attainable with a given telescope has been the subject of a number of studies. The results of these studies are collected in the figure, compiled by E. W. H. Selwyn, which shows the limiting magnitude as a function of aperture and focal ratio of the telescope.

To record a perceptible image of a nebula also there is required a minimum difference between its brightness and the general sky brightness. This contrast can be increased by taking the photograph with light of such wave length that the nebula is relatively bright and the sky is relatively faint. Because much of the nebular light is therefore rejected, this procedure requires long exposure time or particular photographic skill.

3. Field.—For most of the large refractors, which generally have focal ratios in the range *f*/15 to *f*/20, the field of critical definition amounts to 1° to 2° in diameter. In order to cover larger areas lenses of shorter focal length and of focal ratio *f*/7

BY COURTESY OF MOUNT WILSON AND PALOMAR OBSERVATORIES

ASTRONOMER OPENING SLIDE TO EXPOSE PLATE AT EYEPIECE IN THE PRIME-FOCUS CAGE OF 200-IN. HALE TELESCOPE AT PALOMAR OBSERVATORY

to *f*/4.5 usually are employed. However, simple doublets of this focal ratio have only a small field of good definition and in order to photograph a larger field it is necessary to use a more complicated multielement lens. Among the most useful of these wide-field lenses are a series of four-element objectives, *f*/7, designed by F. E. Ross, which have a field of several degrees.

The field of good definition of a reflecting telescope also decreases with decreasing aperture and with increasing focal length, and is only a few minutes of arc for the 100-in. reflector at Mt. Wilson observatory, near Pasadena, Calif., and the 200-in. reflector at Palomar observatory, Palomar mountain, Calif. In 1929 Ross designed a lens that, when placed a short distance in front of the focus, extended the useful field to an area nearly 1° in diameter. Since lenses of this type changed the focal length very little they were called zero correctors. By the early 1960s nearly all of the large, modern reflectors were provided with auxiliary lenses of this character.

4. Schmidt Telescope.—In 1931 Bernhard Schmidt of the Hamburg observatory, Bergedorf, Ger., designed and constructed a new type of telescope that represented an ideal composite system. The Schmidt telescope consists of a figured correcting plate, which the light passes through, and a spherical reflecting mirror, which then brings the light to a focus on a spherical surface with a radius half that of the mirror. It is therefore necessary to bend the photographic film or plate to fit this curved focal surface. Since the Schmidt telescope has a much larger field of good definition than either a reflector or refractor of the same focal ratio, it is superior whenever coverage of a large area on a single exposure is required.

By the 1960s many 24-in. (aperture) Schmidt cameras were in operation; the largest was the 48-in. camera of the Mt. Wilson and Palomar observatories.

5. Other Modern Telescopes.—During the early 1940s A. Bouwers in the Netherlands and D. D. Maksutov in the U.S.S.R. independently discovered a composite system somewhat similar to the Schmidt telescope. In the Bouwers-Maksutov telescope the light passes through a weak spherical lens and is focused by a spherical mirror onto a curved film. The advantage of this system is that its lens involves only spherical surfaces and for this reason it is easier to construct than a Schmidt corrector plate. Furthermore the over-all length of the telescope is shorter than that of a Schmidt telescope of the same aperture and focal length. The disadvantage of the Bouwers-Maksutov telescope is that its definition, while superior to that of an ordinary refractor or reflector over a wide field, is not as good as that of a Schmidt telescope. By the 1960s the largest two Bouwers-Maksutov telescopes in operation were the 20-in. (aperture) at Alma-Ata and the 18-in. at Simeis, both in the U.S.S.R.

With Schmidt or Bouwers-Maksutov telescopes it is possible to photograph with good definition a field of from 5° to 15° in diameter, depending on the size of the instrument. (Although this is much smaller than the field of an ordinary hand camera, it must be remembered that astronomical requirements of definition and of scale are much greater than those that can be met by hand cameras.) Various modifications of these telescopes make it possible to extend the usable field to as much as 50° but for still larger fields a different type of instrument is necessary (see *Celestial Photographs: Meteors; Artificial Satellites,* below). A very wide-field system invented by J. L. Greenstein and L. G. Henyey in the 1940s uses a spherical mirror that focuses the light on a spherical focal surface. There is, however, no film at this focal sphere; instead there is a complicated lens system some distance above it which refocuses the light onto a flat plate. In this way a different section of the mirror is used for photographing each part of the sky and the field of good definition is quite large. The largest Greenstein-Henyey camera, owned by the Yerkes observatory, has a mirror 12 in. in diameter, but the effective aperture is only 0.2 in. and the effective focal length 0.4 in. This instrument photographs a field of 140° at one time, only a little less than the whole hemisphere of 180°.

6. Photographic Plates and Films.—The photographic materials used in astronomy are ordinarily coated on glass plates because of the relative freedom from stretching achieved in this way. Film is used only if it has some special advantage, as in some Schmidt cameras because it can be bent easily, or in solar or planetary photography because large numbers of exposures are taken in rapid succession. Ordinary photographic emulsion is sensitive only to the wave-length region 3,000 Å to 5,000 Å. (An angstrom unit, written Å, is $\frac{1}{100,000,000}$, or 10^{-8}, centimetre. The limits of human vision extend from about 4,000 Å, violet, to 7,000 Å, red, while 5,000 Å is green.) After the discovery of sensitizing dyes by Hermann Vogel in 1873 the short wave-length region that can be photographed was extended to 3,000 Å; more recent inventions pushed the long wave-length limit to 13,000 Å.

BY COURTESY OF MOUNT WILSON AND PALOMAR OBSERVATORIES

ASTRONOMER USING GUIDE-SCOPE TO CHECK FOCUS OF 48-IN. SCHMIDT TELESCOPE DURING AN EXPOSURE

Astronomical plates and films are considerably more sensitive than commercially available materials but on the other hand they become fogged more easily and must be kept under refrigeration until shortly before use. There is a range of speeds of astronomical plates available: generally the more sensitive a plate is to light, the grainier its structure is when developed and the poorer its resolution is. Thus one must always compromise between speed and resolving power.

III. CELESTIAL PHOTOGRAPHS

1. Sun.—The sun is extremely bright, brighter than almost any other source, and therefore can be photographed with very long focal-length instruments and on large scale. Furthermore fine-grain (and therefore relatively slow) plates can be used for the maximum resolution of fine detail on the sun's surface. Under these conditions the resolution is limited chiefly by the unsteadiness of the earth's atmosphere and by the deformation of the optics of the telescope caused by solar heating. In the early 1900s George Ellery Hale discovered that a considerable part of the daytime unsteadiness occurs near the ground as a consequence of convection of heated air. Therefore he arranged for the construction of the 60-ft. and 150-ft. solar towers at Mt. Wilson, each of which has an objective lens of 12-in. aperture at the quoted distance above the focal plane. The solar towers are fixed refracting telescopes with vertical axes, equipped with coelostats, or systems of flat mirrors driven to follow the sun's apparent daily motion, that direct the sunlight down into them. Each of the towers is actually composed of two completely independent structures, one inside the other. The outer tower serves as a screen to prevent the inner tower, which bears the optical equipment, from being set into vibration by the wind. The combination of great height above the ground and shielding from wind proved quite successful in limiting the effects of atmospheric unsteadiness and improving the image quality. Subsequently several other tower telescopes were built, including those at Potsdam, Ger., at Arcetri, Italy, and at the McMath-Hulbert observatory near Pontiac, Mich. The last observatory in particular pioneered in making motion pictures of rapidly changing solar phenomena. Solar telescopes are often used in conjunction with a spectroheliograph (*q.v.*) to record a photograph of the sun in the light of a single wave length, *i.e.*, in the light of a single element, such as hydrogen or calcium.

In an attempt to obtain solar photographs of even better resolution two groups of astronomers were led in 1956–57 to use balloons to take their telescopes to heights above nearly all the atmospheric unsteadiness. A. Dollfus of the Paris observatory and D. E. Blackwell and D. W. Dewhirst of Cambridge observatory took an 11-in. refracting telescope of 180 ft. effective focal length to a height of 20,000 ft. in a manned balloon, while M. Schwarzschild and J. R. Rogerson of Princeton University observatory and J. W. Evans of Sacramento Peak observatory, Sunspot, N.Mex., sent an automatically operated 12-in. reflector of 200-ft. effective focal length to a height of 84,000 ft. in an unmanned balloon. Both telescopes were composite systems consisting of an objective together with an enlarging lens, so that the over-all tube length was considerably smaller than the effective focal length, and both took many exposures on continuous rolls of film. The definition of both sets of photographs was very good, those taken from the unmanned balloon being the finest solar pictures ever taken.

The solar corona is the very faint outer envelope of the sun, only about $\frac{1}{1,000,000}$ as bright as the sun. It can be photographed easily at eclipses—when the bright solar disk is hidden—but at other times sunlight scattered by particles in the earth's atmosphere and by imperfections in the optical parts of a telescope ordinarily completely masks the faint coronal light. In 1931, however, Bernard Lyot of the Paris observatory succeeded in photographing for the first time the solar corona outside eclipse. By using an ingenious telescope of his own design termed the coronagraph, and by working on the Pic du Midi (elevation 9,400 ft.) in the Pyrenees, Lyot was able by 1936 to photograph the inner corona out to 7′ of arc from the sun's limb. With still further instrumental refinements, and with the use of a polarizing monochromatic filter (*see* LIGHT: *Polarization and Electromagnetic Theory*) that transmitted a band of radiation only 1.5 Å wide, Lyot by 1941 not only obtained pictures of the corona but also made direct photographs of the chromosphere, prominences and sunspots that rivaled in quality those given by the spectroheliograph. Two more coronagraph observatories were constructed: the Zürich observatory station at Arosa, Switz. (elevation 6,600 ft.), and the Harvard station at Climax, Colo. (11,500 ft.).

2. Moon and Planets.—The moon and the planets near the earth, though fainter than the sun, are relatively bright objects, comparable with brightly illuminated outdoor scenes on the earth. Thus it is possible to use long focal ratios and short exposure times in photographing these objects. In many cases it is advantageous to use an enlarging lens to increase the effective focal length of the telescope and consequently the scale of the image on the plate. Because the main effect that limits the definition is the unsteadiness of the image caused by turbulence in the earth's atmosphere, it is customary to take large numbers of exposures in the hope that some will be taken during short moments of "good seeing." After the films have been developed the best images are selected for further study; it is even possible to make a composite print from several different negatives of the same planet to average out the fictitious details caused on a single picture by the earth's atmosphere and by flaws in the film. Experience has shown that, except on a very few superbly steady nights, a telescope of 20- to 40-in. aperture is the best for this type of photography. A larger telescope looks through a greater volume of the earth's atmosphere and is therefore more likely to be affected by unsteadiness of the air.

Photography has made it possible to map the moon in detail and to study, particularly by comparing photographs taken in light of different colours, the surfaces and atmospheres of the planets (*see* VENUS; MARS; JUPITER).

3. Artificial Satellites.—In Oct. 1957 the U.S.S.R. launched the first artificial earth satellite, and a new subject for celestial photography was created. The first Russian sputniks were large and bright enough for many amateur astronomers and photographers to obtain pictures of their paths across the sky with simple terrestrial cameras. Many scientific problems can be solved by obtaining precise positions of artificial satellites. The United States put into operation a network of 12 cameras specially designed for tracking satellites. These Baker-Nunn cameras are modifications of the Schmidt camera, equipped with a complicated three-component corrector lens and a spherical mirror. The cameras have a focal length of 20 in., work at a focal ratio of *f*/1 and have a field of good definition 30° in diameter. They use roll film, and a single exposure photographs an area 5° wide and 30° long; inside the telescope is an illuminated precision clock, which gives the exact time of the observation. The telescopes have specially designed mountings that make it possible for them to track alternately on the orbital motion of the satellite and on the diurnal motion of the stars. In this way the image of even a faint satellite can be recorded during one phase of the exposure, and the images of faint stars near it in the sky during the other phase. By measurements of the developed film accurate positions of the satellite can be obtained. A precision of about one second of arc has been obtained with these cameras, the limiting factor being the difficulty of determining the precise time (an accuracy of better than 0.001 sec. is required) at remote points on the earth.

4. Meteors.—Meteors or "shooting stars" are solid bodies, ranging in size from small grains to rocks as big as a house, which are heated to incandescence as they plunge through the earth's atmosphere. There is no way of predicting when or where they will appear and they burn out so quickly that once seen it is too late to turn a camera to them. Therefore it is only by accident that a telescope being used for another purpose will occasionally record a meteor trail. For serious scientific work on these objects it is necessary to patrol continuously a large area of sky with very efficient cameras in order to record the meteors down to as faint a limit as possible. The most effective cameras employed to this end are the so-called "Super-Schmidts," designed by James G.

Baker for the Harvard observatory. Each of these cameras has a four-element corrector together with a spherical mirror and may be described as a complicated combination of a Bouwers-Maksutov and an achromatized Schmidt camera. Four of these cameras were constructed, each with an aperture of 12 in. and a focal ratio $f/0.67$ and each with a field of good definition 52° in diameter. The focal surface is curved too steeply for ordinary film to be bent to fit it, so the cameras use special hemispherically molded films. After development these curved films are copied photographically onto flat glass plates for measurement and storage. The Super-Schmidt cameras contain electrically driven rotating shutters, which interrupt a meteor trail at accurately known time intervals, and thus make possible a measurement of a meteor's angular speed through the sky. The cameras are operated in pairs, separated by distances of 50 to 100 mi. so that the height and space velocity of any meteor photographed from both stations can be determined by measuring its apparent shift with respect to the background stars.

5. Aurorae.—The aurora borealis, or northern lights, is one of the most impressive sights offered by the night sky. Although many successful pictures of individual parts of an auroral display have been taken with hand cameras, the whole phenomenon is so vast that a camera covering nearly the whole sky is needed for a complete photograph. The Greenstein-Henyey camera, which photographs a field 140° in diameter on one exposure, has proved ideal for this work. One of these cameras fitted with a motion-picture attachment was used by A. B. Meinel and his co-workers at the Yerkes observatory to photograph the changes in form and structure of typical aurorae. (D. E. O.)

6. Charts of the Heavens.—The advantage that photographs of clusters and nebulae have over visual observation is obvious. A glance at a photograph shows the whole of the object in all its beauty. The field of view of a telescope is small and a complete conception of the nebula has to be built up from successive elements. It has always been mentioned that Gill foresaw the possibility of recording the positions of stars from a single plate; the next step was to connect individual plates to make a complete survey of the heavens, as had been—and is—the final aim and purpose of transit observing. The first effort in this direction was made by Gill, who (1885–89) took photographs covering the sky from the south pole to declination 18° S. which, measured by Jacobus C. Kapteyn of Groningen, gave approximate coordinates and magnitudes of nearly 500,000 stars that form the *Cape Photographic Durchmusterung.* In a more ambitious scheme initiated in 1887 by Amédée Mouchez, director of the Paris observatory, 18 observatories of the world combined to make the *Astrographic Chart,* or a picture of the whole sky which should show all stars down to the 14th magnitude, to which was added later a catalogue of all stars to the 11th magnitude. By 1958 the catalogue was substantially complete but the chart covered only approximately 50% of the sky. In this connection mention should be made of a series of plates that came later, taken by Franklin Adams in 1903–04 at the Cape of Good Hope and in 1909–10 at Godalming, Surrey, Eng., with a photovisual objective of 10-in. diameter. Two hundred and six of these plates, each covering an area of $15° \times 15°$, chart the whole sky to the 16th magnitude.

The extreme delicacy of the gelatin film, especially during development and fixation, led in the beginning to a certain distrust of measurements made on photographic plates. Experience showed these fears to be groundless and photographic methods to be well suited to measurements of the most exacting kind. With properly designed instruments the economic factors are also favourable. An undertaking which effectively utilized these advantages was the reobservation by photography of the zones of the great Astronomische Gesellschaft (A.G.) catalogue, in which the positions of stars to the 9th magnitude were originally measured with meridian circles at many different observatories. In 1913 Frank Schlesinger initiated at the Allegheny observatory, Pittsburgh, Pa., a program of observations with a wide-angle lens which proved to yield accurate star places over a plate 5 square degrees (sq.deg.). Although successful results were obtained with the 25-sq.deg. field, the frequent difficulty of not having enough bright reference stars for plate reductions led Schlesinger at the Yale University observatory in 1927–28 to employ a specially designed 5-in., $f/14$ Ross lens that covered a field of 140 sq.deg. Other workers soon adopted the photographic method and by 1938 the northern A.G. zones had been completely reobserved by Yale and a number of European observatories.

The most ambitious project of charting the sky was the National Geographic society-Palomar observatory sky survey, made with the 48-in. Schmidt telescope during the years 1949–1956. The whole sky north of declination 27° S. was divided into fields approximately 40 sq.deg., and two photographs of each field were taken, one in blue light and one in red, for a total of almost 1,800 photographs. These photographs show stars as faint as the 20th magnitude and permit estimates of the stars' brightness and colour to be made. The band of wave lengths used for the red exposures was so selected that the diffuse nebulae had several emission lines, and therefore appeared very bright. The sky survey provided an unusually complete record of stars and nebulae, which proved invaluable in many statistical and research programs.

The proper motions of stars can be measured by wholesale photographic methods, the most direct method being to photograph a star field at two different times, separated by several years, with the same telescope. Then if the two photographs are compared, the fastest moving stars can be identified as those whose two images are displaced by the greatest amount, while the majority of stars that move more slowly have nearly coincident images. This method of finding stars with large proper motions was pioneered by Max Wolf in Germany and by F. E. Ross in the United States. Furthermore the proper motion of every star on the pair of photographs can be measured in this way if there are some reference objects on it with known motions. Such a proper-motion survey was undertaken at the Lick observatory with a specially designed 20-in. refractor. The extragalactic nebulae, which are so far away that their apparent motions are very small, served as the reference objects. The whole northern sky was photographed for the purposes of this survey during the period 1948–56; a second series were to be taken about 25 years later.

As an early example of astronomical work made practicable by the measurement of photographs, mention may be made of the determination of stellar parallaxes by Charles Pritchard at the Oxford University observatory in the year 1887. Most researches that depend on the measurement of small distances are now made by means of the photographic plate, though close double-star measurement is an exception. E. Hertzsprung devised methods involving the use of a grating and colour filters to ensure freedom from error in finding the distance between the components of double stars and their position angles, but it is considered that the photographic method is unsuited for pairs whose separation is less than about a second of arc.

In addition to the advantages already mentioned, others that pertain to the sensitive plate are that its receptivity is cumulative; by continued application it can see where the eye is blind. The impressions are permanent and constitute a record that can be measured and consulted at will. Faint comets, for example, are discovered by photographing the region in which the object is believed to lie and searching the developed plate. In this manner 6 of the 11 satellites of Jupiter and 1 of the 9 satellites of Saturn were discovered; satellites X and XI of Jupiter are so small that they were found only with the 100-in. Mt. Wilson reflector by S. B. Nicholson in 1938. A similar method for finding minor planets has been very fruitful, and examination of the series of celestial photographs of the Harvard College observatory has brought to light many novae that have appeared in past years but which were not detected visually at the time of their appearance. This great collection of photographs that was accumulated systematically over many years constitutes a record of the state of the sky at approximately regular intervals. It was especially fruitful for the discovery of variable stars and for the determination of their light curves. *See* also references under "Photography, Celestial" in the Index.

See E. W. H. Selwyn, *Photography in Astronomy* (1950); G. Z. Dimitroff and J. G. Baker, *Telescopes and Accessories* (1945).

(N. U. M.; D. E. O.)

PHOTOGRAPHY, SPARK, a technique that derives its name from the type of illumination employed for the photograph, utilizes the light produced by a small electric spark of extremely short duration and great intensity. This technique should not be confused with the electronic flash ordinarily used for photography.

The spark method finds many applications in the photography of rapidly moving objects; for example, the earliest known spark photograph was an ordinary snapshot of a newspaper clipping fastened to the surface of a rapidly spinning disk. The size of the spark is so small that it can be used to project a silhouette directly on the photographic film, and, in ordinary practice, the conventional camera lens is not required.

The spark itself is generated by the discharge of a high-voltage capacitor across a gap between two electrodes. The circuit consists of the condenser, the main gap, and a trigger gap formed by a third electrode placed between the two main electrodes. Electrical energy is slowly stored in the condenser over a relatively long period of time, since the spacing of the electrodes is wide

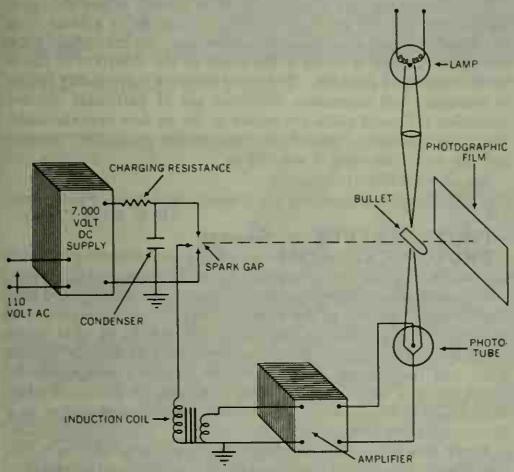


FIG. 1.—SCHEMATIC WIRING DIAGRAM OF SPARK PHOTOGRAPHY APPARATUS

enough to hold the voltage, and is discharged with sudden violence through the main gap at the instant the circuit is effectively completed by sparking the trigger gap (*see* CAPACITOR).

The gap and condenser are designed to produce the most brilliant flash of light possible in the shortest time. By grouping the elements of the condenser in a ring around the gap so that the discharge of electricity takes place in a concentric path, the duration of the spark can be shortened to 10^{-7} seconds and good exposure obtained at spark to photographic plate distances of 4 to 10 ft. with an operating capacitance of 0.1 microfarad and potential of 7,000 v.

Fortunately, the light from the spark is rich in ultraviolet radiation and its photographic effectiveness is thereby increased in taking direct spark shadowgraphs. More brilliant sparks can be obtained for other applications by increasing capacitance and voltage, but the duration of the light is also increased, approaching several microseconds in extreme cases.

Firing the spark at the desired time during the brief period the moving object is in front of the plate is usually the most difficult feature of this photographic system, and many ingenious methods of triggering have been developed. This operation must be extremely precise; a tolerance of 10^{-5} seconds is common, and fast electronic circuits are required. The particular method chosen depends on the application, but ordinarily some property of the object itself starts the trigger operation. The simplest of all methods is the make-or-break contact. If the object is ferromagnetic, a magnetic trigger can be used; if it can be charged to a high potential, an electrostatic trigger is suitable; if the geometry of its motion can be arranged so that it cuts the path of a beam of light, a photoelectric trigger gives good results; or, if the object is traveling faster than the speed of sound, a sonic trigger will work.

The overall operation is conveniently illustrated by tracing through the sequence of events involved in taking the spark photograph of a bullet in flight using the apparatus shown in fig. 1. The room is darkened, the photographic plate put in position, and the gun is fired. Since a photoelectric trigger is used, the gun is aimed so that the trajectory intersects the beam of light from the lamp to the phototube. As the bullet interrupts this beam, it changes the amount of light falling on the phototube and thereby generates a voltage pulse in the electronic circuit. This pulse is amplified and used to fire a gas discharge tube in the output of the amplifier. The discharge tube in turn sends a surge of current through the primary of an induction coil, and the high voltage surge resulting in the secondary is applied to the electrode of the trigger gap, producing a weak spark across this gap. The trigger spark ionizes the air in the main gap, causing it to break down, the condenser discharges through the main gap, and the spark photograph is taken. The duration of the light is sufficiently short to produce clear photographs of even the fastest projectiles.

Applications to Ballistics.—Spark photography is of great value to the ballistics (*q.v.*) engineer, enabling him to answer many questions on the flight of bullets and the flow of the air about them. Such problems as that of determining the distance from the muzzle at which the velocity of the erupting gas becomes less than that of the bullet are readily solved. It is of particular interest in the case of shot shells where the disposition of the shot and wads may be easily observed. Work of this nature led to the commercial development of shot shells without the top card wad over the shot, for it was observed by spark photography that this wad interfered with the proper flight of the shot.

Aerodynamics Range.—As the projectile flies from gun to target, it undergoes violent resistive forces because of its high-velocity motion through the air, and if the flight path is to be computed, these forces must be measured. Here spark photography gives the ballistician a tool of great precision in the so-called aerodynamics range. The projectile is fired into a long, enclosed gallery containing from 10 to 25 spark-photography stations spaced at intervals along its length. As the projectile passes each station in turn, two spark pictures are taken in perpendicular planes (one horizontal, say, and the other vertical) and the time of the event is recorded on a high-speed chronograph.

Thus, each pair of spark photographs records the position of the projectile at a measured time, and all of the records can be combined to determine the retardation of the projectile's motion and the aerodynamic drag. The inclination of the projectile's axis to its direction of motion can also be measured from each pair of pictures, and from these measurements the projectile's stability can be computed (*see* CHRONOGRAPH: *Velocity Chronographs*).

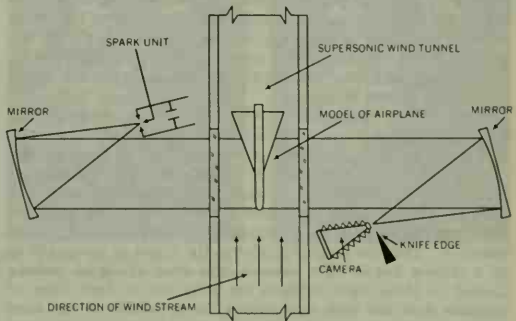


FIG. 2.—SCHEMATIC DIAGRAM OF SCHLIEREN OPTICAL SYSTEM FOR PHOTOGRAPHING FLOW OVER MODEL OF AIRPLANE IN SUPERSONIC WIND TUNNEL

BY COURTESY OF (LEFT) BALLISTIC RESEARCH LABORATORIES, ABERDEEN PROVING GROUND, U.S. ARMY. (CENTRE, TOP AND BOTTOM RIGHT) THE REMINGTON ARMS COMPANY, INC.

EXAMPLES OF SPARK PHOTOGRAPHY

(Left) Sound-wave pattern created by smooth projectile traveling at three times the speed of sound; (centre) disposition of 12-gauge shot and wads at 3½ ft. from muzzle of skeet-bored gun; (top right) 12-gauge shot being released from plastic wad and shot protective device at 18 in. from muzzle; (bottom right) 12-gauge shot with plastic wad fired from full-choke bored gun used in trapshooting

Applications to Physics.—Many processes of physics not only take place with extreme rapidity, such as the flight of bullets, but also require special optical apparatus in order to be recorded in a useful manner. For example, the flow of air over an airplane in a supersonic wind tunnel (*q.v.*) is invisible to the naked eye but can be seen clearly if viewed through the particular combination of light sources, mirrors, and lenses known as a Schlieren system. Near the speed of sound the flow over the airplane becomes unsteady and changes violently from one instant to the next. Waves sweep back and forth over the wings at high speed, and the exposure must be as brief as in ballistic photography if the details of the flow processes are to be recorded clearly.

Spark photography furnishes the key to the instrumentation by providing a light source having both a short duration and the very small size required by optical systems. Its use in a Schlieren system is shown in fig. 2. All of the light from the spark is brought to a focus at the knife edge, and the lateral dimension of the spark must be limited to a small value, ranging from 0.01 in. in small Schlieren systems to 0.1 in. in large. If a limited number of photographs are to be taken in rapid succession, several sparks placed side by side may be used in a Schlieren system with small orifices replacing the knife edges, each orifice being located at the conjugate focus of one of the sparks. Rates of up to 1,000,000 pictures per second have been obtained (*see* AERODYNAMICS).

Other processes in physics require the photography of high-speed objects which are brightly luminous themselves, such as a rocket with a burning jet of exhaust gases or a very high-speed missile that glows like a meteor as it streaks through the air. The light from these objects would fog the film of a direct shadowgraph or obscure the image of a microflash photograph. Again, a spark light source can be combined with an optical system to provide a suitable means of photography. In one system, the spark casts a shadow of the object on a motion-picture screen rather than on a photographic film directly. The screen is photographed by a camera placed adjacent to the spark but to one side so that the images of the object itself and its shadow on the screen are displaced from one another on the camera's plate. In this way, the light from the object is separated from the shadow on the movie screen and does not impair the silhouette of the object seen in the spark photograph.

Shock Wave Phenomena.—One of the most spectacular examples of spark photography shows shadows produced by compression waves in the air. These waves are seen as lines, usually curved, with a dark front edge and a light rear edge. Strong compression waves, known as shock waves, have fronts that amount to surfaces of very small thickness through which the pressure, density, temperature, and, consequently, index of refraction change violently. They are roughly similar to the fronts of waves rolling up a shallow beach. The rays of light from the spark passing tangent to these wave surfaces are refracted to form lines of alternate dark and light representing the projection of the wave surfaces on the photograph. The technique is very sensitive and wave patterns are recorded in fine detail.

Shock waves are produced in air by any disturbance that is sufficiently strong and abrupt. Electric sparks, explosives, projectiles and aircraft traveling at speeds close to or greater than the speed of sound all generate shock waves. An example of pure wave photography is found in the study of the reflection of shock waves from solid surfaces. The wave patterns surrounding bodies at transonic and supersonic velocities are of particular interest since they tell much about the nature of the air flow over the body. Even the turbulent layer of air next to the projectile's surface and the wake following it are visible.

See also PHOTOGRAPHY.

See W. G. Hyzer, *Engineering and Scientific High-Speed Photography* (1962). (R. E. E.; A. C. Cs.)

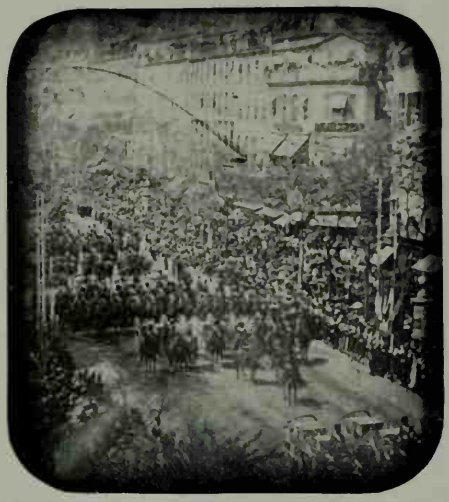
PHOTOGRAVURE: *see* GRAVURE.

PHOTOJOURNALISM is a form of news reporting in which the principal means of communication is the photographic image, usually with a written or spoken explanation to amplify and give clarity and coherence to the visual statement. The simplest and the most common form of this visual presentation of news is the single news photograph. More complex forms include the picture story and the picture essay, in which related photographs are combined in a single graphic unit. The rise of television after World War II increased the importance of the motion picture as a photojournalistic tool.

Early History.—The development of printed photojournalism was dependent upon the inventions of photography and of a method of reproducing the photographic image on the printed page. A French inventor, Joseph Nicéphore Niepce, by 1826 had achieved limited success in developing both. For a time thereafter photography developed more rapidly than photoengraving; until late in the 19th century woodcuts, steel engravings, etc., redrawn by artists from photographs, were the only means available for reproducing photographs on the standard printing press. One of the first public events to be photographed was a great fire in Hamburg, Ger., in 1842, recorded on daguerreotypes by Hermann Biow and C. F. Stelzner. Ironically, the *Illustrated London News*, forerunner of the modern illustrated press, in its first issue (May 14, 1842) published reproductions of an artist's conception of Hamburg in flames. In 1855 the English photographer Roger Fenton issued 360 photographs of the Crimean War made by the wet collodion process. Woodcuts copied from a few of these photographs were reproduced in the *Illustrated London News*. During the American Civil War, Mathew B. Brady (*q.v.*) organized photographic documentation teams which covered practically every major battle and took more than 7,000 photographs. Although a few of these appeared in woodcut form in *Harper's Weekly* (founded in 1857), Brady sold few of the photographs and died penniless. Most of his war photographs are included in the *Photographic History of the Civil War*, ten volumes (1911). Alexander Gardner, originally on Brady's staff, published in 1865 two albums entitled *Gardner's Photographic Sketch Book of the War*, containing a total of 100 original prints from negatives taken by himself, T. H. O'Sullivan, and others.

By 1880 the much faster gelatine dry plate replaced collodion wet plates, eliminating the need of taking a darkroom to the

The first news photograph, a view of the charred waterfront of Hamburg after the great fire of 1842. Daguerreotype by C. F. Stelzner



Troops of Napoleon III marching through Paris on their return from the Italian front; a rare daguerreotype taken by an unknown photographer about 1858

The first newspaper reproduction of a photograph, "A Scene in Shantytown." It appeared in the *New York Daily Graphic*, March 4, 1880

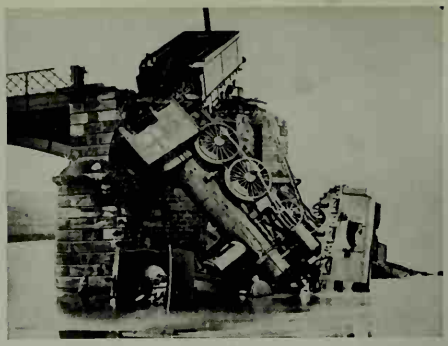
THE BEGINNINGS OF PHOTOJOURNALISM

Four pictures from the first photo interview, 1886. French physicist Marie Eugène Chevreul (left) is interviewed on the eve of his 100th birthday by the photographer Paul Nadar

BY COURTESY OF (TOP LEFT) MUSEUM FÜR HAMBURGISCHE GESCHICHTE, BILDARCHIV, (TOP RIGHT, CENTRE LEFT, BOTTOM) GEORGE EASTMAN HOUSE

PHOTOJOURNALISM

Members of the Paris Commune pose beside the fallen Vendôme Column, May 16, 1871. This photograph, taken by an unknown photographer, led to the punishment of those responsible, including the artist, Gustave Courbet (ninth from right, in back row) who was forced into exile



Wrecked German troop train near Mézières, France, taken by an unknown photographer in 1870 during the Franco-German War

EARLY WAR PHOTOGRAPHS

"Field Kitchen of the 8th Hussars," taken in 1855 during the Crimean War by Roger Fenton, one of the first photographers to cover a war under fire

"Home of a Rebel Sharpshooter, Gettysburg," 1863, by Alexander Gardner, one of many photographers who worked under the direction of Mathew B. Brady to record the American Civil War

BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE RIGHT) THE GERNSHEIM COLLECTION, (BOTTOM) THE LIBRARY OF CONGRESS

Crowds watching the great fire that followed the San Francisco earthquake of 1906, by Arnold Genthe, a portrait photographer and pioneer social realist

The attempted assassination of William Gaynor, mayor of New York City, aboard the docked liner "Kaiser Wilhelm," Aug. 9, 1910; photographed by William Warnecke of the *New York World-Telegram*. A recently discharged city employee shot and seriously wounded the mayor, who eventually recovered

"Breaker Boys Inside the Coal Breaker," about 1909, one of many pictures by Lewis W. Hine which helped arouse public indignation against the practice of child labour

EARLY DOCUMENTARY PHOTOGRAPHS

"Bandits' Roost, 59½ Mulberry Street," 1888, by Jacob A. Riis, a police reporter and author who crusaded against slums and sweatshops in New York City

BY COURTESY OF (TOP) THE ART INSTITUTE OF CHICAGO, PEABODY PHOTOGRAPHY PURCHASE FUND, PRINT BY ANSEL ADAMS, (LEFT CENTRE) THE "NEW YORK WORLD-TELEGRAM AND THE SUN," (CENTRE RIGHT) GEORGE EASTMAN HOUSE, (BOTTOM RIGHT) THE JACOB A. RIIS COLLECTION, MUSEUM OF THE CITY OF NEW YORK

PHOTOJOURNALISM

The coffin of Sir Winston Churchill being carried down the steps of St. Paul's Cathedral, London, Jan. 30, 1965. By Ralph Crane

Skier soaring above Innsbruck, Aus., at the IX Winter Olympic Games, 1964. By Ralph Crane

Dead and captured Viet Cong guerrillas, South Vietnam, 1963. By Larry Burrows

PHOTOGRAPHS, (TOP LEFT) RALPH CRANE, "LIFE," © 1965, TIME INC., (TOP RIGHT) RALPH CRANE, "LIFE," © 1964, TIME INC., (BOTTOM) LARRY BURROWS, "LIFE," © 1963, TIME INC.

A camel caravan passing the crumbling walls of Balkh, once the capital of Bactria under Alexander the Great, in north Afghanistan. One of a series of pictures, taken by James Burke in 1963, which traced the campaigns of Alexander

COLOUR IN PHOTOJOURNALISM

Colour photojournalism came into its own during the 1950s and 1960s. Before then, colour photographs were widely considered too expensive to print, too inaccurate in rendering natural colour; colour film was too "slow" for most action photography. But new films and new printing techniques remedied that, for the most part. The new "fast" film and new techniques for rapid printing especially helped colour news photography (plate VI) as distinct from colour photography used in picture essays. Thus, the photograph of Sir Winston Churchill's funeral on plate VI, which would once have taken weeks to reproduce, appeared in an American magazine within 48 hours, along with 19 additional pages of colour devoted to the funeral. Colour also played an important part in the development of the picture essay, adding a new realism to longer journalistic treatments of topics, ranging, even on this page, from Afghanistan to zoology

A laser beam burning a tiny scar into the eye of a rabbit in an attempt to replace a detached retina without surgery. From an essey by Fritz Goro on lasers

A leaping humpbacked whale, from an essay on whales by John Dominis, 1963

Three U.S. F-86D jets flying at 35,000 ft. From an essay on jet flight by Howard Sochurek, 1956

PHOTOGRAPHS, (TOP) JAMES BURKE, "LIFE," © 1963, TIME INC., (CENTRE RIGHT) FRITZ GORO, "LIFE" © 1963, TIME INC., (BOTTOM LEFT) JOHN DOMINIS, "LIFE," © 1963, TIME INC., (BOTTOM RIGHT) HOWARD SOCHUREK, "LIFE," © 1956, TIME INC.

PHOTOJOURNALISM

U.S. soldier killed by a sniper during the last hours of World War II, May 7, 1945. Photographed by Robert Capa

Guardia Civil, by W. Eugene Smith, from a picture essay entitled "Spanish Village," 1951

Inmates of the Buchenwald Concentration Camp, 1945, by Margaret Bourke-White

PHOTOGRAPHS: (TOP LEFT) ROBERT CAPA—MAGNUM, (TOP RIGHT) W. EUGENE SMITH, "LIFE," © 1952, TIME INC., (BOTTOM) MARGARET BOURKE-WHITE, "LIFE," © 1945, TIME INC.

scene of action. As a press camera, a hand camera fitted with a focal plane shutter, used at eye level and taking 9 x 12 cm. or 4 x 5 in. negatives, was favoured. Flash powder (1886) and later flashbulbs (1929) and electronic flash (1937) were used for artificial illumination.

Though technology had opened the way for the practical and economical use of photographs in print, daily newspapers were slow to accept the new medium.

On March 4, 1880, the *New York Daily Graphic* printed the first newspaper reproduction that retained to some degree the range of intermediate gray tones of the photograph. This experimental photoengraving was made with a crude halftone screen devised by Stephen H. Horgan. In 1882 Georg Meisenbach patented a single-line screen which was turned 90° halfway through the exposure, resulting in crosslines. Later, Frederic E. Ives and others developed the more practical crossline halftone screen, which by 1893 was perfected by Max and Louis Levy into the screening method still in common use. In 1897 Horgan, who had moved to the *New York Tribune,* was successful in printing a halftone on a high-speed press. (*See* also PHOTOENGRAVING.)

Monthly magazines, both in England and the U.S., were much quicker in adapting themselves, and photographically illustrated articles became a regular feature from the mid-1880's onward. Most newspapers first regularly printed halftones in the Sunday supplements, sections added by the *New York Times* in 1896 and by the *New York Tribune* and the *Chicago Tribune* in 1897. In October 1912 the *Illustrated London News* became the first periodical to publish an integrated picture and text section of eight pages printed by rotogravure, the rotary intaglio printing process invented in 1890 by Karl Klic of Vienna (*see* GRAVURE). The *New York Times Sunday Magazine*, printed by rotogravure from 1914, started a trend toward "roto" sections in U.S. newspapers. The *Illustrated American* started publication in 1890 specifically to develop magazine photography, but then devoted progressively less and less space to photographs. The *New York Times' Mid-Week Pictorial* (1914) followed the same pattern; at first it filled its pages with photographs of World War I, but by the end of the war feature articles occupied much of the magazine.

During this period photojournalism was conceived of as a single picture or a group of single pictures. Although sets of pictures had appeared, such as the series on the scientist Marie Eugène Chevreul photographed on the eve of his 100th birthday by Paul Nadar and published in the French weekly *Le Journal Illustré* in 1886, sequences of pictures working together did not become a feature of the illustrated press until the late 1920s.

Photojournalism and the Sensational Press.—In U.S. newspaper publishing in the latter part of the 19th century, illustrations became weapons in the competition for readers, and a lavish use of pictures emerged as one of the identifying characteristics of "yellow journalism." The use of "fake" photographs, altered by art work and other means, was widespread. It is doubtful if this kind of falsification was attempted in Europe.

An English tabloid, the *London Daily Mirror*, in January 1904 became the first newspaper to be illustrated exclusively with photographs. Impressed with the success of the *Daily Mirror*, Joseph Medill Patterson started the *Illustrated Daily News* (later the *Daily News*) in New York on June 26, 1919. Using many photographs and terse news stories, the *Daily News* by 1924 had the largest daily circulation in the United States. Photographs of murders and scandals received extravagant display in the 1920s as several new tabloids challenged the circulation leadership of the *Daily News*.

After the massive coverage given the 1935 trial of Bruno Hauptmann, convicted of kidnapping and murdering the infant son of Charles A. Lindbergh (*q.v.*), the press was accused of "trial by newspaper." As a result, the American Bar Association in 1937 adopted Canon 35 to encourage the judiciary not to permit cameras in courtrooms. Although the National Press Photographers Association, a professional organization formed in 1947, fought for the canon's repeal, all federal courts and most state courts continued to bar photographers. Despite the prohibition of photography in British and German lawcourts, Arthur Barrett in 1908 took sensational pictures of suffragette leaders in a London court with a camera hidden in his top hat; a similar news "scoop" was achieved by Erich Salomon at a murder trial in Berlin in 1928 with a camera in a briefcase.

Documentary Photojournalism.—Long before photography was exploited by the tabloids it was used for straightforward documentation. The first photographic social reportage was made by a Scottish photographer, John Thomson, in 1876 and published the following year under the title *Street Life in London.* The publication consists of 37 photographs and articles by Thomson and a journalist, Adolphe Smith, describing the living and working conditions of the subjects photographed. Previous to this, between 1868 and 1877, Thomas Annan made a photographic documentation of Glasgow slums to be demolished, and a number of his pictures show the slum dwellers themselves, rather in the style of Jacob Riis's photographs. Riis, a reporter for the *New York Evening Sun*, was the earliest to use photojournalism for social reform in the United States, from 1887 onward. Artists' drawings from his photographs of the New York slums appeared in the *Sun* and in his books—*How the Other Half Lives* (1890) and others. Another early reformer, Lewis W. Hine, directed his camera toward child labour and other social problems of the early 20th century.

A later example of documentary photojournalism was the Farm Security Administration's photographs of rural America during the depression years of the 1930s. A group of the nation's outstanding photographers, including Walker Evans, Arthur Rothstein, Gordon Parks, Carl Mydans, and Dorothea Lange, working under Roy E. Stryker, amassed a photographic record of more than 200,000 negatives, which were widely reproduced in newspapers, magazines, and books.

Candid Photography and Picture Magazines.—The production of new designs of small plate and miniature cameras in Germany in the mid-1920s, and the simultaneous trend toward stark realism in photography and movies gave rise to a new kind of photography—a preoccupation with human situations. Already in the early 1890s the London photographer Paul Martin operated unobtrusively with a small hand camera hidden in an attaché case and caused a sensation with his candid snapshots, but lack of an illustrated press to disseminate Martin's pictures caused his pioneer work to be forgotten.

The leaders in the revival of the "candid" approach were Germans, particularly Erich Salomon, Felix H. Man, and Wolfgang Weber. Salomon astonished the world with his candid snapshots of statesmen and other celebrities in unguarded moments, especially at international political conferences. He worked chiefly in single pictures for the *Berliner Illustrirte Zeitung* from 1928 onward using, until 1932, the small Ermanox plate camera. Another influential figure was Henri Cartier-Bresson, a French photographer who started using a Leica in 1932.

The pioneer of the picture story of a series of related photographs of a general event was Felix H. Man. In 1929 he made the first nocturnal photo-reportage, in Berlin, and in the same year photographed for the first time conductors, musicians, etc., during performances by available light—also using an Ermanox camera. Another innovation developed by Man was the intimate picture series of famous personalities, beginning with "A Day with Mussolini," published in the *Münchner Illustrierte Presse* in 1931. The same magazine in February 1929 had published the first reportage of Wolfgang Weber, on the New York traffic problem.

Stefan Lorant, Berlin editor of the *Münchner Illustrierte Presse* and from 1930 its brilliant editor-in-chief, was the main force behind the rapid rise of the new photojournalism. He laid down the axiom that the camera should be used like the notebook of a trained reporter to record events as they occur, without trying to stop them to arrange a picture. This trend in the course of a few years transformed the German illustrated weekly magazines, of which there existed in 1930 no fewer than thirteen. Also very influential was the House of Ullstein, in Berlin, which published the *Berliner Illustrirte Zeitung, Die Dame*, and a number of other magazines.

Dephot (Deutsche Photodienst), an agency founded in Berlin in 1929 by Alfred Marx and Simon Gutman, was until 1932 the leading enterprise in the sphere of photojournalism in Germany. Its two principal photographers were Man and Umbo, and they were joined in 1930 by Kurt Hübschmann (later Hutton). Alfred Eisenstaedt, chief photographer of the Associated Press in Berlin, adopted the reportage style and other agencies gradually followed suit. Three Dephot-trained Hungarian photographers, Robert Capa and H. and Ina Bandi, transplanted the new style to Paris, where they settled in 1933.

It was introduced in Great Britain by Man and Kurt Hutton when Stefan Lorant founded *Weekly Illustrated* in 1934, and in the United States when Henry R. Luce founded *Life* magazine in November 1936, with Alfred Eisenstaedt as staff photographer. Only a few weeks later (January 1937) *Look* magazine, founded by John and Gardner Cowles, Jr., began publication. Numerous others—*Focus, Pic, Click, Foto,* etc.—appeared subsequently in the United States but none matched the successes of *Life* and *Look*. In 1938 the British *Picture Post* was founded by Edward Hulton, with Lorant as editor and Man as chief photographer until 1945. In 1949 the French publisher Jean Prouvost founded *Paris-Match,* which in the 1960s remained the largest-selling and most-esteemed picture magazine in Europe, where such publications were proliferating. The vast majority of the European picture weeklies in the 1960s were sensation-seekers. Good photojournalism and fine photographs were to be found in the monthly magazines such as *Du, Réalités, Magnum,* and *Holiday.*

The picture magazines made photojournalism teamwork between photographers and reporters, but picture selection, cropping, and layout play an important role in presentation. Wilson Hicks, a former executive editor of *Life,* stated that the fusion of words and pictures performs a more effective function than either could perform alone. The picture magazines also developed the photo essay, in which the photographer, through his photographs, comments on his subject as well as reports it. A classic example is W. Eugene Smith's "Spanish Village," published in *Life* on April 9, 1951.

During World War II both sides put photographers into battledress to record the massive conflict from the first German breakthrough in Europe to the great Hiroshima denouement. Goebbels used the picture-documentary to great effect in *Signal,* a powerful propaganda picture-paper which found its way into all the neutral countries, to spread the news of German conquests. In Britain each of the three armed services raided Fleet Street and the provincial press for their liveliest cameramen, who produced some of the most memorable photographs to come out of the war. To assure adequate coverage of all fronts, the United States Wartime Photographic Pool was organized, with photographers from the U.S. armed forces, Associated Press, Reuters, and other agencies as well as illustrated weeklies. Outstanding combat photographers included Robert Capa, W. Eugene Smith, Margaret Bourke-White, and Bert Hardy and David Douglas Duncan, who later covered the Korean War for *Picture Post* and *Life,* respectively.

During the 1950s newspapers started a trend toward the use of photojournalistic approach pioneered by the periodicals. The "press camera" was gradually replaced by smaller twin-lens reflex and 35-mm. cameras, whose fast lenses combined with fast films made "available light" photography possible. Use of colour reproductions increased, with a few newspapers printing colour news pictures on a daily basis. The Polaroid process, photo-offset printing, and electronic engraving machines became popular, especially among the smaller newspapers. Picture stories and essays appeared frequently in such outstanding newspapers as the *New York Herald Tribune, Louisville* (Ky.) *Courier-Journal, Milwaukee* (Wis.) *Journal,* and *Charlotte* (N.C.) *Observer.*

Syndicates and Agencies.—Most news publications depend upon photo syndicates and agencies to supply national and international picture coverage. The first successful United States syndicates were International News Photos and New York Times' Wide World Photos (sold to the Associated Press in 1941). Both appeared in 1919. They were followed by Acme News Pictures in 1923 and Associated Press Newsphotos in 1927. Obtaining news and feature pictures from staff photographers, member newspapers, and "stringers" (independent photographers who sell single news photos to the Syndicate as occasion arises), the syndicates distributed photographic prints and reproductions in matrix form to subscribers.

The scope and speed of the syndicates' coverage was increased by the transmission of pictures by telephone wire, cable, and radio in the 1930s. The AP Wirephoto network, which began with 40 members in 1935, by 1964 had grown to about 700 U.S. members and was serving about 100 countries. Phototelegraphy networks were also started by Wide World, Acme, and International. After a series of mergers Acme and International became United Press International in 1958. The introduction of "facsimile" receivers in the 1950s automated the reception of the phototelegraphy signal, and made wire picture service economically feasible for smaller newspapers. The two major services, AP and UPI, transmitted three-colour separation prints on many major news stories and in 1963 transmitted photographs between the United States and Europe via the Telstar II Satellite.

Picture agencies were established to serve as intermediaries between freelance magazine photographers and their markets. In 1947 Henri Cartier-Bresson, David Seymour, Robert Capa, and George Rodger founded Magnum Photos, a cooperative agency similar to Dephot (Deutsche Photodienst) to handle the photographs of a group of the world's outstanding photojournalists. Other important agencies included Black Star, Pix, Globe, Camera Press, and Rapho Guillumette.

Motion Pictures.—From about 1900 motion pictures were a part of photojournalism. Shortly after the introduction of the movie camera in 1895 it was used in covering the Spanish-American War and the Boer War and such public functions as Queen Victoria's Diamond Jubilee (1897). Soon companies were organized to produce short newsreel films which were originally shown—interspersed between other entertainment—in music halls. With the establishment of motion picture theatres, the newsreels were released twice a week, and most theatres presented them along with feature-length films, although a few theatres specialized in newsreels.

The newsreels usually consisted of "feature" news and did not compete with the printed media for complete news coverage. The documentary approach of "dramatizing" news events was used in the "March of Time" films, a monthly series started by Time, Inc., in 1935. During World War II this technique was used in documentary films and is now adapted for television. Vast newsreel coverage of World War II brought the reality of the overseas battles into the neighbourhood theatres.

After World War II television provided much more complete visual coverage of news than newsreels had attempted. The networks and most stations hired staff photographers to supply film for the daily newscasts and the news documentaries, and news coverage grew to occupy a substantial segment of the telecast day. Of the new motion-picture techniques developed for television, two of the most important were the use of the "close-up" shot to fill the small television screen and of synchronous-speed sound recording on the film to add the natural sounds of the news event to the visual picture.

See also PHOTOGRAPHY; NEWSPAPER; PERIODICAL.

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PHOTOMETRY deals with the calculation and measurement of the characteristics of light and until recently was restricted to visible light. In modern photometry, however, the same methods of measurement are employed for ultraviolet and infrared light.

Photometry includes theoretical photometry (or photometrics) and experimental photometry. Theoretical photometry comprises physical photometrics, which deals with the spectral distribution of light, and its visual effects on people; and geometrical photometrics, which considers the space distribution of light. Experimental photometry treats of apparatus and experimental methods. For a discussion of the applications of photometry to illuminating engineering *see* LIGHTING.

Physical Photometrics.—The early photometrists (1700s) based their work on the idea of light as a separate entity produced by a candle; these crude ideas persisted into the 20th century. Visible light is now understood to be part of the spectrum of electromagnetic radiation, other radiations having longer or shorter wavelengths to which the eye does not respond. Thus the modern approach to photometry is through the physics of radiation (*see* LIGHT).

Electromagnetic radiation includes such phenomena as radio (wireless) waves, infrared, ultraviolet, and X rays, separated into regions on the basis of wavelength. For radiobroadcasting, wavelengths may be expressed in metres (1 m. = 39.37 in.). For visible radiation, the micron, μ = a millionth (10^{-6}) of a metre, is ordinarily employed. Two other units of wavelength are sometimes used for light: the millimicron ($m\mu$) = 10^{-9} metre; the angstrom (Å) = 10^{-10} metre.

The approximate limits of the visible region are 0.4 μ and 0.7 μ, or 400 $m\mu$ and 700 $m\mu$, or 4000 Å and 7000 Å. Radiation at 0.4 μ is normally seen as violet; as wavelength is increased, hue changes through blue, green, yellow, orange, and red. Radiation at 0.7 μ appears deep red, while much beyond 0.7 μ it is invisible (infrared). If radiation is much shorter than 0.4 μ, it is also invisible (ultraviolet).

Radiation in a very narrow band of wavelengths is said to be homogeneous. The yellow light produced by heating common salt in a Bunsen flame is practically homogeneous, as is that from the sodium-vapour lamp used in highway lighting.

Such electric discharge devices as mercury-vapour and neon lamps produce line spectra; *i.e.*, homogeneous radiation is emitted simultaneously at several distinct wavelengths. The set of wavelengths at which energy is emitted is a characteristic of the gas or vapour in which the discharge takes place (*see* SPECTROPHOTOMETRY). A low-pressure mercury-vapour lamp, for example, produces four strong radiations in the visible region: 0.406 μ (violet), 0.435 μ (blue), 0.546 μ (green), and 0.578 μ (yellow). There are additional lines in the ultraviolet and infrared. An incandescent lamp, on the other hand, produces a continuous spectrum; sunlight is also essentially continuous, as are spectra produced by all sources that radiate because of their temperature.

It is often necessary to know not only the wavelength but also the amount of radiation. This amount can be determined by transforming some of the radiant energy into another form, such as heat, and measuring the result. A blackened surface can be placed where the radiation is to be measured. Radiant energy on the surface is converted to heat and the temperature rise is measured; this serves to determine the radiant power incident on the surface (*see* HEAT: *Radiation*).

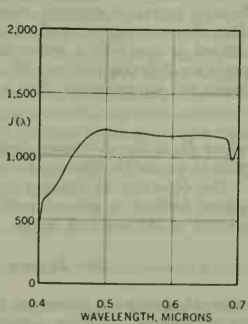

FIG. 1.—SPECTRORADIOMETRIC CURVE FOR DIRECT SUNLIGHT. OBSERVER AT SEA LEVEL, SUN AT 60° FROM THE ZENITH, AND RAYS PERPENDICULAR TO RECEIVING SURFACE

Specification of homogeneous radiation on a surface requires knowledge of the wavelength and the radiant power being received (expressed in watts per square metre). The specification of a line spectrum consists in a designation of the radiant power associated with each wavelength. A continuous spectrum is specified by the radiant power per unit wavelength band.

Fig. 1 represents measurements of direct sunlight. The ordinates $J(\lambda)$ are expressed in watts of radiant power incident on a square metre of surface at the earth, per micron band width. Similar spectroradiometric curves are available for blue and cloudy sky, as well as for incandescent and fluorescent lamps.

From such a curve, the total radiant power D_r between any two wavelengths λ_1, λ_2 can be obtained by measuring the area under the curve. Expressed mathematically

$$D_r = \int_{\lambda_1}^{\lambda_2} J(\lambda)\,d\lambda \qquad (1)$$

where D_r is in watts per square metre, $J(\lambda)$ is in watts per square metre per micron, and λ is wavelength in microns. D_r and $J(\lambda)$ refer to a particular receiving surface (such as the surface of the earth or a surface set up at a known distance from a lamp) and specify radiation either received or emitted by that surface.

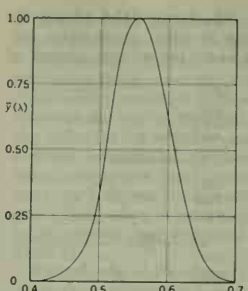

FIG. 2.—STANDARD LAMPROSITY (LUMINOSITY, VISIBILITY) FUNCTION $\bar{y}(\lambda)$ FOR THE EYE. INTERNATIONAL STANDARD CURVE FOR DAYLIGHT VISION, SHOWING HOW PEOPLE RESPOND TO DIFFERENT WAVELENGTHS

The evaluation of equation (1) with $\lambda_1 = 0.40\ \mu$ and $\lambda_2 = 0.70\ \mu$ gives total radiant power per unit area for the visible spectrum. However, this is not the best criterion of perceived brightness. A blue lamp, for instance, may radiate the same number of watts in the visible region as a green lamp, but will appear much dimmer. Normally, people are more sensitive to green than to blue light. Under daylight conditions people are most sensitive to yellow-green ($\lambda = 0.554\ \mu$) and progressively less sensitive as the limits of the visible spectrum are approached. There are, strictly speaking, no precise limits; wavelengths somewhat shorter than 0.4 μ or longer than 0.7 μ can be seen if the radiation is intense enough.

This property of human vision is reflected in fig. 2. The ordinate $\bar{y}(\lambda)$ indicates the relative visual effectiveness of homogeneous radiation of wavelength λ. Such a curve can be obtained by comparing a yellow-green of wavelength 0.554 μ with homogeneous radiation of any wavelength λ. Contiguous white surfaces are illuminated by each of these sources. If the variable radiation is also at $\lambda = 0.554\ \mu$, the two surfaces appear equally bright only when the lamps are adjusted so that the same number of watts per square metre fall on each. Thus $\bar{y}\ (0.554) = 1.00$. But if λ is any other wavelength, less power is needed in the 0.554 μ radiation than in the light of wavelength λ to obtain a brightness match. For instance, if a typical observer compares a red light of $\lambda = 0.650\ \mu$ with the standard, he finds that 1 watt per square metre at 0.650 μ is balanced by only about 0.1 watt per square metre of the yellow-green radiation. Thus at 0.650 μ, $\bar{y} = 0.10$.

The curve of fig. 2 may be called the lamprosity (luminosity or visibility) curve. Visibility and luminosity are more familiar terms, but have various scientific meanings and their use for $\bar{y}$ tends to cause confusion.

The data for fig. 2 were obtained by methods basically equivalent to that described in the preceding paragraph. Considerable variation results from different methods and individual differences among observers. As the result of experiments made with a large number of observers, however, K. S. Gibson and E. P. T. Tyndall of the U.S. National Bureau of Standards recommended the values plotted in fig. 2; these were adopted by international agreement in 1924.

With these standard values of $\bar{y}(\lambda)$ each small wavelength band can be weighted in accordance with its ability to excite visual function. Each wavelength is weighted with respect to its lamprosity by writing

$$D_l = 647.8 \int_0^{\infty} \bar{y}(\lambda)\, J(\lambda)\, d\lambda \qquad (2)$$

D_l is called luminous flux density or luminous pharosage, and is

expressed in units called lumens. The factor 647.8 adjusts for the original definition of the lumen in terms of an older unit called the standard candle instead of by the modern method of equation (2).

Fig. 3 shows how any spectroradiometric curve can be evaluated for visual response. Curve A represents sunlight (fig. 1), B is the lamprosity function (fig. 2), while C is obtained by multiplying the ordinates of A and B at each wavelength. In other words the ordinates of curve A have been weighted with respect to $\bar{y}$ (λ). The area under curve A represents the integral of equation (1) and is expressed in watts per square metre. Measurement with a planimeter shows in this example 328 watts per square metre being received from sunlight. Similarly, the area under curve C represents the integral given as equation (2), and shows the visually weighted sunlight at 82,700 lumens per square metre.

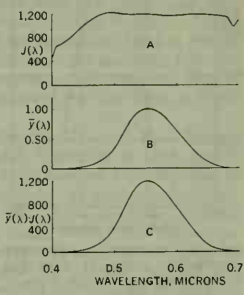

FIG. 3.—METHOD OF CALCULATING PHAROSAGE WITH THE STANDARD LAMPROSITY CURVE

Geometrical Photometrics.—In physical photometrics the photometric magnitudes are based on physical measurements of radiant power that are visually weighted. Besides D_l, it is convenient to have a number of related photometric magnitudes. These additional quantities are associated with D_l in a simple geometric manner; these relationships are the subject of geometrical photometrics.

Luminous flux (called pharos) F_l is obtained by

$$F_l = \int D_l dS \tag{2A}$$

where dS is the element of area. In many cases D_l is essentially constant over the area, and luminous flux is obtained by multiplying D_l by area. For instance, if the sunlight of fig. 3 falls on an opening with an area of $\frac{1}{2}$ sq.m. perpendicular to the sun's rays, the number of lumens through the opening is

$$F_l = D_l S = 82{,}700 \times \tfrac{1}{2} = 41{,}350 \text{ lumens}$$

In fig. 3 the data are given for a surface that is normal to the sun's rays. If the surface is tilted from this optimum position, radiant power will be spread over a greater area and the amount per unit area will be reduced. This is expressed by

$$D = D_m \cos \psi \tag{3}$$

where D is pharosage (flux density) on tilted surface, D_m is pharosage (flux density) on surface that is normal to the incident rays and ψ is angle between the direction of the rays and the inward-drawn normal to the surface. Equation (3) applies to radiant pharosage D_r (watts per square metre) and also to luminous pharosage D_l (lumens per square metre).

Another important equation is the inverse-square relation, which applies if the dimensions of the light source are small compared with the distance from source to surface. If the receiving surface moves along a line through the centre of the light source, then D varies inversely as the square of the distance between surface and source. In combination with equation (3)

$$D_2 = D_m \left(\frac{l_1}{l_2}\right)^2 \cos \psi \tag{4}$$

where D_2 is pharosage on tilted surface at distance l_2 from source, D_m is pharosage on a surface that is normal to light rays and at a distance l_1 from source, and ψ is angle of incidence.

Equation (4) applies either to radiometric quantities (watts per square metre) or to photometric quantities (lumens per square metre). A knowledge of pharosage D_m at a known distance l_1 allows the calculation of pharosage D_2 at any distance l_2 and at any angle. In earlier literature, equation (4) is written

$$D = \frac{I}{l^2} \cos \psi \tag{4A}$$

where $I = D_m l_1^2$, the intensity of the source (candles).

The concept of intensity of candlepower was rapidly becoming obsolete in the 1960s. When candles and oil lamps were employed, the dimensions of the source were so small that the inverse-square relation was applicable in almost all cases. With such sources as fluorescent lamps, the dimensions are often so large that equation (4A) does not apply and the concept of candlepower becomes essentially useless. Caution in the application of equations (4) and (4A) should be emphasized. The inverse-square relation is significant only at distances that are large compared with the dimensions of the source. Empirically, the distances l_1 and l_2 must be at least five times the greatest dimension of the source if equations (4) and (4A) are to give results that are accurate to within 1%. For instance, with a clear incandescent bulb that has a filament 3 cm. in greatest dimension, the inverse-square relation should not be used at distances less than 15 cm. from the centre of the filament. For a fluorescent lamp 1.22 m. long, distances should exceed approximately 6 m.

Before the more general method of calculation can be treated, one more photometric concept must be introduced. This concept is helios associated with the popular idea of brightness. The helios produced by a large, uniform source is defined as π times the incident pharosage per unit solid angle, or

$$H = \pi \frac{D_m}{\omega} \tag{5}$$

where H is helios (blondels), D_m is pharosage incident on the cell (lumens per square metre), ω is solid angle (steradians) subtended at the cell by the opening in the shield.

To measure the helios of a uniform sky, for instance, an ordinary photographic exposure meter of the photoelectric type may be pointed at the sky. The photocell produces a current that depends on the lumens per square metre incident on the cell, and the microammeter in the instrument can be calibrated to read directly in any units desired. The cell is shielded to receive light only from the sky. But ordinarily the helios of the sky is not uniform. For the value in a particular direction, the shield is changed to admit light only from a small part of the sky. This condition is expressed mathematically by specifying that the solid angle ω shall be small

$$H = \pi \lim_{\omega \to o} \frac{D_m}{\omega} \tag{5A}$$

Equation (5A) gives the helios for any source at any point in space and in any direction. Helios is a generalized and extended concept that includes as a special case the idea of brightness of a surface. If the source is a surface and the medium between it and the observer is nonabsorbing and nonscattering, then brightness and helios are identical. Ordinarily a surface will be found to have a different helios when viewed from different directions. Matte (nonglossy) surfaces, however, are found to have essentially the same helios, no matter how they are viewed. A piece of white blotting paper, for example, seems equally bright in all directions. This characteristic is idealized in the perfectly diffusing surface, defined as one with a helios independent of viewing angle. A perfectly diffusing surface with a helios of one blondel emits one lumen per square metre; that is

$$H = D_0 \tag{6}$$

where D_0 is the pharosage from the surface. Equation (6) applies to perfectly diffusing surfaces only.

The definition of helios allows the development of the unit-sphere method, a general method of calculating pharosage for sources of any size and shape. From equation (5A)

$$D = D_m \cos \psi = \frac{1}{\pi} \int H \cos \psi d\omega \tag{7}$$

where the integral is taken over the entire cone of light determined by the source. If H is a constant, equation (7) assumes the simple form

$$D = \frac{H}{\pi} \sigma'' \tag{8}$$

D is the pharosage on any surface. The area σ'' is obtained by projecting onto the illuminated plane the portion of a unit sphere which is cut out by the convergent cone of light.

Fig. 4 shows the light cone (of solid angle ω) and the unit sphere. The light source itself is not shown. It may be any surface or volume source with a boundary that determines the cone. The pharosage (flux density) is to be calculated at the point P. The cone cuts the unit sphere in some kind of an irregular contour. This area σ' on the unit sphere is projected onto the illuminated surface to give the area σ''. The concepts of reflectance and transmittance are also often useful. The luminous reflectance ρ_l of a surface is equal to lumens reflected divided by lumens incident, or

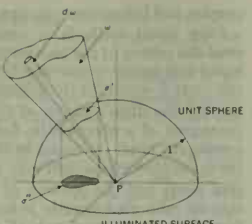

FIG. 4.—UNIT-SPHERE METHOD OF CALCULATING PHAROSAGE FROM LARGE SOURCES

$$\rho_l = F_{lo}/F_{li} = D_{lo}/D_{li} \tag{9}$$

Similarly, the luminous transmittance τ_l is defined as the ratio of transmitted lumens to incident lumens.

$$\tau_l = F_{lo}/F_{li} = D_{lo}/D_{li} \tag{10}$$

For example, find the helios of a perfectly diffusing surface that has a reflectance of 0.60 when this surface is illuminated normally by direct sunlight (fig. 1). According to fig. 3, the incident luminous pharosage D_{li} is 82,700 lumens per square metre. From equation (9), the reflected pharosage D_{lo} is $\rho_l D_{li}$ or 49,600 lumens per square metre, and by equation (6) the helios (brightness) H is 49,600 blondels.

The principal concepts and units of radiometry and photometry are summarized in Table I. The same symbols are employed in both systems, a subscript r or l being used when necessary to distinguish the radiometric from the photometric. The two systems differ only in that the radiometric quantities are true physical magnitudes, while the photometric quantities are these physical magnitudes evaluated with respect to human visual experience. This evaluation is done by means of the $\bar{y}(\lambda)$ curve shown in fig. 2. Thus $\bar{y}(\lambda)$ belongs to neither system but effects a liaison between them. Another quantity of similar character is the total lamprosity $\bar{y}_l$ which expresses the total lumens per watt for an entire spectrum. It is evaluated by means of the expression

TABLE I.—*Concepts and Units*

Symbol	Radiometric system Name	Unit	Photometric system Name	Unit
F	radiant pharos (radiant power, radiant flux)	watt	luminous pharos (luminous flux)	lumen
D	radiant pharosage (radiant flux density)	watt/m²	luminous pharosage (luminous flux density, illumination, luminosity)	lumen/m²
$J(\lambda)$	pbengosage	watt/m² micron	.....	
H			helios (brightness)	blondel
ρ			luminous reflectance (reflection factor)	numeric
τ			luminous transmittance (transmission factor)	numeric
$\bar{y}(\lambda)$	spectral lamprosity (luminosity, visibility), lumen/watt			
$\bar{y}_l$	total lamprosity (luminous efficacy, luminous "efficiency"), lumen/watt			

$$\bar{y}_l = \frac{\int_0^\infty \bar{y}(\lambda)\, J(\lambda)\, d\lambda}{\int_0^\infty J(\lambda)\, d\lambda} \tag{11}$$

and is useful in expressing the photometric effectiveness of a given radiation.

The concepts, names, and units of photometry have never been thoroughly standardized; considerable variation in nomenclature is to be found in the literature. Table I is an attempt to present a simple system of photometric concepts. Besides these quantities, there is the concept of intensity or candlepower, mentioned earlier. There is also phos (quantity of light) in lumen-seconds and phosage in lumen-seconds per unit area. In place of the single concept of pharosage or flux density, some writers prefer to use the two ideas of illumination (lumens per unit area incident on a surface) and luminosity (lumens per unit area emitted by a surface).

Moreover, numerous units are employed in practice. In most countries the unit of illumination is the lumen per square metre, also called the lux or metre-candle. In Great Britain and the U.S., however, commercial practice in the 1960s still favoured the lumen per square foot, also called the foot-candle. Brightness units are even more numerous and confusing. It is simplest to ignore these units, to use a single system and to convert quantities to that system when necessary by use of the conversion factors of Table II.

Experimental Photometry.—The fundamental measurement in photometry may be considered as the determination of such spectroradiometric curves as fig. 1. The spectrum is obtained with a prism or diffraction grating, and the radiant power is measured at various wavelengths. Such a spectral distribution gives information from which can be determined (fig. 3) the radiant pharosage, the luminous pharosage, and the hue.

TABLE II.—*Conversion Factors*

Multiply	by	to obtain
Illumination		Pharosage
Foot-candles	10.764	Lumens/m²
Metre-candles (lux)	1	Lumens/m²
Lumens/cm²	10,000	Lumens/m²
Pharosage		Illumination
Lumens/m²	0.0929	Foot-candles
Lumens/m²	1	Metre-candles (lux)
Lumens/m²	10^{-4}	Lumens/cm²
Brightness		Helios
Lamberts	10,000	Blondels
Millilamberts	10	Blondels
Foot-lamberts	10.764	Blondels
Stilbs	3.14×10^4	Blondels
Apostilbs	1	Blondels
Candles/in²	4,869	Blondels
Candles/ft²	33.82	Blondels
Candles/cm²	3.14×10^4	Blondels
Candles/m²	3.14	Blondels
Equivalent ft.-candles	10.764	Blondels
Helios		Brightness
Blondels	0.10	Millilamberts
Blondels	0.0929	Foot-lamberts
Blondels	2.054×10^{-4}	Candles/in²
Blondels	2.957×10^{-2}	Candles/ft²
Blondels	0.3183	Candles/m²

A good spectroradiometer is large and expensive, and painstaking care is required in its use. Thus there is need for simpler methods of measuring the various photometric quantities (Table I). In direct photometry, it is convenient to have a physical standard against which the photometers can be calibrated. Theoretically, a photometric standard is redundant, since everything can be referred to the watt and the standard lamprosity function. But in practice a photometric standard is useful. The early standards were actual candles, but they were replaced by such carefully specified sources as the Harcourt pentane lamps and the Hefner amylacetate lamp. Such lamps gave fairly reproducible results but were replaced (1909) in Great Britain, France, and the U.S. by calibrated carbon-filament electric lamps. In 1931 the U.S. National Bureau of Standards developed the platinum black-body standard. A small tube of fused thoria (ThO_2) acts as a black-body radiator (*see* BLACK BODY) and is held at constant temperature. The helios of this radiator is defined as 1.885×10^6 blondels (brightness = 60.0 candles per square centimetre). These standards are used only by such organizations as the National Physical Laboratory in Great Britain or the U.S. National Bureau of Standards. Other photometric laboratories employ standardized tungsten-filament incandescent lamps.

Thermocouples and bolometers, vacuum and gas-filled photocells, barrier-layer photocells, and the human eye are sensitive to visible radiation and serve in various types of photometers.

Thermocouples and bolometers depend on the heating effect of the radiation. Most of the radiant energy that falls on a blackened body is transformed to heat. The temperature rise indicates the amount of radiant energy. Such devices are essentially nonselective, being equally sensitive to radiation of all wavelengths. With suitable optical filters, however, it is possible to admit only wavelengths in the visible region and to make the instrument re-

spond in accordance with the standard curve for the eye. Such instruments have not been used commercially because the small response is difficult to measure.

The thermocouple uses the Seebeck effect to measure the temperature rise caused by the absorption of radiant energy. At the junction between two metals (copper and constantan, for instance), a small blackened target is attached. When radiation falls on this target, its temperature rises and an electromotive force is generated. The resulting electric current produces a galvanometer deflection directly proportional to the incident radiant pharosage. In the bolometer (*q.v.*) a wire or thin metal strip is blackened and absorbs radiant energy. The temperature rise of the metal increases its resistance, and the change is measured in a Wheatstone-bridge circuit. The bolometer has been employed extensively by the Smithsonian Institution for the spectral measurement of sunlight, and it has also been used in stellar photometry (*see* PHOTOMETRY, CELESTIAL).

Photoelectric devices are much more selective than thermocouples or bolometers. Vacuum photocells using cesium have been employed successfully in many photometers. Unfortunately the response curves for such cells are very different from the curve for the eye. Photocells are sensitive in the near ultraviolet and some of them also have high response in the infrared. To evaluate the different wavelengths properly, therefore, the cell should be fitted with coloured glass or gelatin filters. Photocells are often used with D.C. amplifiers to obtain a larger current. Another method is to flicker the light by means of a motor-driven shutter, which allows the use of a multistage A.C. amplifier. A modification of this method is employed in the Hardy photoelectric spectrophotometer.

A photoelectric device of the utmost simplicity is the barrier-layer cell. It consists of a metal disk coated with selenium, and it requires no battery. Copper-oxide cells are also used. When light falls on the surface, electrons are released and a current flows through a microammeter that can be calibrated to read directly in photometric units. The entire photometer, consisting of barrier-layer cell and microammeter, can be made so compact that it can be carried in the pocket. The response curves for barrier-layer cells are more nearly like the curve for the eye than in the previous cases, and can be corrected by a suitable filter. Many photometers of this type are made without correction and are calibrated with light from incandescent lamps. They can then be used in measuring lighting installations that employ tungsten lamps, but large errors may be introduced if they are used with other kinds of light.

The eye was for many years the only receptor used in photometry, and even in the 1960s visual photometers were still sometimes used. Although the eye is not a measuring instrument, it does provide a delicate means of determining *equality*. Thus in visual photometers, either the standard or the unknown are varied until perceptual equality is reached. Visual photometry is a tedious and time-consuming process which will probably be superseded by photoelectric methods.

Now consider the application of the foregoing to the measurement of pharosage (luminous flux density), pharos (luminous flux), helios (brightness), and intensity (candlepower).

One way to measure pharosage is to place a barrier-layer cell at a given point on a surface and to measure the photoelectric current. The microammeter may be separate, connected to the cell by flexible leads, or cell and current-indicating instrument may be built together to form a self-contained unit. In either case, the scale can be calibrated to read directly in lumens per square meter or in lumens per square foot. The instruments are calibrated by placing a standardized incandescent lamp at known distances and using the inverse-square relation, equation (4). Commercially available meters of this type are very convenient to use and are accurate enough for most engineering purposes.

Also available commercially for measuring pharosage is a type of device that employs a cesium photocell, connected with flexible leads to a box containing amplifier, batteries, and ammeter. It is more complicated than the barrier-layer cell instrument, though it can be built to measure smaller amounts of light. Thermocouples and bolometers also can be used to measure pharosage.

Only visual methods of measuring pharosage were employed until the advent of the photoelectric cell. Perhaps the best-known visual instrument is the Macbeth illuminometer. A matte white test plate is placed on the illuminated surface. The observer looks through the illuminometer at this plate and compares it with the outer part of a photometric field that is lighted with a small incandescent lamp contained in the instrument. The brightness of the outer part of the field may be varied by moving the incandescent lamp, and the position of the lamp is read on a scale that may be calibrated directly in lumens per square metre. The current through the lamp is kept constant by use of a rheostat adjusted to an ammeter. The observer adjusts the position of the lamp until the two parts of the photometer field appear equally bright. The value of pharosage is then read on a scale attached to the illuminometer lamp.

Another important measurement is the determination of pharos or total luminous flux. The total number of lumens emitted by a lamp can be measured by finding the pharosage in all directions at constant distance from the lamp and summing these values after multiplying by proper weighting factors. A much simpler method is to take a single reading with an integrating sphere photometer or Ulbricht sphere. The lamp to be tested is placed in a sphere coated inside with a matte white paint. Theory shows that the pharosage produced by reflected light at any point on the sphere wall is independent of how the light is distributed from the lamp and depends only on the total pharos. Thus if any opening is made in the sphere wall and a barrier-layer cell is inserted, its reading will be directly proportional to the total lumens from the lamp and the instrument can be calibrated to read total lumens.

Integrating spheres are employed extensively by lamp manufacturers in testing their product. Besides the barrier-layer cell, cesium photoelectric cells are often employed in integrating spheres; many such photometers still used visual methods in the 1960s.

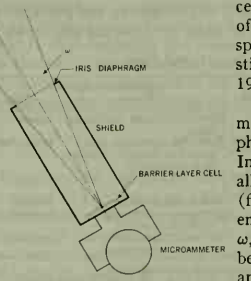

FIG. 5.—PHOTOELECTRIC HELIOS (BRIGHTNESS) METER

Helios may be obtained by a modification of the barrier-layer pharosage (illumination) meter. Instead of receiving light from all directions, the helios meter (fig. 5) shields its cell and light enters only through a solid angle ω, equation (5). The scale can be calibrated to read blondels or any brightness unit (Table II). Helios is also measured by the Macbeth illuminometer and the Luckiesh-Taylor brightness meter, a visual instrument that operates like the Macbeth but is more compact. Reasonably compact helios meters employing photo-multiplier tubes are also available.

In older treatises on photometry, attention was given principally to visual methods of comparing intensity (candlepower) of lamps. The standard lamp and the unknown lamp are set on a bar photometer. Between them is a screen with which it is possible to visually compare the separate pharosages produced by the two lamps. Distances are varied until the two half-fields appear equally bright, and the intensity of the unknown is then calculated from the inverse-square relation, equation (4A). Photoelectric methods have largely eliminated such measurements, particularly since the prevalent use of large-area light sources reduces the need for intensity determinations.

Photometry in the 1960s was in much the same condition that electrical measurements were about 1880. After 1880, highly accurate and convenient electrical instruments were developed and electrical engineering advanced safely and rapidly on the basis of precise measurement. A similar development is needed in illuminating engineering, where research is frustrated by the lack of accurate measuring instruments. Further research and development in photometry will ultimately yield dividends in better visual

conditions in schools, factories, and homes.

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PHOTOMETRY, CELESTIAL. Celestial photometry deals with the measurement and evaluation of light from the stars. Information obtained by the application of celestial photometry has aided astronomers significantly in determining the composition of stars and nebulae and in computing their distances from the earth. This article covers the techniques of visual, photographic, and physical photometry, considering in detail photoelectric photometry, a physical technique which had reached great importance by mid-20th century.

Historical Survey.—It requires only an elementary casual observation to realize that the stars are of different brightnesses, and, by a mere inspection of the sky, anyone could for himself arrange the stars in order of brightness. This is exactly what the ancient astronomers did: in Ptolemy's *Almagest* (*c.* A.D. 150) the stars visible to the naked eye are divided into six classes of magnitudes, the brightest stars being designated "first magnitude stars" and those just visible to the naked eye forming the sixth magnitude. Each magnitude class is further divided into three subgroups.

When the telescope was invented it was at first used merely as a means of extending to the fainter stars this process of assigning magnitudes by simple eye estimation, a process which culminated in the 19th-century publication of the great visual "Durchmusterungs" or surveys of which the *Bonner Durchmusterung* (B.D.) was the first. It gives magnitude estimates for 324,188 stars, the estimates being made by Friedrich W. A. Argelander and his colleagues. The work was extended to the southern hemisphere by E. Schönfeld who produced the *Südliche Durchmusterung* and by J. M. Thome and C. D. Perrine who were responsible in the 20th century for the *Córdoba Durchmusterung*.

But before the completion of the publication of the *Córdoba* estimates the *Durchmusterungen* had become out of date, and eye estimation had been replaced by photometric measurement. The magnitude nomenclature was retained but attention had been devoted to giving it a precise quantitative meaning. In 1854 N. Pogson argued in favour of adopting a light ratio of 100 to 1 for a difference of five magnitudes, the difference of magnitude between two stars being then defined as 2.5 times the logarithm (to base 10) of the measured ratio of the amounts of light received from them. This definition (which requires further examination—*see* below) gives values in rough agreement with the older visual estimates and has been universally adopted; but it still remains to fix some definite magnitude of the scale. It is natural to aim at doing this in such a way as to make measured magnitudes correspond roughly to the *Durchmusterung* values and this has been done in different ways for the different visual catalogues referred to through the bibliography attached to this article. The Harvard system of visual magnitudes (due to Edward Charles Pickering and his collaborators) came to be generally recognized as standard, and the zero point of the Harvard system was, in effect, fixed by making the mean measured magnitude of certain selected stars agree with the mean of the B.D. values for the same stars.

Once the magnitude divisions of the *Durchmusterung* catalogues had a rational basis of measured intensity ratios, the census of the stars contained in them could be used for statistical studies which sought to determine the distribution of stars in depth and thus to learn the structure and extent of the universe as then known. As astronomy developed in the early years of the 20th century, there were many other lines of investigation in which the magnitudes of the stars, which originally had only a descriptive significance, became increasingly important in gauging their distance and their physical characteristics. These applications of stellar photometry are considered later in the present article; one example would be the powerful method of distance determination based on the periods of Cepheid variables. (*See* STAR.)

At the turn of the century the photographic plate was rapidly taking over the role of receiving and recording the star images in the focal plane of the telescope. As the human eye was displaced, systems of magnitudes other than visual were developed; the magnitudes based on the blue-sensitive photographic plate were called photographic magnitudes. The labour of extending the census of the stars begun in the *Durchmusterungen* to the faint limits reached with large telescopes was a natural task for photographic methods, because of the great number of star images that could be recorded on a single exposure. This information was needed for the analytical studies of the galactic system being undertaken by statistical astronomers.

By 1920 photoelectric photometry was being used on the brighter stars, particularly for astrophysical problems where high accuracy was required. As the sensitivity gradually improved, photoelectric methods assumed increasing importance, and by mid-century were becoming the standard of reference by which other systems were calibrated.

In all of these nonvisual systems, it was necessary to fix the zero point of the scale by assigning a definite magnitude to a particular star, or to the mean of a selected group of stars. In the case of photographic magnitudes the zero was defined to make the average agree with visual magnitudes between magnitude 5.5 and 6.5, for stars of spectral type Ao (white stars). This having been done, it is found that for other stars the photographic and visual magnitudes do not agree. Thus for the average of what are known as "main sequence" stars of spectral type Ko (reddish stars) the photographic magnitudes are about 0.8 greater than the visual. The difference is due to the colour of the stars; since the maximum responses of the eye and the photographic plate are to light of different wavelengths, the difference of photographic magnitude between two stars will only be equal to the difference of visual magnitude between the same two stars if the stars involved are of the same spectral energy distribution, that is, of the same colour.

The difference between the photographic and visual magnitude of a star is, in fact, a recognized measure of the star's colour. This difference is taken in the sense photographic minus visual, and is known as the star's colour index. The colour index is directly related to the star's surface temperature, being negative for the hottest (bluish white) stars, and positive for the cool (reddish) stars. This relation is an example of the physical information about a star derivable from photometric measurements.

Definition of Magnitude.—The circumstance that the colours of the stars are not all the same requires a more careful examination of the definition of magnitude. Pogson's definition states that two stars differ by one magnitude if the logarithm of the ratio of the quantities of light received is 0.4, that is, if the light ratio is 2.512 (the antilogarithm of 0.4). But the question arises: what light ratio? If the stars are of the same spectral energy distribution it does not matter; if the light ratio is 2.512 for one wavelength, it is 2.512 for every other wavelength. But if the two stars are of different spectral energy distribution, then the light ratio can only be 2.512 for one wavelength, and the difference of magnitude between them will vary with wavelength. How then are we to define magnitude?

The definition has clearly to be related to the physical operation of measurement. The general principle of measurement of the difference of magnitude between two stars is that the light from each is received in some definite apparatus, and the beam from the brighter star is reduced until the response of the apparatus to the two beams is the same. The reduction of the light from the brighter star must be achieved by some definite physical operation, subject to the condition that the reduction factor is the same for all wavelengths, and this reduction factor must be

measured by a physical method for each operation. This having been done, the measured reduction factor is the ratio of the brightnesses of the two stars, and the difference of magnitude is then 2.5 times the logarithm of the brightness ratio, that is, 2.5 times the logarithm of the reduction factor. This defines the concepts of "brightness" and "magnitude" with respect to the particular apparatus used, and it is easy to see that, with one exception, this is all that can be done, and that the terms "brightness" and "magnitude" cannot have an absolute meaning but can only be defined with respect to some specified apparatus.

The exception referred to is the case in which the apparatus is sensitive only to a very small range of colour, that is, of wavelength, and provided this condition is satisfied the magnitudes obtained will not depend on the particular kind of apparatus used. Such magnitudes are called monochromatic magnitudes, and each system of monochromatic magnitudes refers to a specified wavelength. It is now being realized that monochromatic magnitudes are of importance in various astrophysical problems, and more attention is being paid to them (*see* section on *Spectrophotometry* below). But they suffer from the defect that a severe restriction is imposed on the quantity of light available; and accordingly for the fainter stars it is on the older heterochromatic magnitudes that we have to rely, that is, on magnitude measurements in which the receiving apparatus is operated by light of a considerable range of colour. We have seen above that under these conditions the concept of magnitude can be defined with respect to the particular apparatus used.

It is easy to see that this restriction cannot be removed. Consider the simplest case of heterochromatic photometry, this being the case in which the brightness is the integral of the quantity of light received at each wavelength multiplied by the sensitivity factor of the apparatus at that wavelength, the sensitivity factors being regarded as constant for the apparatus used (*i.e.,* not dependent on the light intensity), and the integration being taken over the whole range of colour to which the apparatus is sensitive. Taking, for example, the case of visual photometry, the receiving apparatus is the combination of the human eye and the optical train used, and the sensitivity factors will involve the transmissive properties of the optical train to light of different wavelengths. Consequently, for stars of different colour, the ratios of the integrated brightnesses, and so the differences of magnitude, will depend on the particular photometer and telescope used. The same is true for photographic photometry, in which the receiving apparatus is the combination of plate and optical train, it being understood that some specified process of measurement is applied to the photographed images. In particular, we must expect photographic magnitudes to be different for different types of photographic emulsion, and for different kinds of telescopes. Thus photographic magnitudes determined with refractors, for which most of the ultraviolet light is absorbed by the lenses, will be different from those determined with reflectors, for which a large part of the ultraviolet is reflected by a silvered surface, and still more by an aluminized surface. Further, the earth's atmosphere has to be regarded as part of the optical train. Its effect on the difference of magnitude between two stars can be eliminated if both are observed at equal angular distances above the horizon. But observers who do not use the same equal altitude above the horizon must still expect small differences between their results. And observers at mountain stations have less atmosphere over them than those near sea level. The preferred method is to determine the atmospheric absorption in each photometric system by measures of standard stars at varying altitudes above the horizon, and then to compute the magnitude differences that would be observed for all stars outside the atmosphere.

While the effects of the earth's atmosphere can be eliminated by reasonably straightforward procedures, there are more serious complications. In the case of visual photometry the Purkinje effect compels us to regard the sensitivity factors as being dependent on the intensity of the light received, and so, if two stars of different colour are equal in magnitude when a small telescope is used, the redder of the two will appear the brighter if we employ a larger telescope the transmissive properties of which, with respect to wavelength, are similar to those of the smaller one. For this reason alone a system of visual magnitudes must be defined with respect to a definite instrument. There is an analogous effect for emulsions which introduces a further restriction in photographic work. If, using a definite instrument, under definite standard conditions, two stars are found to be of the same magnitude for one duration of exposure (by which is meant that some definite process of measurement applied to the two images gives the same result), they will not necessarily be of the same magnitude for a different duration of exposure. Accordingly, strictly speaking, a system of photographic magnitudes must be defined, not only with respect to a definite instrument, working with a definite type of emulsion, under definite atmospheric conditions and applying a definite process of measurement to the images, but also with respect to a definite duration of exposure.

These difficulties all disappear in monochromatic photometry, which will be discussed later, but in heterochromatic photometry the magnitude of a star can be defined precisely if, and only if, a definite instrument is specified, working under definite conditions. Systems of magnitude obtained with different instruments working under different conditions will be different, the differences depending on colours. It is possible, by careful intercomparison between the different systems of visual or photographic magnitudes, to deduce, in an empirical way, corrections whereby each system can be reduced to some standard system. The corrections will depend on the colours of the stars, which are measured by their colour indices; they can be considerable and may amount to a third of a magnitude in extreme cases. If, however, the wavelength range used in a given magnitude system is restricted by carefully specified filters, the transformation equations between observers using different telescopes will have quite small correction terms and simple linear relations will be adequate. It is particularly important to control the ultraviolet radiation which enters into the heterochromatic summation which forms, say, a photographic magnitude, or indeed any magnitude system which is centred on the blue-violet part of the spectrum. By excluding wavelengths shorter than 3,800 Ångström (Å) units several troublesome factors which introduce differences between observers of the same stars with different telescopes are eliminated. These factors include the most variable part of the atmospheric absorption, the unequal ultraviolet absorption of the flint glass in different refracting telescopes, the decreasing ultraviolet reflectivity of silver mirrors as they tarnish, and the varying weight given to the wavelengths shorter than 3,650 Å, where the Balmer discontinuity due to hydrogen absorption causes a precipitous drop in the radiation from stars of early type (*see* SPECTROSCOPY, ASTRONOMICAL: *Continuous Spectra*).

Nevertheless it is still true that magnitude systems, and the colour indices which are the differences between them, are rarely capable of exact repetition on any telescope other than the one on which they were derived. The numerical results obtained on a specified list of standard stars remain the best definition of a particular system.

The following is a formal definition of magnitude difference: for a definite instrument, working under definite conditions, the difference of magnitude between two stars is 2.5 times the logarithm, to base ten, of the ratio by which the beam from the brighter star has to be reduced so as to make the instrumental response to it the same as the response to the beam from the fainter star, it being stipulated that the two beams are transmitted through the optical train in an identical manner, and that the method of light reduction employed is such that the light for each wavelength involved is reduced in the same ratio.

It is important to notice that an implication of this definition is that if two precisely similar stars, both emitting the same total amount of light at any wavelength, differ in magnitude by Δm, as measured by any instrument, then, provided there is no obscuring matter in interstellar space, the distance of the fainter star will be $10^{0.2\Delta m}$ times the distance of the brighter. To see this we apply in imagination a method of light reduction which is actually used for photometric work in the laboratory. We imagine the distance of the nearer star to be increased until the instru-

mental response to its beam is the same as that for the more distant star; since the stars are supposed to be precisely similar this means that we have now placed them at the same distance. If there is no obscuring matter in space the light reduction produced by the change of distance will be the same for all wavelengths, and so will conform to the condition of the definition above; further, the reduction ratio will be determined by the inverse square law. Hence the difference of magnitude Δm between the stars is 2.5 times the logarithm of the ratio of the squares of their distances, and by taking antilogarithms the result follows. Since this result is the basis of modern galactic research, it is of high importance that our definition of magnitude should be correctly translated into photometric practice.

It is convenient to remark at this point that the imaginary process, used above, of varying the distance of a star, is employed to define an important conception. The absolute magnitude of a star is defined as being the magnitude that the star would have if moved to a standard distance of 10 parsecs (*see* PARSEC) from the earth. The absolute magnitude of a star is an expression of its intrinsic brightness, not its apparent brightness as seen from the earth; the apparent brightness depends on the distance of the star as well as on its intrinsic brightness. It should be noticed that absolute magnitude has been defined with reference to some specific instrument, since the definition involves the conception of magnitude. For each magnitude system there is thus a different absolute magnitude for the same star. In particular, visual and photographic absolute magnitudes of a star may differ considerably.

In visual photometry the fundamental operation is the measurement of the difference of magnitude between two stars. Visual magnitudes are essentially determined by a series of photometric operations involving pairs of stars, these operations leading to a knowledge of the mutual differences between the magnitudes of the stars over the whole sky. In photographic photometry the mutual differences between the magnitudes of all stars in a field small enough to be photographed on one plate are obtained from a single set of photometric operations, and other photometric operations give magnitude differences between different fields. For both visual and photographic work, and for other measurements in which a "physical" receiver takes the place of the eye or photographic plate, the result is the same; photometric methods only measure differences of magnitude, and, indeed, the definition given above is restricted to a definition of magnitude difference. For any particular magnitude system it remains to assign a definite magnitude to some star or to the mean of some group of stars. It has been indicated in the previous section how this has been done for visual and photographic systems.

Modern Astronomical Photometry.—We now turn to a brief survey of the work of the three decades after 1915. It was for the most part photographic, this being due to the circumstances that the problems before astronomers required photometric results for faint stars, and the power of the photographic plate of accumulating the effect of continued exposure to light renders it applicable to extremely faint sources. The photographic plate also has the great advantage of registering a large number of images at a single exposure, and some modern problems demand results for all stars in various sample areas of the sky, each sample area being small enough to be covered by one plate. Naturally enough the work that was carried out was indicated by problems of current interest, and it will be as well to review in brief what some of the main problems are, and to indicate as we go what photometric programs have been carried through to meet their needs.

Our knowledge of the dimensions of the galactic universe, and of the distances and dimensions of the extragalactic nebulae, is based on photometric observations of Cepheid variables. The median absolute magnitude (*i.e.*, the mean of the absolute magnitudes at maximum and minimum light) of a Cepheid is related to its period by what is known as the period-luminosity relation, and consequently photometric observations of a Cepheid will lead to a knowledge of its distance. For the photometric observations give both the apparent median magnitude and the period; the latter gives the median absolute magnitude, using the period-luminosity relation, and then the distance can be calculated from the apparent and absolute median magnitudes. It is in this way that the distances of the globular clusters, and of the extragalactic nebulae are ultimately determined, the distances of the former leading us to a knowledge of the dimensions of the galactic system, and those of the latter opening up the way to an extended knowledge of the universe. It is thus important to be able to make photometric measures of Cepheids in any part of the sky, and this can be most conveniently done by establishing a number of what are known as magnitude sequences in various parts of the sky. Each such sequence consists of a series of stars in the same field of view, selected so that their magnitudes form a series with, so far as is possible, roughly equal magnitude intervals between consecutive members, the magnitudes themselves having been measured carefully. Any Cepheid can then be investigated photometrically by a series of comparisons between it and the members of a conveniently near sequence. The sequences are also used for the photometry of other variable stars.

In connection with the study of galactic structure we require to know the numbers of stars, in various parts of the sky, down to various magnitude limits. It would be quite impracticable to survey the whole sky to faint magnitude limits, but valuable information can be got by confining the measures to sample areas, as has been done in the *Harvard-Gröningen Durchmusterung*, which is a photographic catalogue extending down to the 16th magnitude. Another valuable catalogue of the same kind is the *Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1–139*, which gives photographic magnitudes for stars in sample areas extending from the north celestial pole to declination $-15°$, and reaches stars of the 18th magnitude.

Another important development lies in the measurements of the integrated magnitudes of extragalactic nebulae, that is, magnitudes, not of individual stars in the nebulae, but of nebulae as a whole. For the remote nebulae it is impracticable to detect individual stars and measure their magnitudes, and so the Cepheid method of determining distances is not directly available; but measures of the integrated magnitudes lead to a statistical knowledge of the distances; since it may be assumed that on the average the measure of the brightness of a nebula is a measure of its distance, the fainter nebulae being the more distant. From the measures of integrated magnitude a statistical relationship has been discovered between magnitude and displacement of spectral lines to the red, and this has been interpreted as a relation between the distance of a nebula and its velocity of recession. This velocity-distance relation is the observational foundation on which the relativity theory of the expanding universe is based, and the importance of nebular photometry in connection with this theory needs no stressing. Indeed, the observational tests which might distinguish between various cosmological models of the universe are utterly dependent on photometry. The older test, based on the rate of increase of the number of counted nebulae with progressively fainter limits of integrated magnitude, is now recognized as not very sensitive. The departure of the velocity-distance relation from strict proportionality is a more hopeful test, but again the test depends critically on precise photometry of very faint objects. The red shift changes the apparent colour index of distant systems, necessitating troublesome corrections that can be accurately known only from spectrophotometric measurements. The possibility of temporal changes arising from evolutionary aging of stellar populations introduces a further uncertainty into the comparison of distant extragalactic nebulae, seen as they were 1,000,000,000 years ago, with nearby systems. (*See* LIGHT: *Waves and Interference.*)

From what has been said it will be apparent that a good deal of modern photometric work aims at the obtaining of data for the whole sky, and so the whole of a program cannot be carried out at a single observatory. This means that the various systems of magnitude involved must be reduced to a common standard. Such a reduction is vital to modern work, and to facilitate it considerable attention has been devoted to the derivation of standard magnitudes for a sequence of stars, known as the north polar sequence, which consists of a set of stars down to the 20th magni-

tude in the neighbourhood of the north celestial pole. These standard magnitudes were adopted as the result of a careful intercomparison of photographic magnitudes measured at Göttingen, Greenwich, Harvard, Mount Wilson, Potsdam and Yerkes observatories, and they represent a magnitude system known as the international system. The main object of laying down this standard system was to make it available as a reference system with which any particular system of measured magnitudes can be compared, and since, as we have pointed out, the corrections required to reduce one photometric system to another depend on the colours of the stars, the colours of the standard sequence must be known. The older colour indices were derived by comparing photographic and visual magnitudes, but the measurement of visual magnitudes for the fainter members of the sequence is impracticable, and accordingly visual magnitudes have been replaced for this purpose by what are known as photovisual magnitudes. These are obtained by the methods of photographic photometry, but using plates sensitized to green and yellow light in conjunction with a filter removing the violet end of the spectrum. Photovisual magnitudes have been determined at Mount Wilson for the stars of the north polar sequence down to the 19th magnitude (photographic). They form a system which is naturally not identical with any of the visual magnitude systems, but they approximate to visual magnitudes, and serve the purpose of giving, by comparison with the standard photographic magnitudes, the colours of the north polar sequence stars.

If in any program of measures obtained at a northern observatory the precaution is taken of including the stars of the north polar sequence, the material is available for reducing the program measures to the standard international system, provided the program includes measures of the colours of the program stars. For equatorial or southern observatories the north polar sequence is not directly available for observation, and an intermediary sequence has to be employed.

In the following sections some details will be given of the technique of astronomical photometry. These sections will be followed by a section dealing with the new and expanding subject of spectrophotometry.

Methods of Light Reduction.—From what has been said above it is obvious that a vital operation in any kind of practical celestial photometry is that of reducing a beam of light from a star and measuring the ratio in which it has been reduced, an essential condition being that the reduction ratio should be independent of wavelength. The following are the methods most favoured.

Variable Aperture Methods.—The original beam of light from a star is perfectly uniform in cross section, hence, if the area of the beam utilized is varied, the light will be varied in the same ratio. For this purpose diaphragms, circular- or sector-shaped, or gratings of wires or tapes equally spaced may be used. If the uniform cross section of the original beam is subsequently disturbed, an appropriate correction must be applied—thus care must be exercised in employing these methods when a refractor is used since the lens may absorb differently over different parts of its area. The weak point about variable aperture methods is that the reduced image has a different diffraction pattern from the original.

Polarizing prism arrangements are used in some well-known photometers, including the Zöllner photometer and Pickering's meridian photometer; but the prisms must be carefully selected by independent tests.

Filter and Wedge Methods.—A neutral-tinted glass may be cut in the form of a plate, or made into a wedge with a wedge of clear glass cemented to it so that the combination is achromatic. The fraction of the light absorbed by the plate or any part of the wedge may be found by laboratory methods, the most accurate being photoelectric methods using a rotating sector. The direct use at the telescope of the rotating sector does not appear to have found favour in celestial photometry. In applying it to photographic photometry there would be the difficulty that Talbot's law is not obeyed unless the sector is run at very high speeds; for speeds of the order of 50,000 r.p.m. for a sector disk with one slot it appears to be obeyed to an approximation of the order of 1%. (*See* VISION OR SIGHT: *Response to Variable and Intermittent Illumination.*) Wire gauze screens are a special case of variable aperture methods, but the absorption of the screen is not readily calculated and must be measured and tested for uniformity in the laboratory. Wire gratings, in addition to their use in variable aperture methods, give diffracted images, and the ratio of the light falling into the diffracted image to that falling into the main image may be computed from a knowledge of the dimensions of the wire and spacing, or may be measured by a separate method. The grating method has been used in photographic photometry and possesses the advantage that images of a known magnitude difference are obtained from the same exposure.

Visual Photometers.—We have seen that the essential principle of every photometric measurement is that the light from the brighter of two stars should be reduced till the response of the receiving apparatus to it is the same as the response to the beam from the fainter star, and that the two beams should be transmitted through the apparatus in an identical manner. This last condition is essential, since, if it were not satisfied, the absorptions of the two beams by the apparatus would not necessarily be the same. But in visual photometry, in which the human eye is involved, the operation becomes one of reducing the intensity of the brighter of two images until the eye judges that it is of the same brightness as the fainter; and this means that the two images must be viewed simultaneously. It is clearly impossible to do this for two stars in different parts of the sky, and at the same time to adhere to the condition that the two beams must be transmitted in an identical manner through the same apparatus. Accordingly each of the two star images is matched successively with an intermediate image; the beams from the two stars are transmitted identically through the same optical train, and the light from the intermediate source can be transmitted through a different optical train. The intermediate source of light may be an artificial star, or it may be a real star in the sky, and visual stellar photometers may be divided into two classes according to which of these alternatives is employed. Examples of the first type are the Zöllner photometer and Pickering's wedge photometer, the latter representing a type of instrument used at the Lick, Yerkes, and Leander McCormick observatories for measuring the magnitudes of comparison stars against which the magnitudes of variables are estimated. The Pickering meridian photometer with which the Harvard photometry was performed is an example of instruments using a real star as intermediary, as is also Danjon's "cat's eye" photometer. (W. M. H. G.; E. A. Br.; A. E. W.)

Photographic Photometry.—In photographic photometry the distinctive part of the receiving apparatus is the photographic plate used in conjunction with some definite operation of measurement applied to the developed images. Both the size and density of the image vary with magnitude, the developed image of a star being denser and larger the brighter the star. The operation which gauges the total effect may consist of measuring the size of the image, or of measuring the absorbing power of the image when it intercepts a light beam, or of a combination of the two in the so-called iris photometer. In the latter, the size of the aperture centred on the image, which will permit a given constant amount of light to come through and around the image, is used as a measure of the total effect. These measurements, whatever the method, arrange the stars in a sequence of increasing brightness, but with the true brightness ratio between any unequal pair still unknown. Just as in visual photometry, an intensity reducer of known reduction ratio must be introduced to equalize such pairs of stars, and thus to build up a scale of true relative brightness.

Double exposures are the usual method of introducing the known intensity ratio. The first exposure is taken in the normal way. Then after a slight shift to avoid superposition, the same field is photographed a second time with the known reduction factor imposed. The reduction may be by means of a gauze screen, or by a calibrated neutral glass filter, or by diaphragming the telescope to make a smaller aperture. As a practical matter only one selected reduction ratio can be applied to all the stars on one plate. The intensity ratio of a nearly equalized pair can be found by interpolation on the numerical scale which gauges the blackness or

diameter of all the images. Then by an overlapping process involving many such pairs a graphical relation between photographic effect and true relative brightness or magnitude difference may be built up.

Once a scale of magnitudes has been established for the stars in a standard field, stars in any other area of the sky may be compared with them by exposing the same plate successively to each field, both exposures being of equal length. In less accurate survey work, where an accuracy of 0.1 magnitude is adequate, magnitudes are read off by visual estimation of steps between images of calibrated standard stars.

In addition to the standard photographic and photovisual magnitudes which are the basis of the international system, other magnitude systems based on photography are sometimes used. The magnitudes obtained with a panchromatic plate and a red filter are called photored magnitudes. Infrared-sensitive photographic emulsions and a deep red filter have been used for an effective wavelength still farther removed from the normal photographic range. The latter combination strongly favours the coolest stars with large positive colour index. Red and infrared photographs are better able to show distant stars in directions where there is heavy obscuration because they use light of a wavelength which suffers much less attenuation in interstellar dust clouds.

Two defects of photographic photometry must be mentioned. The total range of magnitudes that may be successfully measured on one plate is limited, and the reduction ratio used in the standardization of the intensity must be small enough so that there will be a good number of overlapping steps in that range. In the successive application of this relatively small reduction factor to cover the enormous range between stars which appear bright to the naked eye and the faintest star images registered on plates from the great reflecting telescopes, there is danger of accumulation of error. This accumulation can arise from multiplication of only a small error in the original evaluation, or from the random errors in its repeated use in equalizing ever fainter star images. For this reason the photoelectric method, treated in a later paragraph, has been adopted increasingly as the one to be relied upon in establishing standard magnitudes.

A second defect of photographic photometry is the difficulty, especially with large telescopes, of transferring a magnitude scale from a standard area to a new field by the method of superposition of equal exposures. The procedure assumes identical image quality in the two cases, which, because of unavoidable small differences in guiding, seeing (atmospheric turbulence), and focus is rarely achieved. The difficulty may be circumvented by spreading out the image into a small uniformly blackened area. On some telescopes, extrafocal images may be used for this purpose. The *Schraffierkasette* spreads in-focus images over a small square by giving an oscillatory motion to the plateholder. The latter method has been valuable for comparing the integrated light of diffuse sources such as extragalactic nebulae with stars of known magnitude. The faintest images, however, are lost in the spreading out process, and the practical limit of photometry is at least two magnitudes brighter than the in-focus limit of the telescope.

The modern technique to avoid difficulty in transfer of standards involves establishing a few photoelectric standards in the field in question. Then interpolation by the photographic method can give magnitudes of hundreds of stars on a single plate with an accuracy only slightly below that which would be obtained by laborious photoelectric measurement of each in succession. Prior to improvements in photoelectric methods made between 1945 and 1955, however, this was not possible. Photographic magnitudes were the almost universal standard of photometric comparison for the 30 years between 1915 and 1945 because only by photography could the measurements be extended to the extremely faint objects at the limit of large reflecting telescopes. And it was just in the range near the limit that some of the important advances were made. The knowledge of the distances and dimensions of extragalactic nebulae that followed E. P. Hubble's identification of Cepheid variables in the nearer external systems is an example of the advances that were made entirely within the domain of photographic photometry.

Physical Photometers.—The auxiliary instrument, often called a microphotometer, which evaluates the absorbing power of a star image on a photograph gives an impersonal numerical result in the form of a scale reading. Photographic photometry of stars is thus "objective" in that the human eye is not called upon to make a judgment of equality, as it is in visual photometry. The distinguishing characteristic of physical photometers is the use of a detector of radiation which converts the starlight directly into an impersonal "pointer reading." In one form the absorbed radiation is converted into heat. A classic illustration of this type of instrument is afforded by Sir William Herschel's exploration of the solar spectrum with a blackened thermometer bulb—the motion of the mercury thread constituting the pointer reading. In a second type the radiation releases electric charges—internally as in a selenium or lead sulfide film to produce increased electrical conductivity, or externally as from the cathode of a photoelectric cell. The latter phenomenon is the basis of astronomical photoelectric photometry, a technique which had assumed so important a place by the 1960s that extended treatment is reserved for a later section. In both types of physical photometer it is usually true that the pointer reading is directly proportional to the quantity of incident radiation. The calibration or equalization procedures that form so large a part of photographic photometry are thus eliminated. This simplification is a contributing factor to the higher precision that is regularly obtained with physical photometers.

The photometers which depend on heating effect are in general nonselective; they measure the incident radiant energy irrespective of its wavelength or spectral distribution. C. G. Abbot's water-flow pyrheliometer for measuring total solar radiation is an example of such an instrument. It was based on the simple and fundamental principle of registering the temperature rise in a stream of water flowing around the absorption vessel. S. P. Langley's bolometer, developed in 1880 for measuring the energy in the various parts of the solar spectrum, was much more sensitive. It depended on the increase in electrical resistance of a thin blackened platinum strip warmed by the absorbed radiation.

Photometry of stars with a heat-sensitive detector has been done principally with the radiation thermocouple. This instrument consists of a tiny disk of blackened metal foil attached to the junction of two dissimilar metals; bismuth and antimony are a favourable combination. The warming of the junction by the heat of the star absorbed on the metal foil generates a thermoelectric voltage which is indicated on a sensitive galvanometer. Sir William Huggins obtained a barely measurable indication from several bright stars with such an arrangement in 1868. Improvements in the construction of the instrument led to considerably increased sensitivity, and in 1914 W. W. Coblentz was able to measure more than 100 stars with a 36-in. reflector. The work was extended by E. Pettit and S. B. Nicholson with the 100-in. reflector of the Mount Wilson observatory (Pasadena, Calif.). The magnitude thus obtained was called a radiometric magnitude. The scale was made to agree with the visual scale for Ao stars, as had previously been done for the photographic magnitude scale. One value of this magnitude scale is its close approach to the hypothetical concept of bolometric magnitude, defined as a measure of the total radiation from a star, over the entire range of its spectrum, as received at the top of the earth's atmosphere. This concept, introduced by A. S. Eddington, is useful in studies of the internal constitution of stars.

Radiometric magnitudes of stars are heavily influenced by the radiation coming in the unseen infrared portion of the spectrum, and the cool red stars show the greatest difference (called the heat index) from visual magnitudes. Long-period variables, such as Mira (Omicron Ceti), have a heat index as high as eight magnitudes at minimum and are among the radiometrically bright stars at all phases of their cycle. But for most stellar types, measurements with the 100-in. telescope were limited to objects visible to the naked eye.

The thermocouple technique thus fails by several orders of magnitude of serving as the basis of a generally useful magnitude scale. For many years, however, it was the only technique that could detect the infrared thermal radiation from relatively cool

bodies such as the moon and the planets. Direct indication of the surface temperature of these bodies was first obtained from thermocouple measurements made by Coblentz at Lowell observatory (Flagstaff, Ariz.) in 1922. More recently other more sensitive heat-sensitive detectors have been developed which permit measurement of quantities of infrared radiation considerably smaller than that possible with the thermocouple. William M. Sinton and John Strong used a pneumatic cell developed by Marcel Golay to scan the infrared spectrum of Mars. F. J. Low developed a germanium bolometer, cooled by liquid helium, which approaches the ultimate limit set by statistical fluctuations in the exchange of quanta between receiver and surroundings. It was first applied to astronomical measurements in the early 1960s.

PHOTOELECTRIC PHOTOMETRY

In principle photoelectric photometry consists of measuring the electrical current flowing in the external circuit of a photoelectric cell when the various quantities of luminous flux to be compared are allowed to fall successively on the cathode. (*See* PHOTOMETRY; PHOTOELECTRICITY.) The extension of this principle to astronomical sources requires electrical instruments capable of measuring very small currents, since the amount of light available, even with a large telescope, is so much smaller than that commonly encountered in illuminating engineering. The low intensity makes cathode fatigue unimportant, and strict proportionality between quantity of light and current holds over an extremely wide range of intensities. Modern developments in photoelectric technique have improved the sensitivity to the point where the whole range of astronomical intensities may be covered. Any object that can be photographed can, with sufficient pains, be measured photoelectrically. The photoelectric cathode is, however, a selective detector of radiation; like the photographic plate or the human eye, it responds unequally to different wavelengths. By the choice of cathode material and the addition of suitable filters, the range of wavelengths used in photometry can be varied over wide limits.

Historical Development.—The first practical photoelectric cells were made by J. Elster and H. Geitel in 1890, only two years after W. Hallwachs established the existence of the photoelectric effect. The first astronomical use of the photoelectric cell was the measurement of ultraviolet light from the sun by Elster and Geitel in 1892. The step from this observation to the measurement of starlight was a considerable one, and did not come until 1913. P. Guthnick in Berlin, H. Rosenberg in Tübingen and J. Kunz and J. Stebbins at the University of Illinois (Urbana) made successful observations in that year, all independently and all with similar apparatus. The photoelectric cells were of the Elster and Geitel type, with hydrogen-sensitized potassium cathodes. An electrometer was used to measure the current, since even the bright stars produced an effect too small for a galvanometer. The practical working limit for the Illinois apparatus was a current of 10^{-14} amp., corresponding to seventh magnitude with a 12-in. telescope. Great care was necessary to avoid spurious effects from leakage currents over the surface of the photoelectric cell, or over other insulators in the system.

The improvements in sensitivity that came in the succeeding decades consisted partly of refinements in the method of measuring the current from the cathode, and partly in improvements in the yield from the cathode itself. Sinclair Smith showed in 1932 that a stable electrometer at the fixed Coudé focus of a reflecting telescope (*q.v.*) could give considerably higher sensitivity than the type customarily used at the end of a moving telescope. The development of electronic tubes with extremely high input resistance (the so-called electrometer tubes) enabled A. E. Whitford to develop an amplifier that could be moved about at the end of a telescope; this type of current measuring apparatus was carried to its ultimate limit by G. E. Kron. In order to avoid fluctuations caused by cosmic ray ionization, it is advantageous to put the amplifier tube and photocell in an evacuated container. In this type of amplification, it is necessary to use a high resistance in series with the photocell in order to obtain a voltage to apply to the input grid of the amplifier tube. The "resistance noise" generated by this high resistance adds to the unavoidable "shot noise" fluctuations in the cathode current caused by the random spacing of the photoelectrons released by the incident light. When the overall accuracy is determined by cathode shot noise alone, then the equipment is doing as well as it can with the particular cathode being used.

With the introduction of secondary emission multiplication as an amplifying principle in the years 1936–39, the offending load resistor could be removed and a close approach to the ultimate shot-noise limit became possible. In the practical form of the multiplier phototube there are 9 to 12 multiplying surfaces in cascade. Each photoelectron impinging on the first multiplying surface releases three to four secondary electrons, which are multiplied in turn at the second multiplying surface and so on. A total amplification of the cathode current by a factor of 1,000,000 or more is common, a value more than adequate to ensure that any further amplification by traditional vacuum tubes will not add to the overall noise level. In the decade after 1946, the multiplier phototube became the almost universal tool in astronomical photoelectric photometry.

The potassium-hydride cathode used in the first successful photoelectric measurements of stars in 1913 remained the principal type in use until about 1940. It is sensitive to a relatively narrow band of wavelengths in the blue-violet. The much greater spectral range of the cesium-oxide cathode, with its peak response in the near infrared, was first used for astronomical photometry by John S. Hall at the Yale observatory. The thermionic emission from this cathode at room temperature is larger than the photoemission produced by most stars, and had to be reduced by refrigeration with solid carbon dioxide. A major improvement in cathode efficiency was realized from the cesium-antimony surface developed by P. Görlich in 1938. It is sensitive from the ultraviolet through the yellow with a maximum response in the blue-violet. One electron is emitted for approximately eight incident quanta, a ratio so markedly superior to that for other cathode surfaces that its use has become standard.

Modern Techniques of Observation.—The photoelectric photometer at the end of a telescope may be considered to begin with a small diaphragm in the focal plane. Usually a series of diaphragms of graduated diameters is provided, so that nebulae as well as stars may be measured, and so that the smallest practical diaphragm may be chosen in cases where it is necessary to exclude the light of the sky, or stars adjacent to the one being measured. There is provision for sliding filter glasses into the beam, often in front of the diaphragm. A total reflecting prism slides in just back of the diaphragm to provide visual inspection of what is in the diaphragm area. If faint stars are to be measured, the multiplier phototube is mounted in a thermally insulated box with provision for surrounding it with solid carbon dioxide for refrigeration. This is necessary because all sensitive cathodes have a thermionic emission level higher than the response caused by a faint star. After the millionfold amplification on the secondary emission surfaces, the output current will generally be in the range 10^{-6} to 10^{-11} amp. Further amplification will be needed. Usually this is arranged so that the final output is recorded on a moving paper chart. Assuming that 1 milliampere will be required to operate the recording meter, the overall amplification may be as high as 10^{14}. The wide range of currents that must be measured is covered by gain controls in the amplifier. These ratios can be made to be simply the ratio of certain fixed resistances.

With bright stars, the light of the night sky is unimportant, and a moderately large diaphragm can be used. The recording meter operates similarly to a laboratory voltmeter and little time need be spent on each star. On telescopes smaller than 24 in., scintillation of the star may be the main source of noise. This effect averages out on telescopes of larger aperture. As fainter stars are attempted, however, more care must be exercised. The smallest diaphragm that will safely contain the atmospheric tremor disk of the star is chosen, in order to reduce the contribution from the light of the night sky. An auxiliary guiding eyepiece working on a second star around the edge of the field is advisable in order to ensure that the star being measured stays on centre. The faintest objects cannot be seen with the eye, and must be centred

in the diaphragm by an offset procedure, using a coordinate system based on a photograph of the region made with the same telescope. The offset proceeds from a star near the object in question which is sufficiently bright to be centred in the diaphragm by visual means.

On the faintest objects the light of the night sky becomes the major fraction of the light coming through the diaphragm, and the measurement consists of determining as accurately as possible the relatively small difference between the diaphragm area containing the object in question and an equivalent blank sky area adjacent to it. The cathode shot noise, generated mainly by the unavoidable light of the night sky, may have an amplitude larger than the star signal. Considerable averaging is necessary to obtain a reliable measurement, and a program of alternate exposures to sky and star lasting an hour or more may be needed to build up sufficient accuracy. In this range, integration of the charge coming from the multiplier offers some advantage; the longer the exposure time the greater the accumulated difference between sky and sky plus star. Electronic schemes involving the storing of the charge on a condenser have been developed by H. L. Johnson and others. An alternative approach uses counting methods to perform the integration. Each photoelectron released at the cathode becomes a burst of 1,000,000 electrons at the output of the multiplier phototube, a signal easily registered on electronic counting devices. This technique was used by W. A. Baum to push the photoelectric technique to the very limits of the faintest photographic images detectable with the 200-in. telescope of the Palomar observatory (Calif.). The limit reached was photographic magnitude 23.8.

Special Applications of Photoelectric Methods.—The higher photometric accuracy obtainable by photoelectric methods was applied very early to observations of the light curves of eclipsing binaries. A single observation gave an accuracy of the order of 0.01 magnitude, as opposed to .05 to .08 magnitude by visual photometry, and an intermediate accuracy by photographic methods. By combining observations extending over many cycles, Kron was able to achieve a final curve with a probable error of only 0.001 magnitude, corresponding to a relative error of 0.1%. With this increased precision the full power of the methods that had been worked out for deriving the physical properties of stars from analysis of the light curve and the radial velocity curve could be realized. Shallow eclipses that had previously been missed were found at their predicted times. Not only was the list of stars with well-determined diameters and densities considerably lengthened, but secondary features such as the reduced brightness of a star at the outer edge (darkening at the limb) could be derived with real confidence. The latter effect, directly observable only on the sun, gives information on the atmospheric structure of a star.

The simplicity of colour measurements by the photoelectric method led to its early use in that field. The ratio of response through two chosen filter glasses gives a colour index directly, without establishment of two separate magnitude scales. The method is thus suited to colour surveys of widely scattered objects. From such a survey of B-stars, Stebbins and his collaborators found that almost all of the more distant ones in the plane of the Milky Way had been reddened by interstellar dust clouds. The normal or intrinsic colours, as tested on the nearer stars, had the expected correlation with spectral type. The difference between observed colour and normal colour, called the colour excess, is a measure of the reddening and also of total absorption of light suffered as a result of scattering by interstellar dust clouds.

Distances calculated from the spectroscopically determined luminosity of giant or supergiant stars, or from the period-luminosity relation of Cepheids, had previously assumed that space was transparent; for reddened stars the inferred distances were therefore too great. Correction for absorption losses by means of the measured colour excess has become one of the essential steps in establishing distances by the photometric method, and photoelectric colour measurements are usually used in determining the excess.

Photoelectric methods are well adapted to measurement of small differences because the linear response lends itself so directly to simple subtraction of a large background. The detection of very faint stars against the light of the night sky has already been mentioned. The photometry of extragalactic nebulae, where the tenuous outer portions have a surface brightness only a few per cent of that of the sky, is a similar case. Another example is the demonstration by Hall and by W. A. Hiltner that starlight which has passed through interstellar clouds is slightly polarized. This observation has been interpreted as evidence for a weak magnetic field in the Milky Way which aligns interstellar dust particles. In a differential measurement between two planes of polarization on the same star, Hiltner was able to maintain an internal probable error of only 0.016%, or one part in 6,000.

At first photoelectric magnitudes were used as a check on older photographic and photovisual magnitudes. An initial study for magnitude sequences in three fields chosen from the *Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1–139*, carried out by Stebbins, Whitford and Johnson, showed the first serious systematic difference in scale between the photographic and photoelectric results. The photographic scale had made the stars too bright by a third of a magnitude at the 18th magnitude. The "selected areas" had been the ones used in establishing the magnitudes of Cepheids in external galaxies, and the correction was one of the factors contributing to the general upward revision of the scale of extragalactic distances that took place in the 1950s.

In this early photoelectric work yellow and blue filters were chosen to give a close approximation to the International system of photographic and photovisual magnitudes; in the fainter ranges these had been based on the use of silvered reflectors and included some ultraviolet in the photographic band of wavelengths. Shortly after it had been shown by H. L. Johnson that exclusion of wavelengths below 3,800 Å from the blue band eliminated almost all of the ambiguities in transforming magnitudes obtained by various methods on widely separated telescopes, a new standard system of magnitudes was introduced in 1953 by Johnson and W. W. Morgan. It is called the UBV system, the symbols U, B and V representing respectively the ultraviolet, blue and visual magnitudes of an object. Carefully specified filters and a particular type of photoelectric cathode defined the wavelength range entering into each heterochromatic magnitude. The zero point for the visual magnitudes was fixed to agree with the International photovisual system established by the north polar sequence. The ultraviolet-free blue magnitude approximates the International photographic magnitude, but is more precisely defined. The ultraviolet magnitude encompasses a band between 3,000 Å and 4,000 Å, peaked at 3,500 Å. As in the original definition of colour index, the U, B and V magnitudes of an Ao star are taken to be identical.

In the years since its introduction, the UBV system has been widely adopted, not only by photoelectric observers, but by observers engaged in photographic photometry. Plate and filter combinations reproducing the sensitivity bands and colour system of the photoelectric method are used. Each field photographed is calibrated by a number of stars in it which have been previously measured photoelectrically; many hundreds of stars on a single plate can thus be referred to the standard stars of the UBV system without the pitfalls of the double-exposure photographic transfer method referred to in the section of this article on photographic photometry.

The primary standards of the UBV system were originally 108 relatively bright stars of known luminosity and spectral type, well distributed over the sky. These had been repeatedly measured with the particular telescope, photocathode and filters which define the system. The north polar sequence was found to contain an inadequate range of types and luminosity classes, and is no longer relied upon for reference. The number of standards has since been increased by intercomparison of new stars with the original set, carried out independently at different observatories. The basic philosophy in using the system is the assumption that the photoelectric method may be relied upon for the precise intercomparison of a previously unmeasured star with a standard over a considerable range of difference in brightness and colour and over a wide angular separation on the sky. Experience has shown that a given photo-

electric photometer can cover a range of 10^4 to 10^5 with good precision (10.0 to 12.5 magnitudes). Thus not many overlaps with different optical systems are necessary to span the total range of astronomical magnitudes—nearly a factor of 10^{20}, or 50 magnitudes between the sun and the faintest known stars.

The ultraviolet magnitude, the third wavelength band included in the UBV system, adds valuable astrophysical information about a star not given by the blue-visual colour index; the latter is mainly an indicator of stellar temperature, as was its predecessor the International photographic-photovisual index. The ultraviolet-blue index is sensitive to the luminosity and the chemical composition of a star; metal poor stars stand apart. In addition, the two colour indices together give an indication of interstellar reddening. The UBV system has been extensively employed in studies of clusters of stars, both of the globular and the galactic type. From comparison of the colour-magnitude diagrams of these clusters have come the principal clues as to the ages of clusters and the evolution of the stars within them.

SPECTROPHOTOMETRY

Spectrophotometry of stars seeks to derive information about their physical properties by studying the distribution of energy through the range of the observable spectrum. A colour index is the simplest possible measurement of this type; the finest detail would be represented by high-dispersion analysis of the star's spectrum, including determination of the intensity profile of each spectrum line. Between these extremes, relative intensity measurements on short segments of the continuous spectrum of stars may be made with a resolving power ranging from one Å to a few hundred Å. When the band is not more than a few Å wide, the measured intensity ratios can be said to represent a system of monochromatic magnitudes. Such a system has not been used to any extent in comparing the brightness of stars, even though it would have an advantage in elimination of the previously mentioned instrumental differences between observers which make a unique definition of heterochromatic magnitudes so difficult. Too small a fraction of the total light is contained in the narrow portion of the spectrum specified for the monochromatic magnitude, and the measurement is restricted to the brighter stars; heterochromatic magnitudes have to be used to reach the faint stars so important in cosmological problems. But for the comparison of the spectral distribution of radiation in different stars, the brighter stars furnish examples of most recognized types, and the specification of narrow bands gives the same advantage of uniqueness in defining the differences of magnitude that describe the distribution. The magnitude differences are in effect a series of colour indices, without the ambiguities that inevitably accompany heterochromatic photometry.

Photographic methods have been used for most of the spectrophotometric studies of stars. The spectrum is formed by placing a prism in front of a small telescope. A grating over the objective is a common method for introducing the intensity steps needed for calibration of the photographic intensities. W. M. H. Greaves, C. R. Davidson and E. G. Martin began the first series of measurements by this method at the Greenwich observatory in 1926. H. Kienle at Göttingen, R. C. Williams at the University of Michigan (Ann Arbor), and D. Barbier and D. Chalonge of Paris made important contributions. The French workers used the clear air of a high-altitude station on the Jungfraujoch in the Alps to extend their measures farther into the ultraviolet.

Spectrophotometry by photoelectric methods labours under the handicap that only one portion of the spectrum can be measured at a time. On account of the long observing periods that would be necessary, high resolving power is not ordinarily attempted. When wide bands must be used in order to reach faint objects, a series of filters is a simple expedient. A single photoelectric cathode can cover the spectrum from 3,400 Å to 10,000 Å. Stebbins and Whitford used six filter bands distributed over this range. Because of the lines and bands of the star's spectrum necessarily included, results with filters are not strictly comparable with monochromatic magnitudes read at selected points in the continuous spectrum. Hall introduced the technique of scanning the spectrum with a photoelectric cell behind the exit slit. In this early work the exit slit was 400 Å wide. A. D. Code was able to reduce it to 10 Å, narrow enough to show the principal spectrum features and to give true monochromatic magnitudes.

The temperatures of the stars can be found much more precisely from monochromatic magnitudes than from colour indices. It is necessary, however, to establish an absolute standard for the relative monochromatic comparisons between stars. This can be done by comparing the stars with a terrestrial source of known spectral energy distribution, such as a carefully calibrated tungsten filament lamp. Such a source serves as an artificial star at a suitable distance from the telescope, and is measured in the same way as are the actual stars. The stellar temperatures derived in this way are called colour temperatures. For the range of the spectrum between 3,700 Å and 4,500 Å, Barbier and Chalonge found that an Ao star had a colour temperature of 16,500° K.

Spectrophotometric comparisons of reddened and unreddened stars of the same type have shown how the interstellar absorption varies with wavelength. Since most of the highly reddened objects thus far identified are O- and B-stars, whose spectra are not complicated by strong spectral lines and bands, photoelectric photometry with filters is well adapted to the study. The wide range of the cesium-oxide cathode is an advantage. The law of variation of absorption with wavelength must be investigated for light paths in various directions within the interstellar medium. Once the law is known, a measured colour excess, which is merely the amount that the absorption in the shorter wavelength band of a colour system exceeds that at the longer, can be multiplied by an appropriate factor to give the total absorption at any desired wavelength for any specified magnitude system. Then the observed magnitude may be corrected to restore the star to its unobscured brightness, as is required in proper calculation of its photometric distance.

Spectrophotometric analysis of the light of galaxies has also been a task for photoelectric filter photometry. The diffuse nature of galaxies makes it impractical to form a spectrum of a whole system with spectroscopic equipment. As would be expected from a composite source made up of stars with a variety of spectral types, the spectral distribution is not like that of any single star. But since most of the light of external galaxies comes from stars that can never be resolved and studied individually, the spectral distribution curve contains one of the slender clues to the nature of the stellar population in these systems.

See also ASTRONOMY and PHOTOGRAPHY, CELESTIAL.

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PHOTON, Albert Einstein's name for the theoretical quantum (discrete unit) of radiant energy. Max Karl Planck had posited that light (*q.v.*), for example, is emitted in quanta rather than con-

tinuously. *See* PHOTOELECTRICITY; COMPTON EFFECT; *see* also references under "Photon" in the Index.

PHOTOPERIODISM, the functional or behavioural response of an organism to changes of duration in the periods—daily, seasonal, yearly—of light and darkness. Flowering in plants, breeding in animals, and migration in birds are among the many well-known photoperiodic responses that have received intensive study. Temperature, nutrition, and other environmental factors interact with photoperiod and modify the response. Closely related varieties of a species may respond differently to identical photoperiodic conditions because of inherited differences. Photoperiodism was discovered first in plants and soon afterward was demonstrated in animals.

Plants.—W. W. Garner and H. A. Allard, of the U.S. Department of Agriculture, first reported in 1920 that flowering of some kinds of plants was controlled by the daily duration of light. They suggested the term "photoperiodism" to designate "the response of organisms to the relative length of day and night." Garner and Allard recognized three types of plants on the basis of day lengths favourable to flowering: short-day plants, which fail to flower when days exceed a certain duration called the critical day length; long-day ones, which fail to flower unless the days exceed a critical day length; and indeterminate ones, which flower about equally well regardless of day length. Critical day lengths for both long- and short-day plants differ widely from species to species and even among varieties of a single species.

Responses of plants other than flowering are influenced by photoperiod. Among these are the formation of bulbs, tubers, thickened roots and runners, colouration of stems and leaves, abscission of leaves, and development of certain anatomical features.

The photoperiod response of plants depends on duration of darkness, not light, a fact not understood at the time the phenomenon was named. Thus, a short-day plant flowers when nights are long and a long-day one when nights are short or absent. A brief period of artificial light in the middle of a long dark period divides it into two short ones and thus promotes the flowering of long-day plants and inhibits that of short-day ones.

Growers of chrysanthemums now produce these highly seasonal flowers throughout the year by proper control of night length and other cultural conditions for adapted varieties. Artificial light keeps the plants from blooming until they attain sufficient size or until the desired date is reached. The light is then discontinued or in some times of the year the plants are covered with black cloth during part of the day, thereby increasing the night length adequately to bring them into bloom. This practice is in extensive use in greenhouse production of chrysanthemums in the United States and over several hundred acres of plants grown out-of-doors in Florida and California.

Artificial control of day length is similarly used to regulate the time of flowering of orchids, China asters, feverfew, and tuberous-rooted begonias. Experiments show that the growth of some kinds of woody nursery plants can be maintained in the greenhouse during the winter by the use of artificial light. The uses of artificial light to improve production of various kinds of plants are constantly increasing.

The photoperiodic reaction occurs in the leaf, but the response generally occurs elsewhere. A product generated in the leaves evidently moves to the growing points, where it controls flower-bud formation. This product is a flower-promoting one produced by dark periods favourable to flowering, not a flower-inhibiting one produced by unfavourable dark periods. Some workers believed this flower-inducing material to be a special flower-forming hormone, "florigen," but such a substance had not been isolated from a plant and identified by the mid-1960s. Knowledge of the initial photochemical step in photoperiodism was obtained by studies of the way in which light acts. Red light having a spectral range of about 5,500 to 7,000 Å (Ångström units) and an absorption maximum near 6,500 Å is more effective than any other kind for preventing flowering of short-day plants and promoting flowering of long-day ones. A second but far less effective region of absorption occurs in the blue. Flowering is controlled in both kinds of plants by light of the same wavelength ranges, indicating that the basic photochemical reactions are identical, although in one type they suppress and in the other promote flowering.

The inhibition of flowering of some short-day plants by exposure to red light can be prevented by exposing them immediately afterward to light of somewhat greater wavelength; namely, far-red light of about 7,350 Å. A similar cancellation of the action of red by far-red radiation occurs in the germination of light-sensitive seeds and in the control of growth of the stem and other parts of dark-grown seedlings, indicating that the same photocontrol is present in all these phenomena. Many of these responses can be repeatedly reversed by successive alternating exposures to red and far-red light. The ultimate response to such a series of exposures is dependent on the kind of light given last.

Reversibility arises from the photochemical interconversion of two forms of a photoreceptive pigment called phytochrome. A red-absorbing form is converted by red light to the far-red-absorbing form; this in turn is reconverted by far-red light to the red-absorbing form. The far-red-absorbing form of phytochrome is believed to be biologically active, probably an enzyme: but the action it catalyzes is not yet known. The red-absorbing form is thought to be inactive.

Discovery of these characteristics of phytochrome led to its physical detection in the live plant. The method used was a spectrophotometric one, based on the changes in optical density of the tissues resulting from converting the phytochrome from one absorbing form to the other. Phytochrome has been detected in about 50 species by this method.

Phytochrome has been obtained as a bright blue solution in relatively pure form from several plant species. In red light the colour fades, but in far-red it reintensifies, indicative of its reversible change. Phytochrome is a protein with a molecular weight of about 100,000. It is stable for many weeks at low temperatures but degenerates quickly at room temperatures. The chemical structure of the chromophoric group that gives the compound its blue colour is unknown, but the absorption spectrum is closely similar to that of phycocyanin, the prominent pigment of blue-green algae.

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Animals.—The most conspicuous activities of animals which are closely correlated with certain seasons of the year, and hence with changes in day length, are bird migration, reproduction, and changes in pelage and plumage. Each of these occurs with marked regularity at a particular time each year. By retaining animals in captivity and subjecting them to artificial increases and decreases in day length, bird migration, reproduction, and other activities have been induced out of season. It has been concluded, therefore, that in nature the changing daily periods of light and darkness determine to a great extent when many seasonal activities occur. Before the northward migration to the breeding grounds in spring, birds undergo a marked change in physiological state. This is shown by increased activity of the reproductive organs and deposition of large amounts of fat. When these same changes were induced experimentally in winter by exposing captive birds to artificial increases in day length, the birds migrated northward in winter when released. By employing different schedules of day length at various seasons of the year, it has been demonstrated that the rate of change in physiological state depends on the daily amount of illumination. As little as nine hours of light per day is stimulating. The response is rapid under long days and slow under short days. Gradual increase in amount of light per day is not necessary. Constant day lengths are effective, as are decreasing day lengths, provided that the daily amount of light is stimulating. Therefore, migratory birds that winter on or near the Equator, where the day lengths are constant, or in the Southern Hemisphere, where the day lengths decrease after Dec. 21, could have the onset of their spring migration regulated by day length. Prerequisite to the response to light that occurs in winter and spring is exposure to short days or long nights in autumn.

This phase of the annual cycle is called the preparatory phase, since failure to complete it precludes the subsequent response. Under experimental conditions completion occurs uniformly and more rapidly with longer nights. Day lengths in autumn wind the "clock" within the bird, so to speak, while the day lengths of winter and spring make it run and determine how fast it runs.

In most birds, mammals, and other vertebrates breeding is seasonal. By experimental manipulation of day length, reproductive activity has been induced out of season. Where the species breed normally beginning in autumn (*e.g.*, brook trout, deer, sheep, and goats), decreasing daylight or short days following long days are effective. For species that breed in spring (*e.g.*, starling, junco, ferret, and mink), increasing daylight or long days following short days are effective. Change in breeding season occurs in some birds and mammals when they are transported from the Southern to the Northern Hemisphere, or from the region of the Equator to temperate latitudes. Although day lengths are constant on the Equator and change little in the tropics, there is some evidence that day length does regulate the breeding and plumage cycles of tropical birds. Experimental modification of the breeding cycle of invertebrate animals (*e.g.*, snails, crustaceans, and insects) by means of day length has also been demonstrated.

Attempts to discover how length of daylight affects the breeding cycle have shown that the light stimulates the eye or part of the brain near the eye. The stimulus produced by the light eventually reaches the pituitary gland (the master endocrine gland located at the base of the brain), which secretes the hormones that, among other functions, control the growth of the reproductive organs. There is good evidence that the length of the dark period and the ratio of light to darkness are important factors in determining the reproductive response. The effects of day length on the migratory response (mentioned above) also apply to the reproductive response in some birds. Response to light can be modified by temperature, nutrition, and inherent internal factors. Important among the last is a daily rhythm of about 24 hours' duration (termed circadian), which makes it appear as though the organism were keeping track of each day. The response to light-dark cycles seems to depend in part on the time that the light and dark periods occur within these 24-hour periods. A few species of birds and mammals studied did not show any influence of light on the reproductive cycle.

The most conspicuous seasonal change in pelage and plumage occurs in those mammals and birds that are white in autumn and winter and brown in spring and summer (*e.g.*, varying hare, ermine, and ptarmigan). By experimental manipulation of light, either of these colours can be produced out of season. Molt into white plumage or pelage can be induced by short days. Temperature is not a factor. Day length also influences the time of annual molt in birds, growth of wool in sheep, and production of winter pelage in mink and ferret.

A number of less obvious seasonal activities also occur in response to day lengths. In the potato aphid, the production of winged individuals (as opposed to wingless individuals) normally occurs in autumn and is dependent on a period of darkness of 12 to 14 hours. In the strawberry root louse, occurrence of sexually reproducing individuals, which occurs normally in autumn, can be produced out of season by shortening the days.

Practical application of knowledge of photoperiodism is common in poultry management, for daylight length affects laying, sperm production, and body weight of the fowl.

See also PHOTOCHEMISTRY: *Kinds of Photochemical Effects;* PHOTOSYNTHESIS; PLANTS AND PLANT SCIENCE: *Growth;* RHYTHMS, BIOLOGICAL.

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PHOTOSPHERE, the layer of the sun from which is emitted most of the sun's light that reaches the earth directly; *i.e.*, without absorption and reemission. The sun is a globe of gas with no sharply defined surface, and it is viewed through absorbing layers of very low density; the photosphere may be regarded as the innermost layer that can be seen. *See* SUN.

PHOTOSYNTHESIS is the process by which green plants harness the energy of sunlight absorbed by chlorophyll to build organic compounds from carbon dioxide and water. The reaction is often referred to as assimilation or fixation of carbon.

Fundamental Role of Photosynthesis.—For their subsistence, growth and multiplication, all living beings, plants and animals alike, need organic food. The organic foodstuffs are utilized by living cells as building stones and as sources of energy. The energy stored in the foodstuffs is released mainly by respiration, the reaction in which organic matter combines with the oxygen of the air yielding carbon dioxide and water as final products. The rate at which living beings die and consume each other is so high that they would all disappear from the earth within the lifetime of a human generation if there were not a process providing for the re-formation of organic matter.

While there are many ways by which organic substances are decomposed in respiration and similar reactions, there is only one reaction, photosynthesis, that for millions of years has counterbalanced death and decomposition. In the course of photosynthesis the hydrogen of water is used to transform carbon dioxide into carbohydrate; simultaneously the oxygen of the water is liberated as free oxygen gas. Among the many pigments appearing in the plant kingdom only chlorophyll and, to a lesser extent, carotenoids and phycobilins are known to convert sunlight into chemical energy. Chlorophyll is the green dye whose colour is so characteristic of meadows and forests. The green plants may transform the carbohydrates produced by photosynthesis into fats, proteins and many other substances. Thus, directly or indirectly, all the organic food of plants or animals depends upon the photosynthetic process. In the cycle of synthesis and death the basic materials, carbon dioxide and water, can be used over and over again, while the energy released upon the destruction of organic matter is lost forever; it is dissipated as heat in space and must constantly be replaced by the sun's radiation.

Origin and Evolution of Life.—The chlorophyll system is a highly complex structure that ceases to function whenever its protein components are damaged. Obviously, therefore, life cannot have started with the particular synthetic reaction that is its sole support at present. Life probably began with organic substances produced by ultraviolet radiation or by electrical discharges when the earth's atmosphere consisted mainly of hydrogen, methane, ammonia and water vapour. Experiments have shown that such a gas mixture, if subjected to electrical discharges, yields many aliphatic and amino acids. Contemporary living cells still use these simple compounds as building stones, not only for proteins and fats but for the synthesis of even more intricate organic molecules. The most famous example is the formation of the porphyrin ring, the parent structure of chlorophyll and of hemin, the red pigment in blood. It is formed by a succession of a few simple condensation steps. This synthesis starts with glycine and acetic acid, compounds now assumed to have been present in large quantities at the beginning of organic evolution on earth. It is likely, therefore, that porphyrins and hence their iron and magnesium derivatives, *i.e.*, hemin and chlorophyll, appeared early and took part in the emergence of the first living things. (*See* LIFE, ORIGIN OF.)

Thus the complex mechanism of photosynthesis may have evolved as a part of the first organisms. Even at the initial stages of life the simplest photochemical reactions (reactions initiated by light) known to occur with porphyrins must have been instrumental in speeding up and selecting special types of synthetic reactions. Because the process of photosynthesis as found in present-day plants can be broken up into separate sets of partial reactions, it is assumed that, during evolution, these were added one by one, with the light-absorbing chlorophyll complex as the original centre. The last of these evolutionary steps was the capacity to release free oxygen. In this way photosynthesis has first furnished and

then maintained the supply of oxygen in the atmosphere, which made the Darwinian evolution of respiring organisms possible. The preceding developmental step, the photochemical reduction of carbon dioxide at the expense of compounds other than water, seems never to have risen above the level of unicellular microorganisms.

Rate of Carbon Dioxide Turnover.—In bright sunlight the rate of the photosynthetic reaction is about 15 to 30 times the respiratory rate. A sunflower leaf may gain 9% of its dry weight per hour. Considering that respiration proceeds continuously while photosynthesis occurs only during the hours of light, the net rate of the latter is about five times greater. This means an excess of carbohydrate, which is partly stored and partly used for the growth of the plant. Nongreen plants and animals, which constitute the heterotrophic organisms, depend upon this excess for their organic food.

Land plants, which utilize the carbon dioxide present in the air, grow faster if supplied with more carbon dioxide than they can now find in nature. This averages only 0.03% of the gas volume at the earth's surface. Aquatic plants thrive on the carbon dioxide dissolved as gas or as carbonates in the water. The best estimate for the rate of the total carbon dioxide reduction on earth is a turnover of 10^{10} tons of carbon per year, more than two-thirds of which is contributed by the flora of the oceans. An amount of carbon dioxide equal to the total readily available reservoir passes through the life cycle in about 350 years. The cycle of carbon requires also one of oxygen and of hydrogen. Since both these elements are available in larger quantities, it takes about 2,000 years to renew all the oxygen in the air and 2,000,000 years to decompose all water on earth.

Probably there was more carbon dioxide in the atmosphere of the earth at earlier times. The enormous deposits of coal and oil, the so-called fossil fuels, are the remnants of once living plants and microorganisms. These products of ancient photosynthesis (which, since the beginning of the Industrial Revolution around 1750, man is returning to the air in ever increasing amounts as carbon dioxide) have been out of circulation for many millions of years.

Efficiency of Photosynthesis.—In land plants, between 1% and 3% of the light falling upon a green plant is transformed into chemical energy. Important as this answer may be for problems of agriculture, it is of no value in respect to the theoretical understanding of the process of photosynthesis. Most of the incident radiation is lost by reflection, transmission and ineffective absorption by pigments other than chlorophyll. Only a fraction is absorbed by the active pigments. The efficiency with which this latter fraction is utilized in the course of the photochemical process is of great theoretical interest. It is measured by the minimum number of light quanta necessary to bring one molecule of carbon dioxide to the energetic level of a carbohydrate. From the mid-1920s to the early 1960s a prodigious amount of work was devoted to the determination of this number. It is certain that eight quanta of red light totaling 320 kilogram-calories (kg.cal.) suffice to store the equivalent of 112 kg.cal. in terms of organic matter. The net efficiency of photosynthesis, therefore, is about 35%. Much higher efficiencies are alleged to have been found in certain experiments where plants were kept under unusual conditions. In the unicellular green alga *Chlorella* the quantum yield remains essentially constant over the entire range of the chlorophyll absorption spectrum. This means that, expressed in terms of calories, the efficiency increases in the direction from blue to red in the spectrum, because the energy content of the light quanta decreases according to the laws of physics. Chlorophyll in the living cell obeys these laws exactly as do the chlorophyll-sensitized photochemical oxidations in vitro.

Artificial Food Production and Space Travel.—Because the earth's human population is increasing so rapidly, with no corresponding increase in food production, scientists have wondered how much more food would be available if full use could be made of the great efficiency of photosynthesis, which in laboratory experiments has been found to approach 35% of the intensity of the radiation absorbed by the active pigments. The average acre of land under cultivation yields hardly more than one ton of total dry organic matter per year because most of the light falling on the surface is not trapped by chlorophyll and thus is lost for photosynthesis. If agriculture were superseded by the continuous cultivation of tiny aquatic algae in thin layers of fertilized water, the same area could produce between 30 and 50 times more edible material. Before such a project can become practical, two other problems must be solved: how to maintain, easily and cheaply over large areas, conditions for optimal growth of algae and how to induce people to eat them. A technological photochemistry for the synthesis of selected chemicals is certainly practicable. By contrast a completely artificial manufacture of food, imitating photosynthesis, does not appear to be a sensible aim to strive for. One cannot conceive of an artificial device as small and as efficient as a green plant cell for the purpose of producing all necessary nutrients.

The problem of how to nourish human beings and supply them with oxygen during long-lasting expeditions into outer space can be solved on the basis of natural photosynthesis. Oxygen for respiration would be provided by illuminated plants, which in turn would use the exhaled carbon dioxide and other waste products of man's metabolism as the raw material (carbon source, vitamins and mineral nutrients) to grow and produce the necessary food. In short, the carbon cycle of the organic world on earth would have to be duplicated in miniature. The light energy to keep it running could be obtained either directly from the sun or indirectly from the power that promotes the space rocket.

A third problem, the conversion of light energy into electricity for industrial purposes, is solved in principle on the basis of purely physical reactions found in "solar batteries," and a solution may be found for photochemical reactions also, yet neither method of utilizing light resembles the photochemistry of chlorophyll in plants. (*See* also PHOTOCHEMISTRY.)

Energy Storage (Decrease in Entropy).—Light energy may be used in several ways: (1) to speed up reactions that would proceed in the dark in the same way but at much slower rates (autoxidation, the bleaching of colours, for example); (2) for reactions that will not occur unless light energy is available (for instance, the release of oxygen from water at normal temperatures); and (3) for a reaction in which the new products still hold as potential chemical energy a part of the light energy originally absorbed. In the course of organic evolution photosynthesis reached the third stage and achieved an over-all molecular efficiency of 35%. This efficiency is due to the incorporation of water as a reactant into the photochemical system and to the subsequent release of free oxygen arising from water.

There are many other mechanisms in nature in which light plays a role (vision, for instance) and some in which carbon dioxide is transformed into organic matter without an over-all gain in energy. The latter fall in two classes, one where light is not needed at all and one where it is needed but does not produce a net gain in free energy. A few species of autotrophic bacteria are known to grow in the absence of light with carbon dioxide as the sole source of carbon. They utilize the energy derived from the oxidation of inorganic compounds such as ferrous iron salts, sulfur, thiosulfate, hydrogen sulfide and molecular hydrogen. This fact was generally ignored in earlier attempts to understand the mechanism of photosynthesis. The amount of organic matter formed by this means was considered insignificantly small as compared with photosynthesis, and the reduction of carbon dioxide in the dark appeared to be fundamentally different from photochemical reduction. In the decade between 1930 and 1940, however, it became evident that many organisms and tissues, from propionic acid bacteria to pigeon liver, include carbon dioxide among their metabolic substrates. In these cases a specific enzymatic system provides for the proper coupling between an energy-yielding reaction, respiration or fermentation, and a reaction in which hydrogen is transferred to carbon dioxide or its equivalent derivative. The result is called a carboxylation. Since the very life of autotrophic organisms depends on catching what little there is of carbon dioxide in the air, their carboxylation enzymes are usually more efficient than the same enzymes found in heterotrophs. The decisive difference

between both classes of organisms lies, however, not in the way in which the carbon dioxide molecule is attacked but in the energy balance. No ordinary metabolic synthesis can end with an over-all gain and storage of chemical energy, because an excess of combustible material, previously synthesized, has to be sacrificed to make the reaction go.

In photosynthesis it is the energy of light that in the course of the very reaction furnishes the necessary combustible material or hydrogen donor by the "splitting" of water. The utilization of light energy, however, is not sufficient to guarantee a successful accumulation of chemical energy. This was shown by studies on the metabolism of purple bacteria, strongly coloured yellowish, red or purple unicellular microorganisms. Because their growth depends on light, they were first believed to photosynthesize as do the green plants. Investigations proved that purple bacteria are unable to produce molecular oxygen and are unable to reduce carbon dioxide simply with water. In addition to radiant energy they need energetically valuable hydrogen donors. According to the specificity of each species, the purple bacteria require for the assimilation of a certain amount of carbon dioxide an equivalent amount of either sulfur, hydrogen sulfide, thiosulfate, molecular hydrogen, aliphatic acids or alcohols. In purple bacteria, therefore, the energy of light is not quite so successfully stored as in the green plants but is partially wasted. The light serves here only as a promoter, as it were, of reactions that might as well be carried on thermally in the dark. The overall gain consists quite visibly in the appearance of complex living forms in place of the simple molecules of "food." This conversion means a decrease in entropy within the system under observation.

In 1940 it was found that the photochemical reaction proper is the same in purple bacteria and in green plants. Certain species of unicellular green algae change to a type of metabolism similar to that of some purple bacteria if they are incubated during a few hours in pure hydrogen gas. Upon subsequent moderate illumination, they reduce carbon dioxide as usual, but they do not evolve oxygen. Instead they absorb the equivalent amount (twice the volume) of hydrogen. Once adapted to the use of hydrogen the same algae can reduce carbon dioxide, as do the "Knallgas" bacteria, in the dark, if some oxygen is supplied instead of light. Under the influence of intense irradiation the algae revert to normal photosynthesis with the production of oxygen. This reversible separation of carbon dioxide reduction from oxygen evolution or from the absorption of light demonstrated what had long been postulated—that photosynthesis consists of a series of complicated reactions that must be studied separately before the process as a whole is clearly understood.

After 1940 all students of the problem agreed that at least three sets of partial reactions may be distinguished: (1) decomposition of water with the aid of light absorbed by chlorophyll, leading, on the one hand, to compounds having a surplus of hydrogen and serving as intermediary hydrogen donors, and, on the other hand, to compounds having a surplus of oxygen; (2) transfer of hydrogen from the intermediary donors to carbon dioxide; (3) disposal of the compounds having a surplus of oxygen. The permanent conversion of radiant energy into chemical energy is possible only because green plants accomplish the task of removing the surplus oxygen by liberating molecular oxygen and not by consuming hydrogen donors, as do, for instance, the purple bacteria. This picture of photosynthesis requires, among other things, that all the oxygen evolved be derived from water and not from the reduced carbon dioxide molecule.

Research Methods.—Between 1775 and 1880 Joseph Priestley, Jan Ingenhousz and Jean Senebier were the first to discover that plants have the power to change the composition of the surrounding air. Since then the gas exchange of plants in the light, in contrast to that in the dark, has been used to study the course and rate of photosynthesis. Chemical analyses of these gases or simple recordings of pressure changes produced by plants in closed vessels, as well as the magnetic properties of oxygen and the infrared absorption of carbon dioxide, have served to clarify the reaction. Determination of the products and intermediates formed, namely sugars, sugar esters and fats, was at first not widely used. After the discovery of radioactive carbon isotopes (C^{11} and particularly C^{14} with a half life of more than 5,000 years), the isolation of intermediates became the most important tool in the biochemistry of photosynthesis. This radioactive tracer method was soon extended to radioactive phosphorus, P^{32}, and to tritium or radioactive hydrogen, H^3 or T. The stable isotopes H^2 or D (deuterium), C^{13}, O^{18} and N^{15} also may serve as tracers, in particular O^{18}, to trace the path of oxygen. The methods just mentioned will not provide any clues as to what happens after a light quantum has been absorbed by chlorophyll and in which way the light energy is transformed into potential chemical energy. Physical methods such as the measuring of changes in light absorption (or light emission) by chlorophyll and other coloured substances in vivo are better suited to elucidation of the photochemical events proper. These determinations are made with recording spectrophotometers and phosphofluorimeters. Finally it has become necessary to study in minute detail the structure of the parts of the cell that contain the chlorophyll as revealed by the electron microscope.

Factors Governing Photosynthesis.—Photosynthesis is influenced by temperature, light intensity, carbon dioxide concentration and water supply as external factors. The internal factors influencing its course are twofold: first, the concentration of the pigments and the activity of the enzymatic catalysts involved in photosynthesis; second, other metabolic reactions, such as respiration and fermentation, that have no direct connection with the photosynthetic process. Among the internal factors must be included also the inherited traits characteristic for different species. It is well known that certain plants can grow in arctic regions and others only in the tropics. It has been found that the chemistry of photosynthesis is identical in lower and in higher plants.

Each of the factors influencing photosynthesis may become the one that is mainly responsible for the limitation of the over-all rate. At low light intensities and otherwise favourable conditions, photosynthesis proceeds at a rate directly proportional to the incident radiation. Under these circumstances the light energy is utilized with the greatest efficiency. At high light intensities and high temperatures, the rate remains a function of the carbon dioxide concentration, so long as the mechanism of photosynthesis is not saturated with this substrate. If carbon dioxide also is present in sufficient amounts, the rate is determined by internal factors, most likely by the slowest of several enzymatic processes connected with the reduction of carbon dioxide. Since a truly photochemical reaction is not influenced by changes in temperature that determine the rate of ordinary processes, the rate of photosynthesis remains practically constant in spite of temperature changes as long as the light intensity is the rate-determining factor. This is the case at low or moderate light intensities and high temperatures. Conversely, in bright sunshine and at moderate temperatures photosynthesis is influenced by changes in temperature exactly as are other metabolic processes. These observations on limiting factors were among the first that led to the concept of photosynthesis as consisting of a sequence of photochemical or "light" reactions and thermal enzymatic or "dark" reactions. An ingenious way of separating the light from the dark reactions in the analysis of photosynthesis was first described in 1929. It consists of illuminating a plant with light flashes of very short duration (less than $\frac{1}{1,000}$ sec.) separated by dark periods of considerably greater length ($\frac{1}{100}$ sec. to 1 sec.). In this way the temperature dependencies just mentioned were clearly demonstrated. It was further shown that most metabolic poisons inhibit not the photochemical but the dark reactions in photosynthesis. Studies of the influence of poisons on the course of photosynthesis, performed in analogy to similar investigations in the field of respiration, allowed for a separation, in theory, of reactions preceding the photochemical reduction of carbon dioxide and reactions following it. These theoretical deductions were borne out by later experimental analyses of the mechanism of photosynthesis.

Activity in Chloroplasts and Plant Extracts.—In comparison to the general development in biochemistry, studies of photosynthesis with cell-free systems lagged behind because no familiar photosynthetic activity could be seen in fractions of plants or in plant extracts. It was first believed that photosynthesis was a

photochemical decomposition of carbon dioxide in contact with chlorophyll and water. Once it had been realized that the photochemistry of pigments and the enzymatic synthesis of organic compounds were only loosely connected, one began to look for the appearance in cell extracts of simpler reactions which might be part of the natural system.

The chlorophylls, together with the other pigments, are attached to, and form part of, specific lamellar protein structures, each layer measuring about 50 Å (angstrom units) across (1 Å = one ten-millionth of a millimetre). In higher plants and some algae the lamellae are bundled together as grana in special organs called chloroplasts. In blue-green algae and photosynthetic bacteria the lamellae lie either parallel to the entire cell wall or appear as variably coiled bodies within the cells. Associated with the pigments are enzymes and catalysts of types familiar to biochemists from their studies of respiration and fermentation.

In 1939 it was first shown by R. Hill that it is possible to obtain from higher plants suspensions of chloroplasts that still produce oxygen upon illumination yet have lost the ability to reduce carbon dioxide. The chloroplasts have to be suspended in a solution of ferric oxalate and ferricyanide. The ferric salts are photochemically reduced to ferrous salts. In the same way quinones and dyestuffs are reduced in the light while oxygen is evolved. These experiments show that the chlorophyll complex and the enzyme system concerned with the photolysis of water (*i.e.*, the disruption of the water molecule by the action of light) can be kept functioning after the faculty to fix carbon dioxide has been lost.

It is fairly easy to isolate chloroplasts by grinding green leaves. Such chloroplasts quickly lose their capacity to fix and reduce carbon dioxide. This power can be restored partially and with difficulty only by the addition of the enzyme-containing plant juice and by replenishing various co-factors that have become either oxidized or diluted. By contrast the capacity to release oxygen is preserved even if the chloroplasts are freeze-dried in a vacuum (*i.e.*, are lyophilized) and submitted in the dry state to extraction with petroleum ether. It is in this way that the need for plastoquinone has been demonstrated by its removal and re-addition to chloroplast preparations, which when rewetted were again able to produce oxygen.

Chloroplasts contain at least two oxidative enzymes, the cytochromes f and b_6, believed to assist in the disposal of those hydroxyl groups remaining from the photochemical dehydrogenation of water. That cytochromes can act specifically in a purely photochemical and not only in an aerobic metabolism became apparent when they were found in purple bacteria, which are photosynthetic but at the same time anaerobic organisms lacking the ability to produce free oxygen. Also implicated in the release of oxygen by green plants are enzymes that contain manganese or that combine with a benzoquinone derivative called plastoquinone ($C_{52}H_{98}O_2$), which is one of a series of the ubiquinones found in all living cells. The amount of plastoquinone may be as much as $\frac{1}{10}$ to $\frac{1}{5}$ that of chlorophyll. In addition the chloroplasts contain flavins and pyridine nucleotides as well as heme proteins, compounds similar or identical to those that play a part in the production of energy-rich phosphate during respiration. Triphosphopyridine nucleotide (TPN) instead of diphosphopyridine nucleotide (DPN) is specifically reduced by chloroplast preparations—an important finding because this provides the bridge between pigment activity and carbon assimilation.

Active Pigments.—The two green chlorophylls *a* ($C_{55}H_{72}O_5N_4Mg$) and *b* ($C_{55}H_{70}O_6N_4Mg$) were isolated in 1905 and their structures finally established about 1936. The bacterio-chlorophylls *a* and *b*, occurring in purple bacteria, are related pigments whose absorption spectrum is shifted toward the infrared. The chlorophylls are identical in all plants. They belong, like hemin—the dye responsible for the colour of blood—to the class of porphyrin-metal complexes. An important difference between chlorophylls and hemins exists in their photochemical properties. The presence of a complex bound atom of magnesium does not destroy the typical porphyrin fluorescence of the chlorophylls, but the presence of the heavy metal iron in the hemins quenches the porphyrin fluorescence completely and makes the latter dyes photochemically inert. The slight difference between chlorophyll *a* and chlorophyll *b*—a formyl group (—CHO) in *b* where *a* has a methyl group (—CH_3)—is reflected in the absorption spectrum. Chlorophyll *b* absorbs light at slightly shorter wave lengths.

One of the side chains of the porphyrin ring in chlorophyll is esterified with phytol, $C_{20}H_{40}O$, a colourless alcohol, which also is found as a side chain in vitamin K. The role of phytol in both substances is obscure. Chlorophyll looks green because it is somewhat more transparent for green light than for blue and red, yet green light is equally effective if absorbed. For the wave lengths longer than 7300 Å chlorophyll is quite transparent. This is the reason a landscape seen through a dark-red filter shows the leaves of trees and the lawn brighter than the surroundings (including the blue sky), an effect familiar from infrared photography. Chlorophyll is insoluble in water. Extracts can be obtained simply by immersing green leaves in alcohol or acetone. In the cell, chlorophyll is bound to protein. It can be extracted in its combination with protein, in the form of a colloidal aqueous solution, if the plant cells are mechanically crushed.

The carotenoids present in the chloroplasts vary in composition and number with different species of plants. Their chemical structure has nothing in common with that of chlorophyll. The formula for carotene is $C_{40}H_{56}$, for xanthophyll $C_{40}H_{56}O_2$ and for fucoxanthol $C_{40}H_{56}O_6$. Some of these pigments were known to act as photoreceptors in such phenomena as phototaxis and phototropism, but until 1930 it was believed that only the light absorbed by chlorophyll was available for photosynthesis. Botanists, however, wondered how brown algae, in which most of the incident radiation is absorbed by the yellow pigments, could use light so effectively for growth. In 1941 it was finally established that some of the yellow pigments participate in photosynthesis. The degree to which this takes place varies considerably in different plants. In the diatoms, which are responsible for the bulk of photosynthesis in the ocean, the light absorbed by carotenoids is just as effective as that absorbed by chlorophyll. The mode of action of the carotenoids is, however, merely that of an "accessory pigment." The excitation energy is not utilized within the molecule itself but is transferred to chlorophyll *a*, as shown by the colour of the resulting fluorescence. This is also the way in which phycocyanin and phycoerythrin, the characteristic pigments in blue-green and red algae, contribute to photosynthesis in these plants. No cell capable of photosynthesis has been found that did not contain chlorophyll *a* in addition to the other pigments mentioned. Even chlorophyll *b* seems to act as an accessory pigment by letting the excitation energy go over to chlorophyll *a*.

Until about 1960 it appeared, therefore, as if only chlorophyll *a* was engaged in the actual conversion of light (electromagnetic energy, photons) into chemical energy. While measuring photosynthetic efficiencies of light of different colours, Emerson had observed that light of wavelengths longer than λ 700 millimicrons (mμ) (a barely visible dark red colour, yet weakly absorbed by the chloroplast) is much less efficient than the rest of the visible spectrum in causing the release of oxygen gas. This low efficiency can, however, be bettered if the monochromatic dark red light beyond λ 700 mμ is offered to the plant together with light of comparable intensity, provided it is composed of rays of shorter wavelengths than λ 680 mμ. If, for example, 1,000 quanta of normally effective light release 100 molecules of oxygen from the absorbing chloroplast and 1,000 quanta of the dark-red light release only 20, the result of irradiating the plant simultaneously with both lights does not amount to the sum of both effects. Instead of the expected 120 molecules of oxygen, more, about 160 molecules, may be evolved. Two things follow from this "enhancement" of the yield. First, the plant must "sense" the difference in colour—hence there must be two pigments instead of one in order to produce two chemically distinguishable results. And second, the far-red absorbing pigment, which alone is hardly able to cause an evolution of oxygen, must contribute to the efficiency of the photosynthetic gas exchange by means of some intracellular energy-rich product. Spectroscopic evidence has confirmed that more than one chlorophyll-like pigment participates in the light-inducing reactions. The difference between the pigments does not appear in the structure

of chlorophyll *a* but in the binding of the one extractable pigment to various proteins and lipids. The latter determine whether the absorbed light energy will be used for either hydrogen transfers or for light-induced phosphorylation (*see* below).

Illuminated chloroplasts, as well as intact green cells, phosphoresce after illumination ceases. With sensitive instruments it can be shown that, after the light has been turned off, a red light of the same colour as the fluorescence of chlorophyll is emitted. Its intensity first declines steeply within a few seconds, but some residual light emission lingers on for many minutes. This phenomenon, a chemiluminescence, is caused by the reversal of the very first photochemical steps in photosynthesis.

Products and Intermediates of Photosynthesis.—The photosynthetic reaction is summarized in the most general chemical terms by the equation:

$$n\mathrm{CO_2}\ (\text{carbon dioxide}) + n\mathrm{H_2O}\ (\text{water}) + \text{light} = n\mathrm{O_2}\ (\text{oxygen}) + (\mathrm{CH_2O})_n\ (\text{carbohydrate})$$

The factor n is introduced because a number of different carbohydrates are made in the course of the reaction. It is a matter of definition which ones should be called the "product(s) of photosynthesis." A derivative of a three-carbon sugar, triose phosphate, is the first carbohydrate to appear after the photochemical reduction of carbon dioxide has run its course, but only cane sugar (sucrose), starch or, in some cases, fats are accumulated as storage products in the plants. Whether experimental results conform strictly to carbohydrate formation as in the equation above depends on the type of photosynthesizing cell and on the light intensity. A leaf that has stopped growing will at high light intensity absorb carbon dioxide and produce oxygen plus sugar and starch as expected. If the light intensity is low and the object studied is a fast-growing microorganism, the over-all product will not be carbohydrate or some fat but an entire new living cell. In order to obtain an intelligible answer to the question of the intermediate course of photosynthesis in microorganisms, one has either to prevent growth, by removing nitrogenous compounds from the environments of the cell, or to see to it that the analyses comprise only the chemical changes that occur in very short times, in minutes or even seconds.

Investigations on the biochemical pathways leading from carbon dioxide to various organic compounds became truly fruitful after World War II, when the atomic bomb project provided comparatively large quantities of C^{14}, the long-lived radioactive carbon isotope. The very first experiments with isotopes settled the long-disputed question whether carbon dioxide reacts directly with chlorophyll, particularly with the magnesium atom in the molecule. No such reaction occurs.

For 60 years after it was first proposed in 1870, the hypothesis that formaldehyde is produced in photosynthesis was a favourite assumption in various theories. This hypothesis can safely be discarded because, mainly through the efforts of M. Calvin and A. Benson, it is known definitely that the first recognizable organic compound that contains the carbon dioxide taken up by the plant is phosphoglyceric acid:

$$\mathrm{H_2O_3P \cdot OCH_2 \cdot CHOH \cdot COOH}$$

The newly assimilated carbon forms the carboxyl group, —COOH. The next step is where the path of carbon comes nearest to the action of light. Reduction of TPN and the phosphorylation of adenosine diphosphate (ADP) to adenosine triphosphate (ATP) are thought to be the only biochemical steps that are closely linked to the primary photochemical process in the chlorophyll complex. The resulting $TPNH^+$ and ATP serve to reduce phosphoglyceric acid (PGA) to phosphoglyceraldehyde (PGAL) according to a familiar metabolic pattern. PGA appears, therefore, as the only stable intermediate compound between free carbon dioxide and triose phosphate, the most reactive of cellular carbohydrate esters.

Carboxylation and Light-Induced Phosphorylation.—The old question how leaves manage to attract the little carbon dioxide (0.03%) that is in the air and hold it for good was solved when it was found that a phosphorylated, energy-rich five-carbon sugar, ribulose diphosphate (RuDP), adds one molecule of carbon dioxide and immediately decomposes into two molecules of PGA. This is an irreversible enzymatic dark reaction, a carboxylation that does not require light nor any other source of energy except that contained in the RuDP molecule itself. The same carboxylation reaction proceeds also in some nonphotosynthetic organisms capable of using the carbon of carbon dioxide for their enzymatic synthesis of organic substances. Thus in order to trap the free carbon dioxide the plant first has to produce the necessary RuDP. Since the latter is unstable in the presence of carbon dioxide, it must be continually re-formed from ribose monophosphate and ATP. The rate of photosynthesis, however, is usually ten times or more that of respiration in the same cell. It follows that the ATP used in photosynthesis has to be furnished somehow by the photosynthetic process and not by a respiratory dark reaction, which would be the normal way the cell uses to obtain the phosphate energy needed in general metabolism. Such inquiries led to the discovery, and later to the detailed study by D. Arnon and others, of light-induced phosphorylation. This photophosphorylation occurs even when the illuminated plant cell shows no measurable gas exchange, either of oxygen or of carbon dioxide. It is therefore another means, and often the first step, by which light energy is harnessed for metabolic purposes. The fixation of carbon dioxide is not the only reaction that requires the simultaneous occurrence of photophosphorylation: the following reduction of PGA to PGAL requires a second phosphorylation step before the carboxyl group can accept the hydrogen from reduced TPN.

Carbon Reduction (Calvin-Benson) Cycle.—Each molecule of carbon dioxide, a one-carbon compound (C-1), brought from the atmosphere into organic binding requires the presence of one molecule of ribulose diphosphate, a five-carbon compound (C-5), yielding a six-carbon compound (C-6). If this would lead to a glucose molecule and the latter would be stored away by the plant, there would soon be no C-5 left to continue the reaction. In addition to the fixation and reduction of carbon dioxide, the plant must have the means to replace the C-5 that has been used up. In their famous experiments with radioactive carbon dioxide Calvin and Benson found that within one minute of steady photosynthesis the radioactivity appears not only in the carboxyl group (—COOH) of the first carbon fixation product, PGA (a three carbon acid), but also with increasing activity in the two residual carbons of this compound. These two other carbons are derived from the original RuDP (*see* above). Thus it became clear that a cycle exists whereby the first reduction product, triose (C-3), is partly used to resynthesize pentose (C-5). Indeed the ribulose diphosphate is a product of a very complex cycle in which carbohydrate fragments containing between two and seven CHOH groups exchange places while attached to a number of specific enzymes. When the cycle is suddenly interrupted by killing the plant, some of the members of the cycle may be identified as individual sugar-phosphates, having 3, 6, 5 and 7 carbon atoms. They are formed in quick succession in the light by various ways, and the new C-3 molecules combine with already existing sugar-phosphates.

Two C-3 molecules give one C-6. One C-3 and one C-4 give one C-7 (sedoheptulose phosphate). The C-4 in turn is derived from the C-6 thus leaving a C-2 fragment, which by picking up another C-3 produces one C-5 (pentose-phosphate). The C-7 combines with the next C-3 and breaks up into two C-5 molecules. Over-all, then, three C-5s add three C-1s to give six C-3s (PGA to be reduced to C-3), of which five continue the cycle while one is available for the growth of the cell. In fast-growing microorganisms not all of the available three carbon compounds find their way into sugars and starch. Three-carbon amino acids, such as serine and alanine, appear during the very short time needed to put tracer carbon into all the members of the carbon cycle. The connection to fat metabolism is made by means of a second carboxylation, which leads, via phosphoenol pyruvic acid, to malic acid or aspartic acid.

Since some of these compounds are part of the normal respiratory and fermentation metabolism, it can be understood why, occasionally, respiration and photosynthesis in the same cell seem to influence each other very strongly. By increasing or decreasing the amount of a photosynthetic intermediate, respiration can

interfere with the kinetic pattern of the reaction proceeding in the light. This is particularly true in dim light, when the reactions leading to the synthesis of sugars are not much faster than those causing their breakdown.

See also references under "Photosynthesis" in the Index.

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PHRAATES (Parthian *prdty;* New Persian *farhad*), the name of five Parthian kings of Persia.

PHRAATES I, son of Priapatius, reigned *c.* 176–171 B.C.; is said to have subdued the Mardi, a tribe in the Elburz Mountains. He was succeeded by his brother Mithradates I.

PHRAATES II, son of Mithradates I, reigned *c.* 138–128 B.C. He was attacked in 130 by Antiochus VII Sidetes, who after initial successes was defeated and killed in a battle in Media which ended Seleucid rule east of the Euphrates. Phraates was killed in battle against invading Saka nomads in the eastern part of the Parthian Kingdom. His defeat was attributed to the defection of Greek captive mercenaries in his army (Justin, *Epitoma Historiarum Philippicarum*, xlii, 1, 5).

PHRAATES III "the god," son of Sinatruces (Sanatruces) ruled *c.* 69–57 B.C. On his accession the Roman general Lucullus was preparing to attack Tigranes (*q.v.*) of Armenia, who had wrested several vassal states from the Parthian Kingdom. Phraates declined to assist Tigranes and Mithradates VI of Pontus against the Romans but rather supported the son of Tigranes when he rebelled. Phraates made an alliance with Pompey and invaded Armenia (66 B.C.). Pompey abandoned all of Mesopotamia to Phraates, but later he reversed his stand, supported Tigranes, imprisoning his son, and occupied the Parthian vassal states of Gordyene and Osroene. Before any action could be taken Phraates was murdered *c.* 57 B.C. by his two sons Orodes II and Mithradates III.

PHRAATES IV, who reigned with one interval from 37 to 2 B.C., was the son of Orodes II. He was appointed successor to his father in 37 B.C. after the death of Pacorus I (*q.v.*). He murdered his father and his brothers to secure his throne. In 36 B.C. M. Antonius (Mark Antony) attacked Parthia, marching through Armenia into Media Atropatene. He was defeated and lost much of his army. In 34 B.C. Antony made an alliance with the vassal king of Media against his Parthian overlord, Phraates. Antony invaded Armenia and arrested Artavasdes, king of Armenia, whom Antony suspected of treason. At the withdrawal of Antony to fight Augustus, the Parthians reoccupied Media Atropatene. A revolt broke out in Parthia, and Tiridates II (*q.v.*) drove Phraates from the throne, the latter taking refuge with the Saka nomads. A short time later, in 30 B.C., Phraates, with the aid of Saka allies, reversed the situation and Tiridates fled to the Romans with the son of Phraates as a hostage.

Augustus made peace with Phraates, returning his son and receiving the Roman standards and prisoners captured at Carrhae in return. Armenia and Osroene were recognized as Roman dependencies. Augustus also sent Phraates an Italian concubine called Musa. On her advice, Phraates sent five of his sons to Rome, after which Musa and her son Phraates V murdered Phraates IV in 2 B.C.

PHRAATES V or Phraataces (a diminutive form, Parthian *prdtk*) ruled *c.* 2 B.C.–A.D. 4. He married his mother Musa and the two ruled jointly. Under him, war with Rome threatened to break out about the supremacy in Armenia. When Augustus sent his adopted son Gaius Caesar into the east in order to invade Parthia, the Parthians preferred to conclude a treaty (A.D. 1) by which Armenia was recognized as being in the Roman sphere. Together with his mother, Phraataces was slain or driven into Syria where he died *c.* A.D. 4. *See* also PERSIAN HISTORY: *Parthian Empire, 2nd Century B.C.–3rd Century A.D.* (R. N. F.)

PHRA-NAKHORN is a small *changwad* (province) located on the east bank of the Mae Nam Chao Phraya River in the heart of Thailand's commercial rice-producing area. It is the most populous and densely populated province in the country. Area 424 sq.mi. (1250.8 sq.km.). Pop. (1960), 1,577,003; pop. density 3,719.3 per square mile. In it are located: Bangkok, the nation's capital, with a population of 1,299,528 in 1960; the Don Muang Airport, one of the largest and busiest international airports in Southeast Asia; and Klongtoi Harbour, a flourishing seaport and river port. Most of the country's truck and fruit gardening, commerce, industry, governmental services, and largest religious and educational institutions are concentrated in the province. Phra-nakhorn is also the focal and dispersal centre for Thailand's rail, air, and highway networks. (T. F. B.)

PHRAORTES (Iranian FRAVARTISH), a name used by Herodotus apparently in reference to Khshathrita (Kashtariti), king of Media from *c.* 673 B.C. to *c.* 652. According to Herodotus' history (i, 102) this king was the son of Deioces (*q.v.*) and began the Median conquests. He first subjugated the Persians and then a great many other peoples of Asia, till at last he attacked the Assyrians. He was then defeated and killed in battle (*c.* 652).

Another Phraortes was a usurper who reigned for a short time in Media in the following century, at the time of the rebellion against Darius I. Darius' rock inscription at Bisitun relates that "a man of the name of Fravartish [*i.e.*, Phraortes], a Mede, rebelled in Media and spoke to the people thus 'I am Khshathrita, of the family of Uvakhshatra [Cyaxares].'" After a short reign this king was defeated by Hydarnes and afterward by Darius himself. He was taken prisoner and executed at Ecbatana. It was the deception of the usurper Phraortes that probably led to Herodotus' mistake in regard to the name of the earlier king.

(ED. M.; I. M. D.)

PHRYGIA, the name from about 1000 B.C. of a large inland district of Asia Minor, the inhabitants of which were called by the Greeks *Phryges*. Its extent varied in different periods: in the 11th–8th centuries B.C. it seems to have comprised largely the whole of the central Anatolian Plateau, both west and east of the Halys River (modern Kizil Irmak). Most ancient authors confined the name to an inland district roughly from longitude 29° to 32° or 33° E and from latitude 38° to 40° N. The northwestern corner of Asia Minor was sometimes known as Phrygia Minor or Hellespontine Phrygia. The real core of Phrygia at all times lay on the comparatively small plateau between the Sangarius (Sakarya) River and the upper course of the Maeander (Buyuk-menderes). Phrygia in its narrower sense is a tableland 3,000 to 5,000 ft. high, dotted with isolated mountains that rise to 8,000 ft. and intersected by several river systems.

In the Phrygian homeland there were at least two centres, one being Gordium (*q.v.*) near which royalty and nobility were buried in great tumuli (mounds), the other "Midas City" (mod. Yazilikaya) perhaps called by the Greeks *Metropolis, i.e.*, "the city of the (great) mother," which was a religious centre. The best-known feature of central Anatolia was the so-called royal road, established officially by the Persian kings, but in fact of much greater antiquity. It ran from Sardis through central Anatolia to the Cilician Gates (Kulek Boghazi) and thence to Susa. An equally important parallel road ran farther north from Smyrna through central Phrygia via Dorylaeum (Eskisehir) and Ancyra (Ankara), crossing the Halys by a bridge, the remains of which still exist at Kalecik beneath later work. At Bogazkoy, the former Hittite capital, it met a crossroad running northward to the Black Sea at Sinope, southward through Mazaca (Kayseri), along the Euphrates to Syria, or eastward to the Caucasus. A small section excavated at Gordium by the University Museum of Pennsylvania expedition

shows it to have been surfaced, paved, and flanked with curbstones.

History.—Many ancient authors are said to have written on Phrygia, but their works are lost. The tradition of the Macedonians (Herodotus, vii, 73) claimed that the Phrygians were invaders who crossed into Asia Minor from Thrace, where they were known as Bryges. The Greeks mostly believed that this took place before the Trojan War. If translated into historical events, this would correspond to the period when the Hittite Empire was collapsing. At present little archaeological evidence exists to help in clarifying this period. However, the valley of the Sangarius, which is mentioned by Homer as the scene of the earliest Phrygian advance, certainly contains one of their oldest and most important capitals (Gordium), while the adjacent plateau to the southwest was of particular sanctity and is marked by a remarkable series of rock-cut cult sites (*see* below, *Religion*).

The Phrygians first appear clearly in history in the Assyrian royal annals under the name of Mushki. In about 1160 B.C. a great army of 20,000 Mushki, led by five kings, advanced down the upper Euphrates and settled in the provinces of Alshe (later Anzitene), Purukuzzi, and Kummuh (later Commagene). They were allied with the Gasgas, the great enemies of the Hittite kings, which suggests that they had joined with the Gasgas in overthrowing the Hittite Empire. The Assyrian king Tiglath-pileser I (1116–1076) defeated them in about 1100 in a pitched battle and deported 6,000 to Nisibis.

It is probable that the Phrygians represented the westerly half and the Mushki the easterly half of a joint empire with capitals at Gordium and Mazaca respectively. The Mushki are mentioned by the Assyrians together with Tabal, an area in the south of the Anatolian Plateau, north of the Taurus Range; they correspond to Meshech and Tubal, the sons of Japheth in the Bible. Between the 12th and 9th centuries B.C. this confederacy occupied the whole of the Anatolian Plateau and took over much of the arts and cultural traditions of the Hittites whom they had destroyed. Politically, Tabal consisted of at least 24 kingdoms, vassals of a "Great King" of Tabal, with his capital at Bit-Burutash.

About 730 the Assyrians split the confederacy by annexing Tabal and Hilakku, and the centre of opposition shifted to the west, to Phrygia proper. Of this the king was Midas, son of Gordius, a legendary figure of such wealth that he was thought by the Greeks to have the power of turning things to gold by his touch. Phrygia was by then in touch with Greece through Lydia (*q.v.*), thanks to the ancient trade routes leading to the Aegean Sea. Midas not only married a Greek princess but made rich offerings, including his own throne, to Apollo at Delphi, being the first foreign ruler to do so; clearly he was making a bid for Greek support. In 717 he tried his strength with Assyria in alliance with the king of Carchemish and seized Cilicia, thereby closing the trade routes through the Taurus Mountains. But the Assyrian king Sargon II drove him out.

About 700 the Phrygian empire was suddenly overthrown by the Cimmerians (*q.v.*) from beyond the Caucasus, who also menaced the Assyrian world. Turning west, they drove through Phrygia and Lydia, inflicting ruin on many Greek cities. Midas, having been defeated by them in battle, is said to have committed suicide. The remarkable discoveries of the American expedition to Gordium have revealed in the great tumulus there the burial place probably of Midas himself, an elderly little man surrounded with rich gifts, though no gold was present, perhaps having all been surrendered in tribute to the Cimmerians. Excavations showed that the Phrygian city of Gordium was violently destroyed or burned at this time.

By the middle of the 7th century B.C. the leadership of Asia Minor had been taken over from the Phrygians by the Lydians, whose king, Gyges, founder of the Mermnad dynasty, entered into treaty relations with the Assyrian king Ashurbanipal, against the new threat of the Scythians. Though Gyges was himself killed by the invading Cimmerians *c.* 643 B.C. (some scholars prefer earlier dates), 20 years later the Scythians destroyed the Cimmerians in Phrygia. Under the Mermnad dynasty, however, Phrygia, though absorbed into the Lydian kingdom, regained some prosperity. But after 546 it was absorbed into the Persian Empire, being combined with the Hellespont, Paphlagonia, and Cappadocia to form the third satrapy. The Phrygians contributed a contingent in Xerxes' army (480), but Phrygia subsequently declined and seems to have become a hunting ground for slaves for the Greek market. In 333 B.C. Alexander of Macedonia marched through Gordium and there cut or untied the "Gordian knot" (*q.v.*).

After Alexander's death Phrygia became a battleground for the contending forces of his former generals (*see* HELLENISTIC AGE: *Outline of Political History*). At first it formed the nucleus of the territory of Antigonus, who set up his capital at Celaenae, but after the decisive battle at Ipsus (301 B.C.) it was transferred to Seleucus as an annex to the kingdom of Syria.

About 275 B.C. all the Phrygian lands east of the Sangarius came into the possession of a horde of Celtic invaders (Galatae) from the Danube lands and was renamed Galatia. At the same time western Phrygia was taken from the kings of Syria by the newly founded monarchy of Pergamum (*q.v.*). The Phrygian territory remained a bone of contention between the kings of Pergamum and Syria and the Galatians until in 189 B.C. the Romans expelled the Syrian kings from Asia Minor, confined the Celts to Galatia, and left the western half of the peninsula under the undisputed control of the Pergamene rulers. After the end of the Pergamene kingdom (133), Phrygia was disputed between Mithradates V of Pontus and Nicomedes II of Bithynia; awarded by a corrupt Roman commission to Mithradates, who seized it before the award was ratified; and finally annexed *c.* 116 to the Roman province of Asia. The rest of Phrygia fell under the provinces of Galatia and Cappadocia (*qq.v.*). About A.D. 300 the Roman emperors made two provinces, Phrygia Prima and Secunda, of Phrygia west of the Sangarius. But under the Byzantine Empire the name of Phrygia disappears in the 5th century A.D., the two provinces becoming Pacatiana and Salutaris.

Economy.—Little is known of Phrygian society. Vast lands were owned by the great shrines such as Pessinus (*q.v.*), as was the Oriental custom, the high priests being virtually autonomous rulers. Society was probably feudal and, though the word Phrygian is said to mean "free," they were certainly exported to Greece as slaves. An intelligent and evidently cultivated elite existed at Gordium and Midas City, capable of reading and writing; together with an important nucleus of craftsmen and merchants, some doubtless being foreigners—Greeks, Phoenicians, Syrians, and Urartaeans.

A staple industry was sheep rearing, which provided a fine wool much in demand in Miletus, Pergamum, and other Greek centres of industry. Phrygian carpets were also famous, and Phrygia was

BY COURTESY OF THE HITIT MUZESI MUDURLUGU, ANKARA; ARTS COUNCIL OF GREAT BRITAIN PHOTOGRAPH

TERRA-COTTA ARCHITECTURAL PLAQUE FROM PAZARLI (6TH CENTURY)

supposed to be the origin of the art of embroidery (Latin *phrygio*, "embroiderer"); their embroidery designs may be seen on garments of King Urpalla of Tyana on his sculptures at Ivriz and Bulgar Maden, and are reflected on the house facades (*see* below).

The neighbourhood of Midas City still harbours considerable forests, and timber was clearly an important economic factor. Another specialty was horse rearing, the Phrygians probably being, like many of the Indo-Europeans, an equestrian aristocracy ruling over other native peoples. Also exported were carpets, raw materials such as realgar (arsenic monosulfide), crystal, onyx, mica, ruddle (red ochre), and steel.

Art and Architecture.—Metalworking was certainly practised in Tabal. Sargon captured in Urartu "cups in the manner of Tabal," while Phrygian bowls of bronze and silver were exported to Greece. They may also have been the makers of some of the large wine bowls with bulls' heads or other figures associated with tripod stands which were exported to the west.

Skill in metalworking produces tools for cutting rock and stone. The architecture of the Phrygians is best envisaged from their amazing rock carvings in the form of temple facades reproduced in life size, between Eskisehir and Afyonkarahisar. These show a gabled building, presumably of wood, with large horned *acroteria* ornaments at the apex of the gable, usually with a window in the pediment, and the ends of the walls heavily ornamented with rectangular patterns. Discoveries at Pazarli and Gordium show these ornaments to have consisted of terra-cotta revetment plaques. This form of wooden architecture, akin to that of Lycia, perhaps goes back to Bronze Age prototypes. It was of some influence on early East Greek architecture. According to classical tradition, the Phrygians invented the frieze (Latin *phrygium*).

Domestic houses of the 8th century B.C. at Gordium are built sometimes of stone, sometimes of crude brick, using a timber framework, some being of megaron (a long, rectangular hall, characteristic of Mycenaean houses) type. At Gordium a massive Phrygian city gate with associated buildings and city wall has been excavated.

Remains of sculpture are scanty, but include a remarkable stone group carved in the round from Bogazkoy, representing the Mother Goddess wearing a high headdress and flanked by two small musicians, one playing the lyre, the other the double flute. The Phrygians were reputedly great musicians and the inventors of cymbals, flutes, triangles, pan-pipe, and the Phrygian mode (*see* MODES, MUSICAL). From near Ankara come some stelae showing the goddess Cybele in a shrine. Woodworking for both architecture and cabinetmaking reached a high level of skill; witness the remarkable inlaid marquetry screens and other furniture found at Gordium. The woods used there were cedar, juniper, pear, box, maple, poplar, black pine, and yew.

Throughout Phrygian art great play is made with interlacing or isolated geometric ornament—swastikas, meanders, lozenges. Human figures are weak; animals are stylized. With this interest in ornament went an interest in mazes and maze dances, the so-called Trojan game.

Religion.—There are several strata to be disentangled in the religion of Phrygia. The oldest and most basic and characteristic worship was the cult of the Great Mother, Kubila (Cybele), called Cybeba by the Lydians, Kubaba by the Luwians, but also Agdistis, "she-of-the-rock," by the Phrygians (*see* GREAT MOTHER OF THE GODS). It was a worship of primeval antiquity in Anatolia, going back at least to the Neolithic period as shown by finds of clay statuettes of the goddess seated with her lions at Hacilar near Lake Burdur. One of her greatest shrines was at Pessinus, where the story of Agdistis was told, describing her origins and her love for her consort Attis (*q.v.*), who, according to one version of the story, castrates himself, as a result of which he perishes but is annually resuscitated, thus representing the revival of the flagging forces of nature in spring; of this myth there were several variant forms which filtered westward to the Greeks.

Many centres of worship of the Great Mother were on mountain tops after which she was named (*e.g.*, Berecynthian, Dindymene, Sipylene Mother). The sanctuary at Sipylus, where there was a rock-carved statue of her, identified by the Greeks with Niobe weeping for her children, has been identified as a water sanctuary. In fact, she was believed to issue from bare cliffs beside fresh water, and her sanctuaries were set up in such places. In the 8th–6th centuries great facades representing her temples (*see* above) were carved on such rock faces in the specially sacred plateau from which the sacred Phrygian rivers rise. Some show the goddess in a niche between rampant lions. Some of these are called tombs; but, if so, they are tombs of Attis. In fact, in later times the tomb was described in inscriptions as a bridal chamber.

FROM E. AKURGAL, "DIE KUNST ANATOLIERS"

ROCK-CUT TEMPLE FACADE AT ASLANKAYA, NEAR AFYONKARAHISAR

The Indo-European stratum in the Phrygian religions is represented by Zeus (Mazeus; *cf.* Iranian Mazda) or Bagaios, or Papas; and Men, a male equestrian moon god. Wine, an ancient Anatolian invention, was sacred to Sabazius (*q.v.*), reputed son of Zeus and Leto-Semele. The cult of the Cabeiri (*q.v.*) which was reputedly transmitted to Miletus from Phrygia was associated in Greece with that of Dionysus.

Minor figures of cult were a hero Tyris or Tyrimnos and Ascanios or Ascaenos. The Phrygians followed the practices of taking omens from birds (augury) common to the other southern Asianic peoples (Cilicians, Pamphylians, Pisidians, and Lycians).

The conversion of Phrygia to Christianity began early, certainly by the 2nd century A.D., and progressed very rapidly, though the influence of the native religion may also be traced in various heresies, especially that of Montanus, which arose in Phrygia.

Script and Language.—Some of the bronze vessels from the great tumulus at Gordium bear inscriptions on wax in the Phrygian language written in an alphabet closely resembling the earliest Greek script. Other short dedications in the same script occur on the rock-cut temple facades, all being datable to the late 8th century B.C. It is possible that the Phrygian and the Greek alphabet were both simultaneously developed from a common Phoenician origin. The Phrygian alphabet apparently continued to be used until the 5th century B.C.

The language, interlarded with Greek, continued to be spoken in remoter areas until the 2nd or 3rd centuries A.D., being found on short funerary inscriptions written in Greek characters in bilingual form. These remnants of the language, supplemented by 30 or so words recorded by Greek writers, are too few to provide a clear picture of its affinities or structure, but it is evidently an Indo-European language of the *satem* group. Similarities have been found in it to Slavonic, Armenian, and even to pre-Phrygian Hittite languages: the traditional connection with Thracian cannot be proved as Thracian is virtually lost.

Phrygian literature is unknown, but the Phrygians were reputed to have been the inventors of animal fables. In this they were probably the transmitters of older Oriental themes going back to Sumerian times.

See also references under "Phrygia" in the Index.

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PHRYNE (4th century B.C.), Greek *hetaira* or courtesan. Her real name was Mnesarete, but because of her sallow complexion she was called Phryne ("toad"). She was born at Thespiae in Boeotia, but lived at Athens, where she earned so much by her beauty and wit that she offered to rebuild the walls of Thebes, on condition that the words "destroyed by Alexander, restored by Phryne the courtesan" were inscribed upon them. At a festival of Poseidon and also at the festival at Eleusis she walked into the sea naked with her hair loose, suggesting to the painter Apelles his great picture of Aphrodite Anadyomene ("rising from the sea"), for which Phryne sat as model. She was also (according to Athenaeus) the model for the statue of the Cnidian Aphrodite by Praxiteles, whose mistress she was; copies of the statue survive in the Vatican and elsewhere. When accused of blasphemy (a capital charge) she was defended by the orator Hyperides. When it seemed as if the verdict would be unfavourable, he tore her dress and displayed her bosom, which so moved the jury that they acquitted her; another version makes Phryne tear her own dress and plead with each individual juror.

See Athenaeus, *Deipnosophistai*, xiii, 590d–591f.

PHRYNICHUS. 1. Athenian tragic poet (fl. *c.* 500 B.C.), older contemporary of Aeschylus, and the earliest tragedian of whose work some conception can be formed. His first victory was probably about 510 B.C., and according to the Suda lexicon he was the first to introduce the female mask, *i.e.*, women characters, into his plays. The extant fragments are too meagre to be revealing: the titles *Danaides* and *Aegyptii* indicate the same theme as an Aeschylean trilogy, and the *Alcestis* (whether tragedy or satyr-play is not clear) anticipates Euripides. After the fall of Miletus in 494 he produced the *Capture of Miletus*, which so harrowed Athenian feelings that he was fined 1,000 drachmae; in 476 his *Phoenissae*, in which news of the battle of Salamis comes to the Persian court, proved a more acceptable subject and won the first prize.

Themistocles, archon in 493 and choregus in 476, may have been behind this venture into contemporary history instead of myth; except for Aeschylus' *Persae* in 472 the precedent was not followed up. Aristophanes in the *Wasps* and *Birds* recalls affectionately the honeyed sweetness of the old Phrynichan lyrics, which were still favourites in his day.

For fragments *see* A. Nauck (ed.), *Tragicorum Graecorum fragmenta*, "Teubner Series" (1926).

2. Athenian poet of the Old Comedy (fl. *c.* 420 B.C.), contemporary of Aristophanes, who began producing in 430 and won two victories. His most clearly recognizable subjects show an odd parallelism with Aristophanes: his *Monotropos* ("The Solitary"), who rejected contemporary civilization, was placed third when the *Birds* was second, in 414, and his *Muses*, second to the *Frogs* in 405, presided over a contest between Sophocles and Euripides.

For fragments *see* T. Kock (ed.), *Comicorum Atticorum fragmenta* (1880–88) and J. Demianczuk, *Supplementum comicum* (1913).

3. Phrynichus Arabius, of Bithynia (2nd century A.D.), grammarian and rhetorician, whose chief works were *Sophistike Paraskeue* ("A Grounding in Sophistic"), of which a few fragments and a summary by Photius survive, and an *Attikistes*, extant in an abridged form, called the *Ekloge* ("Selected Atticisms"). He is critical not only of contemporary deviations from the best Old Attic usage but also of what he considers the lapses of his Attic models themselves. In spite of some mistaken pedantry his judgments are often acute and learned, and a useful commentary on the language of his own day.

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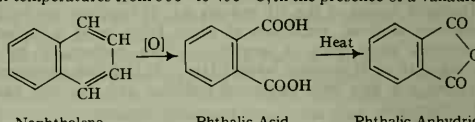
4. An Athenian general in the Peloponnesian War. He took a leading part in establishing the oligarchy of the Four Hundred at Athens in 411 B.C., and, according to Thucydides, was assassinated in the same year. (A. M. De.)

PHTHALIC ANHYDRIDE AND PHTHALIC ACIDS.

Phthalic anhydride, a derivative of phthalic acid, although in commerce produced from naphthalene, is the starting material for the manufacture of many important chemicals, such as dyes, resins, plasticizers, and solvents. Phthalic acid, which is also called orthophthalic acid or orthobenzenedicarboxylic acid, is one of three dicarboxylic acids of benzene. The other two are meta- and paraphthalic acids. Only the ortho isomer forms an anhydride (above 200° C), which is called phthalic anhydride.

Phthalic Anhydride.—Phthalic anhydride, $C_6H_4(CO)_2O$, is a colourless solid, melting at 131.1° C to a liquid that boils at 284° C. It sublimes at temperatures below the boiling point, the sublimed product taking the form of flexible, threadlike crystals that have a silky lustre. On contact with water the anhydride is converted to phthalic acid. The term "phthalic" was derived from "naphthalene," for from this coal-tar derivative the anhydride and the parent acid were first prepared.

Phthalic anhydride was first obtained by Auguste Laurent in 1836 by oxidizing tetrachloronaphthalene with nitric acid. It was made by this and other relatively costly methods until the discovery of a less expensive process based upon the oxidation of naphthalene with sulfuric acid (patented in 1896). The oxidation was effected with the aid of mercuric sulfate as a catalyst. The reaction, it is alleged, was discovered by chance when a thermometer in a hot mixture of naphthalene and sulfuric acid was accidentally broken. The process was applied on a huge scale in the manufacture of phthalic anhydride for use in the preparation of synthetic indigo. This process was superseded about 1917 by a more economical one in which naphthalene is oxidized with air, at temperatures from 350° to 450° C, in the presence of a vanadium



Naphthalene Phthalic Acid Phthalic Anhydride

oxide catalyst, a process discovered by H. D. Gibbs of the Bureau of Chemistry and Soils, U.S. Department of Agriculture, and almost simultaneously in Germany.

When phthalic anhydride is treated with a dihydric or polyhydric alcohol, a resinlike ester is formed. Esters of this nature, which belong to the class of alkyd resins and especially mixed esters made by treating phthalic anhydride and fatty acids with glycerin, are extensively used in industry, in paints, varnishes, lacquers, enamels, and electrical insulating materials. The esters impart to the protective coatings the valuable property of adhering especially well to metallic surfaces.

Other esters of phthalic acid, made by treating phthalic anhydride with monohydric alcohols, are oily liquids boiling at high temperatures. The dimethyl, diethyl, and dibutyl esters are used in large quantities in plastics and protective coatings as solvents and plasticizers of cellulose esters and synthetic resins. In addition, the dimethyl ester is used as an insect repellent, the diethyl ester as an ingredient of perfumes, and the dibutyl ester as a retardant in smokeless gunpowders.

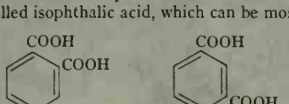
Phthalic acid, dissolved either in water or in phthalic anhydride at temperatures above 200° C, and in the presence of certain catalysts, breaks down into benzoic acid and carbon dioxide. These products are similarly formed when the vapour of phthalic anhydride mixed with steam is subjected to the action of suitable catalysts at high temperatures; *e.g.*, 450° C. These methods for decarboxylating phthalic acid are employed on a large scale in the manufacture of benzoic acid.

In the dye industry phthalic anhydride is used as such in the preparation of a number of dyes, but a more important use is in the synthesis of anthraquinone and its derivatives. A minor use of phthalic anhydride is in the preparation of phenolphthalein.

Simple derivatives of phthalic anhydride that are of some interest in chemical technology are tetrachlorophthalic anhydride, $C_6Cl_4(CO)_2O$; phthalyl chloride, $C_6H_4(COCl)_2$ or $C_6H_4(CCl_2)$-$(CO)O$; and phthalimide, $C_6H_4(CO)_2NH$, the latter being used in

large quantities for the manufacture of anthranilic acid (*o*-aminobenzoic acid), whose methyl ester is much used for artificial grape flavouring. It should be emphasized that the many esters of orthophthalic acid are made, as mentioned above, from phthalic anhydride rather than the acid.

Phthalic Acids.—Orthophthalic acid, of itself, is of no importance commercially. The same holds true for the meta acid, also called isophthalic acid, which can be most readily prepared by



Orthophthalic Acid Metaphthalic Acid Paraphthalic Acid

the oxidation of *m*-xylene. It melts at temperatures above 300° C and is sparingly soluble in cold water, but much more so in hot. It forms no anhydride. Paraphthalic acid, also known as terephthalic acid, is prepared by the oxidation of *p*-xylene or caraway oil, the latter a mixture of cymene and cuminol. It can also be made from *p*-toluidine, as follows:

$$CH_3{\cdot}C_6H_4{\cdot}NH_2 \rightarrow CH_3{\cdot}C_6H_4{\cdot}CN \rightarrow CH_3{\cdot}C_6H_4{\cdot}COOH \rightarrow COOH{\cdot}C_6H_4{\cdot}COOH$$

It sublimes without melting and is very sparingly soluble in water, alcohol, and ether. It also forms no anhydride. Since 1950 this acid has become of considerable commercial importance, for its ethylene glycol ester is the important man-made fibre Terylene, or Dacron. (G. C. C.; J. H. Ss.)

PHUKET, the only island *changwad* (province) of Thailand. Area, 309 sq.mi. (801 sq.km.). Located off the west coast of peninsular Thailand in the Andaman Sea at about latitude 8° N, this island is accessible from *Changwad* Phangnga to the north by ferry across a narrow strait. Phuket is a comparatively level area studded with isolated hills reaching a maximum elevation of 1,700 ft. The island receives about 95 in. of rainfall annually, most of which occurs from April through November. Pop. (1960) 75,652, giving a density of about 244.8 persons per square mile. Nearly half of the people are Chinese.

Phuket is noted for its rich tin mines, found both in the gravels of the island's lowlands and on the adjacent shallow sea floor. These ores have been worked by the Chinese since ancient times. A European company began modern dredging operations in 1907. At present, most of the tin is mined by river and ocean boat dredges, hydraulic pumps, and gravel pumps. Phuket accounts for about one-third of Thailand's tin production.

In the past the island has been called Tongka, Junk Ceylon, and Jonsalam. European merchants began trading on Phuket in the 16th century. It was invaded by the Burmese during the 18th-century wars between Burma and Thailand, but was relieved by Thai troops from the mainland. In addition to the city of Phuket several small fishing and farm villages dot the island.

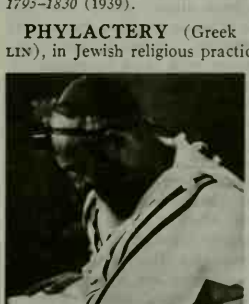
The city of Phuket (pop. [1960] 28,163) is the capital of the *changwad* and the largest Thai port and commercial centre on the Andaman Sea. It has a roadstead harbour. Products moving to the west coast of peninsular Thailand by road, rail, and boat are assembled at Phuket and carried south to Penang and Singapore and also north to Burma. Phuket exports tin, rubber, wood charcoal, lumber, and fish products, and imports food (rice) and manufactured products such as clothing, machinery, and petroleum products. (T. F. B.)

PHYFE, DUNCAN (*c.* 1768–1854), U.S. cabinetmaker who interpreted fashionable European styles in a manner distinguished by grace and excellent proportions, was born near Inverness, Scot. Duncan was brought to the United States by his mother in 1784. The Fife family settled in Albany, N.Y., where Duncan worked as an apprentice cabinetmaker and eventually opened his own shop. The new wealth of New York city drew him there in 1792. About 1793 he changed his name to Phyfe. In 1837 Phyfe took his two sons into partnership and the firm was listed by a contemporary directory as "Duncan Phyfe and Sons." In 1847 he sold his business and went into retirement. He was one of the first U.S. cabinetmakers to successfully use the factory method to manufacture furniture. Phyfe's first New York shop was located on Broad street. Subsequently he moved to Fulton street, west of Broadway, where in later years he employed over 100 carvers and cabinetmakers. He died on Aug. 16, 1854.

Phyfe did not originate a new furniture style. About 1800 his workshop was executing delicate furniture in the Sheraton style; by 1825, as taste changed, his pieces became heavier and in the Empire style. The Sheraton chairs, tables and sofas often had delicate, reeded legs; and the Empire pieces, massive claw feet. His furniture was decorated with typical period ornaments—harps, lyres, acanthus leaves, bow knots and lion masks. The furniture, generally made of high-quality mahogany, was often executed in sets for fashionable New Yorkers. The patronage of John Jacob Astor helped to make it popular. In 1825 Phyfe was commissioned to make a box which was fitted with glass bottles containing water from the Erie canal which was sent to Lafayette as a souvenir of the opening of the canal. Interest in Phyfe's cabinetwork was revived in 1922 when the Metropolitan Museum of Art, New York, organized a comprehensive exhibition of his work.

See Charles O. Cornelius, *Furniture Masterpieces of Duncan Phyfe* (1922); Nancy McClelland, *Duncan Phyfe and the English Regency, 1795–1830* (1939). (J. T. Br.)

PHYLACTERY (Greek PHYLAKTERION; Hebrew TEFILLIN), in Jewish religious practice, a small leather case containing four pentateuchal texts written on parchment, which, in accordance with Deut. 6:8 (and similar statements in Deut. 11:18 and Ex. 13:9 and 16), were to be worn as constant reminders of God and the obligation to keep the Law during the daily avocations. They were not used on Sabbaths and festivals, as the day itself was, in those cases, a reminder. The idea of such an outward sign is common, and the ancient Hebrews wore amulets and signs, perhaps originally tattooed; Isa. 49:16 evidently denotes this custom.



PAUL GROSS

WORSHIPER WEARING PHYLACTERIES

The *shel rosh* is fastened to the centre of the forehead. The *shel yad* is placed on the inner side of the left arm, just above the elbow, facing the heart; its leather thong is wound around the arm seven times, ending in the hand in the form of the Hebrew letter *shin*

In modern times phylacteries are worn by men on the left arm and on the forehead only at the morning service (except on the Sabbath and festivals) and at the afternoon service on the 9th of Ab. Reform Jews, interpreting the biblical commandment figuratively, do not wear them at all. The hand phylactery (*tefillin shel yad*) has one compartment and the texts are written on one parchment; the head phylactery (*tefillin shel rosh*) has four compartments, each with one text. The extracts are Ex. 13:1–10 and 11–16; Deut. 6:4–9 and 11:13–21.

Linked with *tefillin* are the door text and fringes (or tassels). The former is a text containing Deut. 6:4–9 and 11:13–21 rolled in a glass or metal tube and placed on the right of each door, so that everyone who enters or leaves shall be reminded of God. The latter is based on Num. 15:37–41, which ordains the knotted tassel as a mnemonic. The word phylactery occurs only once in the Bible, in the New Testament (Matt. 23:5).

Bibliography.—G. Langer, *Die jüdischen Gebetsriemen* (1931); *The Jewish Encyclopedia*, vol. x, pp. 21–28; *The Universal Jewish Encyclopedia*, vol. viii, pp. 522–523.

PHYLLITE, a group of rocks which are in practically all cases metamorphosed clayey sediments, consisting essentially of quartz, chlorite and muscovite, and possessing a well-marked parallel arrangement or schistosity. The name is from the Greek *phyllon*, a leaf, probably because the rocks yield leaflike plates. They form an intermediate group in the series of altered clays or

shaly deposits between clay slates and mica schists (*q.v.*). The clay slates have a similar mineral constitution to the phyllites, but are finer grained and are distinguished also by a much better cleavage; in the phyllites white mica (muscovite or sericite) is more abundant as a rule than in slate, and its crystalline plates are larger; the abundance of mica gives these rocks a glossy sheen on the smooth cleavage planes. The foliation is generally flat or linear, but in some rocks is undulose or crumpled. From the imperfection of their cleavage phyllites are rarely suitable for roofing materials; their softness renders them valueless as road stones, but they are not uncommonly employed as inferior building materials. They are exceedingly common in all parts of the world where metamorphic rocks occur, as in the Scottish Highlands, Cornwall in England, Anglesey in Wales, northwest Ireland, the Ardennes, the Harz mountains, Saxony, the Alps, Norway, the Appalachians, the Great Lakes region in the United States, etc.

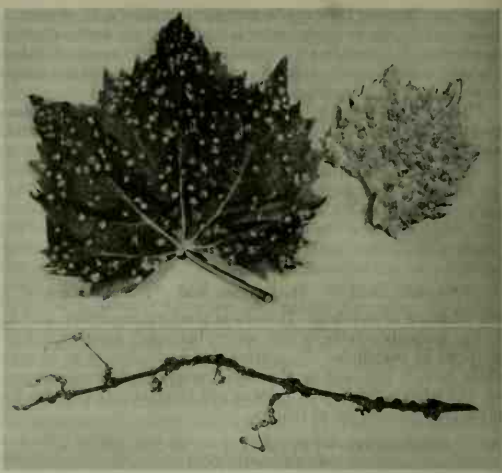
A microscopical section of a typical phyllite shows green chlorite and colourless mica, both in irregular plates disposed in parallel order, with a greater or smaller amount of quartz which forms small lenticular grains elongated parallel to the foliation. Grains of iron oxide (magnetite and hematite) and black graphitic dust are commonly present. Feldspar generally is absent or scarce, but some phyllites are characterized by the development of small rounded grains of a plagioclase feldspar, albite, often in considerable numbers. The minute needles of rutile, so often seen in clay slates, are not often met with in phyllites, but this mineral forms small prisms which may be intergrown with black magnetite; at other times it occurs as networks of sagenite. Other phyllites contain carbonates (usually calcite but sometimes dolomite) in flat or spindle-shaped crystals, which often give evidence of crushing. Tiny blue needles of tourmaline are by no means rare in phyllites, though easily overlooked. Garnet occurs sometimes, a good example of the garnetiferous phyllite being furnished by the whetstones of the Ardennes, in which there are many small isotropic crystals of manganesian garnet. Hornblende, often in branching feathery crystals, is a less frequent accessory. In some phyllites a mineral of the chloritoid group makes its appearance; this may be ottrelite, sismondine or other varieties of chloritoid, and occurs in large sub-hexagonal plates showing complex twinning, and lying across the foliation planes of the rock. The structural variations presented are comparatively few. The most finely crystalline specimens have generally the most perfect parallel arrangement of their constituents. (J. S. F.; X.)

PHYLLOXERA, the common name for aphidlike plant pests of the family Phylloxeridae, the most notorious member of which, because of its devastation of vineyards, is the grape phylloxera, or grape louse, which will be emphasized in this article.

Description.—Phylloxera are included with the aphids in the superfamily Aphidoidea. Phylloxeridae differ from typical aphids in details of wing venation and in the absence of any form of viviparous, or live-bearing, reproduction. From the Adelgidae, a small family (by some considered a subfamily, Adelginae, of Phylloxeridae), phylloxera differ in possessing fewer antennal segments, in carrying the wings folded flat over the back instead of inclined in a rooflike manner, and in not producing wax in flocculent masses. Members of the family are small (about one millimeter), rather stout, and in the wingless forms taper toward the hind end. The antennae are three-segmented and the body is usually uncovered. In a few species there are dorsal wax glands.

Phylloxeridae feed on the sap of plants, which, like aphids, they extract from leaves or roots by means of their suctorial mouth parts. In some species part of the annual cycle on their host plants is passed on the leaves and part on the roots. In others, part of the cycle is spent on one plant host and part on another of the same genus. Both types of migration occur in the life history of species of *Phylloxera*, a genus now restricted by many authorities to the species that occur naturally in Europe on oak or chestnut trees, excluding the grape phylloxera, which is frequently separated as *Viteus vitifolii* (though it is still often seen as *Phylloxera vitifoliae* in many writings).

The greenish-yellow grape phylloxera is native to the eastern part of the United States, where it lives on indigenous species



INRA, PONT DE LA MAYE, FRANCE

FIG. 1.—GALLS ON GRAPE LEAVES AND GRAPE STEM, CAUSED BY THE GRAPE PHYLLOXERA, VITEUS VITIFOLII

of grapes (*Vitis riparia, V. rupestris,* and *V. berlandieri*). It was introduced into Europe between 1858 and 1863, when American vines were brought over for grafting purposes, and has since reached almost all the vine-growing countries of the world. It was first recognized as a serious pest in its subterranean form. Feeding on the native European vines (*Vitis vinifera*), it caused extensive destruction.

Life Cycle.—The biology of this species is complex. Its life history on the American vines, which differs notably from that on the European vines, is as follows. In late autumn the fertilized egg is laid on the bark. The egg is elongate-ovoid and is attached to the surface by a short stalk. It hatches in the spring into a young wingless female (fundatrix), which makes its way upward to the opening leaves of its host and begins to feed on the upper surface. At the site of the feeding puncture, a gall develops on the lower surface of the leaf in the form of a thick-walled flask-shaped structure. The gall has a narrow mouth opening on the upper surface and is covered by interlocking hairs. The insect lives inside the gall and reaches the adult stage after undergoing four molts; then, without mating, it lays eggs, from which emerge a further generation of young (the gallicolae). These parthenogenetically produced offspring wander out of the gall and establish themselves elsewhere on the leaf. By their feeding they induce the development of new galls similar to those they left. There are about seven generations of these gallicolae, all of which reproduce without being fertilized. They are relatively fecund and produce eggs that give rise not only to offspring with a leaf-colonizing behaviour like themselves, but also, increasingly as the autumn progresses, to offspring which descend the trunk of their host and either attach themselves to the roots or shelter in crevices of the bark until the winter is over. In due course, without being fertilized, this generation lays eggs, producing a further generation of the root-dwelling form. These, the radicicolae, persist through the year on the rootlets and, like the gallicolae, undergo four molts between hatching and maturity. The adult females are distinctly less pro-

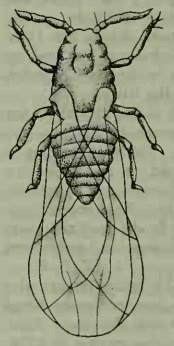


FIG. 2.—WINGED MIGRANT FEMALE

Hatched from the egg of the root Phylloxera, this form flies to other vines where it lays, parthenogenetically, eggs of two kinds, male and female

lific. The radicicolae move freely in and on the soil and even, in exceptional environmental conditions, may ascend the vine, settle on the leaves, and assume the way of life of the gallicolae. In time the radicicolae lay eggs that give rise to offspring of gallicolous habit. The radicicolous form, with its mobility, is liable to be transported to other vines. In addition to producing offspring similar to themselves, as the season advances the radicicolae produce offspring that develop into winged adults. These emerge from below ground and migrate to the upper parts of the vine. Each, without mating, lays a few eggs (up to eight) on the bark of the lower part of the trunk. Although the adults are superficially alike, some lay relatively large eggs and others, small eggs. The young that emerge from the large eggs develop into females; those from the small eggs become males. Such, at least, is the general rule. There is some variation; a female may sometimes lay eggs that give rise to both male and female offspring.

The sexual forms are devoid of mouth parts and the alimentary canal is closed behind. After fertilization the female lays a single egg. From this, in the following spring, emerges the young, starting the cycle anew.

On the European vine the gall-forming phase is almost wholly absent, and reproduction is limited to the production of unfertilized eggs by the radicicolae. It is this root-infesting form that menaced the cultivation of the European vine by inducing the development of nodules on the young roots, which later become necrotic. Since perhaps 12 generations of the pest may be produced in a year, massive colonies may develop, and the injury that they cause may be sufficient to kill the roots.

Control Measures.—The devastation caused to the European

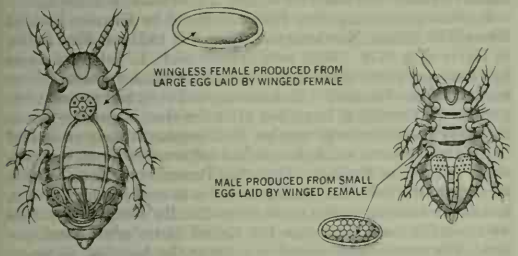


FIG. 3.—MALE AND FEMALE FROM EGGS LAID BY WINGED MIGRANT FEMALE

The female dies after laying a single egg which hatches out in the spring as a female insect known as a fundatrix. This form produces eggs from which are hatched gallicolae. Some of these remain in the buds while others descend to the roots as radicicolae

vine in the 30 years following the introduction of grape phylloxera was immense. It was virtually halted by adoption of the use of root stocks from American vines, or from crosses between American and European vines. Later an attempt was made to develop hybrids suitable for growing on their own root systems, capable of producing a commercially acceptable crop, and possessing a high degree of resistance both to grape phylloxera and to fungal diseases. Direct combative measures are widely used against the pest. One of the commonest is the use of carbon bisulfide as a soil fumigant to kill the subterranean forms. Modern insecticides are continually being tested for the same purpose and for disinfestation of young vines before planting. *See* also APHID; GRAPE.

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PHYSICAL EDUCATION. This article traces the history of physical education and its growing role in national school systems. Specialized applications of physical education, such as for those affected by physical injury or congenital handicap, are dealt with in PHYSICAL THERAPY AND REHABILITATION, MEDICAL AND VOCATIONAL. (*See* also PHYSICALLY HANDICAPPED, EDUCATION OF.)

History.—While physical education was one of the later subjects to be included in school curricula, it is one of the oldest forms of education. Primitive societies trained their young in physical skills for survival and often in skills of dance for purposes of ritual or mimetic magic. Early civilized communities developed this training and some of them—in China, Assyria, and Egypt, for example—evolved organized games. It is, however, to Greece from the 6th century B.C. onward that modern civilization has looked for much of its inspiration and for a philosophy of physical education. The Olympic Games (*q.v.*) would hardly have been possible unless systems of physical education had been established in the individual states (*see* also GAMES, CLASSICAL; GYMNASIUM). At Sparta physical education was rigorous and military in character. It was closely controlled and organized by the state both for boys and girls. At Athens no girls participated in physical education and the boys' training, at first designed for military ends, was later more liberally interpreted and became inseparable from general education. Strength and health were cultivated not only for their own sake but because they allow man greater freedom to develop his mental capacities. This realization also fortified all later interest in physical education.

Under the Roman Empire there were various forms of specialized training for soldiers and gladiators, athletes, and other professional entertainers. In Rome and other cities the baths provided facilities and coaching for many activities, some recreational, some therapeutic (*see* BATH). The physician Galen (*q.v.*; *c.* A.D. 130–*c.* 200) systematized physical exercises and devised programs of physical education for a population concerned no longer with national survival or athletic competition but with the more mundane problem of keeping fit.

Galen's works were the basis for the revival of interest in physical exercise, including gymnastics, which occurred during the Renaissance. The leading authors were Geronimo (Girolamo) Cardano (1501–76) and Hieronymus Mercurialis (1530–1606). The keen interest in the physical education of the aristocracy is manifested in *Il Cortegiano* ("The Courtier"; 1528) by Baldassare Castiglione and *The Governour* (1531) by Sir Thomas Elyot (*q.v.*).

In the 18th century the writings of J. J. Rousseau (*q.v.*; 1712–78) and the inspired teaching of two Germans, J. B. Basedow (*q.v.*; 1723–90) and J. C. Guts-Muths (1759–1839), and the Swiss philanthropist J. H. Pestalozzi (*q.v.*; 1746–1827) nourished a widespread concern for the physical education of the population at large. During and after the Napoleonic Wars three pioneers made notable contributions to the theory and practice of physical education—P. H. Ling (*q.v.*; 1776–1839) in Sweden, Franz Nachtegall (1777–1847) in Denmark, and F. L. Jahn (*q.v.*; 1778–1852) in Germany. Their conception of physical education was primarily gymnastic. Ling had classified gymnastics into military, aesthetic, medical, and educational. During the 19th century the last two aspects received particular attention. The characteristics of Swedish physical education and the use of beams and wallbars or ribstalls became the day's order of exercise. In Germany, however, physical education was never disassociated from political faction and was often intimately connected with military training, never more so than during the Nazi regime (1935–45). The horizontal and parallel bars and the pommel horse became intrinsic features of German gymnastics which were called "Turnen."

Physical Education in the Schools.—At the end of the 19th century all over Europe games and sports became popular and made their impact upon physical education in the schools, which was then still predominantly gymnastic. Their role in education has become more important during the 20th century.

United Kingdom.—In the 19th century the number of public schools (as independent day and boarding schools are called) multiplied as the prosperity of the middle classes increased. In these schools physical education took the form of organized games, with pride of place given to the team games of football (Rugby and soccer) in winter and cricket in summer. Schools such as Eton and Westminster, which are situated near rivers, also took up rowing. The games were at first developed by boys in opposition to their headmasters, and compulsion to play was imposed on the other boys. Rugby School, the model for so many others, gave

its name to the particular form of football played there. It was not until mid-century that teachers generally began to consider games as instruments of education. It was later still that games were organized for the whole school rather than for the older boys and better performers. The benefits sought were practice in self-government, the inculcation of team spirit, and the development of character. The gymnastic systems of the continent were rejected or at most accepted as minor sports.

Children who went to elementary schools had little or no physical education, though military drill was sometimes given by a visiting noncommissioned officer. About the year 1870 several different systems of exercises were tried in schools. The Swedish system, introduced in 1878 by Miss Concordia Löfving from Stockholm, was eventually preferred for girls. Miss Löfving was succeeded by Miss Martina Bergman, later Madame Bergman Österberg, who founded the first women's college for training specialist teachers of physical education in 1885. After the South African War (1899–1902) revealed the unfitness of most recruits, the board of education attempted to develop a system of physical education based on military drill by publishing the much-criticized *Model Course of Physical Training* (1901). In 1908 physical education in state-aided schools was placed under the newly established medical department of the board of education, and men and women inspectors of physical education who had been trained in the Swedish system were appointed. In 1909 a new syllabus of physical exercises was published, giving a detailed exposition of the Swedish system. Revisions were published in 1919 and 1933.

Meanwhile many teachers had on their own initiative introduced football, cricket, swimming, and other sports into the elementary schools but the lack of playgrounds, playing fields, and swimming pools prevented them from becoming universal. Nevertheless since 1908 the two traditions of physical education in Great Britain —organized games and Swedish gymnastics—have been steadily fused. The Education Act of 1918 made it permissive for local education authorities to provide facilities for social, recreational, and physical training, not necessarily in association with a school. The Education Act of 1944 made this provision obligatory. Since 1920 many schools for children 11 and over (secondary schools) have been built and all include one or more gymnasiums equipped with Swedish apparatus. Since 1945 many experimental types of apparatus have been installed. There has also been an increased provision of playing fields for secondary schools, and even for primary schools (schools for children under 11). In the latter no special gymnasiums are provided, the playground and school hall offering the facilities for physical education.

In the U.K. the curriculum of a school is to a great extent drawn up by the head teacher and there is therefore no uniform allocation of time to physical education. In primary schools a daily period is usual and the children are generally instructed by the class teacher who takes all their other lessons. Many secondary schools allocate four periods a week, including games and swimming, but boys and girls who are preparing for examinations usually have fewer periods. Specialist teachers are aided by a number of other teachers who have an interest in or qualification for a particular game.

The approach to physical education, especially to the teaching method, has undergone profound changes since 1945: first, formal directed teaching from tables of exercises and activities has been largely abandoned in favour of more individual work with emphasis on skills, whole body movements, and natural activities; second, women teachers, led by inspectors, organizers, and training-college lecturers, and inspired by the pioneer work of Rudolf von Laban who was formerly a professional dancer performing in central European dance and ballet, have evolved "movement training." Laban's fundamental bases of movement have been used to give special significance to the terms "time," "weight," "space," and "flow." In movement training individual differences can be allowed to determine individual rates of development and levels of achievement. Men teachers have also adopted many of the principles of movement training without always using Laban's terminology.

Two British government publications, *Moving and Growing* (1952) and *Planning the Programme* (1953), gave guidance along the new lines. In boys' secondary schools, weight training, circuit training (a number of activities, *e.g.*, heaving, sit-ups, etc., in a circuit with a given number of repetitions for each activity), and other specialized forms of training have found a place in gymnastic lessons. For older boys and girls in secondary schools there has been a great proliferation of games and sports. Outdoor activities, camping, climbing, sailing, skiing, and expedition work have also been incorporated in many school programs.

The newer British universities have copied Oxford and Cambridge in that games and sports are administered, financed, and, for the most part, coached by the students themselves. Nevertheless most of them have lecturers in physical education, or departments of physical education, whose function it is to assist and encourage the students in their physical recreations. Several of these lecturers conduct optional subsidiary courses for graduates who intend to enter the teaching profession. In 1964 only one university, Birmingham, had a compulsory program of physical education for all students in their first year. The same university was also unique in Great Britain in having a course of undergraduate study in physical education contributing to a first degree.

All teacher-training colleges include a professional course in physical education for primary school teachers. Future instructors for secondary schools are trained in specially equipped and staffed colleges. The national organization for these teachers is the Physical Education Association of Great Britain and Northern Ireland (founded 1899).

United States.—Physical education in the U.S. has developed from many sources, some indigenous and some imported. It continues to absorb and innovate so that it is constantly changing.

German gymnastics were first introduced by Charles Beck at Round Hill School, Northampton (Mass.) in 1825 and Karl Follen at Harvard in 1826. Both were friends of F. L. Jahn and came to America as political refugees. It was to English-speaking Americans that they introduced their turnen and they had no great impact on the country at large, but after the abortive revolutions in Germany in 1848 a large number of European turners emigrated to the United States and had a marked influence on physical education. In 1866 the Nordamerikanischer Turnerbund, the association formed by the individual clubs, opened a normal college (that is, a teachers training college) and thereafter the German gymnasts were steadily assimilated into the United States educational system. The association changed its name to the American Gymnastic Union in 1919 and in 1941 the normal college was merged with the University of Indiana.

Meanwhile in 1828 Catherine Beecher (1800–1878) founded the Hartford Female Seminary and included in the curriculum hygiene and "calisthenics," exercises without apparatus originally designed to promote graceful movement (Gk. *kalos* + *sthenos,* "beautiful strength"; *see* also GYMNASTICS).

The Czech *Sokol* Gymnastic Society opened its first gymnasium in 1865. The first Young Men's Christian Association's buildings with gymnasiums were erected in 1869 in San Francisco, New York, and Washington, D.C. Prominent YMCA leaders included Luther Halsey Gulick (1865–1918) and James Huff MacCurdy (1866–1940). The International Training School of the YMCA (Springfield College) was established in 1887 at Springfield (Mass.) and continues to train physical educators. In 1861 Dio Lewis started a normal school in Boston for training teachers and attracted much attention. Calisthenics formed an important part of his system hut it is difficult to determine whether he owed any debt to the German or Swedish systems.

About 1860 the "Swedish Movement cure" was receiving limited attention as a therapeutic system. Not until 1883 did the Swedish system become a form of physical education in the United States. It was introduced by Hartvig Nissen who came to Washington in that year and by Baron Nils Posse in Boston two years later. Mrs. Mary Hemenway, a Boston philanthropist, whose son had given the Hemenway Gymnasium to Harvard in 1879, financed a normal school of gymnastics in Boston to train teachers in the Swedish system. This was adopted in many schools but it attracted more support from girls and women than from men. The

emergence of the Dewey philosophy of education (*see* EDUCATION, HISTORY OF; DEWEY, JOHN) was accompanied by a move away from formal gymnastics toward individual programs and education for leisure-time recreation. Inevitably the Swedish system lost support and by 1900 the tide of opinion had also turned against calisthenics.

Physical education in elementary schools for children below the age of 12 now includes singing games, simple rhythms, stunts, tumbling, climbing on apparatus, folk dance, games leading up to major team games, and sports including volley ball and softball. Class periods average half an hour daily and the instruction often is given by the class teacher. Many schools use physical fitness tests, and national age norms on standard tests are available.

Upper elementary and junior high schools for children over 12, having abandoned Swedish and German gymnastics about 1910, aim to develop physical fitness, to improve motor skills, to promote group cooperation through team sports, and to teach recreational sports for later life. Three to five periods a week are devoted to instruction and the curriculum is presented in progression from grade to grade. Achievement is measured by standard tests and scales.

In senior high schools there is more emphasis on basketball, baseball, and football for boys and on social dance and modern dance for girls, but tennis, golf, swimming, wrestling, conditioning exercises, and track and field are also taught. Open-country pursuits such as hiking, skating, and skiing are introduced where possible. Boxing is generally not appproved.

In colleges and universities athletics, aquatics, dance, and recreational sports are the media of physical education. Many colleges require men and women students to undergo instruction for two years. Much testing is done and students may be directed to the physical education which they need.

Interscholastic and intercollegiate activities have long been well developed, especially for boys and men. College football receives most emphasis in intercollegiate sport, and stadiums holding 100,000 spectators have been built to stage the games of the bigger universities (*see* also STADIUM). Admission receipts are an important source of income for much college sport and for high-school sport in many states. At schools the coaches of teams are invariably physical education teachers. At colleges some external coaches are employed, while others are members of the college department of physical education. Regulations for interscholastic and intercollegiate competition and other related problems are laid down by the National Collegiate Athletic Association (NCAA) and its local subdivisions and the corresponding National Federation of State High School Athletic Associations. Intramural athletics are encouraged in elementary schools, junior and senior high schools, and in colleges. They consist of a voluntary program under staff direction assisted by student managers and officials.

The old normal schools for training teachers of physical education have gradually been incorporated in colleges and universities. In the second half of the 20th century more than 400 colleges and universities offered a "major" in physical education and the number of such colleges was increasing each year. Research into physical education was at first centred in the Teachers College, Columbia University, whose first Ph.D. with a "major" in physical education was awarded in 1927. Since then programs of research have been developed in many universities and colleges.

The most important professional organization is the American Association for Health, Physical Education and Recreation (AAHPER), founded in 1885. The American Academy of Physical Education (1926) is a select body of high academic standing which has a number of "corresponding fellows" in other countries.

A World View of Physical Education.—There are few countries —whether advanced or still emergent—which do not take physical education seriously. The programs of most of them include, as well as their own indigenous recreations, elements derived from the gymnastic system of the continent of Europe and from the games and sports of Great Britain and the United States. This is true of countries as different as China, Japan, the U.S.S.R., India, the African states, and the South American countries. There are three international organizations directly concerned with physical education: (1) the International Federation for Physical Education; (2) the International Council of Sport and Physical Education, which operates under the auspices of UNESCO; and (3) the International Council on Health, Physical Education and Recreation affiliated to the World Confederation of Organizations of the Teaching Profession.

See also GYMNASTICS; GYMNASIUM; DANCE; FOLK DANCE.

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PHYSICALLY HANDICAPPED, EDUCATION OF.

The education of the physically handicapped deals with techniques, curriculum adjustments, and therapeutic services which enable them to receive educational opportunities as nearly as possible equivalent to those made available to others. The term "physically handicapped" sometimes is used interchangeably with "exceptional children" in U.S. educational circles but the latter term usually also includes the mentally handicapped and those who are superior, or gifted. Actually, the physically handicapped often have overlapping disabilities, as in the case of cerebral palsy. The classification includes those who may have a major motor or sensory handicap but are most disabled by personal-social deviations. There are also factors which cause physical impairment that has not been determined as being purely physical, purely mental, or purely emotional in origin. A conservative estimate of the number of physically handicapped is approximately 10 to 15% of the school-age population.

The most commonly accepted list of physical handicaps is the following: orthopedic defects, neurological handicaps, special health problems, multiple handicaps, blindness, impaired vision, deafness, hard of hearing, speech defects, emotional disturbance, social maladjustment. School programs are also provided for those with mental deviations, such as the intellectually gifted, the mentally retarded, and those with low intelligence quotients.

For the purposes of this article certain orthopedic and neurological handicaps are cited to illustrate special methods, problems, and programs involved in the education of the physically handicapped. The blind and the deaf were the first groups of the physically handicapped to attract attention and for whom special educational programs were established. For the history of these developments *see* BLIND, TRAINING AND WELFARE OF; DEAF AND HARD OF HEARING, TRAINING AND WELFARE OF. *See* also RETARDED CHILDREN; REHABILITATION, MEDICAL AND VOCATIONAL.

Orthopedic Handicaps.—The orthopedically handicapped have defects that are caused by a deformity in or interference with normal functioning of the bones, muscles, or joints. The condition may be congenital or acquired due to accident or disease. Some examples of orthopedic disabilities are: clubfoot, spina bifida, cleft palate, Friedreich's ataxia, congenital amputations, Erb's palsy, bone fractures, osteomyelitis, arthritis, poliomyelitis, amputations, burn contractures, bone tumours, bone cysts, muscular dystrophy, curvature of the spine, and Perthes' disease.

Learning ability varies with intelligence and with possible damage to the brain. Continuous educational programs are important for the orthopedically handicapped youngster who is considerably retarded in school achievement. It is believed that such a lag often is due to long hospital placement, convalescent care, and lightened school programs. Other factors appear to be the lack of experiencing daily activities into which other children enter, overprotection on the part of parents, possible withdrawal from groups as protection against feelings of incompetency and frustration,

and the sense of being different from other children. Many schools, because of existing laws and factors of safety and physical limitations, require the orthopedically handicapped child to attend a special class for crippled children.

Neurological Handicaps.—The neurologically handicapped are those whose crippling conditions arise from injury to the central nervous system. One of the most serious is cerebral palsy, a neuro-muscular condition which results in disturbance of motor functioning. Failure of normal development or damage to different parts of the brain before, during, or after birth results in malfunctioning of a single extremity or a combination of extremities and may involve speech, vision, and hearing. These conditions are manifested in spasticity, athetosis, ataxia, rigidity, and tremors. Cerebral palsied children have varying degrees of disability. Although a large percentage, especially those whose affliction is severe or moderately severe, is believed to have accompanying mental deficiency, there are all degrees of mentality represented in the total group. Children who are within the normal intelligence range, and who have no serious sensory or psychological disabilities, require the same kind of learning experiences that are provided for nonhandicapped children. Those whose coordinative skills are most severely affected will need the patient understanding of resourceful teachers. Adapted teaching aids may need to be employed. For many of these children learning is a difficult process. For children with hand involvements, these may include bookstands and the use of large crayons instead of pencils. Special equipment for those with postural problems enables children to participate at sand tables, easels, and workbenches. The curriculum content must emphasize the experiences that children with severe handicapping conditions have missed. Field trips are more important than they are to nonhandicapped children. The socializing aspects of group participation play an important part in the program.

The curriculum content for the mentally retarded cerebral-palsied must be particularly geared to the development of adequate personal and social behaviour. Academic skills will be of concern only to the extent that they can be used in life situations. Progress must be modified to the slower developmental rate of the learners and work units need to be of shorter duration. The curriculum and the instructional program must be directed toward efficient living; at the adolescent level, much emphasis must be placed upon occupational orientation. Those who are not educable, or whose severe physical disabilities are combined with significant mental retardation, should have a program involving preparation for living in the home and community and, perhaps, adjustment to a sheltered workshop.

Children who are not significantly handicapped mentally, but whose major learning problem stems from sensory defects, must learn a method of communication. The personal-social aspects of growth and development are important to them too, but the deafened must learn to read lips, or to use a hearing aid, and to overcome accompanying speech disabilities. The partially sighted and blind must learn to use sight-saving materials and some need to learn braille, if possible.

Because of the proneness of the cerebral palsied to distractibility, susceptibility to stimuli, and confusions of spatial and figure-ground relationships, several investigators have indicated the need for classrooms that are free from distracting influences and for teaching materials that fasten the attention of pupils upon one learning element. Some, as M. I. Dunsdon in England, have suggested that many cerebral palsied children may respond to phonic rather than sentence-matching methods in reading, and to verbal memory methods in arithmetic.

In contrast to those who would organize the entire educational program for cerebral palsied children around an especially designed stimulus-reducing classroom and special teaching methods, there are other educators who would use these methods only for certain types of instruction or for selected groups of children. A "clinical" teacher could be employed for children with perceptual disabilities, taking individual children for short periods of instruction. It is obvious that the instruction of cerebral palsied children is a problem requiring individual evaluation of learning disabilities, and individual plans of attack.

Another type of neurologically handicapped child is represented by the group called brain-damaged or brain-impaired. The disability is characterized by bizarre behaviour caused by an early injury to the brain, or by a disturbance in the development of the brain. The resultant behaviour may be in motor functioning, as in the cerebral palsied, or in such autonomic functions as sleep and respiratory or vasomotor control, or in the psychic functions that contribute to personality development, with personality immaturities, emotional disturbances, and neurotic symptom formations. Children who are cared for from the onset of their disability will have favourable prognosis. In many cases, intellectual functioning will be adequate; intellectual retardation is often more apparent than real.

Special Health Problems.—Those with special health problems include the cardiopathic, tuberculous, diabetic, epileptic, allergic, and those with lowered vitality. The cardiopathic may suffer from rheumatic heart disease, congenital heart disease, or subacute bacterial endocarditis. Children with any of these health problems may be handicapped in their schoolwork to the extent that special classes or programs are needed.

Programs.—Responsibility for the school placement of the handicapped is best determined by a group of experts, together with the parents or family of the disabled person. Their recommendations are influenced by the existing resources in his community. The United States Department of Health, Education and Welfare lists four organizational patterns.

1. Special schools and classes for long-term placement. This type of program is designed for the child who represents a permanent disability and who needs an adapted curriculum. Ordinarily, the child spends most of his time in the special class. At the upper age levels, many schools assign special-class children to some experiences in the regular school programs. Some programs involve short-term assignments in such classes and eventual absorption into the regular class. Where intellectual difference is not a major consideration, there is emphasis on special classes for adjustive facilities for short-term placement only. For the deaf and the blind, the period of special-class placement may have to be longer, since such children must learn special techniques of communication. Nevertheless, both deaf and blind children with normal intelligence may do well in regular school classes after they have mastered the communication skills.

2. Special supplementary instruction services for exceptional children who thereby can make adequate adjustments in the regular school. Included are services for children with speech defects, who are usually provided with speech training at regular intervals by specialists in speech correction; hard-of-hearing pupils who may profit from periodic lip-reading instruction or assistance in the use of hearing aids; and the partially sighted who may meet with a specialist for supplementary instruction, special reading materials, and guidance. For partially sighted children, considerable differences exist in the types of school services provided.

3. Home or hospital instruction. A large number of schools conduct instructional programs in the home and in hospitals for severely disabled children. Programs may include daily group instruction, itinerant bedside instruction, and the use of electronic devices in the home. The individuals are temporarily or permanently incapacitated to the extent that they cannot be served in the regular school in special classes, even when school transportation is provided.

4. Residential school programs for blind, deaf, or socially maladjusted children. While many of these institutions and schools come under the administration of welfare and mental hygiene agencies, they constitute an important field of special education. Their function is primarily one of education and rehabilitation.

A survey conducted by the United Nations Educational, Scientific and Cultural Organization, *World Survey of Education* (1955), indicated that the above four organizational patterns encompass the programs provided in most countries. There are variations in administration and supervision and wide variations in the adequacy of programs and the percentage of various groups provided for. Some countries rely almost entirely on voluntary

charitable organizations for whatever education is provided for certain groups of the physically handicapped.

In England and Wales under the act of 1945 local education authorities are required to make provisions for the education of all school age children with any physical or mental handicap (see *below*). Physically handicapped children, depending on the seriousness of their disability, are educated in special schools. The program in Scotland under the education act of 1946 as amended is similar.

On the continent, France has established open-air schools and schools for backward, crippled, or abnormal children and the Federal Republic of Germany has provided special schools and special classes in regular schools. The Netherlands provides special schools for the handicapped and Denmark provides for special instruction either in special classes or within the normal class, depending on the number of handicapped children within a school district. Norway provides for special schools for children of limited ability and for those suffering from speech defects, and in Sweden there are special schools for the handicapped; an increasing number of local school districts have established auxiliary classes for the mentally retarded and larger school districts have special classes for children with other handicaps. (E. D. GA.)

Great Britain.—The following discussion of education for handicapped children in Great Britain indicates changes and developments over a period of years.

The provision of special forms of education for physically handicapped children has been the responsibility of the education authorities since before the beginning of the 20th century. The years after the end of World War II have brought a good deal of new thinking, while better social provisions and better medical treatment have changed the look of the problem.

The law is laid down in the Education Act, 1944, and the regulations made from time to time under this act. "Special educational treatment" is to be provided from the age of two if the parents request it and in any case from the age of five. It continues at least until the age of 16 unless the child improves enough to be able to return to an ordinary school. All provision is free of charge. Ten types of handicaps are defined by the ministry and one of them is "physically handicapped." In fact these physically handicapped children fall into four main groups: (1) children with defects of locomotion or motor defects, *e.g.*, poliomyelitis; (2) children with severe heart disease, *e.g.*, congenital heart disease; (3) children with cerebral palsy; (4) miscellaneous, *e.g.*, epileptic children, who are sent to these schools because there is a nurse on the premises.

Two surveys spanning a period of 30 years provide interesting comparisons of numbers and rates per 1,000 of total school enrollment of children in schools for the physically handicapped in London. At the time of the first survey, 1928, out of a total school enrollment of 639,000 there were 4,061 in schools for the physically handicapped. Thirty years later, in 1957, the figures were 443,000 and 1,325, and the rate per 1,000 of total school enrollment had dropped from 6.36 to 3.00. But special schools are not the only places where handicapped children are educated. A proportion of some, *e.g.*, spina bifida, are confined to bed in a hospital, at school, or at home, and quite a number of severely handicapped children are to be found in ordinary schools, particularly perhaps children of high intelligence whose disability, *e.g.* poliomyelitis, has developed after they have been in the school for some time.

Nevertheless something very dramatic happened during the 30 years under review. The reduction in the number of handicapped children of school age underlines the improvements that have taken place. Nonpulmonary tuberculosis responded to the pasteurization of milk and the reduction in the number of tuberculous cows, and the number of children affected by nonpulmonary tuberculosis in London schools declined by 90% between 1928 when there were 726 and 1957 when there were 73. Over these same years there has been a widespread reduction in the virulence of the hemolytic streptococcus and with this a fall in the number of children who developed cardiac defects after an attack of rheumatic fever, so that, in place of the 1,088 children with rheumatic carditis in the schools in 1928, there were only 72 in 1957. The improvements in hygiene and medical treatment have contributed only to a limited extent to this reduction and it will be necessary to take extreme care to ensure that this fall is not reversed in years to come. Immunization against poliomyelitis was still too new in 1957 to show any effect on the numbers of children crippled by this disease, but since the more general use of vaccines the incidence of paralytic poliomyelitis has greatly declined.

The methods of selection of children for special education are of crucial importance. While all blind children need to go to a school for the blind, severely crippled children may do well in ordinary schools. A number of variants must be considered—the attitude of the child's family, the intelligence and character of the child himself, educational attainments, age, and sex. Ordinary schools too vary both in their physical character and in their attitudes to the problems of the handicapped. The degree of physical handicap is only one of many problems that have to be taken into account in finding a suitable place for a handicapped child.

Among so many variables someone, perhaps the school physician, should be in a position to obtain full information and make a suitable recommendation to the Education Committee, who are the final arbiters.

The intervals between reviews of the decision on special education may vary with each child and his problems, but should not at first be more than 12 months, and the review will take into account the changing physical condition and the response to education and social demands. These reviews should be a fundamental reassessment of the child's needs both from the school and from the community and how these can be met.

Education for handicapped children may be: (1) Individual by a teacher visiting the child in the hospital or in his home. (2) Hospital-school; *i.e.*, a school (with one or more teachers) attached to the hospital and either giving individual bedside teaching or, when possible, teaching in small groups. (3) Special schools for the physically handicapped, day or boarding. The classes are small and the teachers experienced in the problems of handicapped children. Medical services including physiotherapy and speech therapy can be given, so that teachers and therapists can cooperate and the child loses as little schooltime as possible. Day schools are not possible in rural areas. In towns the choice of a boarding school may be the answer to a social as much as to a medical problem. (4) Ordinary school, where the handicapped child is given the special attention of the school physician and what special consideration the school can give him.

The progress from hospital to ordinary school can often be observed as the child's physical condition improves. In the past there have been marked differences between countries in the use of special education; *e.g.*, in the United States children with handicaps were kept in ordinary school, where in Great Britain they would have been considered fit for special education. Following the success of special education for spastic and deaf children more special education is being made available in the United States, while in Great Britain the importance of keeping the handicapped child in as normal a society as possible is becoming more fully appreciated.

In the early years of school much attention is paid to physical methods of treatment in the hope that in the later years the more formal education will be uninterrupted. Around the age of 12 a special review of the child's future is desirable, when education, medical care, employment, and life after leaving school should be considered. The parents of the child must be fully involved and the youth employment officer can give early advice which may modify the type of education and medical treatment. It should be emphasized too that a child can at any time return to an ordinary school if it is to his advantage.

This whole question of assessment is being reexamined. In 1956 a committee set up by the Central Health Services Council recommended the creation of a special centre in each of the 15 hospital areas in Great Britain for the assessment of the needs of the epileptic, and in Baltimore, Md., and in Kansas City, Mo., methods of assessment have been on trial.

The actual education of these children presents fewer problems than those of some other handicapped children. As, with the exception of some of the children with cerebral palsy, they do not have specific sensory defects like the blind and deaf, they have not been deprived of essential sensory stimuli in their early years. On the other hand, limitations on locomotion from infancy may have reduced their field of experience and most have spent long periods in hospitals with resulting backwardness in attainments, even when emotional development is not affected. The teacher's part is to make good these areas of ignorance. Because of the difficulty in getting about, the school lays more than usual emphasis on visits to outside establishments and each child can be helped to develop some individual skill by which he can compensate for his defect.

So many children with cerebral palsy have impaired sensory perception and so many have impaired intelligence that special schools have to be provided for them. On the other hand some, who are not deaf and do not have difficulties of spatial perception, can work alongside other physically handicapped children.

The teacher in a special school like this is always faced with the more than usually severe emotional problems of the children. When the child's position inside the family is regulated he has to come to terms with the community and with the adolescent problems of sexual development.

In Great Britain there have for many years been the "open-air schools," to which children with a number of defects are admitted for a short term. Created in the early years of the 20th century, these were for children with primary tuberculosis as well as for those with debility following other illness, usually specific infectious diseases. While the total demand has declined, children with asthma and chronic bronchitis do well in these schools with their high environmental and nutritional standards.

Diabetic children are usually taught in hospital clinics to regulate their life according to their disability, but they need the help and intelligent cooperation of the family. When this is not available admission to a hostel (student residence) may be a means of saving a life. The child can attend an ordinary school whether from his home or his hostel. (D. Pi.)

Principles.—The quality of education in any of the educational settings depends on the well-trained teacher. Teachers are called upon to integrate professional information from psychology, education, and medicine into making hypotheses for instruction and therapeutic service. Consequently, special education, as adapted to each type of exceptional child, has developed some rather distinctive techniques and materials which distinguish it from regular education. The educator of the physically handicapped should have a college degree with a major in general education and several years of experience in teaching normal children. Most countries require additional specific training.

Teachers so trained are certified by local or state boards of education or other education authorities. They may teach integrated classes of normal and physically handicapped, but also are prepared primarily to teach special classes. Because of the variety of school placements necessary to meet the needs of disabled children in any community, teachers may be placed as home or itinerant teachers, consultants, resource room teachers, or teacher-principals.

The most successful approach to optimum educational programs has been the team approach. In this approach the nurse, the social worker, the school psychologist, speech, occupational, and physical therapists, the psychiatrist, and the teacher work together. They pool their information and skills to determine the best possible plan for each child.

The major principles observed in the education and guidance of the physically handicapped are:

1. Early discovery and proper diagnosis of disabilities.
2. Total appraisal and evaluation of the potentials as well as the disabilities of each individual. This should be periodic and continuous.
3. Adequate and continuous treatment of the disability.
4. Proper placement in a school setting.
5. Adaptive teaching techniques for overcoming the particular disability which the individual has. Such a disability may be physical, mental, sensory, emotional, or a combination of two or more of these, as in the case of the multiply handicapped.
6. Prevocational training and guidance for maximum usefulness to the individual himself and to society.
7. Provision for special services which may be necessary to integrate the handicapped in a normal school setting.
8. Provision for smooth transition from elementary to secondary schools, with emphasis on more extensive high-school facilities.
9. Parent education every step of the way, in order to help parents to accept the handicapped child emotionally, to instruct him in the best possible way, to cooperate with professionals in working toward total rehabilitation, to provide the social and emotional needs of the disabled without sacrificing the needs of other members of the family, and to assist in constructive action in organizational work in the community.
10. Job training as a partial responsibility of the school. Agencies engaged in vocational rehabilitation work closely with teachers of teen-age youngsters to help them embark upon useful careers.
11. Public education. This leads indirectly to employer education and is a part of the total education plan for the physically handicapped.
12. Psychological orientation of the individual to help him to adjust to his handicap. (E. D. Ga.)

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PHYSICAL THERAPY (Physiotherapy or Kinésithérapie), the treatment of bodily ailment by the application of physical agents such as heat and exercise, is a specialized medical service aimed at the rehabilitation of persons disabled by pain or ailments affecting the motor functions of the body. Physical therapy is one means employed to assist these patients to return to a comfortable and productive life, often despite the persistence of a medical problem. For centuries man used such natural physical agents as hot springs and sunlight to treat his ailments, but the development of physical therapy as a specialized medical service took place largely after World War I. Two forces influenced its growth, epidemic poliomyelitis and the world wars, both of which created large numbers of young, seriously handicapped persons. Physical therapy then became available for the treatment of patients with such diverse problems as fractures, burns, tuberculosis, painful backs, strokes, and nerve injuries. Physical therapy is closely associated with orthopedic surgery, but it is also prescribed by physicians and surgeons in all branches of medicine. Physicians who specialize in physical medicine are called physiatrists.

The objectives of physical therapy may be summarized as follows: relief of pain; improvement or maintenance of functions such as strength and mobility; training in the most effective method of performing essential activities; and testing of function in various areas. Tests cover such fields as muscle strength, degree of joint mobility, breathing capacity, and muscular co-ordination.

Types of Treatment.—The methods most commonly employed by the physical therapist include heat, massage, exercise, electrical currents, and functional training.

Heat.—Heat is used generally for its effect in stimulating circulation and relieving pain in the area treated. It may be applied by infrared lamps, short-wave radiation, or diathermy currents; hot moist compresses or immersion in hot water; application of melted paraffin wax; or by ultrasound.

Massage.—This is used primarily to assist circulation and relieve local pain or muscle spasm. It is usually applied by the therapist's hands alone, although swirling water or mechanical devices may be employed. Of the many massage strokes, the most commonly used are stroking and kneading of the tissues. The lubricant applied to the skin usually is a neutral substance such as talcum powder or mineral oil. *See* also MASSAGE.

Exercise.—Exercise, the most varied and widely used of all physical treatments, is usually designed to do one or more of three things: increase the amount of motion in a joint, increase the strength in a muscle, or train a muscle to contract and relax in useful co-ordination with other muscles under the control of the patient. Exercises may be simple or complex, performed actively by the patient or passively with the therapist carrying the part through the motion. Such passive motion may be useful in improving mobility in a joint, but strengthening or training of a muscle can be accomplished only through its active contraction by the patient. Various exercise equipment is used; and treatment may be given with the patient immersed in warm water. While a patient is still confined to bed after illness or injury, exercises may be begun to prevent stiffness or weakness from developing. As he improves, the exercises become more complex and strenuous, until the damaged parts are again capable of meeting the demands of daily activity. In addition to its obvious use following stiffness or paralysis, exercise may be used to improve the breathing of patients with lung disorders, assist circulation, relax overly tense muscles, correct faulty posture, etc.

Electrical Currents.—Currents of very low strength may be applied through the skin to superficial muscles, causing them to contract spontaneously. This may be used to help train weakened muscles and also to test the status of nerves supplying those muscles. Electrical currents are applied to assist the penetration of the skin by certain medicines, and for numerous other purposes.

Functional Training.—This teaches the patient how, in spite of a handicapping ailment, to carry out most safely and effectively the activities of his daily life. This may mean learning to use crutches, a brace, or an artificial arm; or it may involve working out and practising the best way for a mother to do her housework with one hand or for a workman to board the factory bus with a stiff leg. Such training often requires long hours of practice; it may be facilitated by the use of assistive devices which make it easier to fasten buttons, hold a fork or dial a telephone.

Others.—Other treatments such as ultraviolet radiation and cold applications are also often used. Therapeutic use of X-rays is considered a separate specialty and not a physical therapy procedure.

Training of Physical Therapists.—Treatment usually is administered by a therapist rather than by the physician. The qualified therapist, however, can give only that treatment specifically prescribed by the physician. Physical therapists are usually employed in hospitals, but many also work in schools for crippled children, physicians' offices, factory health units, and patients' homes. Training to prepare for this work includes courses in three fields: (1) a broad background in science, particularly anatomy, physiology, and psychology; (2) courses dealing with the processes of disease and healing, such as medicine, orthopedics, pathology, and neurology; and (3) treatment techniques. A period of internship under supervision also is required. Most physical therapy trainees are between the ages of 17 and 30, and the majority are women. In the U.S., training varies from a postgraduate professional certification course of 12 to 18 months to a four-year undergraduate program providing both professional certification and a college degree. Postgraduate students may be basically prepared through obtaining a university degree in sciences or through training as nurse, physical education instructor, etc.

Standards for training and practice vary somewhat from one country to another, but within each country they usually are set and maintained by a national professional organization. In the United States the American Physical Therapy association and in Great Britain the Chartered Society for Physiotherapy have done much to advance the standards of their members. In 1951 the World Confederation for Physical Therapy was inaugurated, and by 1958 the national associations of 15 countries were recognized as members, agreeing on basic standards and working for the advancement of the profession.

Physical therapy services developed most rapidly in those countries which first solved major problems of infectious disease and malnutrition. In the second half of the 20th century, in some areas of the world, it was still nearly nonexistent; it was most widely developed in the Scandinavian countries, Great Britain and the commonwealth, and in the U.S.

See also REHABILITATION, MEDICAL AND VOCATIONAL.

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PHYSICAL UNITS are standards for measurement. A civilization so primitive that it has not yet begun to barter is difficult to imagine. The moment an exchange of goods begins, the questions "How much?" and "How many?" arise; and before either can be answered, physical units of at least the crudest kind must be agreed upon. In the Old Testament (Gen. 23:16) "Abraham weighed out for Ephron the silver which he had named"—the price of Sarah's tomb. Since prehistory the rotating earth has been used to divide the flow of time into such units as days. Natural units of length, such as the foot, have doubtless been in use since people walked upright. Early in human history measurements of mass, time, and length were considered fundamental. Standard objects were preserved in the public buildings of antiquity to stabilize measures of weight, length, and volume employed in trade. Yet among these physical bases for comparison the utmost diversity of size and name existed throughout the world at the beginning of the 19th century.

In the 17th century when members of the great national academies in Europe were exchanging opinions through a voluminous correspondence, the frequent diversity of results could be harmonized only through a comparison of units. All English-speaking nations used the foot, pound, and second for commercial purposes. On the continent of Europe, however, the unit of time was the only common standard. Only in the last decade of the 18th century was any serious action taken to reach international agreement concerning units.

Metric System.—The initiative was taken by the French National Assembly (1791) when it appointed a commission of 12 outstanding men of science to revise the French system of weights and measures. Their revision was so simple, clear, and natural that it later won acceptance by many other nations. Their chief concern was with the units of length and mass; the fundamental unit of time had been provided by astronomers who were using 1/86,400 of a mean solar day as the second of time (*see* TIME MEASUREMENT).

Geodesists working for the commission took eight years for an accurate determination of the earth's arc from Dunkerque to

Barcelona. On Dec. 10, 1799, the French Legislative Assembly voted to define their standard of length—to be called the metre—as the 10^{-7} part of the earth's quadrant. On the same day the mass of a cubic decimetre of water, at its maximum density, was voted the standard of mass and was named the kilogram.

It might have been expected that this metric system would obtain ready adoption in Western Europe and the Americas. France made the use of these units compulsory beginning in 1801; but the conservatism of merchants who sold cloth by the aune (ell), and of farmers who sold meat and vegetables by the livre was too strong. In 1837 a more stringent law was passed penalizing those who used any units except the metre and the kilogram after Jan. 1, 1840.

Up to 1840 Greece and the Netherlands were the only other nations to adopt the metric system. England authorized its use in 1864, the U.S. in 1866, and Germany in 1868. Since then the metric system has been legalized by all leading countries. In Europe and South America its use is almost exclusive. (*See* also WEIGHTS AND MEASURES; METROLOGY.)

International Bureau of Weights and Measures.—In 1875 each of 20 nations sent two delegates to a *conférence diplomatique du mètre* at Paris. A proposal to establish an international standardizing bureau had been discussed by an international convention (1872) that had practically created such a bureau, had outlined its duties as the custody and comparison of standards, and had even made financial provision for the work. These plans were later ratified by the governments concerned, so that the International Bureau of Weights and Measures was by 1875 a *fait accompli*. In the 1960s it continued, in its pavilion near Sèvres, a safe depository for the international standards and a laboratory for certification of copies and solving related problems.

Introduction of Arbitrary Standards.—As early as 1867 metrologists had begun to suspect that the original standard metre, a metal bar known as the *mètre des archives*, might not be very permanent since it was an end measure (its full length defined the metre) and therefore subject to slight abrasion in use. The preparation of a new bar upon which the metre could be duplicated in line measure (between marks on the bar) thus became one of the first problems.

By autumn 1889 a new platinum-iridium bar for the metre and a platinum-iridium cylinder for the kilogram were deposited in the underground vault at the International Bureau. The definitions of these units were changed from natural to purely arbitrary quantities. Without any reference to a quadrant of the earth's meridian, the polished bar with fine rulings marking the standard of length was, at the temperature of melting ice, to "henceforth represent the metric unit of length." Without any reference to a cubic decimetre of water, the new kilogram was to be the prototype unit of mass. The fact that standards of length and weight can be copied with much greater accuracy than they can be determined afresh from some natural unit decided the question in favour of the arbitrary standard.

The kilogram was first taken as the mass of a cubic decimetre of water at its temperature of maximum density, which also defined the unit of density. The litre was defined as the volume of a cubic decimetre, identical with the volume of a kilogram of water (*see* WATER: *Water as a Standard*).

During the first half of the 19th century, however, a distinct difference was detected between 1,000 cc. and the volume of a kilogram of water. Accordingly, in 1901, the following definition was formulated:

> The unit of volume, for determinations of higher precision, is the volume occupied by the mass of one kilogram of pure water at its maximum density and under normal atmospheric pressure; this volume is called the *litre*.

The relation between the litre and the cubic decimetre became a matter of experimental determination. In the 1960s the accepted value was 1 litre = 1,000.028 ± 0.002 cm^3. The practice recommended by the U.S. Bureau of Standards and the National Physical Laboratory in Great Britain is to graduate standard volumetric glassware in millilitres—marked ml. instead of cc. For volume derived from geometrical dimensions, the appropriate unit is cm^3.

Electrical Standards.—Electricity and magnetism are detected mainly by mechanical effects. Industrial units of power, work, and energy had been introduced haphazardly, and early in the 19th century electrical measurements were superposed. Order was introduced into this chaos by men who had the vision to see that magnetic and electrical effects must be measured in terms of mechanical quantities.

C. F. Gauss, in his great paper "On the Intensity of the Earth's Magnetic Field, Expressed in Absolute Measure" (1833), described two simple experiments that measured the strength of the earth's magnetic field H in terms of length, mass, and time, much as the pendulum is used to measure the gravitational field (*see* GEOMAGNETISM).

The determination in absolute measure (fundamental units) of the electromotive force (emf) that produces electric currents was accomplished by F. E. Neumann in 1845. He formulated the expression $E = -dN/dt$, where E is the emf generated in a closed circuit through which the number of magnetic lines of force is changing at the rate of dN/dt. Electromotive force was thus reduced to mechanical measure.

In 1851 W. E. Weber used Neumann's idea and C. S. M. Pouillet's tangent galvanometer to measure an induced current in absolute units. Having thus measured both emf and current for the same circuit, he was able, by use of Ohm's law, to compute the electrical resistance of the circuit in absolute measure (*see* INSTRUMENTS, ELECTRICAL MEASURING).

As early as 1851, H. L. F. von Helmholtz and Lord Kelvin had introduced the idea of electrical work and had explained the meaning of the equation: work = power × time = $Eit = i^2Rt$, the link between electrical and mechanical quantities. Coefficients of self- and mutual-induction had also been defined, and in certain cases had been computed from mechanical dimensions. Yet great confusion existed because observers had employed different units. All was arbitrary; nothing was coherent save the underlying principles of physics. Computation was tedious because of wasteful conversion from one unit to the other.

Resistance.—The British Association for the Advancement of Science in 1861 appointed a committee on electrical standards of resistance. By 1869 this committee had established the essential theory of units (*i.e.*, the principles that must control any consistent and useful system), had endorsed the metre-gram-second (mgs) system, and had prepared a wire standard (the B.A. unit) as nearly as then possible equal to 10^7 mgs units of resistance.

A second committee appointed in 1872 recommended a change to the centimetre-gram-second (cgs) system and adoption of the ohm, a unit of resistance equal (as nearly as realizable) to 10^9 cgs absolute units. Both recommendations were adopted by the first International Congress of Electricians in Paris (1881).

Electromotive Force.—Since its invention (1800) the voltaic cell has been used as the unit of emf (*see* BATTERY). First came the Daniell cell; then the Bunsen; later the Clark; in the 1960s the mercury-cadmium cell (1892) of Edward Weston continued to be employed. Compared with any one of these cells, the cgs unit of emf defined by Neumann's formula is almost infinitesimal. Accordingly a practical unit of 10^8 cgs units, the volt, was approved by the British Association and by the International Congress of Electricians in 1881.

Absolute Practical System.—The word absolute signifies that the unit (*e.g.*, volt, ohm) is defined in terms of the cgs mechanical unit by a numerically simple relationship; the word practical signifies that the magnitude of the unit, except for the unit of capacitance, is convenient to use in practical engineering. Besides the ohm and volt, three other practical units were established at the 1881 congress by the following resolutions:

> That the current produced by a *volt* in the *ohm* be called an *ampere*.
>
> That the quantity of electricity produced by a current of 1 *ampere* in 1 *second* be called a *coulomb*.
>
> That the unit of capacity be called a *farad*, which is defined by the condition that a *coulomb* in a *farad* raises the potential 1 *volt*.

The second International Congress of Electricians (Paris, 1889) defined three more practical units as follows:

> The *joule*, the practical unit of energy, is equal to 10^7 cgs units. It is

equal to the energy disengaged as heat in 1 *second* by a current of 1 *ampere* flowing through a resistance of 1 *ohm*.

The practical unit of power is the *watt*. The *watt* is equal to 10^7 cgs units and is the power of 1 *joule* per *second*.

The practical unit of self-inductance is the *quadrant* which is equal to 10^9 cgs units.

At the fourth congress (Chicago, 1893) the unit of inductance was changed from the quadrant to the henry, and the international system of units was set up.

International System.—The need for a system to be used in electrical measurements led to a group of international units corresponding as closely as possible to the absolute practical system. At the Chicago congress the international ohm was defined as "the resistance of a column of mercury of uniform cross-section, having a length of 106.300 cm. and a mass of 14.4521 g. when the temperature is 0° C." This represented the best experimental result of that time (1893) in realizing a resistance of 10^9 cgs units or 1 absolute practical ohm. It was larger than the B.A. ohm in the ratio of 1 to 0.9866. The congress defined the international ampere as that "unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications, deposits silver at the rate of 0.001118 grams per second." This was made as close as possible to the absolute practical ampere which is 0.1 cgs unit of current. The international volt was so defined that a Clark cell at 15° C had an emf of 1.434 international volts. This was as close as possible to 10^8 cgs units of potential difference; *i.e.*, an absolute practical volt.

The need for standardizing laboratories led to the establishment of the German Physikalisch-Technische Reichsanstalt (1887), the English National Physical Laboratory (1899), and the U.S. National Bureau of Standards (1901). From their work it became apparent that the recommendations at the Chicago congress were not consistent with the definition that the international volt is "the electromotive force that, steadily applied to a conductor whose resistance is 1 international ohm, will produce a current of 1 international ampere." This was corrected at the London International Conference (1908) by keeping the international ohm and ampere as primary units and letting the international volt be a derived unit.

MKS or Giorgi System.—The International Committee on Weights and Measures announced that after Jan. 1, 1948, the international units should become obsolete and that the absolute practical units were to be measured in terms of mechanical units. The recommendations included the use of the metre, kilogram, and second as fundamental units in place of the centimetre, gram, and second. Thus the powers of 10 used with the cgs electromagnetic units could be eliminated, as first pointed out by G. Giorgi of Rome, Italy (1901).

At the sixth International Congress (St. Louis, Mo., 1904) Giorgi showed that with the metre, kilogram, second, and ohm as fundamental and arbitrary units the system of absolute practical units would remain unchanged. The mks (metre-kilogram-second) units form a complete and logical system for the mechanical units. To include the electrical practical units Giorgi used the ohm, though any one of several practical units (*e.g.*, ampere, ohm, volt, henry, farad, coulomb, and weber) could serve as the fourth unit since they are interrelated by electromagnetic theory. The International Committee on Weights and Measures adopted the following definitions of mechanical and electrical units in the mks system (effective Jan. 1, 1948), selecting the ampere as the fourth unit:

I. *The Newton* (*unit of force*).—The newton is the force which gives to a mass of 1 kilogram an acceleration of 1 meter per second per second.

II. *The Joule* (*unit of energy or work*).—The joule is the work done when the point of application of the newton is displaced a distance of 1 meter in the direction of the force.

III. *The Watt* (*unit of power*).—The watt is the power which gives rise to the production of energy at the rate of 1 joule per second.

IV. *The Ampere* (*unit of electric current*).—The ampere is the constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular sections, and placed 1 meter apart in a vacuum, will produce between these conductors a force equal to 2×10^{-7} newtons per meter of length.

V. *The Volt* (*unit of potential difference and electromotive force*).—The volt is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

VI. *The Ohm* (*unit of electric resistance*).—The ohm is the electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the seat of any electromotive force.

VII. *The Coulomb* (*unit of quantity of electricity*).—The coulomb is the quantity of electricity transported in 1 second by a current of 1 ampere.

VIII. *The Farad* (*unit of electric capacitance*).—The farad is the capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

IX. *The Henry* (*unit of electric inductance*).—The henry is the inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

X. *The Weber* (*unit of magnetic flux*).—The weber is the magnetic flux which, linking a circuit of 1 turn, produces in it an electromotive force of 1 volt as it is reduced to 0 at a uniform rate in 1 second.

These definitions are intended to fix unit magnitude and do not necessarily specify methods for practical determination. For example, the definition of the ampere is only one case of the general formula expressing the forces between current-carrying conductors and was chosen for its verbal simplicity.

A question arising with every electrical system of units is whether the rationalized or the unrationalized form should be used. This question is concerned with the factor 2π or 4π in equations relating electrical quantities. In the rationalized system the factor 2π or 4π appears in the equations for those situations in which there is circular or spherical symmetry. In the unrationalized system the π factor does not appear in the equations for circular or spherical symmetry but does appear where there is no symmetry. It is not possible to get rid of π in one place without its appearing in another. About 1890 O. Heaviside wrote: "the unnatural suppression of 4π in the formulas of central force, where it has a right to be, drives it into the blood, there to multiply itself, and afterward break out all over the body of electromagnetic theory."

A group of units called the Heaviside-Lorentz system formed such a rationalized system, but it was used only in some theoretical treatises. It did not come into general use because its units differ from those of the absolute practical system. In 1950 the International Electrotechnical Commission voted the approval of the rationalized mksa (a for ampere) system. This action did not affect the absolute practical standards such as ampere, volt, and ohm, but it did affect the values of the permeability and permittivity of free space.

In the rationalized system the force f per metre length between two infinite parallel wires d metres apart in a vacuum and carrying currents of I_1, I_2 amperes is given by

$$f\left(\frac{\text{newton}}{\text{metre}}\right) = \frac{\mu_0 I_1 I_2}{2\pi d}$$

where μ_0, the permeability of free space in the rationalized system, has a value of $4\pi \times 10^{-7}$ newtons/ampere^2. If I_1 and I_2 are each 1 ampere and d is 1 metre, then the force per metre length is 2×10^{-7} newtons/metre as given in the mks definition for the ampere.

In the unrationalized system μ'_0, the permeability of free space is 10^{-7} newtons/ampere^2 and the force f per unit length is given

$$f\left(\frac{\text{newton}}{\text{metre}}\right) = \frac{2\mu'_0 I_1 I_2}{d}$$

This result agrees with the mks definition for the ampere. However there is circular symmetry in this problem and one might expect π in the equation, as in the rationalized system.

A similar situation exists in electrostatics for the permittivity ϵ_0 of free space. The capacitance C (farads) of an electric capacitor with plates of area A metre^2 separated by a uniform distance of d metres in a vacuum is given in the rationalized system as

$$C = \frac{\epsilon_0 A}{d}$$

In the rationalized system ϵ_0 is about 8.854×10^{-12} farads per metre. For the unrationalized system the permittivity ϵ'_0 of free space is about 1.113×10^{-10} ($4\pi \times 8.854 \times 10^{-12}$) farads per metre and the capacitance C of this condenser is given by

$$C = \frac{\epsilon'_0 A}{4\pi d}$$

In this case there is no circular or spherical symmetry and the π factor does not appear in the equation written in the rationalized system. These two constants, the permeability and permittivity of free space, are related by J. C. Maxwell's electromagnetic theory to the velocity of light c in free space by

$$\mu_0\epsilon_0 = \mu'_0\epsilon'_0 = 1/c^2$$

The value of c is about 3×10^8 metres per second.

The introduction of the mksa rationalized system greatly simplified electromagnetic calculations. Previously there had been at least eight different systems of electrical units in fairly common use.

Dimensions of Units.—An expression containing the fundamental units which enter into the measure of any physical quantity, together with the powers to which they enter, is known as the dimensions of that quantity. Thus, if L is length, M is mass, and T is time, the dimensions of velocity are LT^{-1}; those of acceleration LT^{-2}; those of force MLT^{-2}. In any equation between physical quantities, each term, in both right-hand and left-hand members, must have the same dimensions. (For fuller discussion, *see* DIMENSIONAL ANALYSIS.)

A List of Physical Units and Constants.—The following is a short list of important miscellaneous units and constants.

The Metre.—In 1892 A. A. Michelson measured the standard metre in terms of the red light from cadmium and found that there were 1,553,164.13 of these red cadmium wavelengths in 1 standard metre. The International Solar Union adopted this measurement in 1907. It was suggested (1957) that greater accuracy for the standard metre could be obtained by using the wavelength of the orange light emitted by krypton of mass number 86. This new standard metre would be 1,650,763.73 times the chosen wavelength.

Astronomical Units of Distance.—The astronomical unit is the distance from the earth to the sun (149,501,201 km.).

The light-year is the distance light travels in 1 year (9.4614×10^{12} km. or approximately 6×10^{12} mi.).

The parsec is the distance at which the annual parallax (*q.v.*) is 1 second of arc.

Unit Quantities of Heat.—The gram-calorie is the quantity of heat (*q.v.*) required to raise the temperature of 1 gram of water from 15° to 16° C. The kilogram-calorie or the large calorie is 1,000 gram-calories. The British thermal unit, BTU, is the quantity of heat needed to raise the temperature of 1 pound of water through 1° F (*see* CALORIE; CALORIMETRY).

Units of Light Intensity and Light Flux.—The unit of intensity of light is the candle, which is $\frac{1}{60}$ of the intensity of 1 square centimetre of a perfect radiator, known as a black body, when operated at the temperature of freezing platinum.

The unit of light flux is the lumen, which is the flux in a unit of solid angle from a source of which the intensity is 1 candle. The total radiation from 1 candle is, therefore, 4π lumens (*see* PHOTOMETRY).

The Curie and Rutherford Units.—Originally the curie was the amount of radon in equilibrium with 1 gram of radium (*q.v.*). As radioactivity became more important the curie was used as a unit of disintegration rate and as such was not too satisfactory since it is difficult to measure accurately. Accordingly, the International Radium Standard Commission recommended that the curie be defined as 3.7×10^{10} radioactive disintegrations per second. The rutherford, a more convenient unit for the rate of disintegration of a radioactive substance, was recommended by the U.S. National Bureau of Standards. One rutherford is the amount of radioactive substance that undergoes 10^6 disintegrations per second.

The Roentgen.—For personnel protection a unit of X or gamma radiation called the roentgen (r) is used (*see* X-RAYS). By definition 1 roentgen unit is "that quantity of X or gamma radiation such that the associated corpuscular emission per 0.001293 g. of air produces, in air, ions carrying 1 esu (about $\frac{1}{3} \times 10^{-9}$ coulombs) of quantity of electricity of either sign."

Angstrom and X Units.—The angstrom Å is 10^{-8} cm. and the X unit, used in X-ray work, is 10^{-11} cm. or 10^{-3} Å.

Least Squares Adjusted Values.—Until about 1929 physical constants were usually measured individually; but their manifold interrelationships coupled with a marked increase in such measurements have increasingly required groups of constants to be evaluated simultaneously. The largest and most important group of this sort, the atomic constants, was extended until few constants were excluded. G, the gravitational constant, was in the 1960s one of the few with no known relationship to any of the atomic constants.

In such an evaluation a group of fundamental constants is selected as the set of primary unknowns to be determined. If q is the number of these unknowns, the input material then consists of N equations relating the unknowns to measured values. These values are the results of carefully selected high-precision experiments, each of which can be weighted according to its estimated reliability. The number N must at least equal q to permit any solution at all, but it is desirable that N exceed q as much as possible. The N equations in q unknowns constitute an overdetermined set that will never be completely compatible because of errors of measurement; the method of least squares is thus used to find a set of "best" values for the unknowns (*see* LEAST SQUARES, METHOD OF).

In 1952 calculations the values of q and N were 5 and 13 respectively. In 1955 these data were checked for systematic errors by variance analysis with an electronic digital computer. The speed of light was treated as a fixed constant of known value and there remained 11 linear equations in 4 unknowns subject to least squares adjustment.

At that time the chemists' mass unit was defined as $\frac{1}{16}$ the atomic weight (*q.v.*) of oxygen. But oxygen is a mixture of three isotopes (mass numbers 16, 17, 18); O^{16} has an abundance of more than 99% and the physicists' mass unit was based on this isotope (*q.v.*). Different oxygen compounds yield slightly different abundance ratios of the 3 isotopes, and the chemical mass unit depended on the type of oxygen compound used. To rectify differences between the chemical and physical scales a new unit of mass based on carbon-12 was adopted in the 1960s by the official organizations in chemistry and physics. Carbon-12 is a convenient choice because it commonly is used as a standard in mass spectroscopy (*q.v.*). Thus the ratio of the masses of nuclei to the carbon-12 nucleus is more accurately known than the ratio of carbon-12 to oxygen-16.

The following values recommended by the Committee on Fundamental Constants of the U.S. National Academy of Sciences–National Research Council were presented to the second International Conference on Nuclidic Masses (Vienna, Aus., July 1963). They were adopted by the International Union of Pure and Applied Physics (Warsaw, Pol., September 1963).

Defined Values and Equivalents

Metre	m	1,650,763.73 wavelengths in vacuo of the unperturbed transition $2p_{10} - 5d_5$ in Kr^{86}
Kilogram	kg	mass of the international kilogram at Sèvres, France
Second	sec	1/31,556,925.9747 of the tropical year at 12^h ET, 0 January 1900
Degree Kelvin	°K	defined in the thermodynamic scale by assigning 273.16° K to the triple point of water (freezing point, 273.15° K = 0° C)
Unified atomic mass unit	u	$\frac{1}{12}$ the mass of an atom of the C^{12} nuclide
Mole	mol	amount of substance containing same number of atoms as 12 g of pure C^{12}
Standard acceleration of free fall	g	980.665 cm/sec/sec
Normal atmospheric pressure	atm	1,013,250 dyne/cm²

Thermochemical calorie	cal_{th}	4.1840×10^7 erg
International Steam Table calorie	cal_{IT}	4.1868×10^7 erg
Litre	l	1,000.028 cm^3
Inch	in	2.54 cm
Pound (avoir.)	lb	453.59237 g

Energy Conversion Factors
(Plus or minus error is standard deviation applied to the last digit)

Electron-volt	eV	$1.60210 \pm 2 \times 10^{-12}$ erg
Energy associated with:		
Unified atomic mass unit	c^2/Ne	$9.31478 \pm 5 \times 10^8$ eV/u
Proton mass	m_pc^2/e	$9.38256 \pm 5 \times 10^8$ eV/m_p
Neutron mass	m_nc^2/e	$9.39550 \pm 5 \times 10^8$ eV/m_n
Electron mass	m_ec^2/e	$5.11006 \pm 2 \times 10^5$ eV/m_e
Cycle	e/h	$2.41804 \pm 2 \times 10^{14}$/sec/eV
Wavelength	ch/e	$1.23981 \pm 1 \times 10^{-4}$ eV/cm
Wave number	e/ch	$8.06573 \pm 8 \times 10^3$/cm/eV
°K	e/k	$1.16049 \pm 5 \times 10^4$ °K/eV

Adjusted Values of Constants (partial list)

Speed of light in vacuum	c	$2.997925 \pm 1 \times 10^{10}$ cm/sec
Elementary charge	e	$1.60210 \pm 2 \times 10^{-19}$ C (coulomb)
Avogadro's constant	N_A	$6.02252 \pm 9 \times 10^{23}$/mol
Electron rest mass	m_e	$9.1091 \pm 1 \times 10^{-28}$ g
Proton rest mass	m_p	$1.67252 \pm 3 \times 10^{-24}$ g 1.00727663 ± 8 u
Neutron rest mass	m_n	$1.67482 \pm 3 \times 10^{-24}$ g
Faraday constant	F	$9.64870 \pm 5 \times 10^4$ C/mol
Planck's constant	h	$6.6256 \pm 2 \times 10^{-27}$ erg sec
Charge to mass ratio for electron	e/m_e	$1.758796 \pm 6 \times 10^{11}$ C/kg
Quantum-charge ratio	h/e	$4.13556 \pm 4 \times 10^{-15}$ joule sec/C
Rydberg's constant	R_∞	$1.0973731 \pm 1 \times 10^5$/cm
Bohr magneton	μ_B	$9.2732 \pm 2 \times 10^{-21}$ erg/gauss
Nuclear magneton	μ_N	$5.0505 \pm 1 \times 10^{-24}$ erg/gauss
Gas constant	R	$8.3143 \pm 4 \times 10^7$ erg/°K/mol
Normal volume perfect gas	V_0	$2.24136 \pm 10 \times 10^4$ cm^3/mol
Boltzmann's constant	k	$1.38054 \pm 6 \times 10^{-16}$ erg/°K
Stefan-Boltzmann constant	σ	$5.6697 \pm 10 \times 10^{-5}$ erg/cm^2/sec/$°K^4$
Gravitational constant	G	$6.670 \pm 5 \times 10^{-8}$ dyne cm^2/g^2

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(H. Cw.; J. W. M. D.; E. R. Cn.; R. J. Sn.)

PHYSICS (ARTICLES ON). In their concern with the nature and interrelations of matter and energy physicists have collaborated with philosophers, mathematicians and scientists from other disciplines. A general view of the scope of physics in the 1960s and its place among the sciences is presented in SCIENCE; PHYSICS: GENERAL SURVEY.

To study phenomena systematically and efficiently it has been necessary to devise ways of measuring them in terms of standard units. An understanding of the contributions of physics requires some familiarity with the language of measurement as discussed in DIMENSIONAL ANALYSIS; WEIGHTS AND MEASURES; METROLOGY; PHYSICAL UNITS; GRADUATION AND CALIBRATION.

Ever-developing theoretical systems guide physicists in their efforts to predict and control the behaviour of the physical universe. The significance of some of these broad unifying concepts is discussed under GRAVITATION; COSMOLOGY; RELATIVITY; SPACE-TIME; UNCERTAINTY PRINCIPLE; PARITY, LAW OF CONSERVATION OF. The history of one aspect of the problem of relativity is given under ETHER (IN PHYSICS). Accounts of experiments and observations that prepared the way for relativity concepts are found in MICHELSON-MORLEY EXPERIMENT and LIGHT, VELOCITY OF.

Important aspects of the physical nature of matter are expounded under KINETIC THEORY OF MATTER, which deals mainly with gases. Supplementary to this article is BROWNIAN MOVEMENT. Properties of ionized gases (plasmas), which were drawing increasing interest in the 1960s, are discussed in MAGNETOHYDRODYNAMICS. The transition from gas to liquid is handled from the general theoretical point of view in the article LIQUID STATE, and modern views of solids come under SOLID STATE PHYSICS. For the arrangement of atoms and molecules in crystalline solids the article CRYSTALLOGRAPHY should be consulted. Crystals have a regular ordered structure; in many ways the antithesis of the crystalline state is the COLLOID. Important properties of matter are considered in SURFACE TENSION; VISCOSITY; DIFFUSION; VACUUM; ELASTICITY; FRICTION; RELAXATION PHENOMENA.

The peculiar task of physics in the 20th century has been to effect a synthesis of the properties of matter and radiation in terms of units of electric charge, of matter and of radiation. The field of radiation is covered in ELECTROMAGNETIC WAVES, which deals broadly with the various kinds of waves in the electromagnetic spectrum. The unit of electricity is the ELECTRON, to which an article is devoted. A connecting link between matter and radiation is furnished by the nuclear theory of the atom, which asserts that an atom consists of a positively charged nucleus, surrounded by groupings of electrons in motion. The general nuclear theory is explained under ATOM; the properties of the nucleus, and their profound consequences for physics and chemistry under PERIODIC LAW; COSMIC RAYS; ATOMIC WEIGHT; PROTON; NUCLEUS; NEUTRON; MASS SPECTROSCOPY; ISOTOPE; NUCLEAR MOMENTS.

RADIOACTIVITY is an article of first importance for understanding modern physics. The theory of emission of light and X-rays is discussed in QUANTUM MECHANICS. COMPTON EFFECT; MOLECULAR SPECTRA; PHOTOELECTRICITY; RAMAN EFFECT; SPECTROSCOPY; THERMIONICS; X-RAYS; and SPECTROSCOPY, X-RAY deal with the experimental and theoretical side of radiation phenomena which have a prominent place in atomic physics, while NUCLEAR INSTRUMENTS; CLOUD CHAMBERS; BUBBLE CHAMBER; and ACCELERATORS, PARTICLE describe experimental methods that have had far-reaching results. *See* also ATOMIC ENERGY; PARTICLES, ELEMENTARY; VAN ALLEN RADIATION BELTS; ATOMIC AND MOLECULAR BEAMS.

The general body of physics is considered under comprehensive articles devoted to the main conventional divisions—ELECTRICITY; ENERGY; HEAT; LIGHT; MAGNETISM; MECHANICS; SOUND; with important supplementary articles, among which may be mentioned: under mechanics, BALLISTICS; DYNAMICS; STATICS; WAVE MOTION; HARMONIC ANALYSIS; MOTION, PRINCIPLES AND LAWS OF; FORCE; under heat, THERMOMETRY; CALORIMETRY; LOW-TEMPERATURE PHYSICS; THERMODYNAMICS; STATISTICAL MECHANICS; VAPORIZATION; under light, COLOUR; LUMINESCENCE; OPTICS; LENS; PHOTOMETRY; ZEEMAN EFFECT; SKY; SHADOW; under electricity, ELECTRICITY, CONDUCTION OF; ELECTRICITY, ATMOSPHERIC; PIEZOELECTRICITY; FIELD EMISSION; ENERGY CONVERSION, DIRECT; under sound, ACOUSTICS OF BUILDINGS; ULTRASONICS; NOISE AND ITS CONTROL.

Important instruments and their uses are described under: BALANCE; BAROMETER; BINOCULAR INSTRUMENT; CHRONOGRAPH; COMPASS; CONDENSER; GYROSCOPE; HYDROMETER; INDUCTION

Coil; Instruments, Electrical Measuring; Interferometer; Magnetometer; Microscope; Mirror; Refractometer; Selenium Cell; Stroboscope.

Applied physics is another aspect of the subject which receives representation. The meteorological side is represented by Meteorology; the geophysical by Geodesy; Geomagnetism; Geophysics; International Geophysical Year; and the astronomical by Astrophysics. The bearing of physics in everyday life and industry is described in Aerodynamics; Camera Lucida and Camera Obscura; Electromagnet; Phonograph; Photography; Photogrammetry; Photography, Spark; Radar; Radio; Telegraph; Telephone; Television.

(E. N. da C. A.; H. B. Lm.; X.)

PHYSICS: GENERAL SURVEY. Physics, which may be defined broadly as the study of nature, was long called natural philosophy (from the Greek *physikos*); its exact scope is not fixed nor easily delimited. From decade to decade in modern times, the principal effort in physics has changed as, on the one hand, fields of scientific knowledge were reduced to practice, whereupon they were regarded as branches of engineering or applied physics; and, on the other hand, new fields were opened by fresh experimental or theoretical discoveries. Physics may be called a point of view about the natural world and a method of attack on its problems, a method based upon certain general principles and disciplined by the close interplay between experiment and theory. With a kind of confidence that the understanding of nature may be reduced to a few comprehensive principles, physicists seek for those central ideas by which great areas of common experience may be brought into order and coherence. To achieve their purpose, they proceed by use of mathematical and logical tools, and by experimentation.

Physics comprises especially the study of the structure of matter, the nature of radiation and its interactions with matter, and an attempt at a unified description of fields of force. It has been guided for the past century or more by three powerful conservation principles which appear to be valid in new areas of investigation and which in turn acquire increased stature as they meet the test in new experimental situations. The principle of conservation of linear and angular momentum, first applied to mechanics by the Englishman Sir Isaac Newton (1642–1727), but later generalized to include the electrodynamic field, was the earliest of these. A principle of conservation of energy in mechanics was extended to other forms of energy, especially to heat, about the middle of the 19th century. The third principle is the conservation of electric charge, often an important guide, with the other two conservation principles, in the field of nuclear physics (*see* Energy).

To these three established and tested principles may be added three more recently announced principles, those of the conservation of parity, of baryons and of strangeness, which were undergoing tests in the 1960s in the study of nuclear particles. Exceptions to the conservation of parity were particularly notable and led to fuller recognition of the experimental basis for all conservation principles.

Since the enunciation of the mass-energy relation, $E = mc^2$, by Albert Einstein in 1905, the chemist's principle of the conservation of mass has been merged with the principle of conservation of energy into the more comprehensive principle of conservation of mass-energy. It appears that mass and energy have complementary properties: all transfers of energy from one body or system of bodies to another are accompanied by a corresponding transfer of mass rather than by annihilation of mass. All energy appears to exhibit inertia. In the equations of nuclear reactions, a term representing mass or energy changes is important, corresponding to the energy term in a complete chemical equation.

Insofar as the several conservation principles apply and are helpful in other sciences, physics may contribute to them and promote their development; it has often happened that instruments designed for research in physics have found wide application elsewhere. The cathode-ray tube, for example, was not invented to forward the art of television; rather, it was designed in prototype for the study of electrons.

This article will deal more with basic ideas than with applications of physics. Because of the rapid growth of all science, it has been convenient to set up somewhat arbitrary and often indefinite boundaries between the various fields. In particular, physics was once regarded as dealing with inanimate objects; it has been said, somewhat jocularly, that if there was any life in a subject, it could not be physics. Biology deals with the great area of life sciences, but a growing field of biophysics suggests the temporary nature of such a boundary.

Astronomy underwent radical changes after 1850 as it became to an increasing extent astrophysics. To the telescope, spectroscope, spectroheliograph and kindred instruments was added the radiotelescope; there has been a busy two-way traffic of ideas between atomic and nuclear physics and astronomy. Geology has become in part geophysics. Meteorology is largely a study of the physics of the air. At no time has it ever been possible to draw a sharp line between chemistry and physics, as each has contributed continuously to the other. Few ideas are important in one field that do not have wide applicability in the other. This relationship is obviously apparent in the rapid development of such fields as radioactivity, nuclear energy and isotopes, in which progress has been shared repeatedly by those who called themselves either physicists or chemists.

For convenience, the field of physics is often broken into several related subfields, all of which are viewed through the same general conservation principles, although each field may have in addition its own distinctive ideas and generalizations. These fields are (somewhat in historical order of development) mechanics, heat, sound, light, magnetism, electricity (*qq.v.*) and those of atomic and nuclear structure (*see* Atom; Nucleus). In addition there have developed certain broad mathematical theories by which fields of knowledge are for the time systematized. (See *Theory* below.) A partial list of these subfields, starting with *Philosophiae Naturalis Principia Mathematica,* Newton's great 1686–87 treatise on mathematical principles of natural philosophy, includes kinetic theory, electrodynamics (*see* Electromagnetic Waves), thermodynamics, statistical mechanics and quantum mechanics, and relativity (*qq.v.*). In this article, only brief mention will be made of some of these fields; but the reader may also consult Physics (Articles on) for the titles of the separate articles dealing with the various subfields. This article treats, in succession, the history of physics, the solar system, the electrical nature of matter, radiation, atomic and nuclear structure, solid state physics, theory and instrumentation.

History.—Throughout the centuries men gained a certain practical working knowledge of nature but it was seldom systematized or elevated to the level of general principles. Early philosophical ideas about nature were often void of adequate basis in observation and many were barren of consequences. For example, the Greeks Democritus and Leucippus (both 5th century B.C.) are referred to as early atomists, but it is not evident that their ideas bore fruit. The development of a productive atomic theory had to await the experimental researches of the 19th century. For 24 centuries, little came from Thales' early reports of static electricity and magnetism. The fact that, before 400 B.C., Philolaus reduced the earth to the status of a planet seems to have had little influence on men's thinking for the next 1,800 years. Archimedes (*c.* 287–212 B.C.) was one of the more successful mathematicians and experimentalists, and his law of the lever and principle of buoyancy laid the foundation of a science of mechanics. Throughout the first 15 centuries of the Christian era, little concerted effort was expended on understanding nature, although it would be uncharitable to discount the value of the accumulated ideas, mathematical and astronomical, which were available when the renaissance of learning occurred.

The birth of physics may be said to have resulted from a new attitude typified by precise, quantitative observation and controlled experimentation, coupled with mathematical reasoning. With control of experiments and success of logical predictions derived from them, there came a sense of man's growing power to bend nature to his needs. The physical world was increasingly regarded as understandable and predictable, rather than capricious. Two of the larger developments will be sketched briefly as exam-

ples of how physics proceeds not at a uniform rate unerring in direction but by large and small steps and by the interplay of observation and theory. The first of these, in the very large, concerns the solution of the solar system; the second, in the very small, the growth and consequences of the electrical nature of matter.

The history of physics in the 20th century is well sampled in the progressive work of about 80 scientists who have been awarded Nobel prizes (*q.v.*) since the first award to W. C. Röntgen in 1901 for his discovery of X-rays. Changing patterns of interest, new discoveries in both theory and experiment, and new devices have all been recognized.

Solar System.—Despite a few early claims for the earth's sphericity and its planetary status, a geocentric view of the solar system prevailed for many centuries. Copernicus demonstrated in 1543 that a great simplification in the observed motions of the planets could be made by assuming the earth also to be a planet revolving around the sun. His hypothesis reopened the question of the earth's position in the universe, but it remained only hypothesis for more than a hundred years before other significant steps were taken. The Danish astronomer Tycho Brahe (1546–1601) contributed a vast quantity of precise observational material on the positions of the planets. His disciple, the German astronomer Johannes Kepler (1571–1630) reduced these data to order and extracted from them three empirical laws of planetary motion. These conclusions were that the planets (1) move in ellipses about the sun, with the sun at one focus; (2) sweep out, by their radius vectors, equal areas in equal times; (3) have periods of revolution about the sun such that the squares of these periods are proportional to the cubes of the respective major axes of their elliptical orbits. Kepler could not guess the full meaning of his findings because of the prevailing lack of knowledge of mechanics and of any comprehensive system of understanding.

In Italy Galileo (1564–1642) contributed two important advances: first, by the invention of a telescope which revealed the moons of Jupiter like a miniature Copernican system and showed the phases of the planet Venus as it moved about the sun; second, by laying a firmer foundation in mechanics as a forerunner of the more complete work of Newton. Newton grasped the work of the four men previously mentioned and in his *Principia* performed a major synthesis of terrestrial and celestial mechanics made valid by his penetrating use of mathematical logic, including the rudiments of the calculus which he devised for his purposes. The magnitude of this step can scarcely be overestimated: it showed the wide validity of physical principles and their extension by the law of gravitation to regions far beyond the earth; it removed all boundaries to man's attempts to apply new-found ideas; and, by the many deductions and predictions drawn from the laws of motion, it gave increased confidence in the power of mathematical theory when applied to measurements in the physical world. Newton's laws of motion, in part anticipated by Galileo, were clear guides to all subsequent studies of motion.

The law of gravitation (*q.v.*) provides an elegant example of what may be called a useful theory. Aside from its impact on philosophy and theology, it illustrates what a good theory should do. First, it took into account and employed quantitatively all relevant prior knowledge and observation. For example, Newton showed Kepler's first and second laws to be characteristic of a motion taking place with conservation of angular momentum under a centrally directed force acting between a planet and the sun. The third law was shown to be a necessary consequence of an inverse square law of gravitation, when applied to the motion of an object moving in a curved path; this was in accordance with the then recently stated (1673) law of centripetal force of the Dutch mathematician, astronomer and physicist Christiaan Huygens. Second, Newton's work led to the solution of several baffling problems of long standing—problems to which it was not originally directed—such as the cause of the tides and the orbits of comets. Newton pointed out the necessary oblateness of the earth because of its rotation, a fact then not even suspected, and proceeded to employ the existence of this equatorial bulge to explain the slow precession of the equinoxes. Finally, under constant testing, the *Principia* and its various descendants in mathematical deduction led to a fuller understanding of motion of all kinds. The later ideas of relativity superseded Newton's only in the case of velocities approaching the speed of light. Newtonian mechanics could thus still be regarded as a good first approximation to the more general mechanics of relativity.

The full mathematical development of Newton's mechanics took place in the 18th century, culminating in the publishing in France of J. L. Lagrange's *Mécanique Analytique* (1788) and the *Mécanique Céleste* (1799–1825) of P. S. Laplace. In these works, the implications of gravitational potential and the principle of conservation of mechanical (potential and kinetic) energy played a leading part; and they provided a firm foundation for the subsequent bringing of all forms of energy into the more general conservation principle of the 19th century. Application of Newton's law of gravitation to the detailed examination of planetary motions led, in one memorable triumph, to the discovery of the planet Neptune.

Finally, discrepancies in the precession of the perihelion of the planet Mercury, whose motion did not completely satisfy Newtonian mechanics, was a source of discomfort to astronomers until the German-born Albert Einstein (then of Bern, Switz.) removed most of the observed discrepancy by application of his relativity theory (1905). Hence, in numerous steps, of which the foregoing are but a few important examples, physics advanced to a fuller understanding of mechanics, both terrestrial and celestial, by the interplay of observation, laboratory equipment and theoretical deduction. Discrepancies between theory and observation, however small, often were the guide to new experiments which in turn were the source either of new discoveries or of a revision of basic ideas in the conceptual framework of thinking.

The Electrical Nature of Matter.—A second example of how physics progresses is the growth of the atomic view and its extension to the atomicity of electric charge, from which base the development of nuclear physics proceeded. The chemical experiments of John Dalton of Manchester, Eng., in the first decade of the 19th century laid the experimental foundation for the concept of atomic weight. Rapidly, throughout the 19th century, there grew the idea of a limited number of elements which could combine in an almost limitless number of ways to form chemical compounds —outward complexity with an underlying simplicity. The periodic system of the elements as formulated by the Russian chemist D. I. Mendeléyev served as a framework for the few scores of elements known. In mid-19th century there arose the kinetic theory of gases, which successfully attributed such phenomena as the pressure and viscosity of a gas to the motions of myriad submicroscopic atomic and molecular particles. This theory did much to bring quantitative measurement to bear upon invisible particles and their motions, and it assisted in bringing thermal phenomena firmly within the scope of the newly enlarged principle of conservation of energy. J. Clerk Maxwell of Scotland and Ludwig Boltzmann of Austria, among others, gave the kinetic theory extensive mathematical form, and produced an expression for the molecular velocity distribution function that in subsequent years was verified experimentally.

By 1895 the growing weight of chemical evidence and the success of the kinetic theory in dealing statistically with large numbers of particles left little doubt that atoms and molecules were real. Whatever doubt remained was in large part dispelled by Einstein's analysis and Jean Perrin's experiments in France on the Brownian movement, the random motions of microscopic particles, which had remained unexplained for 80 years. Near the turn of the century, physicists were on the threshold of several significant discoveries which stemmed from experiments on the passage of electric current through gases at low pressure and from the study of optical spectra which, since the work of R. W. von Bunsen and G. R. Kirchhoff in Germany in 1859, had played a prominent part in chemical analysis. An important question persisted: how could simple atoms give rise to such complex spectra as were found? These characteristic spectra must in some way be connected with the structure and inner properties of atoms. In approximately 20 years, several strands of the tangle were unraveled, principally from the discovery of the electron. By 1925 many

important problems had been solved, only to give rise to new and perplexing questions to be solved by the development of quantum mechanics.

The electron, or corpuscle of negative electricity, was the first subatomic particle to be identified as a constituent of all atoms. It was shown by Sir J. J. Thomson of England, in his studies of cathode rays, to have the same ratio of charge to mass, e/m (1.76×10^8 coulomb/gram), regardless of the element from which the rays were derived. Thomson showed by deflecting cathode rays with electric and magnetic fields that this e/m was 1,837 times greater than e/m for the lightest known substance, hydrogen, as measured by electrolysis. The presumption was strong that this swift new-found particle bore the same charge but had only 1/1,837 the mass of the hydrogen atom, a surmise that has stood the test of experiment. The subsequent measurement of the electronic charge by Robert A. Millikan (then of Chicago) in his well-conceived oil-drop experiments (1909–16) demonstrated the definiteness of this charge, now stated as -4.803×10^{-10} electrostatic units, regardless of the source of the electrons. Millikan's work showed that all electric charges, whether positive or negative, must be regarded as composed of these definite small charges, and that electricity instead of being infinitely divisible has an atomic nature. The English chemist and physicist Michael Faraday (1791–1867) had approached this position by his experiments in electrolysis many decades earlier, and his work now returned to prominence as, with knowledge of the charge on an ion in electrolysis, it became possible to compute with accuracy Avogadro's number, the important number representing the aggregate of atoms in a gram-atom, measured to be 6.025×10^{23}.

At almost the same time that Thomson was measuring e/m for electrons, W. Röntgen of Germany found the penetrating radiation which he called X-rays. These rays were generated by the sudden stopping of cathode rays or electrons upon impact with metal targets. Thus, the electron was demonstrably connected with the emission of radiation. It was suspected that this agile particle might be the source of atomic spectra but three important steps had to be taken to prove this connection. These were in turn the discovery by Max Planck of Germany of the quantum nature of radiation, the discovery of the nuclear atom by Sir Ernest Rutherford of Great Britain and the synthesis of a suitable atomic model by Niels Bohr of Denmark.

It was shown by Planck in 1900 from his theoretical studies of thermal or black-body radiation that light must be considered not as transmitted by energy infinitely divisible, as had been previously assumed, but rather as being emitted and absorbed in small bundles of energy which he called quanta. The magnitude of a quantum or photon he showed to be $h\nu$, where ν is the frequency of light and h is a constant of action or energy $\times$ time (6.6256×10^{-27} ergs $\times$ sec.), which Planck introduced into physics. Planck's constant appears to be one of the fundamental atomic constants. In this way was born the quantum theory which, with its descendant, quantum mechanics, became indispensable to the understanding of atomic and nuclear phenomena.

The early quantum theory was given considerable assistance by Einstein who adopted it in explanation of the photoelectric effect. In his important 1905 equation, Einstein showed that the maximum kinetic energy of an electron ejected by light from a metal could be expressed by $\frac{1}{2}mv^2_{max.} = h\nu - \phi e$ where $h\nu$ is, as before, the energy of the photon and ϕe represents work done to assist the electron across the potential barrier of the metal. This equation made no pretense of supplying a detailed mechanism for the potential barrier nor for extraction of electrons from metals, yet it was based firmly upon the concept of energy conservation. More than a half-century later, it still had been successful in every experimental test to which it had been put, ranging from the infrared region of the spectrum to gamma rays.

Also, late in the 19th century A. H. Becquerel, Pierre and Marie Curie (all of France) and Rutherford were leaders in the exploration of radioactivity. These studies were destined to lead to the discovery of other subatomic particles and to the whole field of nuclear physics. In examining the growth of atomic theory, the discovery of the atomic nucleus by Rutherford (1911) is the most relevant event. From the scattering of swift alpha particles from radioactive substances as these particles were directed against thin metal foils, such as gold leaf, Rutherford concluded that the alpha particles often encounter strong centres of repulsion and that most of the mass and the positive charge of the gold atoms must be concentrated in a small region less than 10^{-12} cm. in diameter. If, as became apparent from these experiments, the positive charge was concentrated in a small nucleus, each neutral atom could be regarded as having positive and negative charges of equal magnitude, each charge being an integral number of the fundamental electronic charges. Both the scattering experiments and contemporaneous experiments on the X-ray spectra of metals conducted by H. G. J. Moseley in England in 1913 showed that this positive charge on the nucleus is Ze where Z is the atomic number or ordinal position of an atom in the periodic table of Mendeléyev. Hence a neutral atom must have Z electrons also. The atomic number was recognized as the sure indicator of the chemical element to which an atom belongs, whereas it had become abundantly evident in the discovery of isotopes that atomic weight is a less definite indicator. This field of isotopes, so important to both chemistry and physics, will be discussed later.

In view of the definite photon energy represented by each line in the spectrum of an atom, Bohr was led in 1913 to postulate a large but finite number of recognizable energy states for electrons in atoms, with the transition of an electron from one state of energy to another of lower potential energy as the source of each photon. Inasmuch as the number of such possible transitions is large, the number of spectral lines is likewise large for a given type of atom. Thus a comparatively simple mechanism was again proposed to explain the complex spectral emission of even the simplest atoms. Bohr's theory of atomic structure, whatever its limitations, is a good example of the application of basic physical principles. Central in Bohr's treatment was the quantization of angular momentum, from which the quantization of the energy of photons erupted as a consequence. Bohr postulated a number of "stationary energy states"—states of comparative permanence only—which electrons could occupy in the atom. These were limited to those mechanical orbits of electron rotation about the nucleus characterized by angular momentum $nh/2\pi$, where n is an integer now called a quantum number and h is Planck's constant. Energy exchanges were considered to occur as follows: in order for an atom to emit radiation it must first be excited or receive energy by impact, thermal or electrical, or by the absorption of other radiation. Bohr viewed this as the forcible removal of the electron to a greater distance from the nucleus to which it was bound electrostatically. As the electron settled down from such an excited state, it would emit one or more quanta of radiant energy by one or more successive transitions between energy states. The total energy emitted by the atom in returning to its lowest state of potential energy was thus set equal to the energy originally absorbed. Bohr's model now is mostly of historical interest, but the quantization of angular momentum, the concept of energy states, the emission and absorption of definite quanta of energy in transitions of electrons from one state to another—all these remain. It was necessary to modify the idea of orbits and to revise the system of quantum numbers in favour of a wave-mechanical view that fit the observed facts of spectroscopy better. The work which Bohr did in synthesizing the available knowledge of the time was comparable with that performed by Newton in the earlier illustration: he united into a coherent system the quantum emission and absorption of radiant energy, the basic ideas of conservation of angular momentum, conservation of energy and the balance of electrostatic and mechanical forces. From the simplified view which evolved, he was able to account for the spectrum of hydrogen, the simplest atom. Experimental checking of the consequences of his theory led to the discovery of certain series of lines in the hydrogen spectrum and in the spectra of hydrogen-like atoms (singly ionized helium, doubly ionized lithium, etc.) consistent with theory. A decade or more of intensive research into optical spectra was stimulated by the application of quantum ideas. As experimental evidence piled up, significant discrepancies were apparent in the Bohr model, but the way to modify it was not immediately at hand; when a change

came it was in a form more sweeping than expected, as the older quantum notions of Planck, Einstein and Bohr gave way to the new quantum and wave mechanics of Werner K. Heisenberg of Germany, Erwin Schrödinger of Austria, the German-born English physicist Max Born and P. A. M. Dirac of England. (More will be said of this in later sections.)

In both of these extended examples, there were certain similarities in procedure. Experimental evidence sometimes led theory, as in Kepler's laws of planetary motion or Faraday's laws of electrolysis. At other times the reverse was true, and theory led to new experiments. The final arbiter is experiment, and physicists are accustomed to relinquish even attractive theories when they are found to be at variance with clear experimental evidence. Relativity surpassed Newtonian mechanics, and quantum mechanics surpassed the earlier quantum theory from which it came. In both cases, discrepancies between observation and theory prompted the change to a more comprehensive view; and in each case the result was a more productive theory that gave direction to new experiments.

It may be observed in closing this account of the electrical nature of matter, illustrated strongly by the identification of the electron, that the electron soon after its discovery offered one of the earliest and best evidences for the variation of mass with speed, as inferred from the theory of relativity. Thomson's early measurements of e/m were followed by others made by Walter Kaufmann and A. H. Bucherer of Germany that showed e/m to decrease with increase of speed of the electrons. This variation was properly attributed to an increase in mass of the electron and was shown to be in good experimental agreement with the equation

$$m = \frac{m_o}{\sqrt{1 - v^2/c^2}}$$

as specified in the relativity equations by Einstein; where m_0 is the rest mass, v is the velocity of the particle and c is the speed of light. The observations just reported throw light also on another aspect of development in physics, namely the growing coherence of scientific knowledge: here can be seen a close link between the forefront of knowledge in mechanics, as given in relativity, and the details of atomic structure as met in the study of the electron.

Radiation.—Examining the interactions of radiant energy with matter serves to give a better understanding both of matter and of light and its allied radiations. This two-way traffic is well illustrated in the case of X-rays, where the discoveries of the nature of the rays and of the nature of matter struck by them were complementary. From the early conjectures of Huygens, who viewed light as a wave motion, and of Newton, who viewed it as corpuscular, the view now is of an inseparable duality, although certain experiments accented one characteristic more than the other. The wave aspect gained pre-eminence during the 19th century from the experiments (1811) of T. Young of England, who showed interference of two light beams, best interpreted as evidence of waves. A. J. Fresnel of France extended Young's treatment, discussed diffraction phenomena and formulated a detailed wave theory which was the forerunner of the elegant electromagnetic theory of J. Clerk Maxwell. The discovery of electromagnetic waves by the German physicist H. R. Hertz and the subsequent development of wireless (radio) and radar reinforced Maxwell's theory and extended the electromagnetic spectrum from the infrared end of the optical region to waves thousands of metres long. At the other end of the spectrum, diffraction effects were used to identify the very short wave lengths (about 10^{-10} cm.) of X-rays and gamma rays. However, the high-frequency end of the spectrum gave inescapable evidence for the photon or quantum nature of the radiation. (The interpretation of spectra on the quantum basis has been introduced above.)

Advances in instrumentation in spectroscopy became significant as greater precision in wave length measurement and greater resolving power gave the necessary numerical evidence to implement the quantum view. Massive accumulations of precise data in optical spectra were made, as in the *M.I.T. Wavelength Tables* compiled by G. R. Harrison of Cambridge, Mass., and others. The Zeeman effect, which was discovered at the time when Thomson was measuring e/m for electrons, gave evidence that a particle of the same e/m was present in the splitting of spectral lines from a source situated in a strong magnetic field. The refined extension of Zeeman spectra when combined with the Pauli exclusion principle (*see* below) did much to permit a complete description of the outer electronic architecture for all of the electrons in atoms throughout the periodic table. Thus, the details of the electronic structure of matter could be considered as reasonably complete by the late 1920s. X-ray spectroscopy, particularly the study of X-rays characteristic of each element, showed how the inner electrons of an atom's electronic cloud are disposed.

Two further experimental developments in radiation will be reported because both contributed to the rise of quantum mechanics. The first is the photoelectric effect mentioned above, which gave clear evidence of the absorption of radiation in definite energy bundles and the transfer of this energy to the ejection of a single electron. More recently, nuclear photoeffects were discovered by the ejection of neutrons, protons and mesons from nuclei and by the photodisintegration of light nuclei under the impact of gamma rays, further showing the validity of the energy quantum aspect of electromagnetic radiation. The experiments in 1922 of Arthur H. Compton (then of St. Louis, Mo.) on the ejection of electrons from atoms by X-rays and the accompanying modification of the wave length of the X-rays scattered in the process, appeared likely to remain significant as clear evidence for the ballistic impact of photons on electrons to which the conservation principles of momentum and energy have been applied in detail. The extension of these principles into the atomic and nuclear regions gave added confidence in their extraordinary range of validity. The Compton effect subsequently was extended to the scattering of visible light and the slight modification of wave length accompanying such scattering, as shown in 1928 by C. V. Raman in Calcutta.

Perhaps the most remarkable offspring of these experiments was the postulation of particle waves in 1924 by Louis de Broglie of France, who considered that if a photon which has demonstrable wave properties can also show such ballistic properties, a "particle" (such as an electron, proton, neutron, etc.) may show wave properties. This extension of the dual nature of wave and corpuscle in radiation to a similar duality in particles produced extensive results in both theory and experiment. The wave mechanics which sprang from it are described below. Diffraction effects for electrons (C. J. Davisson and L. H. Germer of the U.S., G. P. Thomson of England, S. Kikuchi of Japan), for protons (O. Stern, then at Hamburg) and for neutrons (E. O. Wollan and C. G. Shull of Oak Ridge, Tenn.) showed the experimental validity of De Broglie's bold suggestion. This is an example of what may be called reversibility of effects, a viewpoint or policy of investigation that has frequently guided physicists to the discovery of converse effects.

The final item under radiation is a brief examination of cosmic radiation—a mixture of electromagnetic radiation and swift particles. The study of cosmic radiation resulted in fruitful by-products that were not expected when it began. In an effort to trace the cause of leakage of electric charge in a well-insulated electroscope, first J. C. McLennan of Canada, then Millikan, following the earlier experiments of V. F. Hess of Austria, sent electroscopes aloft in balloons and verified Hess's discovery that, contrary to expectation, the leakage increased with elevation. This suggested a source of ionization high in the atmosphere; and as subsequent world-wide observation showed, the radiation causing the ionization was entering from beyond the earth and was not intimately connected with the sun, as shown by lack of pronounced day and night or seasonal variations. The origin of these rays called cosmic (so named by Marie Curie of France) is not known, but they appear to be due primarily to very high-energy atomic particles (*e.g.*, protons) which in turn may generate electromagnetic waves and mesons when they collide with atoms high in the atmosphere. The energy of the primary particles is great, often in excess of 10^{18} electron volts (ev), far beyond the energies obtainable by laboratory means.

Directly from cosmic ray studies came the detection by Carl D.

Anderson at Pasadena, Calif., of the positron or positively charged electron (1932) and of mesons (Anderson and S. H. Neddermeyer). Electron-positron pair formation was also observed as important evidence that radiant energy could be converted back into mass with conservation of mass-energy. Physicists learned to copy nature by bringing high-energy reactions under laboratory control. These efforts surpassed the most energetic reactions of natural radioactivity but they still fell far short of the more energetic cosmic ray effects. The laboratory generation of mesons and of antiprotons (negatively charged protons) were among the successes achieved by laboratory means. Cosmic rays offered a stern challenge to the experimenter to devise means for measuring energy bundles far greater than those encountered earlier, and means for differentiating between photons and energetic particles moving near the speed of light and made massive by their enormous energies according to the $E = mc^2$ relation.

Atomic and Nuclear Structure.—It has been seen how the discovery of the electron and the pursuit of spectroscopic knowledge led to the idea of specific energy levels characteristic of atoms. This section first looks further into electronic structure, then more deeply into nuclear structure as represented by radioactivity, natural and induced, and by isotopes and nuclear reactions; it concludes with a resumé of the "particles" of physics.

Additional evidence other than spectroscopic for electronic energy levels came in 1913 from the study of excitation and ionization potentials by electron bombardment (J. Franck and G. Hertz, then of Berlin), wherein atoms were shown to receive energy in inelastic collisions. The ionization potential of an atom (expressed in electron volts) indicates the minimum energy which must be given to the least tightly bound electron to extract it completely. It is greatest (24.5 ev) for helium and least for the alkali metals (*e.g.*, cesium, 3.87 ev). Electrons may likewise be removed by the absorption of photon energy of suitable magnitude, as in X-ray absorption. Studies of these effects contributed much to the allocation of electrons to specified shells as described below.

For many elements, further ionization potentials were known, signifying the energies required to extract the second, third, etc., electrons from an atom. The relative inactivity of the noble gases —helium 2, neon 10, argon 18, krypton 36, xenon 54 and radon 86 —and the chemical activity of the alkali metals next above them in the periodic table of the elements—lithium 3, sodium 11, potassium 19, rubidium 37, cesium 55 and francium 87 (the last not as fully studied as the others since no stable isotope had been found)—were suggestive of the part played by electrons in the chemical bond, a matter pursued by Linus C. Pauling of Pasadena, Calif., and others. The noble gases were regarded as important division points in the periodic system where successive electronic shells become filled and atoms become electronically "satisfied." These shells took their designation from the underlying similarity of X-ray spectra which arise from the disturbance of inner electrons, being in order from the nucleus outward called K, L, M, N, O and P. The number of electrons in successive completed shells is 2, 8, 18, 32, 18 and 8, which were the same numbers "allowed" by detailed application of a principle stated by the Austrian-born physicist Wolfgang Pauli (then of Zürich), that no two electrons are to be described by the same set of quantum numbers. The elements next above each of the noble gases have one additional electron, called a valence electron, which apparently plays the major role in their chemical behaviour. (For a fuller explanation of electron structure, *see* SPECTROSCOPY and SPECTROSCOPY, X-RAY.) These concepts were under continuing study in the 1960s when xenon and krypton (*qq.v.*) were found to react much more readily than had been expected.

Looking beyond the electron configuration, it has been seen how Rutherford discovered the atomic nucleus by alpha particle scattering. To examine nuclear structure, radioactivity and some of the ideas that have stemmed from it should first be considered. Radium, the classic example of an unstable element, spontaneously gives off swift alpha particles and becomes a new element, radon or radium emanation, element number 86 and the heaviest of the noble gases. Rutherford identified the alpha particle as the nucleus of the helium atom of mass 4 and charge $+2e$, designated He^4. Hence, its ejection from the nucleus transfers radium from mass 226 to mass 222, and from atomic number 88 to 86, meaning that a neutral atom of radon would have 86 electrons distributed in six shells as follows: 2K, 8L, 18M, 32N, 18O and 8P. Some substances emit beta particles, identified as swift electrons. Loss of a beta particle from the nucleus enhances the net positive charge by one electronic unit and causes the substance to rise one in the scale of atomic numbers; but, as the electron is so light, no change in mass number is assigned.

Most radioactive substances also give off penetrating gamma rays, the more energetic, shorter wave length and higher frequency cousins of the X-ray, giving evidence of a settling down of the nucleus from an excited state (in the manner of electron settling in the emission of optical spectra, but with far greater energy). Much effort was spent in identifying distinct nuclear energy levels by gamma ray spectroscopy. Each of the 40 or more natural radioactive types was identified by the energy of the rays and particles emitted and by its half life; *i.e.*, the time in which half of its atoms transmute into some other type. Half lives range from a few ten millionths of a second to a few thousand million years. As the many radioactive species, generally grouped in four families springing from the slowly decaying ancestors—uranium, thorium, actinium and radium—must all find their places within a range of atomic numbers from 94 to 82, it became evident that there was a crowding of atoms of different atomic weight in the same positions in the table. Thus arose the concept of isotopes; *i.e.*, atoms of different mass but of similar chemical nature and atomic number.

Isotopes were also found among nonradioactive elements throughout the periodic table, starting with the discovery by J. J. Thomson (1913) of isotopes of neon and chlorine. Thomson demonstrated that the chemical atomic weights of neon (20.18) and of chlorine (35.45) were the result of mechanical mixtures of isotopes with atomic weights of 20 and 22 in the case of neon, and 35 and 37 in the case of chlorine. From this sprang much activity in the field of mass spectroscopy with F. W. Aston of England and A. J. Dempster, K. T. Bainbridge, A. O. Nier and M. G. Inghram of the U.S. as major contributors. One importance of mass spectroscopy lies in its usefulness in finding increasingly precise values of atomic masses, information important in the detailed balancing of energy in nuclear equations. By the 1960s more than 1,000 masses of isotopes had been measured.

An important conclusion could be drawn from the precise knowledge of atomic masses as supplied by mass spectroscopy; namely, evidence of the binding energies of the atomic nucleus. This evidence appeared first in Aston's so-called packing fraction curve which demonstrated a decrease in mass among atoms of progressively higher atomic number if they were considered to be made up of protons (and, later, neutrons). For example, if 16 protons (or their equivalent in mass) were to unite to form one oxygen atom (mass 16.000 as the basis of the old atomic mass scale) there would result a decrease in mass of 0.128 atomic mass units, equivalent to a decrease in energy of 120 Mev (million electron volts). Energy of this amount may be considered to have been released on formation as kinetic energy and gamma radiation; and a similar amount would be required to restore the oxygen atom to its original constituent particles, now regarded as eight neutrons and eight protons. The implications of Aston's curve were clear: among the lighter elements, consolidation (fusion) would lead to significant energy release; as also among the heaviest elements, splitting into smaller components (fission) would release energy. Both of these effects were shown to exist in the large-scale release of nuclear energy in the hydrogen bomb and the uranium or plutonium bombs.

The discovery in 1919, by Rutherford, Sir James Chadwick and Sir Charles D. Ellis of Cambridge, Eng., of the ejection of protons (hydrogen nuclei) from nitrogen atoms when bombarded with alpha particles led into a vast region of nuclear physics and chemistry somewhat indicated by Aston's curve. The equation of this first observed nuclear reaction is worthy of examination:

$$He^4 + N^{14} \rightarrow O^{17} + H^1 + Q$$

In this nuclear reaction equation the superscripts show mass numbers on the basis of oxygen 16; Q represents energy change on the mass-energy basis. In this case a net decrease of mass of 0.0082 atomic mass units signifies an increase of kinetic energy of 7.6 Mev, so the reaction is exothermic and releases energy. The energy equivalent of 1 atomic mass unit (1.66×10^{-24} g.) is 1.49×10^{-3} erg, or 931 Mev.

Another important reaction which proved to be the key to countless others was that accompanying the discovery of the neutron (*q.v.*) by Chadwick (1932) while he was attempting to interpret the strange effects reported by W. Bothe and H. Becker of Germany and by Frédéric and Irène Joliot-Curie at Paris. In these experiments, alpha particles striking beryllium were found to eject radiation of great penetrating power. Chadwick showed by the recoil ejection of protons when struck by this radiation that, by postulating a new particle with no electric charge but with mass comparable with that of the proton, all observed effects could be accounted for.

The equation for the reaction was:

$$He^4 + Be^9 \rightarrow C^{12} + n^1 + Q \text{ (where } Q \text{ is 5.6 Mev)}$$

There also had been success in causing nuclear disintegrations by high-energy protons, as in the work of the physicists Sir J. D. Cockcroft of England and E. T. S. Walton of Ireland, high energy being needed to cause the proton to overcome the electrostatic repulsion of the bombarded nucleus. Neutrons do not encounter adverse electrostatic repulsion as protons do; hence they can drift into nuclei even at low speed and upon entry they can bring about hundreds of nuclear reactions, as was early shown by Enrico Fermi and his collaborators in Rome, by the Joliot-Curies and by others.

A further outcome of alpha particle (and later neutron) bombardment was the discovery of induced or man-made radioactivity, or the ability to render nuclei unstable and truly radioactive by bombardment. The original experiment was performed by the Joliot-Curies (1934), who bombarded aluminum with alpha rays and found a reaction as follows:

$$He^4 + Al^{27} \rightarrow P^{30*} + n^1 \rightarrow Si^{30} + e^0$$

Here P* indicates radiophosphorus which decays with half life of 195 sec. into silicon, with the ejection of a positron, designated e^0 to indicate unit positive charge but negligible mass. As a result of this initial observation, and the subsequent discovery of neutron-produced types, many hundreds of radioactive tracer elements became available for experimental work in medicine, agriculture, biology and chemistry. The particular virtue of radioactive tracer atoms is that chemically they are indistinguishable from normal atoms, yet their presence can be detected by radiation counters. (See *Instrumentation* below.)

The finding of the neutron simplified the concepts of nuclear structure, as only protons and neutrons were needed to satisfy theoretical requirements. The possibility of electrons in the nucleus could be dismissed on theoretical grounds by Heisenberg's principle of uncertainty, as they are too big to fit into the small space afforded. Or it might be said that, if confined within a nucleus, an electron's energy would have to be prodigiously high. The ejection of beta particles from the nucleus was regarded as resulting from the formation of the electron at the instant of ejection when a neutron turns into a proton; similarly, positron emission was evidence of a proton becoming a neutron.

The neutron also played a prominent part in the release of nuclear energy from uranium and plutonium by the process called fission, with explosive violence in the nuclear bomb or at a slower, controlled rate in the nuclear power reactor. Slow neutrons caught by U^{235} or by Pu^{239} caused these atoms to split into fission fragments of intermediate atomic mass with a large release of energy. At the same time, additional neutrons were released and were able to produce new fissions in available material in a self-sustaining reaction.

Three fundamental stable particles sufficed for the rudimentary structure of the atom. For any given type of atom of mass A (basis oxygen 16) and atomic number Z, commonly accepted views called simply for a nucleus composed of Z protons and N neutrons so that $Z + N = A$. There were also required in a neutral atom Z electrons to balance the nuclear charge $+Ze$. The change in the 1960s to a table of atomic masses based on carbon-12 does not change the reasoning here. Neutrons which when free are radioactive with a half life of about 13 min. are, for some unknown reason, stable when bound in the nucleus. Photons may be regarded as particles of zero rest mass which act as carriers of bundles of energy from atom to atom, existing only until their mission is accomplished, even though this may take millions of years, as in the case of stellar radiation. There are a number of other particles whose transitory existence was demonstrated in the years following 1932, with new particles still appearing in the 1960s. Neutrinos are ephemeral neutral particles postulated as necessarily ejected in cases of beta particle emission and in meson disintegration. Were it not for the quite convincing experimental evidence of their existence by F. Reines and C. L. Cowan of Los Alamos, N.M., and others, one might regard neutrinos as the necessary but undetectable scapegoats whose subtle function was to permit the application of conservation of energy and momentum to atomic reactions.

A number of other particles of exceedingly transitory yet demonstrated existence were found in cosmic-ray and high-energy accelerator research, but the function of most of these was not clearly understood in the years immediately following their discovery. Only the pi-mesons seemed to serve in binding nuclei together in a way analogous to the binding of atoms into molecules by electronic forces. The catalog of particles with their masses given in terms of electron masses included e^-, μ^- and neutrinos 0; positive and negative electrons 1; positive and negative mu-mesons 207; positive, negative and neutral pi-mesons 270; neutral, negative and positive K-particles 966; neutrons, protons and antiprotons 1,837; neutral lambda particles 2,182; positive, neutral and negative sigma particles 2,320; and negative and neutral Xi particles 2,580. Those more massive than the neutron and proton are called hyperons. The antiproton generated by the bevatron and studied by Emilio Segre and others at Berkeley, Calif., was the expected negative counterpart of the proton, just as the positron was anticipated by Dirac before its discovery by Anderson. (*See* PARTICLES, ELEMENTARY.)

The phenomenon of positron-electron pair production requires gamma-ray energy at least as great as the self-energy of two electrons, or 1.02 Mev. It would seem that the production of a proton-antiproton pair would require only 1,837 times this energy because the self-energy of the particles formed is greater than the self-energy of two electrons by this factor. However, here is an excellent example of the coalescence of the principles of conservation of energy E, momentum p and mass m into a single invariant quantity expressed in an important equation of special relativity

$$E^2 - p^2c^2 = m^2c^4$$

where c is the velocity of light. In designing the bevatron accelerator that first brought about this reaction of proton-antiproton creation, it was necessary to plan for 7-Bev protons, not just 2-Bev, or approximately 3.5 times the self-energy of the pair created. When antiproton and proton meet they annihilate one another with liberation of their self-energy, as detected in numerous meson "stars" produced in photographic emulsions and in bubble-chamber experiments.

Solid State Physics.—Atomic physics proceeded most rapidly as it dealt with matter in a highly dispersed state, as in gases at low pressure. Matter in the solid state presented a challenge which was being met in experimental and theoretical studies of solids. Many data in this field were gathered through the years as useful engineering information on the elastic, thermal, electrical, magnetic and optical properties of materials. As the 20th century advanced, physicists were attempting to explain these properties and hoped eventually to predict them from knowledge of atoms and their interactions. To this end, the tools of the physics laboratory were used to study crystal structure by X-ray and neutron diffraction, to create single crystals of very pure substances under carefully controlled conditions, to show the effects of small but controlled amounts of impurities on the properties of metals, and

to seek the properties of plastics, ferrites and semiconductors. The knowledge of low-temperature performance of metals (near 0° K.), including the phenomenon of superconductivity, allowed an increasingly effective application of quantum mechanics to atomic and molecular aggregates. Rapid development in the study of solid state devices such as the transistor led by the 1960s to significant changes in instrumentation and communication.

Theory.—It is unlikely that physicists will rest from their labours as long as ignorance about the forces of nature remains. One of the major theoretical endeavours is to gain a more unified view of the several forces which exhibit themselves, as in the gravitational attraction between large masses even at very great distances; the magnetic and electrical forces evident between objects at distances from atomic to terrestrial; the molecular forces between atoms and molecules appreciable from 10^{-8} to 10^{-5} cm.; and the extremely strong but short-range forces which hold nuclear particles together, strong at 10^{-12} cm. but dwindling rapidly at greater distances. None of these forces is fully understood and even less is known of the relationship between them. For the binding of atoms into molecules, electronic exchange forces were postulated; for the binding of nucleons (protons and neutrons) in nuclei, mesonic exchange forces. By analogy, but with little experimental evidence for their existence, gravitons were postulated for gravitational forces (*see* FORCE).

Calculus and differential equations, ably assisted by more elementary mathematics and by vectors and matrices, may be said to be the mathematical language of physics. Newton is commonly regarded to share with the German mathematician G. W. Leibniz the invention of the calculus, a system of computation which he needed to solve in detail the problem of the gravitational attraction between two discrete and approximately spherical bodies such as the sun and a planet. Differential equations were developed and applied with signal success to the formal growth of mechanics, wave motions and problems of the gravitational field. As electricity and magnetism developed experimentally, they were given systematic treatment by Maxwell, who demonstrated the close relationship between electromagnetic phenomena and light. H. R. Hertz's discovery of electromagnetic waves based thereon led, through the engineering development of electronics, into the arts of radio, radar and television. Other major theoretical developments of the second half of the 19th century were thermodynamics and statistical mechanics. The first gave broad form to the relation of heat to other forms of energy and raised the principle of conservation of energy to a pinnacle; the second treated the mechanics of large numbers of particles and joined the mathematics of probability firmly with physical ideas, as in the kinetic theory of gases and, in the hands of J. Willard Gibbs of New Haven, Conn., extended thermodynamics to the field of chemistry.

Each new and promising burst of theoretical ideas was followed by a period of extended testing as these ideas were applied to a widening array of phenomena and, as usually happens, limitations were found at some point. Thus, thermodynamics reached a barrier when applied to the study of wave length distribution of radiant energy from hot bodies, a field for which it was hopefully deemed adequate. Only by Planck's drastic assumption of energy quanta (mentioned earlier in this article) was a satisfactory escape shown. This new theory soon established a domain of its own where it demonstrated its superiority over thermodynamics, as in explaining the photoelectric effect (Einstein); specific heats of solids and gases (Einstein, then of Berlin, F. A. Lindemann of England and P. J. W. Debye, then of Berlin); the early interpretation of spectra (Bohr and the German-born Arnold Sommerfeld); and the scattering of radiation by electrons (Compton). Again, discrepancies and new experimental evidences, particularly the demonstration of particle waves postulated by De Broglie, forced drastic modification in the earlier quantum ideas. There developed after 1925 the wave mechanics of Schrödinger, Heisenberg, Born and Dirac, augmented by the concepts of the spinning electron (by physicists S. A. Goudsmit and G. E. Uhlenbeck of the Netherlands), the exclusion principle (Pauli) and the uncertainty principle (Heisenberg).

The quantum mechanics demonstrated its right to displace earlier theories by its capacity to treat more accurately the evidence of spectroscopy, to recognize and utilize the wave-particle duality and to give a more complete explanation of radioactivity and nuclear structure than did its predecessors. Considerable success was attained in unifying the mechanics, electrodynamics and thermodynamics of 1890 and the quantum theory of 1920 (often called classical) into a more comprehensive body of theory that covered an array of physical phenomena including many not even known at the earlier dates. Foremost in this achievement were relativity, quantum mechanics and quantum electrodynamics. Physicists weathered a number of shocks occasioned by the proposal of drastic new ideas and the need to discard earlier formulations. For example, experiments performed in 1957 at Columbia university, the Institute for Advanced Study at Princeton, the U.S. bureau of standards and The University of Chicago raised serious reconsideration of the idea of "parity," an idea which previously had been accepted without question (*see* PARITY, LAW OF CONSERVATION OF). It may be said that both theory and experiment proceeding alternately step by step usually maintain a healthy state of mutual stimulation, justifying the special faith of the scientist that if he can only find the right question to ask the answer will ultimately be forthcoming.

Instrumentation.—Experimentation requires careful observation and quantitative measurement, there being nothing entitled to the name of science unless facts determined by measurement and expressible by number or symbols thereof can be set down. This implies the use of apparatus designed to bring a phenomenon under control and instruments to measure the effects observed. Much of the progress in physics sprang from the development of meters and other devices to meet special needs. For example, vacuum pumps and high vacuum technique led to the industrial production of electronic tubes of many uses, especially in the field of communications. The cathode-ray tube, so useful in television, radar and a host of other applications requiring quick response for the study of rapidly changing phenomena, came directly from the tubes that J. J. Thomson used in his early experiments on the e/m of electrons, already described. Electron optics, applied at first to the better focusing of electron beams, later found extensive use in the electron microscope, which surpassed by about 100 times the best optical microscope. The field of spectroscopy, with its triumphs in delineating atomic structure, made progress with the help of instruments of higher resolving power, especially when augmented by interferometers of the Fabry-Perot or Michelson type.

Mass spectroscopy progressed from the early mass spectrographs of Thomson and Aston to instruments of high resolving power by which the masses of isotopes could be compared with an accuracy of the order of 1 part in 10,000,000; and rare isotopes were found by even more sensitive means of detection. These instruments employed a combination of electrostatic and magnetic focusing whereby ions were sorted specifically according to their mass. They added a new element of precision to the determination of atomic weights and contributed directly to the experimental validation of the important $E = mc^2$ equation.

Through the design of ultra-high-frequency generators such as the klystron and magnetron, microwave radio (in the 10,000-megacycle region) became important in radar systems in World War II; and these generators afterward found use in the extension of spectroscopy into the 1,000 to 10,000 megacycle region where molecular absorption and magnetic resonance phenomena were studied.

With the rapid growth of interest in nuclear physics, instrumentation likewise grew. For generating high-energy atomic particles, two chief kinds of accelerators became important: those that applied high voltage directly and those that gave charged particles successive increments of energy. Of the first kind were the electrostatic generator of the U.S. physicist R. J. van de Graaff and the voltage multiplier of Cockroft and Walton. Examples of the second type were the linear accelerator and the cyclotron (E. O. Lawrence of Berkeley, Calif.) and its modifications—the synchrocyclotron, which extended the energy range by adjusting the period of acceleration of the ions to allow for relativity increase of mass with velocity; the cosmotron at Brookhaven National laboratory, Long Island, N.Y.; and the bevatron, the 6,000,000,000-ev acceler-

ator, at Berkeley. The betatron of D. W. Kerst (University of Illinois, Urbana), an electromagnetic induction accelerator for electrons, was successfully employed for generating electron and X-ray energies approaching 500,000,000 ev. The synchrotron of E. M. McMillan (U.S.) and V. I. Veksler (U.S.S.R.) for accelerating electrons was reaching 6 Bev in the 1960s, and for protons, 30 Bev.

From its early function of producing nuclear fuels for explosive bombs, the nuclear pile or reactor came to be used as a power reactor in which nuclear fuels (uranium and plutonium) replaced coal and oil in the production of power and as an experimental reactor in which the dense flux of neutrons was employed for producing nuclear reactions in substances exposed therein and from which neutron beams could emerge for experimental uses.

The need for detection of nuclear particles led to the development of several important tools. Basically, detection was by photographic means, as in the original discovery of radioactivity by Becquerel, or by means of ionization effects produced by penetrating radiations and swift particles, as in the case of electrometers, ionization chambers, Geiger-Müller tube counters and the Wilson cloud chamber. In the last named, a combination of photography and ionization made possible the recording of evidence of the passage of swift particles, since they leave visible paths due to fog particles formed on ions which they produce in passing.

Four significant improvements on the original cloud chamber techniques of Wilson increased the chamber's effectiveness as a research tool: the use of magnetic fields to deflect charged particles and enhance the ability to identify them as to charge and momentum; the use of Geiger-Müller counters to control the chamber so as to photograph only those events for which the "trap is set"; the introduction of sheets of absorbing material, such as lead, within the chamber to study the penetrating properties of cosmic ray particles; and the modification of the chamber to the so-called bubble chamber in which ion paths were produced in liquid hydrogen near its boiling point. The bubble chamber, by the greater density of the medium in which tracks were formed, allowed a kind of compacting of the evidence into smaller space, a feature highly desirable in studying interactions of the very short-lived mesons with matter (*see* BUBBLE CHAMBER; CLOUD CHAMBERS).

Electronic circuitry added much to the flexibility of the Geiger-Müller counter as an instrument for particle detection, inasmuch as automatic counting at high rates was made possible and the counters could be connected to detect simultaneous events (coincidence counting) or to reject such events (anticoincidence). By treating the walls of the counter with a suitable material, or by introducing a suitable gas, such as boron trifluoride, a counter could be rendered sensitive to neutrons which by themselves leave no tracks and produce no ionization. The technique of employing photographic emulsions for the detection of nuclear reactions was, in a sense, an extension of the cloud chamber, inasmuch as ion tracks were permanently registered directly in the prepared emulsion. These could be studied at leisure under the microscope, thus bringing into the space of a few millimetres or centimetres the whole history of nuclear events caused by energetic cosmic ray particles or the mutual annihilation of positive and negative particles.

See NUCLEAR INSTRUMENTS; *see* also references under "Physics: General Survey" in the Index. (R. M. SN.)

PHYSIOCRATIC SCHOOL, a school of economic thought that developed in France about the middle of the 18th century, and generally has been regarded as the first scientific school of economics. Economic policies of the European states at that time were mercantilistic (*see* MERCANTILE SYSTEM). They emphasized trade and manufacturing and the importance of precious metals and minimized agriculture. Mercantilists believed that national strength and security depended more on carefully regulated external trade than on the products of the soil. France, being less successful than England in the struggle for trade, was urged by the Physiocrats to give greater attention to agriculture and to internal tax reform.

The term "physiocracy" denotes the rule of nature, and most Physiocrats envisaged a society in which natural economic laws would prevail and in which positive law would be in harmony with natural law. They believed that a natural order ruled over man's activities and guided his destiny, and that the only real problem was to discover the natural order and then to conform to it. The natural order, they observed, was everywhere at hand; it encompassed all of man's social and economic relations; it was orderly, logical, and universally adaptable. This concept underlies the well-known Physiocratic phrase, "Laissez faire, laissez passer." In contrast with prevailing practice, the state, with its vast complex of rules and regulations, would yield to the all-pervading, harmonious rule of nature. The Physiocrats envisaged a predominantly agricultural society and attacked mercantilism because of its mass of economic regulations and because of its emphasis on manufacturing and foreign trade.

The historical background of Physiocracy, briefly stated, is that of a nation bankrupt from the extravagances of Louis XIV and Louis XV. Taxes were levied on nearly all except those who were best able to pay, the nobles and the clergy. The taxes were numerous and punitive and were especially burdensome for the peasants, who were expected not only to produce food but also to provide soldiers. The peasants were impoverished and the land was not yielding normal returns. Conditions went from bad to worse despite attempts at reform. One of the first to call attention to these conditions was Pierre le Pesant Boisguillebert (1646–1714), who urged economic and fiscal system reforms to aid the agrarian interests directly and the state indirectly. His proposals for reform were too liberal to gain acceptance, and he was exiled.

One of the great masters of military fortification under Louis XIV, Marshal Sebastien Vauban (1633–1707), having observed that wars and economic deterioration had impoverished France and left it vulnerable, called for tax reforms to reverse the impoverishment of the peasant. His views were expressed in the well-known phrase, "Poor peasant, poor kingdom; poor kingdom, poor king." He, too, was denounced and dishonoured.

The recognized founder of the Physiocratic School is François Quesnay (*q.v.*, 1694–1774), court physician to Mme de Pompadour and later to Louis XV. His first publications were in the general field of medicine. His knowledge of the circulation of the blood (discovered by William Harvey in 1616) and his belief in the creative, healing, power of nature influenced his later economic analyses. Quesnay's first economic writings, published in the *Grande Encyclopédie*, were entitled "Fermiers" (1756) and "Grains" (1757). His crowning work, and the one which set forth his views schematically, was the *Tableau économique* (1758) written when he was 64 years of age. This work demonstrated the economic relationship between an industry and agriculture and purported to prove that agriculture alone added to the nation's wealth. Quesnay feared that a wide circulation of the *Tableau* might bring about a revolution. His last work, a further development of the *Tableau*, was *Maximes Générales du Gouvernement économique d'un Royaume Agricole* (1760).

Quesnay's writings were not numerous but their influence was great. Among his earliest followers were Victor Riqueti de Mirabeau (1715–89), whose work *L'Ami des hommes ou traité sur la population* (1756) was widely read. This work was largely a plagiarism of the *Essai sur la nature du commerce en général* (1755) written by Richard Cantillon, an English banker in Paris. This work does not strictly belong to Physiocratic literature but it did create a sensation. Mirabeau later published his *Explication du Tableau économique* (1759) and in 1760 his *Théorie de l'impôt*. His last work, *Philosophie rurale* (1763), completed his publications in defense, and in explanation, of the *Tableau*.

In the next decade, the 1760s, du Pont de Nemours (1763), Mercier de la Rivière (1761), Nicolas Baudeau, G. F. le Trosne, and others of minor importance joined the group. Baudeau, who controlled the journal *Ephémérides du citoyen*, used it for disseminating the views and publications of the school. The journal was widely read and influential; copies of it were in the library of Glasgow University when Adam Smith was a professor there. It is held by scholars that Smith had read the articles in this publication dealing with the new French scheme before he visited France and before he met Quesnay.

The school was popularized by the young du Pont, who published

a collection of Quesnay's writings under the title: *La Physiocratie, ou Constitution naturelle du gouvernement le plus avantageux au genre humain* (1767). This is the origin of the term "physiocracy," from which the school took its name. The followers, however, preferred to be known as *économistes*. The term "physiocrats," which is less ambiguous, became current in the 19th century.

The Physiocratic scheme is now of only historic interest. The errors in its assumptions, as viewed by present standards, are many. Yet the *Tableau économique* was the first economic model. Despite du Pont's assurance that the *Tableau économique* is obscure only to those who lack the power of comprehension, it remains somewhat a mystery.

The basic assumption of the Physiocrats was that land, or soil, is the source of all wealth; that manufacturers, while useful and necessary, are able only to give to natural wealth or materials what is now called "form utility" and that trade and commerce give commodities a "place utility" without adding to their value. Only agriculture, the theory held, produces a clear surplus over cost, so only the soil (meaning agriculture as an industry) yields a clear net profit (*produit net*) after costs of production and seed for the next planting have been deducted. It was this clear net profit that the Physiocrats proposed to take as an *impôt unique*, or single tax, thereby removing all the other taxes that had become so burdensome to the entire French economy.

Physiocrats argued that, since only the agriculturalist was productive, all who engaged in trade, commerce, or the professions were sterile and, therefore, that agricultural products were to be sold at a *bon prix* ("good price") and manufactured products purchased by the consumer were to be at *bon marché* ("good bargain," *i.e.*, low price). The value of the net product of land was therefore to be computed not only upon the physical productivity of the land but also upon the market value of the physical product. A *bon prix* would, presumably, increase the value of the net product and thus increase national prosperity. Excessive spending on luxury goods was held to be contrary to the best interests of society and a crime against the state. Reinvestment of funds in agriculture was regarded as a productive capital outlay, but no provision was made for expenditures in the reprocessing of commodities.

Errors in the Physiocratic scheme are matched only by the obscurity of some of the fundamentals. These errors were pointed out by both contemporary critics and subsequent writers. The secretary of the Neapolitan embassy, Abbé Ferdinando Galiani (1728–87), made the theories appear ridiculous. Voltaire, who hated Mirabeau and regarded him as a scoundrel, charged him with "breathing a leper on the human race." Despite this, the scheme was tried in modified form in a few places outside France. In France it was embraced by the court at Versailles (especially by the ladies, who adopted peasant costumes for certain days in the week) but not by A. R. J. Turgot, the only minister who might have made some application of the ideas.

In current economic thought, Physiocracy remains as one of the curious schemes in the tortuous growth of economic science. The influence of the group is seen to have been far more indirect than direct. Its adherents were the first to show the interdependence of the many groups of society. They emphasized the circular flow of wealth within the economic system and offered a dynamic concept of society. The laissez-faire philosophy was a popular protest against tyrannical measures imposed by the state. The Physiocrats spurred a new awareness of the importance of agriculture and of free trade in all commodities both within and between states. Tax reforms were brought about and the importance of all classes in society received a new emphasis. Lastly, the revolutionary economic doctrines found their counterparts in the political world which, in time, led to the French Revolution. They systematized ideas, helped develop the concept of free competition, and highlighted the interdependence of all elements in the economy.

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PHYSIOGNOMY deals with psychological characteristics as related to facial features or body structure. Since many efforts to specify such relationships have been discredited, the term physiognomy commonly connotes pseudoscience or charlatanry (*see* FORTUNETELLING; PALMISTRY). While this disreputable word is scorned among scientists, there is ample evidence that a number of facial and bodily characteristics are definite correlates of psychological function. Familiar examples in medical practice include distinctive physiognomic signs observed in forms of mental deficiency, abnormal psychosexual behaviour, and emotional disturbance (*see* CRETINISM; HYDROCEPHALUS; HERMAPHRODITE; ADDISON'S DISEASE; MALNUTRITION: *Pellagra;* THYROID GLAND, DISEASES OF: *Hyperthyroidism;* MENTAL DEFICIENCY).

Aristotle wrote the earliest known systematic treatise on physiognomy; the chief basis of his work was analogical. People with facial features resembling particular animals were thought to have analogous temperaments; *e.g.*, a bulldog jaw signified tenacity.

In their time J. K. Lavater and C. Lombroso (*qq.v.*) were influential proponents of similar notions that failed to survive empirical scrutiny. For example, Sir Charles Goring published a monumental study that found the Lombrosian system of criminological physiognomy to be fallacious (*see* CRIMINOLOGY). H. L. Hollingworth summarized many experiments and found little relation between physiognomic measurements and psychological traits; D. G. Paterson in 1930 published an evaluation of studies made during the preceding 40 years which revealed a consistent trend of negative results.

Body build as a subdivision of physiognomy has persisted from the time of Hippocrates (fl. 400 B.C.), and the medical significance of differences in body build has been established. E. Kretschmer (*q.v.*) in the 1920s noted a morphological basis for psychiatric diagnosis; similar findings were reported for normal people in the 1940s by W. H. Sheldon and co-workers (*see* PERSONALITY). In neither case are the correlations sufficiently high to be especially useful in psychological diagnosis. However, physiognomic aspects of human character and personality continue slowly to yield to co-disciplinary study involving human genetics, biochemistry, and psychology. By the 1960s, for example, genetic bases had been established for mongolian idiocy (characterized by typical eyelid folds), and the syndrome of dwarfism and mental retardation known as galactosemia (*see* GENETICS, HUMAN).

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PHYSIOLOGICAL CHEMISTRY: *see* BIOCHEMISTRY.

PHYSIOLOGY (ARTICLES ON). The functions that characterize living organisms in general and the major divisions of the science devoted to their study are outlined in PHYSIOLOGY. This general survey is supplemented by PHYSIOLOGY, COMPARATIVE, which discusses the tracing of relationships between different organisms through functional similarities.

Physiology is discussed in relation to various broad fields of biology in such articles as CYTOLOGY; EMBRYOLOGY; ENDOCRINOLOGY; HISTOLOGY; NEUROLOGY, COMPARATIVE; etc. Special applications of physiology in the plant kingdom are treated in the section on physiology in BOTANY and in PLANTS AND PLANT SCIENCE: *Plant Physiology*.

Articles on bodily functions include CIRCULATION OF BLOOD; DIGESTION; HEART, COMPARATIVE PHYSIOLOGY OF; REPRODUCTION; RESPIRATION; SLEEP; etc. Also, many articles on components of the body deal with anatomy and physiology; *e.g.*, BONE; BRAIN; GASTROINTESTINAL TRACT; MUSCLE AND MUSCULAR SYSTEM; REPRODUCTIVE SYSTEM; SPINAL CORD; etc. The physiol-

ogy as well as the anatomy of old age is discussed in DEATH (BIOLOGICAL) and GERONTOLOGY AND GERIATRICS.

Hereditary aspects of physiology are treated in the context of evolution in GENETICS: *Physiological Genetics;* environmental factors in ECOLOGY, ANIMAL and PLANTS AND PLANT SCIENCE: *Plant Ecology.* Background material pertaining to both sets of factors will be found in EVOLUTION, ORGANIC; MAN, EVOLUTION OF; and SELECTION.

Nerves and other excitable tissues require a minimum stimulus for excitation, but when this is produced the response is always one of maximum individual capacity; this principle is discussed in ALL-OR-NONE LAW. Additional articles containing discussions of the physiology of sensory phenomena include HEARING; NERVE CONDUCTION; OLFACTORY SYSTEM; PAIN; SENSATION; SKIN, SENSORY FUNCTIONS OF; SMELL AND TASTE; TOUCH, SENSE OF; VISION; etc.

EMOTION includes discussions of the physiological aspects of emotional states.

All physiological processes involve the physics or chemistry of biological tissues. Sciences related to these studies are outlined in BIOCHEMISTRY and BIOPHYSICS.

Among additional articles and sections of articles contributing important insights are ANATOMY, GROSS; ANATOMY, MICROSCOPIC; ANIMAL EXPERIMENTATION; BIOLOGY: *Physiology;* MEDICAL RESEARCH: *Physiology;* and MEDICINE AND SURGERY, HISTORY OF: *The Rise of Scientific Medicine in the 19th Century.*

The work of such great exponents of the science as Galen, Bernard, Harvey, etc., is summarized in biographical articles.

Many topics not represented by separate articles are treated in articles on broad areas of biology. Also, special aspects of a subject may be discussed in several articles. For example, the all-or-none law is treated not only under that title but also in sections of CIRCULATION OF BLOOD; HEART, COMPARATIVE PHYSIOLOGY OF; and MUSCLE AND MUSCULAR SYSTEM. For comprehensive information on this or any other topic, the Index should be consulted.

PHYSIOLOGY is that branch of the study of plants and animals (biological science) which concerns itself with the ways in which these living organisms carry out the various processes necessary to life. Among biologists it is common to say that "physiology is the study of function." This is a way of saying that physiologists ask about an organism, "What makes it work?" "What does a heart (or a liver or a kidney) do and how does it do it?" "How does an amoeba move or a muscle lift a weight?" These and a multitude of other questions the physiologist asks and seeks to answer.

This article seeks merely to state in some detail what physiology is as a science, to state the problems with which a physiologist is properly concerned, to outline some of the methods by which a physiologist approaches the solution to these problems and to state in general terms the things organisms do and how they do them. No attempt is made to describe in detail the functions of individual organisms, of organs of which they are made up or of individual cells which in turn make up the organs. These are described elsewhere. *See* PHYSIOLOGY (ARTICLES ON).

Scope of Physiology.—Physiologists as a group have as objects of interest the vast variety of living organisms ranging from single-celled organisms such as bacteria, protozoa, algae, etc., through the multicellular animals and plants. Since the things done by the organism as a whole, the roles of individual organs and even the contributions made by cells or parts of cells (*e.g.*, the cell surface, the nucleus, mitochondria, etc.) may be studied, the boundaries of physiology may be said to be virtually limitless. With so many objects and processes for study it is not surprising that specialization has occurred among physiologists and that subfields bearing names indicative of the interest of the workers therein have arisen. Thus there is human physiology, which deals with functions in man, and this may be further subdivided into neurophysiology (functioning of the nervous system), cardiovascular physiology (heart and blood vessels), etc. Plant physiology and other comprehensive major fields have similar subdivisions.

Some physiologists are concerned with similarities and differences between the methods used by various organisms to solve the problems of existence. This branch is known as comparative physiology (*see* PHYSIOLOGY, COMPARATIVE). Closely allied to this is general physiology, a branch that seeks to integrate the findings of all the other branches into one coherent picture. In addition, virtually every other specialized field in the biological sciences, such as embryology, anatomy and pathology (*qq.v.*), is concerned with the physiological aspects of the phenomena of interest to it.

The above amounts to little more than naming the subdivisions of physiology. What questions and what investigations may a physiologist properly pursue? Let us take human physiology. We are conceived, we are born, we grow, live, love, beget offspring, work for a living, grow old and finally die. We have ideas and desires, converse, write books and lead an intellectual life which includes thinking about our relations to God and our fellow man. All these are things we do, but are they proper subjects for investigation by the physiologist? The answer is, "Not all of them, at least not now." The physiologist must be modest in his assault on the mysteries of nature. As stated before he asks questions such as "How does a muscle lift a weight?" "How does a kidney secrete urine?" "Why does one's heart beat faster following exercise?" Such questions are amenable to experimental investigation in that single, possibly influential factors, such as temperature, magnitude of a weight, speed of lifting, etc., can be varied and rules deduced which permit predictions about what will happen in a given set of circumstances in the future. It may ultimately be possible to predict the most complex manifestations of human behaviour from an integration of a large number of these simpler findings.

Experimental Methods of Physiology.—If a person is presented with a complex thing, how is he to go about ascertaining what it does and how it does it? One way is simply to observe it grossly and see what it does. For example, it may move spontaneously. Alternatively it may move only if kicked, shocked with electricity, heated or otherwise stimulated. If it is desired to know more about how and why it does these things, it will help to know more about the parts which go to make up the machine. Some of these may in turn be complex; for example, the engine or gear box in an automobile.

Ultimately the investigator would like to know what the smallest parts are, what role they play in the substructures and what each of these contributes to functioning of the machine as a whole. He will want to know what the fuel or energy source is for work which is done, what kind of temperatures are attained, what kind of pressures can be exerted, etc. Also he will want to know how the whole machine integrates its activities, how messages are sent by one part to another or influence otherwise exerted.

The gross observational, descriptive phase of the study of the functioning of many (but far from all) living organisms has been carried very far, including description of the major role of individual organs. Thus it is known that in man the heart is a muscular pump which causes the blood to circulate through a closed system of tubes, the blood vessels; the kidneys secrete urine; the stomach digests food; etc. Modern physiologists are more concerned with a detailed understanding of the ways in which these over-all processes are accomplished and controlled, the role of the different kinds of cells which make up the organ and the exact chemical and physical processes which contribute to the final result.

How does the physiologist go about establishing the function of a part of an organism? One obvious method is to remove the part and see what deficiency, if any, the organism suffers as a result of the removal. In some cases removal may be fatal, and the investigator cannot observe the organism long enough to learn much. Less drastically, chemical (*e.g.*, drugs) or physical (*e.g.*, clamping off a blood vessel) means of temporarily handicapping the part may be found. Still less drastically, the investigator may induce a change in the degree of a particular activity and see what organ (or part of an organ) increases or decreases its own activity in parallel with the change. In favourable instances a part may be removed and its role taken over by some mechanical device; for example, a heart may be replaced by a mechanical pump. Alterna-

tively, giving certain chemical substances to an organism may compensate for removal of an organ; *e.g.*, the hormone thyroxin may be taken by mouth to compensate for removal of the thyroid gland. Organs having several functions may require, in compensation for their removal, complex measures. Thus the giving of the hormone insulin can compensate only in part for the removal of the pancreas of an animal. The utilization of sugar may be regulated, but other measures are required to compensate for the loss of substances normally produced by the pancreas which assist in the digestion of food. In summary, much that has been learned and is being learned in physiology depends on observation of the changes which take place when the activities of the organism are disturbed.

To assist him in inducing these changes and in observing them, the physiologist uses instruments for controlling and measuring temperatures, pressures, electrical potentials and currents, acidity or alkalinity, oxygen consumption, etc. To visualize the parts he is studying he may use the unaided eye for gross structures, the ordinary microscope for cells and their parts, or the electron microscope for very small cells and the fine structure of cells. Hardly an instrument is invented for producing, measuring or recording a physical or chemical change which does not find a use in the hands of the physiologist.

Characteristics of Living Organisms.—When we look around us and see the vast variety of things which we are willing to accept as living organisms, the thing which almost invariably impresses us is their diversity of form and activity. A plant has no legs, lungs or liver. An animal has no leaves or roots. Even among those things we call "animal" there are great differences in structure and gross activity. Must there be a separate science of physiology for each kind of living thing? In detail, yes, but if we look at the broad outlines, the kinds of things organisms do, we find surprising similarities which may in a sense be taken as a definition of a living organism. Living organisms are discrete from their environment and differ from it in chemical composition. They are forced to make exchanges of materials with the environment but manage to maintain enough control over the exchange so as to retain their structure and composition. They metabolize; *i.e.*, burn or degrade some materials to obtain energy for growth, activity and repair of the living machinery. They reproduce themselves in kind, co-ordinate the activities of their various parts and manage to adjust to the nature of and changes in their environment. These characteristics are discussed more fully in the following sections. Admitting that not all living organisms at all times have all these characteristics (though exceptions are rare), we shall outline them, for it is within this context that the physiologist works.

Discontinuity From the Environment.—Living organisms are obviously different from the region which surrounds them. That is, they are made up in part of chemical compounds, such as proteins, nucleic acids, etc., which do not normally exist in this surrounding region called the environment. Furthermore the organism consists of a cell or group of cells each of which is surrounded by a membrane or cell surface. Within this cell surface the watery solution called protoplasm usually has a chemical composition quite different from the environment. This is true not only about proteins, fats, carbohydrates, etc., but even about the ions of simple salts. Some of these, such as sodium and chloride ions, though plentiful in the environment, may be virtually absent from the cell interiors. Others, such as potassium ions, may be accumulated by the cells so that the concentration inside is much greater (perhaps twentyfold) than that in the environment. The existence of organized structures and the differences in chemical composition between the organism and the environment represent work done by the organism.

It may be said that one of the characteristics of a living organism is that it exists as a discontinuity or inhomogeneity in the environment.

Exchanges With the Environment.—Mere existence as an inhomogeneity in the environment is not enough to distinguish a living organism. A lump of coal, a piece of wood or a complex machine has the same attribute. However, such inanimate things, once established, continue to exist with a given allotment of materials. Living organisms, on the other hand, maintain their structure in spite of changes in the identity of the molecules of which they are made. This requires that the organism exert control over what comes in and what goes out.

The surfaces which cover individual cells, the linings of certain organs (*e.g.*, gut, lung, kidney) and sometimes the external coverings of multicellular organisms are semipermeable. This means that they permit some substances to cross them with relatively little difficulty; other materials, usually large molecules, cannot pass the barrier. The semipermeable membranes control qualitatively the kinds of material which pass the barrier. If this were the only control exerted, those materials which could pass would tend to come to equal concentration inside and outside the organism. Only continued production or consumption of a material could maintain a concentration difference. However, there is frequently superimposed on this passive penetration of the membranes an active pumping mechanism which can move materials from a region of low concentration to one of higher concentration. This, in principle, is like pumping water uphill and requires expenditure of energy on the part of the organism.

Man and most multicellular organisms have two environments, an external environment and an internal environment. The air or water that surrounds the organism as a whole and that may penetrate into the lungs and gut constitutes the external environment, and it is with this that exchanges ultimately take place. So far as most of the cells of the body are concerned, however, they are remote from this external environment. They are surrounded by the blood and tissue fluids, and so far as such cells are concerned this *is* their environment, and they make exchanges with it. This is the internal environment of the organism.

The major places at which exchanges with the external environment occur in the case of man are the lungs, gut and kidney. The skin also participates to some extent. The lungs, gut and kidney have two characteristics in common: (1) they have a very large surface area, and (2) these surfaces are in intimate contact with the smallest branches of the blood vessels (capillaries). In the cases of the lung and kidney the large surface is achieved by many successive branchings of a tubular system. In the case of the gut, much of its wall is lined by a multitude of fine, fingerlike protrusions (villi), giving it a somewhat velvetlike surface. The small intestine alone exposes an area of about 10 sq.m. (more than five times the external body surface area), the lung 55 sq.m. of respiratory surface and the kidney about 6 sq.m. In a similar fashion other organisms provide large surfaces for exchange with the external environment; *e.g.*, gills in fishes and other aquatic organisms, leaves and roots in plants. So it may be said that a second characteristic of living organisms is that they are only semi-isolated from the environment and maintain their composition and structure in spite of the necessity for exchanges of material with the environment.

Metabolism.—The tasks of accumulating some materials and ejecting others, as well as such tasks as transporting food and wastes, moving, creating electrical potentials, growing, etc., require energy expenditure. Living organisms obtain this energy from materials called food. Food serves the dual purpose of (1) providing energy and (2) providing materials for growth (increase in mass) and maintenance or repair of the living machinery. Animals obtain energy by oxidizing food materials such as carbohydrates, fats and proteins or by breaking down molecules such as glucose into smaller ones such as lactic acid. These destructive (degradative) processes which provide energy are called catabolism. The building up of more complex molecules from simple ones (synthesis or growth) which requires energy is called anabolism. The sum total of anabolic and catabolic processes is called metabolism (*q.v.*).

The energy for anabolic processes is supplied in the case of green plants by sunlight (*see* PHOTOSYNTHESIS). A few bacteria (known as autotrophic bacteria) obtain their energy by oxidizing simple inorganic materials such as hydrogen, sulfur, iron, ammonia, etc. The rest of the living kingdom must be supplied with energy directly or indirectly by the green plants.

Living organisms, including green plants in the dark, exhibit a net excess of catabolic over anabolic processes. This is manifested in one or more of several ways: (1) consumption of oxygen, (2) production of carbon dioxide or other oxidation product (*e.g.*, sulfuric acid from sulfur), (3) production of heat, (4) consumption of food materials, (5) production of incompletely broken-down fragments of food materials. If there is an excess of food over and above that needed for maintenance and activity, then growth or fat deposition will occur. Chemical and physical methods of measuring these changes are used by the physiologist to establish the rate of metabolism.

It is well established that a given quantity of food burned in the body produces the same amount of heat as if it had been burned outside. A piece of bread burned by a chemist using a calorimeter produces the same number of calories as it would if it had been eaten and burned in the body. Further, the amounts of oxygen consumed and carbon dioxide produced are the same in both cases.

One common misconception regarding the results of metabolism of living organisms should be disposed of. This has to do with their anabolic accomplishments. Living organisms synthesize large molecules of bewildering complexity from simple materials. In this they superficially oppose the general tendency of the inanimate world to convert complex things into simple ones, indeed to convert any thing or condition from a high energy state to a lower energy state.

The point which must not be overlooked, however, is that while living organisms are carrying out these marvelous, energy-consuming syntheses, they are simultaneously degrading other food materials to obtain the requisite energy. Indeed, in growth as in other work processes the efficiency with which living organisms capture and use the energy theoretically available from the foodstuffs they degrade is usually less than 25% and may be less than 5%. Even in the animate world it has yet to be demonstrated that something can be got for nothing.

Elucidation of the precise details of the chemical reactions involved in metabolism lies in the province of biochemistry (*q.v.*). The physiologist, however, must keep abreast of biochemical findings and integrate them into the over-all picture of the functioning of living organisms. Fortunately it appears that not only the different tissues of a given organism, but virtually all organisms that have been studied, employ much the same over-all schemes of metabolism. Thus the chain of reactions by which a yeast cell breaks down glucose to two molecules of ethyl alcohol is, except for the final few steps, the same as that used by a muscle cell in man to prepare the fragments of glucose for oxidation. Particular organisms or cell types may be capable of carrying out reactions unique to them—such as production of a hormone, a bacterial toxin or an enzyme; but this usually represents only a small fraction of their total metabolic effort and is of interest only in special connections.

While the biochemist studies the individual intermediary chemical reactions of anabolism and catabolism, frequently isolating single enzyme systems which perform only one chemical step, the physiologist is more likely to study the grosser manifestations of metabolism, such as total oxygen consumed by an organism, the carbon dioxide produced, the amount of heat produced, the weight gained or lost by an individual, the nitrogen excreted, etc. The effect of various activities such as sleeping, sitting at a desk and thinking, walking, doing hard physical labour, etc., on metabolism may be studied as well as disturbances of metabolism caused by diseases or the malfunction of an endocrine gland. An attempt is then made to interpret the findings in terms of known biochemical reactions.

Internal Co-ordination of the Organism.—A living organism consisting of many parts which may be physically remote from each other would not long survive if the activities of these parts were not co-ordinated. The price of specialization is dependence on others for performance of activities given up. The gain, if all goes well, is in terms of increased versatility, efficiency, power and elegance of performance for the organism as a whole. For all to go well there must be communication between parts, some means of delivering goods and messages. This is particularly true when the demands for material or service vary from time to time. The mechanisms by which living organisms accomplish this internal co-ordination of their parts are three: (1) a transport system, the circulatory system, which brings some materials to individual cells and carries away others, (2) a system of organs, the endocrine system, which sends chemical messengers (hormones) via the circulatory system to the various parts, and (3) a nervous system, which rapidly carries electrical (and, terminally, chemical) messages from one part to another.

Only in the smallest organisms and individual cells are the distances which separate the parts short enough to permit the random movements of molecules to transport materials and to equalize temperatures. Even in small cells (*e.g.*, protozoa, individual plant cells) a sort of internal stirring of the cytoplasm is resorted to, and a cyclic current in the protoplasm (cyclosis) serves as a primitive transport system. Larger organisms speed up the process of transport by means of a circulatory system. In animals this typically consists of a muscular pumping organ, the heart, which forces a fluid through a system of ramifying tubes whose terminal branches lie in close proximity to the individual body cells. In plants, vascular bundles carry materials between roots, leaves and other tissues. Typically, in both plants and animals, the tubes of the circulatory system are separated from the body cells by the tissue fluid which surrounds cells. Materials move largely by diffusion from the cells to the tissue fluid to the circulating fluid and in the opposite order. The tissue fluid is specifically what was called above the internal environment; *i.e.*, the environment of the individual body cells.

Circulatory systems carry materials from regions where they are in large supply to regions where they are to be (1) immediately utilized, (2) stored or (3) eliminated. Thus oxygen may be picked up from lungs, gills or skin in various organisms. Food is picked up from the gut following digestion or from storage depots such as the liver (carbohydrate) or subcutaneous tissue (fat). These are delivered to the tissues. Conversely the wastes of metabolism are picked up from the tissues and delivered to the lung (carbon dioxide) or kidney (urea and various materials) for elimination. Temperature throughout the body is equalized and controlled by the blood's being warmed in rapidly metabolizing tissues and cooled at the body surface or by less rapidly metabolizing tissues.

In addition to food and wastes the circulatory system carries the chemical messengers called hormones throughout the body. These are produced in endocrine glands (also called ductless glands or glands of internal secretion) or, in some cases, by cells located in organs primarily devoted to other tasks. These hormones induce a new state of activity in some other tissue or organ. Depending on the nature of the hormone and on the nature of the receptor tissue, activity may be either stimulated or inhibited. Indeed a single hormone may cause opposite reactions in two different regions. Thus epinephrine (adrenaline) causes constriction of the blood vessels of the skin and viscera while causing dilation of the blood vessels in the muscles. Since epinephrine is secreted in times of stress, the net result is to shift blood from tissues where it can be temporarily dispensed with to the tissues which may need an unusually great supply. The organism is prepared for "fight or flight."

Hormones function in communication within the organism when time, in terms of a fraction of a second, is of no great importance. Thus the growth hormone secreted by the pituitary gland may as well accomplish its work a few hours from now as immediately. Contrast this with the speed required when a person touches a hot stove. Thousandths of a second are important, and, as seen below, the faster-communicating nervous system comes into use. On the other hand, the hormones can induce a long-continued response which, if the nervous system were required to produce it, would call for long-continued, repetitive stimulation.

Finally, with regard to hormonal control of bodily activities, there exists what has been called push-pull control. By this is meant that one hormone stimulates while another inhibits the activity of a tissue. This principle also is involved in the nervous system. The advantage gained is that of more precise and deli-

cate control of activity. An automobile is equipped with both an accelerator and brakes to attain a similar advantage. Better speed control is obtained than would be possible with either alone.

Control by hormones has been compared with sending letters through the postal system; that is, a message involving a material thing is sent and goes relatively slowly. The nervous system might by similar analogy be compared with a telephone or telegraph system. Messages involving electrical transmission along specifically designed conducting strands are transmitted rapidly from point to specific point. These analogies will not hold up in detail, but they are grossly accurate. While it is true that an electrical impulse travels along a nerve fibre, at the terminus the final stimulation of the cell to be affected is probably accomplished by release of a chemical. However they do it, nerves can carry messages several feet in a few thousandths of a second, whereas (in man) one complete circuit of the blood may require a minute. Thus hormonal messages, even if the hormone were instantaneously secreted, are bound to travel more slowly.

Most of the internal co-ordination in man and the higher vertebrates is accomplished by that part of the nervous system known as the autonomic nervous system. This system is autonomous in the sense that it is not under the control of the will. Indeed we are not conscious of its activities. However, our emotions may affect the autonomic nervous system, causing dilatation or constriction of the blood vessels, acceleration or deceleration of the heart, secretion of hormones, etc. The autonomic system sends both stimulatory and inhibitory nerve fibres to many organs, thus providing for push-pull action and greater delicacy of control.

Homeostasis.—One of the achievements of the internal co-ordination of organisms is the maintenance of homeostasis; that is, a considerable constancy of conditions within the body. The mechanisms whereby constancy is maintained are called homeostatic mechanisms.

Many conditions in the body are so constant that minor departures from the normal can be used in the diagnosis of disease, at least if they persist. Thus (in man), the body temperature, and in the blood the amount of sugar, the slight alkalinity, the concentration of various salts, the number of red or white cells, etc., are constant or vary only within narrow limits. By and large, it is the internal environment which is kept constant. Indirectly the individual body cells are thus helped to have a constant composition and level of activity or, at least, to return quickly to normal if temporarily altered. Those who care to pursue the matter further should keep homeostasis in mind, particularly when reading about respiration, circulation, kidney function, endocrine organs and the nervous system.

Co-ordination With the Environment.—In addition to co-ordinating itself internally, an organism must adjust its activities in such a way as to take into account the nature of and changes in its environment. This involves the ability to sense the nature of the environment and detect changes in it. In some less specialized organisms this ability seems to be simply a general property of the individual cell, although even here there may be localized regions of the cell which are particularly sensitive to given stimuli (*e.g.*, the light-sensitive regions in some protozoa). More specialized organisms have certain cells or groups of cells which are exquisitely sensitive to one or another kind of stimulus (eyes to light, ears to sound, etc.). These are called organs of special sense and along with the nervous system provide for co-ordination with the environment.

The kinds of influences in the environment which serve as signals to an organism may be classified roughly as light, mechanical vibrations, pressure, temperature and chemical constitution of the environment. All the organs sensitive to these environmental factors are of necessity located at or are in direct proximity to the surface of the body. In more highly developed animal organisms many of them are localized in the head region and their nervous connections go directly to the brain. This is particularly true of the organs of sight, hearing, taste and smell. Others, such as the end organs sensitive to touch, heat, cold and pressure, are rather diffusely distributed over the body surface.

The organs of special sense communicate by means of sensory or afferent nerves with the central nervous system (brain or spinal cord). From the central nervous system, motor or efferent nerves carry messages to effector organs such as muscles or glands, which respond by contracting or secreting. What happens in the central nervous system between the time of entry of the sensory nerve impulse and the exit of the motor impulse may be reasonably simple or bafflingly complex. When the spinal cord, and not the brain, is involved, the simplest arrangement is to have the sensory neuron connect directly in the cord with the motor neuron. Such a series—receptor, sensory neuron, motor neuron and effector—constitutes the basic reflex arc. Commonly one or more neurons are interposed between the sensory and motor ones. Such reflex arcs with connections made at the cord level provide for quickly withdrawing a finger which touches a hot stove and other quick reactions. There is no time to think and no thought is necessary. Beyond the simple reflex, increasing degrees of complexity are found. Transmission of impulses up and down the cord and integrating actions of the brain involving large numbers of neurons occur. For a detailed description of these *see* BRAIN; NERVE; and SPINAL CORD.

Adaptation and Adaptive Amplification.—Seemingly opposed to homeostasis, discussed above, are the phenomena of adaptation. These consist of all the changes in position, activity and structure which an organism undergoes so that it can better survive. An animal may grow a heavier coat of fur in winter and shed it in the summer. A man, in adapting to winter, may eat more and become more active, thus producing more heat. Another animal may hibernate, changing the whole level of its metabolism. Of course there are limits to the stress which can be compensated for. Under extreme conditions an organism may be forced to alter its environment (*e.g.*, by building shelters or building a fire) or to remove itself to a new and more favourable environment.

Adaptations are made not only to external situations but to changes within the organism. If one kidney is lost, the other enlarges so as to do the work of two. Similarly, the heart may enlarge in response to a work load. These compensatory hypertrophies are adaptive and their value is obvious. One way of looking at adaptation is to think of it as subserving homeostasis along with the general welfare of the organism. Some structures and activities change in order to maintain others constant.

One of the most distinguishing characteristics of living organisms is their capacity for adaptive amplification. By this is meant their capacity to expend a great deal of energy for an adaptive reaction in response to a small stimulus. Thus a small amount of light falling on the eye or a few sound waves striking the ear of a man may warn him of danger and call for a long-continued response requiring many times the energy put in by the stimulus. *See* also references under "Physiology" in the Index.

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PHYSIOLOGY, COMPARATIVE. The subject of physiology falls into three areas: (1) the physiology of specific organisms, as human (mammalian) physiology, which is important in medicine; insect physiology, plant physiology and similar specialities; (2) general physiology, which is essentially the physics and chemistry of processes common to cells and tissues of most organisms; and (3) comparative physiology, which is distinguished by using kind of organism as one of its experimental variables; for example, comparing the same function in different phyla of animals (most comparative physiologists deal more with animals than plants).

Introduction.—The primary goal of comparative physiology is to learn how different kinds of organisms solve their life problems and thus to learn what functions are common to many kinds of organism and which ones are restricted to specific groups. From such an analysis, biological generalizations are reached that differ from those of general or special-group physiology.

A second goal is to find organisms that are most ideally suited for study of important general functions; for example, the giant nerve fibres of the squid have been exceptionally good for the study of the nature of the nerve impulse.

A third goal of comparative physiology is to study physiological adaptations as related to environmental stresses and thus to account for the distribution of organisms in nature; this is the area of physiological ecology.

Finally, comparative physiology is useful in showing the functional bases for: (1) phylogenetic relations of higher taxonomic groups, phyla and classes; and (2) the adaptations that are effective in establishment of species; that is, the physiological aspects of evolution.

Study of the comparative morphology of both adult and embryo animals formed the basis of animal classification and phylogeny during the first 75 years after Charles Darwin's death, but morphology was considerably supplemented and extended by comparative physiology and biochemistry. The fields of morphology and physiology found a common meeting ground in the molecular organization of cells.

Physiological characters are as definitely determined genetically as are structural characters. When physiological differences in response to an environmental stress are detected among closely related animals (or even among several populations of the same species), it is possible to ascertain, by acclimatization to an altered environment in the direction of the stress, whether such differences are genetically determined or are merely induced by the kinds of environment to which the animals have been exposed.

Maintenance of Water Balance.—All animals must maintain a proper water balance; the problem is different for animals living in the desert, in moist air, in fresh water, in the sea and in salt lakes. In many marine invertebrates the total concentration of all solutes in the blood (osmotic concentration) is the same as that in the sea. Marine bony fish, in contrast, must continually excrete quantities of salts to keep their blood more dilute than their environment. For animals to colonize estuaries and other brackish waters they must maintain their blood more concentrated than the water, often by active absorption of salts. All freshwater animals have mechanisms for excreting excess water which tends to diffuse into their more concentrated blood. Land animals have various mechanisms for limiting evaporative loss and urinary loss of water.

Availability of water also tends to correlate with the kind of nitrogen wastes that the animal excretes: aquatic animals excrete mainly ammonia; amphibians and land animals with ample water excrete urea; other land animals, many of which live chiefly in a dry environment, as insects, snakes and birds, excrete uric acid.

Related to water as a limiting factor for life is the concentration of specific salts; animals tend to use some elements and to exclude others. Potassium and sodium, for example, are handled very differently by most animals and have different effects on active tissues. Marine animals tend to select sodium, potassium and chloride ions and to exclude magnesium and sulfate. Some elements not much used by living things are concentrated by a few kinds of animals; for example, vanadium by some sea squirts or tunicates. Knowledge of water and salt economy as related to environmental stress was given considerable impetus by the Danish comparative physiologist August Krogh in his work on osmotic regulation.

Availability of Oxygen.—Another important environmental component is oxygen; various means exist for obtaining adequate amounts of it. Small or sluggish animals such as protozoans or jellyfish can rely simply on diffusion of dissolved oxygen; large active animals either have tubes for taking oxygen directly to the tissues (insects), or have respiratory pigments in their blood, as hemoglobin (vertebrates, some worms) and hemocyanin (some crustaceans and mollusks). Sensitivity to oxygen deprivation differs markedly; some mollusks and parasitic worms survive long periods without oxygen; diving mammals are adapted to longer deprivation than nondivers; while squid and fast-swimming fish die within seconds when their oxygen supply is shut off.

Ability to survive in low oxygen depends partly on biochemical adaptations and partly on favourable mechanisms for external respiration (breathing). Metabolic enzymes by which energy is made available are remarkably similar for all animals, but some, such as parasitic worms, can rely more on nonoxidative pathways than can animals that depend more on oxygen.

Birds and mammals living at high altitudes have more hemoglobin in their blood than do those living at sea level. In general, small animals have higher rates of metabolism than large ones; *i.e.*, mice consume more oxygen per gram than elephants. Hemoglobin has appeared several times in the course of evolution. The foundations of modern comparative thinking on oxygen and carbon dioxide transport in animals were laid by the British physiologist Sir Joseph Barcroft. (*See* also RESPIRATION.)

Body Temperature.—Most animals are at the temperature of their environment (are poikilothermic or cold-blooded), while birds and mammals regulate their body temperature with fair constancy (are homoiothermic or warm-blooded). A few, such as hibernating mammals, may shift from lack of regulation to regulation at different times. Temperature regulation includes chemical means of heat production and physical mechanisms controlling heat loss; arctic mammals differ from temperate ones primarily in insulation. Actually many poikilotherms adapt their activity so that they are not wholly dependent upon the environmental temperature. Arctic marine animals such as fish are more active metabolically at a given temperature than are similar fish from warmer waters. Many insects perceive and move into a preferred temperature. The cellular mechanisms by which temperature and similar environmental factors elicit adaptive changes in an animal remain largely unexplained. (*See* ANIMAL HEAT.)

Cold-blooded animals are extensively used for the study of various physiological properties because of the greater ease of experimentation when tissues need not be maintained at a high constant temperature.

Nutrition.—Nutritional patterns differ greatly, from the flagellate protozoans, which combine characteristics of both plants and animals and can either carry out photosynthesis or subsist on relatively simple organic compounds, to most other animals, which require complex foods. It is of interest that the essential amino acids are similar for a wide range of animals. The ability to synthesize vitamins diminished as animals became dependent on complex food sources; in fact the most important biochemical evolution occurred before the appearance of "higher" organisms. A few higher animals, particularly insects, have acquired specialized digestive chemical mechanisms for such foods as wool, beeswax and cellulose. Digestion of protein by pepsin is restricted to vertebrates, whereas protein digestion by trypsin (as in man's intestine) is found throughout the animal kingdom. Thus nutrition and digestion (*qq.v.*) provide examples of general functions, common to many animals, and of restricted ones; digestive enzymes also differ according to the nature of the diet.

Effectors.—An important area of comparative physiology deals with effector organs. Animal movement may be by protoplasmic flow, as in amoeboid movement, or by ciliary beat, but most commonly it is by muscular contraction. Muscles range in speed from the very fast eye muscles of a mammal and the fast flight muscles of bees and flies through ordinary postural muscles used in walking and swimming to the slow muscles of visceral organs and the holding muscles of clams and oysters. A variety of physiological and biochemical adaptations are recognized, but the explanation of the time range in muscular contraction of different animals is far from complete. (*See* also MUSCLE AND MUSCULAR SYSTEM.)

Other important effectors are specialized electric generating tissues (electric organs), colour cells or chromatophores and organs of bioluminescence; colour change produced by pigment movement in chromatophores may be controlled by endocrines (crustaceans and frogs) or by nerves (squids and many fish). (*See* ANI-

MAL COLORATION; BIOLUMINESCENCE.)

An instance of the value to other areas of science of comparative studies in physiology is illustrated by the work on the biochemistry of muscle as developed particularly by E. Baldwin and J. Needham: this work supports the idea that echinoderms are more closely related to chordates than to other invertebrate phyla.

Circulatory and Hormonal Systems.—Systems for the circulation of blood may be either open or closed. Open systems, as found in many mollusks and arthropods, lack capillaries to connect arteries with veins and have blood sinuses instead; open systems operate with larger blood volumes and at lower pressures than closed systems. (*See* CIRCULATORY SYSTEM.)

The comparative physiology of endocrine glands is a complex subject, and the endocrine secretions of many invertebrates remain to be identified. In general, hormones concerned with specific functions appear to be chemically different in different phyla. Study of the hormones of metamorphosis in insects has contributed to an understanding of the cellular action of hormones in general. (*See* ENDOCRINOLOGY; HORMONES, VERTEBRATE.)

Sense Organs and Behaviour.—In few areas of comparative physiology is the principle of levels of complexity as clear as in animal behaviour and its control by sense organs and nervous systems. In sensitivity to light, for example, there is general protoplasmic sensitivity in some protozoans, special photoreceptors that are merely intensity detectors in many worms, complex compound eyes in insects and camera eyes in vertebrates and the highest mollusks (squid and octopus), which provide for pattern and colour vision. Visual pigments determine to some extent the spectral sensitivity of different eyes, but the number of kinds of such pigments appears to be definitely limited.

Sense organs for mechanical and chemical stimuli are widely distributed and may operate on different principles for the same sense in different animals; comparative studies have led to discovery of sense organs of types not known in man; for example, humidity receptors in insects. (*See* also NERVOUS SYSTEM.)

Behavioural responses may simply be direct and stereotyped, may be variable within narrow limits or may be highly modifiable according to experience and competing stimuli. Simple behaviour of animals, sometimes called "forced response," was well analyzed by J. Loeb, S. O. Mast, and others during the 1930s, but attempts to understand complex behaviour met with little success; after 1945 a resurgence of interest in animal behaviour occurred. In some animals, such as insects, innate or stereotyped behaviour is dominant over learned behaviour as found in higher vertebrates, but the neurological basis for these differences is unknown. Nervous systems present an interesting sequence from the diffuse nerve nets of jellyfish through segmental central nervous systems as in some worms and arthropods, local reflex centres, headward centres or "brains" and highly integrative centres which have no direct sensory or motor connections. Comparative physiologists have provided important experimental material for the study of nerve impulses and of transmission between neurons in central nervous systems. (*See* also NEUROLOGY, COMPARATIVE; ANIMAL BEHAVIOUR.)

Reproduction.—In the field of reproduction comparative physiology merges with embryology and genetics (*qq.v.*). Study of marine eggs, for example, has contributed to an understanding of processes of fertilization, cell division and embryonic differentiation. No other animal has been as useful in genetics as the fruit fly, *Drosophila*. Also the study of the development of various functions in embryos permits a kind of understanding not possible when adult animals only are used. (*See* EMBRYOLOGY, EXPERIMENTAL.)

Cellular Physiology.—Ultimate explanation of biological function appears most probable by pursuit of cellular physiology, or experimental cytology, and comparative physiologists become cellular physiologists when their experimental material is favourable for understanding some cell function. Comparative study of different cell and tissue types within the same animal is an important approach to basic cell function. (*See* also CYTOLOGY.)

Application.—The preceding examples show that comparative physiology is fundamental in describing the nature of vital processes in various animals. In addition, it has practical applications in describing the physiology of economically important animals such as domesticated birds and mammals, parasitic worms, harmful insects and edible fish. Since the ocean supports animals in large variety and numbers, many comparative physiologists work at marine laboratories such as those at Woods Hole, Mass.; Plymouth, Eng.; and Naples, Italy. For the ecologist, comparative physiology provides a basis for understanding the restriction of plants and animals to particular habitats. For the medical physiologists, the comparative viewpoint is important for placing man in his proper biological perspective.

See also ECOLOGY, ANIMAL; PSYCHOLOGY, COMPARATIVE, and references under "Physiology, Comparative" in the Index.

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(C. L. PR.; X.)

PIACENZA (Latin PLACENTIA), a town and episcopal see of Emilia-Romagna, Italy, capital of the province of Piacenza, lies 42 mi. SE of Milan by rail. Pop. (1961) 91,364 (commune). It is near the head of the Plain of Lombardy, 217 ft. above sea level, on the south bank of the Po (an important crossing of which it controls), just below the confluence of the Trebbia. It is still largely surrounded by its 16th-century walls, an oval circuit of four miles.

No Roman monuments survive, but the rectangular street plan in the centre of the town is Roman. The cathedral (1122–1233) is a fine example of the Lombard Romanesque style, built in brick; the campanile (1341) is 223 ft. high. Other noteworthy medieval churches are the former cathedral of S. Antonino, incorporating elements of 1014 (facade) and of the 13th and 14th centuries; S. Savino, rebuilt in 1107 and restored in 1902, with unusual 12th-century floor mosaics; and S. Francesco, a Gothic building begun in 1278. S. Sisto (1499–1511) and Sta. Maria di Campagna (1522–28) are handsome Renaissance buildings, by the local architect Alessio Tramello. S. Sisto once contained Raphael's Sistine Madonna, sold in 1754 to Frederick Augustus III of Saxony. The Palazzo del Comune, begun in 1280, is a late example of a common 12th-century form. The grandiose Palazzo Farnese, begun for Margaret of Austria in 1558, was never fully completed. Beside it are the remains of the earlier Visconti Castle.

Piacenza is on the main Milan-Bologna railway and is a road centre, served by the Autostrada del Sole. A long-established centre for cereal growing and viticulture, the town has a number of rapidly developing light industries (chemicals, office furniture, buttons).

Placentia was founded as a Roman colony in 218 B.C. and in the same year afforded protection to the remains of the Roman army after the Battle of the Trebbia (*q.v.*). In 207 it withstood a siege by Hasdrubal and in 200 it was sacked by the Gauls. Restored and reinforced, in 187 it became the terminal of the great arterial road, the Via Aemilia, linking it with Ariminum (Rimini), and later the centre of other major Roman roads.

Medieval Piacenza was a leading city of the Lombard League, and despite many political vicissitudes prospered from its control of road and river traffic. A long period of struggle between the Visconti and Sforza families, alternating with periods of papal and of French rule, was concluded in 1545 by the creation of the hereditary duchy of Parma and Piacenza, established by Pope Paul III for his son Pier Luigi Farnese. For the subsequent history of Piacenza until 1860, *see* PARMA AND PIACENZA, DUCHIES OF.

(J. B. W.-P.)

PIACENZA PROVINCE has an area of 1,000 sq.mi. and a population (1961) of 258,947. It extends from the Ligurian Apennines to the Po River, and is largely mountainous. The province is drained by the Trebbia, Nure, Arda, Tidone, and Chiavenna rivers. Along with Parma Province it produces most of the petroleum in Italy, with wells at Cortemaggiore, Velleia, and Montechino. Ferriere has iron and copper mining; Piacenza and Fiorenzuola d' Arda have manufacturing. Agricultural products include cereals, grapes, tomatoes, sugar beets, and tobacco; and there is livestock raising.

PIAGET, JEAN (1896–), Swiss psychologist, a leading investigator of thought processes among children, was born in Neuchâtel on Aug. 9, 1896. At the age of 10 he published an article on an albino sparrow, and his writings on mollusks made his name known to specialists in other countries soon after he was 15. He studied biology at the University of Neuchâtel, obtaining a doctorate in science in 1918. This biological training, coupled with an intense interest in epistemology and logic, led him finally to psychology. In 1921 he was appointed director of studies at the Institut J. J. Rousseau in Geneva; he became a professor at the University of Geneva in 1929, and later also held chairs at the universities of Neuchâtel, Lausanne and Paris.

The most distinctive feature of Piaget's contribution to experimental psychology is his developmental or genetic approach. His system sees cognitive development as a gradual advance toward more thorough and intelligent adaptation to the environment, marked by more complete equilibrium among psychological processes. Perception is fraught with illusion, instability and distortion which the child tempers by systematically collating information obtained from different points of view. A much higher degree of consistency and objectivity, combined with flexibility, is afforded by the gradual acquisition of logical thinking, culminating in the scientific and formal reasoning of which the adolescent is capable. The symbolic operations that participate in thought are derived from concrete interactions with objects.

Much of Piaget's work, originally published in French, has been made available in English, including: *Judgment and Reasoning in the Child* (1952), *The Moral Judgment of the Child* (1948), *The Construction of Reality in the Child* (1954), *The Origins of Intelligence in Children* (1952), *Language and Thought of the Child*, 3rd ed. rev. (1959), *The Child's Conception of Geometry* (1960). He collaborated with B. Inhelder to write *The Growth of Logical Thinking from Childhood to Adolescence* (1958) and *The Early Growth of Logic in the Child* (1964).

See D. E. Berlyne, "Recent Developments in Piaget's Work," *Brit. J. Educ. Psychol.* (1957); J. M. Hunt, *Intelligence and Experience* (1961), for an analysis of Piaget's contributions. (D. E. Be.; B. In.)

PIANOFORTE, a keyboard instrument in which the sound is produced by the action of hammers striking a series of strings stretched across a resonating soundboard. Though early makers adopted the form of the harpsichord and clavichord, the principle of pianoforte tone production really derives from the dulcimer, in which the strings are struck with hammers held in the hand.

The invention of the pianoforte may be attributed to three factors: (1) the desire to make the harpsichord "expressive"; (2) the desire to make the clavichord louder; and (3) the wish to mechanize the dulcimer by bringing it under the control of a keyboard.

The name of the pianoforte (meaning literally "soft-loud") derives from its ability to produce gradations of volume by act of touch. In mid-18th-century England it somewhat confusingly began life as a *fortepiano*, but the name was changed to "pianoforte" toward the end of the century. The modern abbreviation "piano" will be used throughout the rest of this article.

HISTORY UNTIL ABOUT 1800

Invention and Early Development.—Credit for priority of invention has been much disputed, but there is little doubt that it belongs to Bartolommeo Cristofori (1655–1731), who devised his *gravecembalo col piano e forte* in Florence about 1709. This was not the first instrument using keyboard striking action: the *dulce melos* described by Henri Arnault of Zwolle in about 1440 and an instrument said to be dated 1610, in the Belle Skinner Collection, Holyoke, Mass., are early examples of the piano principle. Not long after Cristofori's first piano, independent inventions were demonstrated by Jean Marius in France and C. G. Schröter in Germany, the latter being inspired by the accomplished dulcimer playing of Pantaleon Hebenstreit. But these were inferior to Cristofori's invention. By 1726 Cristofori had arrived at all the essentials of the modern piano action: escapement, check, dampers, and *una corda* mechanism (all of which will be explained later). It is from Cristofori that the modern piano stems. His instruments, however, suffered from an inherent defect. The frames were not strong enough to carry the string tension needed to give full musical effect to the blow the action was able to impart. Not until the 19th-century development of metal bracing, leading to the full metal frame, were the potentialities of Cristofori's remarkable action fully realized. Three of Cristofori's grand pianos have survived: the oldest, dated 1720, is in the Metropolitan Museum of Art, New York.

Cristofori's work received little recognition in his lifetime. In 1732, the year after his death, there appeared 12 sonatas for *cimbalo di piano e forte* by Lodovico Giustini—the first music published specifically for the new instrument; they were published in facsimile in 1933, edited by R. E. M. Harding. It is surprising that, despite the fact that Italy was the birthplace of the new "expressive" music during the 16th century, the piano attracted no Italian composers of greater distinction. It would certainly be wrong to suppose that the developed Cristofori piano was incapable of satisfying a sensitive performer. On the evidence of the New York example his instruments had a surprisingly wide dynamic range, a light, shallow, and sensitive touch, and a balance between treble and bass that was better than many 18th-century English pianos. Domenico Scarlatti had access to several Italian pianos, however, and the style of some of his sonatas suggests that he may have been the first eminent composer to take account of the new instrument.

As Italy abandoned the piano it was quickly taken up in Germany. A description of Cristofori's early mechanism by Scipione Maffei was published in Hamburg in 1725. This, and probably the immigration of Italian workmen, led to the adoption of the Cristofori grand action by the German organ builder Gottfried Silbermann in 1726. Silbermann's pianos were criticized by J. S. Bach for their weak trebles and deep, heavy touch; but by 1745 they had improved sufficiently to gain Bach's approval. But during the period *c.* 1740–*c.* 1770 German development was largely in the rectangular or "square" form of the instrument. This derived from the clavichord, the domestic instrument invariably preferred to the wing-shaped harpsichord by German music lovers, for whom the new grand piano was too large, expensive, and heavy of touch. Endeavours to make an action smaller, lighter, and cheaper than the Cristofori grand type resulted in a square piano action of comparatively crude craftsmanship and limited musical effect. The invention of the square has been attributed to Gottfried Silbermann's pupil, Christian Ernst Friederici (1709–80); but the earliest known example, dated 1742, is by Johann Söcher.

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART, N.Y., THE CROSBY BROWN COLLECTION OF MUSICAL INSTRUMENTS, 1889

DOUBLE-ACTION PIANOFORTE BY BARTOLOMMEO CRISTOFORI, 1720

BY COURTESY OF THE VICTORIA AND ALBERT MUSEUM, LONDON

SQUARE PIANOFORTE BY JOHANN CHRISTOPH ZUMPE, 1767

About 1760 a dozen German piano makers, jobless because of the Seven Years' War, settled in London, bringing with them the Cristofori tradition. Among them probably was Johann Christoph Zumpe, a pupil of Silbermann's, who entered the London factory of the Swiss harpsichord maker Burkhard Tschudi (or Shudi, 1702–73), founder of John Broadwood and Sons, Limited, which became the leading firm of piano makers. Thereafter England became the centre of piano development. Zumpe became exclusively concerned with the manufacture of square pianos. These were immensely popular. As the harpsichord was the prevalent English domestic instrument, the horizontal grand piano also found favour, and this was fitted with action on the Cristofori principle, which achieved such fame that it became known as the "English action."

Of the early composers for the piano, C. P. E. Bach continued to prefer the more delicately expressive clavichord; but in his *Versuch über die wahre Art das Klavier Zu spielen* (1753, 1762) he mentions his endeavour "to play the pianoforte, despite its deficiency in sustaining tone, as much as possible in a singing manner —this is by no means an easy task, if we desire not to leave the ear empty, or to disturb the noble simplicity of the *cantabile* by too much noise." J. C. Bach, however, played the piano by choice and was largely responsible for popularizing it in England, where he gave the first public piano recital on a Zumpe square in 1768. But both these sons of J. S. Bach lived in a period of transition. It was left to Mozart and Muzio Clementi to develop an exclusively pianistic style of playing and composing; and by 1780 the piano had become fully established as the foremost of the keyboard instruments.

The piano first reached maturity, however, not with the English action but with a fundamentally different mechanism—the "German" or "Viennese" action. Invented, probably by Johann Andreas Stein (1728–92) about 1770, the important feature of this action was the application of an escapement to the *Prellmechanik*, a primitive form of square piano action which had in turn evolved from the clavichord. In Stein's grand pianos the frame and stringing were for the first time well matched to the action. The light hammers gave a blow which the strings could sustain, resulting in a singing tone of considerable charm. In the English grands the comparatively powerful and sonorous bass tends to overpower the trebles, which incline toward hardness in an attempt to keep up the power. The English touch was heavier and deeper than the Viennese, and repetition was not so good, or at least was harder to achieve. But with Stein's instruments the trebles were well matched to the bass, and the touch was light and shallow, approaching the clavichord in sensitivity. It is hard to escape the conclusion that Stein was seeking to achieve a louder clavichord whereas members of the Cristofori-English school were thinking in terms of an expressive harpsichord. Herein lies the fundamental difference between the two schools.

Mozart first played a Stein piano in 1777, and he wrote to his father extolling the excellence of damping, equality of tone, and the importance of the escapement in avoiding "blocking": "not one in an hundred makers bothers with escapement, and yet, without it, it is absolutely impossible for a note not to jingle or continue vibrating after being struck." The Viennese pianos were perfectly suited to Mozart's style of playing—singing tone, a quiet steady hand, and smoothness of execution in which passage-work "flowed like oil."

Clementi became known as the "father of the pianoforte." His influence in popularizing the instrument and systematizing its technique was considerable, particularly in England, where he eventually settled and became engaged in piano manufacture. His sonatas, op. 2 (1773), are considered to be the first music entirely suitable for the piano, and his *Gradus ad Parnassum* (1817) was the first piano instruction book. Clementi preferred the English pianos with their greater power and sonority.

Thus, by 1780 there were two fully established schools of piano making, each with its own virtues. Each developed an individual style and technique determined by the nature of the instrument: the Viennese being suited best to lightness, rapidity, and elegance; the English to larger musical forms and brilliance of execution.

The Viennese school culminated with Johann Hummel, Mozart's favourite pupil and probably the greatest virtuoso of the day. Even when virtuoso technique had outstripped the Viennese action some players continued to prefer it, and it was made by Bösendorfer for their cheaper instruments as late as 1914. But while the then-imperfect English piano was to improve by further development, the already perfected Viennese instrument deteriorated by it. The mature Viennese piano of the 1770s remains the ideal instrument for authentic Mozart performance. On any modern piano his music must be scaled down in volume if it is not to sound intolerable. But on a Stein it can be rendered life-size with the full resources of the instrument and with a lightness and transparency of tone which the modern piano can never achieve. In modern times the artistic merits of the Viennese piano are so greatly ap-

BY COURTESY OF "THE CONNOISSEUR"

GRAND PIANOFORTE BY JOHN BROADWOOD, 1798

BY COURTESY OF HUGH GOUGH

MODERN REPLICA OF A VIENNESE PIANOFORTE, ABOUT 1780, BY HUGH GOUGH, LONDON

preciated that many excellent reproductions have been made for concert use.

The Four Basic Actions of the 18th-Century Piano.—The four basic types of action of the 18th-century piano are now explained in further detail.

The Single Action and the Early English Square Piano.—This very simplified form of the Cristofori action was introduced into England by Zumpe. It is shown diagrammatically in fig. 1. The key is pivoted at the pivot point. This strikes the hammer by means of the projecting jack, or "mop stick," throwing the hammer upward to hit the string, from which it immediately falls back. Simultaneously the tail of the key raises the damper by means of the damper stick, the damper being otherwise held against the string by a whalebone spring. The sole merit of this action is simplicity. There is very little control over the tone, which at its loudest is quite feeble. If the key is struck too hard the hammer may bounce back and "block" the tone.

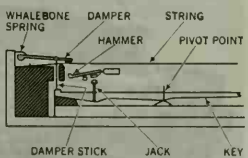

FIG. 1.—ZUMPE SINGLE ACTION, 1760

The expressive qualities of a Zumpe are in every way inferior to a large clavichord. Its popularity in England can only be explained by fashion and the fact that the English never appreciated the clavichord.

Zumpe provided two hand-operated stops to the left of the keyboard for raising the bass and treble dampers respectively. The sympathetic resonance of all the strings could thus be brought into effect for the duration of entire movements. This characteristic of the dulcimer (called the "Pantaleon" effect after its famous exponent) was so admired that some early pianos were entirely undamped. Even when the damper-raising *forte* pedal or knee lever was introduced, it was still the Pantaleon effect that was admired. Clementi's pupil John Field was probably the first to develop the modern selective technique of the sustaining pedal.

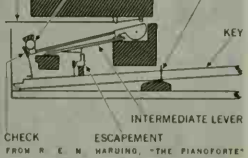

FIG. 2.—CRISTOFORI DOUBLE ACTION, 1726

The Double Action of Cristofori.—The form illustrated in fig. 2 is Cristofori's action of 1726. The key is pivoted at the pivot point. Fixed to the key is the escapement, which conveys the thrust to the hammer by means of the intermediate lever. After hitting the string the hammer falls back but is held against the check until the key is fully released. The damper is not shown. This action avoids most of the shortcomings of the single action, the most important improvement being the escapement. The jack, instead of being rigidly fixed to the key, is hinged in such a way that as soon as it has given its impulse it is deflected, so that even if the note is held the hammer can return to its position of rest. This, together with the check, is an almost complete safeguard against blocking. A weakness of the single action is the slow hammer velocity, resulting in a limited dynamic range. In the double action the intermediate lever conveys the thrust to the hammer butt, giving increased velocity to the hammer and consequently greater control. The "English double action," as it came to be called, eventually superseded the single action in the better classes of square piano, such as were made by Broadwood.

The English Grand Action.—For grand pianos a modification of the Cristofori double action was developed in the 1770s by a Dutchman, Americus Backers; his apprentice, Robert Stodart; and John Broadwood. This action is shown diagrammatically in fig. 3. The working principle is similar to that of the double action, except that the intermediate lever has been eliminated, the thrust being conveyed directly to a notch in the butt of the hammer by means of the escapement, or "hopper," the play of which is regulated by an adjustable screw. This action, in various stages of improvement, continued to be made in English grands until late in the 19th century. The hammers of the early English grands are lightly constructed and covered with leather. (Experiments were made with various materials such as cloth over leather and leather over felt, and all-felt hammers were introduced by Jean Henri Pape in 1826.) Stringing is trichord throughout (brass in the bass and steel in the treble) and no strings are overspun, or "covered." The result is an entirely characteristic tone quality, full but brilliant, on which the full left-hand chords of Beethoven do not sound thick and cloudy as they do on most modern pianos. Many early English pianos have been ruined by being fitted with heavy felt hammers. Dampers are light and consequently by no means instantaneous in effect; but contemporary performers do not seem to have found this objectionable, as good damping would not have been difficult to achieve.

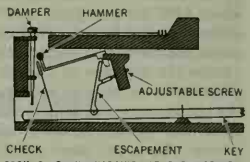

FIG. 3.—ENGLISH GRAND ACTION, 1795

The Viennese or German Action.—In this action, as shown in fig. 4, the key is pivoted at the pivot point. The hammer is mounted in a fork, or "Kapsel," which is rigidly fixed to the key. Also shown are the string, the escapement, and the escapement return spring. The damper is not shown. The essential difference between the Viennese and the other actions is that the hammer is mounted on the key and not on the frame. When the key is depressed the tail of the hammer engages in the escapement notch, causing the hammer to rise and hit the string. Further pressure pushes the escapement aside, allowing the hammer to fall to rest.

The differences between the Viennese and English instruments are considerable. The Viennese damping is more effective. The hammers, like the English, are leather covered, but they are lighter, sometimes hollow, and probably achieve a higher velocity. Viennese stringing is generally bichord and significantly thinner than the English, and the relationship between frame, soundboards, and case of each school is quite differently contrived. These are

factors which contribute to the tonal difference between the two types of instruments.

Grand pianos were rare until about 1780, but thereafter they were made in increasing numbers. Meanwhile the square piano remained popular as a domestic instrument with increased size until about 1860. Toward the end of the 18th century the widespread interest in the orchestra, stimulated by the music of Haydn and Mozart, led to a demand for two- and four-hand transcriptions of orchestral works. The piano compass was consequently extended to keep pace with that of the orchestra, and it had increased from Cristofori's four and a half octaves to a universal five and a half to six octaves in grands by 1800. For many years square pianos were restricted to five octaves (F′ to f′′′′) since any extension either curtailed the soundboard or made the instrument too long. In 1794 William Southwell of Dublin overcame this difficulty by placing a subsidiary frame for the extra treble notes under the soundboard, the hammers rising through a small slit in it to reach the strings.

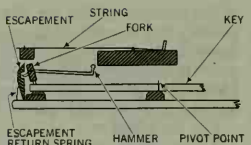

FIG. 4.—VIENNESE ACTION, 1773

During the 18th century pianos were provided with various *timbre*-creating stops in an effort to please those who found it hard to escape the habits of the harpsichord. Three of these survive in modern instruments: the previously mentioned *forte* pedal that raises the dampers; and two soft effects, *una corda* (shifting the keyboard so that the hammers strike only one or two strings in each set, the free strings vibrating sympathetically) and *celeste* (interposing a strip of soft material between hammers and strings). These stops were first worked by hand stops or knee levers. Later pedals were applied, Broadwood taking out a patent in 1783. By about 1790 the two "loud" and "soft" pedals found in the modern instrument had become almost universal. During the period from about 1800 to 1840 a vogue for percussion and other special effects (under the influence of Turkish music) led to the construction of pianos with as many as eight pedals. But such trivialities earned the condemnation of serious teachers and performers. One device from this period, however, survives in many modern upright pianos: this is the *piano* pedal, which shortens the radius of the hammer, thereby significantly reducing the strength of its blow upon the strings.

By about 1860 the upright piano had virtually replaced the square for ordinary home use. Early upright pianos followed the design of upright harpsichords with the strings rising from keyboard level. They were consequently very tall, and many were made in elegant shapes, such as the "lyre," "giraffe," and "pyramid." But by taking the strings down to floor level the upright was made shorter and more suitable for small rooms. This was first done by a progressive maker, John Isaac Hawkins, in 1800. The essentials of the modern upright action were contained in the "tape-check" action of Robert Wornum that was patented in 1842 but probably was invented several years earlier.

DEVELOPMENT OF THE MODERN PIANO

After 1800 the piano, as a result of the increasing demands of composers and performers, began a rapid growth to its modern form, which, for practical purposes, it reached by 1859. The main stimulus was the gigantic pianism of Beethoven (according to Czerny, "marked by enormous strength, incredible bravura, and fluency") followed by the efforts of others to emulate his style and to excel in his works.

Earlier virtuosos brought to the piano a style of playing essentially *legato*, something between harpsichord and clavichord technique. Beethoven's playing opened up new vistas of dramatic quality and expression beyond the capacity of existing instruments. He made no secret of his preference for the English pianos with their greater sonority and brilliance. During this period the famous heads of piano houses gathered around them a brilliant circle of pianists and composers, and the incentive to develop instruments capable of matching the rapidly increasing musical demands was intense.

After Beethoven, the composer-pianists who most influenced piano development were John Field, Chopin, and Liszt.

Field's influence upon Chopin was considerable, and he was probably the first to use the *forte* pedal artistically for the sustaining of widespread chords. Chopin, whose technique derived from C. P. E. Bach, was much opposed to a forceful touch, preferring a square or small upright piano to a more sonorous grand. (The Broadwood grand made for him in 1848 can still be seen in the firm's London showroom. It has a shallow touch with a touch weight of 2½ oz.). Field and Chopin developed the intimate character of the piano. As with Schumann, their music demands a degree of softness, evanescence, and sustained treble tone which none of the earlier instruments possessed.

The great teaching of Beethoven's pupil Czerny paved the way for Liszt, the consummate piano virtuoso of the age. Liszt's playing (influenced by Chopin on one hand and Paganini on the other) combined musicianship and showmanship to an unprecedented degree, and his technique transcended that of all his contemporaries. He adopted a high-seat position in a quest for greater power; but his playing combined great strength with softness and delicacy, and he never sacrificed good tone to noise. Many of his successors were less artistic, with the result that in the 1870s piano makers felt compelled to fortify their instruments by increasing the touch weight to as much as 4 oz., more than twice the weight of a Viennese action. This did not last for long, however, and by the end of the nineteenth century a lighter touch once again became normal.

During the period 1800 to 1859 the efforts of piano makers were directed toward evolving methods of improving the volume, sustaining power, and sonority of the instrument. In practice this involved heavier stringing, frames capable of carrying the increased tension, and a scientific approach to the covering of the hammer and its striking place on the strings.

An inherent structural weakness of the early pianos was the gap across the full width of the soundboard through which the hammers came up. The early makers strengthened this with light wooden braces; but the first maker to tackle the problem seriously was Americus Backers, who placed metal arches from wrest plank to soundboard of his grands as early as 1772. A few 19th-century makers sought a solution in the down-striking action, which made the gap unnecessary.

BY COURTESY OF STEINWAY & SONS
MODERN STEINWAY GRAND WITH OVERSTRUNG FRAME

The weakness of the all-wooden frames became seriously apparent with the extension of the treble compass (where the tension is highest). Makers found the solution in an increased use of metal. Systems of metal resistance were evolved independently by Joseph Smith and by Hawkins in about 1780; but Broadwood first applied iron tension bars to the treble of grands in 1808. William Allen and James Thom, employees of the Stodart firm, invented a metal grand frame in 1820, but this was primarily intended to compensate the differing coefficient of expansion of brass and steel springs under heat. In 1827 Broadwood combined iron tension bars with a fixed iron string plate, and their first complete iron-frame grand was produced for the Crystal Palace Exhibition of 1851. Much of the metal frame development took place in the United States, however, where the first complete iron frame was made by Alpheus Babcock of Boston for a square as early as 1825. The idea was taken up by other U.S. firms and in 1859 came the Steinway overstrung frame, which has been the model for all successful modern grand frames.

Overstringing (or cross-stringing) is a method in which the strings are slightly fanned out, and the bass strings cross over the tenor ones. This has the advantage of allowing greater string length within a relatively shorter case (Pape introduced it into uprights in 1828); but its primary object is to spread the strings so that they affect the soundboard area of maximum resonance and are better disposed for sympathetic resonance when the sustaining pedal is used.

The striking place of the hammer on the string is an important factor in determining the tone quality. Makers of the harpsichord and early piano were, naturally, aware of this acoustical fact, but they made no attempt to achieve uniformity throughout the scale. The first piano maker to give this problem serious attention was Broadwood, who, in 1788, obtained scientific advice and modified his design to provide a uniform striking distance of $\frac{1}{9}$ vibrating length throughout most of the compass.

During the 1830s improvements in the tempering of steel wire and the introduction of overspun bass strings made possible the increased sustaining power obtainable from heavier stringing and greater tension. It was also found that the felt-covered hammers introduced by Pape had the effect of damping the more dissonant harmonics and, since the tendency was toward fullness and mellowness of tone rather than brilliance, the use of felt became widespread, although not universal until after 1855.

Meanwhile, after a slow start in the 18th century, another school of piano manufacture had grown up in France under the leadership of Sébastien Érard, a progressive maker who experimented with metal bracing more or less simultaneously with Broadwood. By 1821 he perfected his double escapement repetition action on which the modern grand action is directly based. Early 19th-century piano music is full of repeated notes in imitation of the violin *tremolando*. Érard's action made possible the repetition of a note without materially raising the key. Its working principle is so much like the modern grand action (described below) that a separate description here is unnecessary.

During the early 19th century the compass of the piano continued to spread, reaching the standard seven octaves (A″ to a⁗) by 1836. In the 1890s a further three notes to c⁗ were added in the treble.

Thus, by 1859 the piano had reached its modern form in all essential details. The subsequent period has been largely one of detail development and standardization. Among post-1859 developments must be mentioned a third pedal (invented by Claude Montal in 1862) for sustaining only the notes of a given chord, the remainder staying damped. This is invariably provided by Steinway and is essential for the performance of the works of certain modern composers. Another Steinway feature is the "duplex scale" (a revival of an idea patented by W. F. Collard in 1821), in which the surplus length of the treble strings is used for sympathetic reinforcement of the tone. Blüthner of Leipzig went further with their "aliquot scaling," which provided independent octave-tuned treble strings for sympathetic vibration.

Among the numerous 20th-century developments the most significant is probably the double keyboard of Emmanuel Moór, the upper keyboard being an octave higher than the lower. This permits widespread chords and other effects impossible for two hands on a normal keyboard. Although admired by Ravel, this clever invention seems destined to share the oblivion of any instrumental innovation which does not attract the imagination of leading composers and performers, who no doubt feel that the 20th-century grand piano is demanding enough without additional complications.

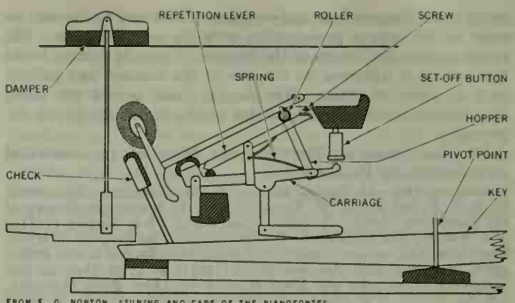

FIG. 5.—MODERN GRAND ACTION

String tension, determined at 16 tons in 1862, increased to as much as 30 tons in modern instruments. The result is a dynamic range, *sostenuto*, and tonal spectrum unknown to Chopin, Beethoven, and even Liszt. The modern piano has undoubtedly the widest range of expression of all solo instruments. In the hands of composers such as Bartok and Stravinsky, it has been reduced to the level of a mere percussion instrument. On the other hand, composers of the stature of Debussy and Ravel showed it to be capable of a diversity of colour and power inviting comparison only with the orchestra.

MODERN PIANO ACTIONS

The working of modern grand and upright piano actions is explained below.

Modern Grand Action.—This (fig. 5) is a refinement and simplification of Érard's action of 1821. It must be remembered that details vary between one maker and another. The key, pivoted at the pivot point, raises the carriage. This carries the hopper, or "bell crank lever," the tip of which imparts the thrust to the hammer by means of a small roller attached to the underside of the hammer shank. Escapement is caused by the engagement of the prolongation of the L-shaped hopper with the adjustable set-off button. Before the key is fully released, the repetition lever (through which the tip of the hopper passes) rises against the pressure of the spring until it is checked by a screw. The repetition lever then supports the roller and enables the hopper to regain its position under the roller in order to be ready for a second blow before the key is materially raised. Shown also are the check and the damper, the working of which is self-explanatory.

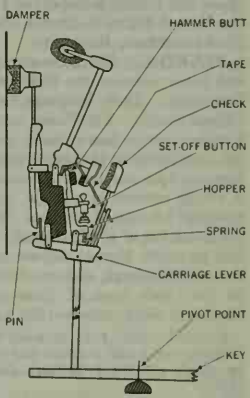

FIG. 6.—MODERN UPRIGHT ACTION

Modern Upright Action.—This (fig. 6) is derived from the "tape-check" action of Wornum. The key pivoted at the pivot point conveys the thrust to the carriage lever, on which are mounted the hopper and check. Thrust is conveyed by the hopper to a

notch in the hammer butt, and escapement is caused by the engagement of the hopper prolongation with the set-off button. The spring ensures the return of the hopper. A special feature is the tape, which is tightened by the rise of the hammer and pulls it back to assist repetition. The damper, held against the string by a spring, is raised by the action of the pin as the key is depressed.

For piano tuning, *see* TEMPERAMENT, MUSICAL; for mechanical reproduction, *see* PLAYER PIANO.

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PIANOSA (ISOLA PIANOSA; ancient PLANASIA), an island of Italy, belonging to the province of Livorno (Leghorn), 8 mi. SW of the island of Elba. Area 6 sq.mi. Pop. (1961) 844. As its name indicates, it is flat, its highest point being about 90 ft. above sea level. It figures in Roman history as the place of banishment of Augustus' grandson, Agrippa Postumus. In the 16th century it suffered from the depredations of the Turks; and in 1864 an agricultural penal colony was established there. (G. KH.)

PIARISTS (ORDER OF THE PIOUS SCHOOLS; CLERICI REGULARES PAUPERES MATRIS DEI SCHOLARUM PIARUM; SCH. P.) are a Roman Catholic teaching order founded in 1597 by Joseph Calasanctius at Rome, where he opened the first free school in Europe for poor children. The original congregation (founded 1617) became an order of clerks regular in 1621. To the usual three vows the Piarists added a fourth: special care of youth. The motherhouse is in Rome. Active for many years in Italy, Spain and central Europe, the Piarists opened their first school in the United States at Devon, Pa. in 1956. *See* also ORDERS AND CONGREGATIONS, RELIGIOUS. (Jo. A. B.)

PIAROA, a South American Indian tribe occupying savanna and forest between the Orinoco and Ventuari rivers in southern Venezuela. Their language belongs to the small, independent Sálivan family. The Piaroa are among the more primitive of the Tropical Forest horticultural groups. Manioc gardens cleared in the forest provide the staple, supplemented by game and fish. The blowgun (*q.v.*) and darts poisoned with curare are used in hunting. A village consists of a single, large, circular thatch-covered house occupied by related families. Villages are moved frequently, the accumulation of goods is small, and clothing is minimal. Few details of native Piaroan culture are known. The tribe seems never to have been large, and was decimated through European contact. In the 1960s most of those remaining had largely abandoned aboriginal ways; trustworthy population data were not available.

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PIAST, the first dynasty of princes and kings of Poland. The legendary Piast, a plowman in the service of the equally legendary Prince Popiel, is said to have been the father of Siemowit, who succeeded Popiel as prince of Gniezno in the second half of the 9th century. The legend was recorded at the beginning of the 12th century, but the use of the name Piast for the dynasty does not occur till the 17th century.

The most prominent members of the main Piast line were: Mieszko I, Boleslaw I, Boleslaw II, and Boleslaw III (*qq.v.*). At Boleslaw III's death (1138) the dynasty split into several lines.

1. The line of Great Poland descended from Mieszko III, third son of Boleslaw III. It died out with Przemysl II (1257–96), prince of Great Poland from 1277 and king of Poland from 1295.

2. The line of Little Poland descended from Boleslaw III's fifth son, Casimir II the Just (1138–94), prince of Cracow and Sandomierz from 1177. It became extinct with Boleslaw V (1226–79), prince of Cracow and Sandomierz from 1243.

3. The line of Kujawy descended from Casimir II's son Konrad I (1187–1241), prince of Mazovia from 1202. His son Casimir (1211?–67), prince of Kujawy from 1263, was the father of Wladyslaw I, king of Poland from 1320. Wladyslaw's son Casimir III (*q.v.*) was the last Piast king (1333–70), but the princely line continued till the death in 1388 of Wladyslaw the Fair of Gniewkowo.

4. The Mazovian line descended from Konrad I's youngest son Siemowit I (1224–62), prince of Mazovia from 1248. The last members of this line were the princes of Warsaw and Czersk, Stanislaw (1501–24) and his brother Janusz III (1502–26).

5. The Lower Silesian line descended from Boleslaw III's eldest son Wladyslaw II the Exile (1105–59), prince of Cracow and Silesia from 1138 to 1146, through his eldest son Boleslaw the Tall (*c.* 1129–1201), who became prince of Silesia in 1163. Split among six branches, Wroclaw, Swidnica, Legnica, Brzeg, Zagan, and Olesnica, this line died out in 1675 with Jerzy Wilhelm, prince of Legnica, Brzeg, and Olawa.

6. The Upper Silesian line descended from Mieszko the Cross-legged (*c.* 1138–1211), prince of Silesia together with his brother Boleslaw the Tall in 1163. This line, after being divided into four branches, Raciborz, Opole, Cieszyn, and Oswiecim, died out with Fryderyk Wilhelm, prince of Cieszyn, in 1625.

See O. Balcer, *Genealogia Piastów* (1893); W. Dworzaczek, *Genealogia* (1959). (A. GI.)

PIATRA NEAMŢ, a town of Moldavia in Bacău Region, northeastern Rumania, lies in the Bistriţa Valley, 219 km. (136 mi.) ENE of Tîrgu Mureş by road. Pop. (1960 est.) 36,024. Stephen the Great reconstructed the town and built the church of St. Ion Domnescu (1497) and the St. Ion Tower. There is a regional museum, and nearby is the Bistriţa Monastery, founded in 1402 and rebuilt in 1554. There are oil refineries, a chemical works, a thermal power station, textile factories, food processing plants, and timber and paper mills.

PIAUÍ, a state of northeastern Brazil, bounded on the north and west by Maranhão, on the east by Ceará, Pernambuco, and Bahia, and on the south by Bahia. It has about 50 mi. of Atlantic coastline on the north, and the entire length of the Rio Parnaíba forms the boundary with Maranhão. The area of the state is 96,886 sq.mi., and its population (1960) was 1,263,368. The chief city and capital since 1852 is Teresina. Piauí is served by the port of Parnaíba and its outport Luís Correia. River boats with 3-ft. draft navigate the Rio Parnaíba as far as the third city of the state, Floriano.

Piauí lies within the semiarid area of recurring droughts characteristic of the backlands of northeastern Brazil. The land surface rises very gradually from sea level toward the south and east; it is a part of the tabular upland supported by sandstone strata which dip gently toward the west. Where the sandstone ends, approximately along the eastern border of Piauí, it faces the broad plains of Ceará as a steep scarp, or cuesta. In Piauí the sandstone tablelands descend gradually toward the Parnaíba and are drained by the right-bank tributaries of that river, including the Gurguéia, the Canindé, the Poti, and the Longá. The drier eastern part of the state is covered with a thorny, deciduous scrub woodland known as caatinga, but toward the west, as one descends into the valley of the Parnaíba, the scrub gives way to a grassy savanna with scattered babaçu palms. In the wetter areas the palms are dense except where they have been destroyed for their oil. Temperature and humidity are high along the coast and along the lower part of the Parnaíba Valley. In the drier interior the daytime temperatures are high, but the nights are cool.

The first settlement of Piauí took place in 1674 when Domingos Afonso Mafrense established cattle ranches on the savannas of

the Parnaíba Valley. In 1718 the area was included in the captaincy of Maranhão, and not until 1811 was Piauí separated from the political unit to the west, with which it is still closely tied economically. Because the caatingas and the steep cuesta on the east have only been scantily settled, connections with settlements in Ceará are not close. Even now Teresina is connected by rail only with São Luis in Maranhão. Piauí has no connected rail system of its own, and only one all-weather highway, which connects Teresina with Fortaleza in Ceará. Products of the state include babaçu nuts, carnauba wax, oiticica oil, castor beans, cotton, and manioc, as well as cattle and goat skins. (P. E. J.)

PIAVE, a river in northeastern Italy, rises in the Carnic Alps on the slopes of Monte Peralba, near the Austrian frontier, and flows southward in its upper course until it reaches Belluno, then enters its narrow gorge at Feltre. It then turns southeast and winds its way across the Venetian plain, reaching the Adriatic at Cortellazzo, 20 mi. NE of Venice. The Piave is 137 mi. long and the area of its drainage basin 1,580 sq.mi. Until about 1500 the mouth of the Piave was farther south, near Treporti on the lagoon of Venice. After several changes, the river settled in a mouth near Caorle; and, after a disastrous flood in 1683, in its present outlet. The variations in water volume are of the order of 1:100 and during late summer most of the Piave's lower course is a great bed of dry gravel. The upper part of the valley boasts major hydroelectric stations at Pieve di Cadore, and Fadalto, while waters of the lower course are used extensively for irrigation. Occasional navigation by barges extends only about 20 mi. inland.

In World War I the Piave became the main line of Italian resistance after the Austrian breakthrough at Caporetto in October 1917; the remaining Italian forces were then reconstituted behind the river. On June 15, 1918, the Austrians delivered a general attack along the greater part of the Italian front, known as the Battle of the Piave, their object being to break through into the rich agricultural area of the Veneto. Two Austrian forces succeeded in getting across, but were forced by Italian counterattacks to recross the Piave, after suffering heavy losses. Later an Italian local attack resulted in the conquest of the area between the old and the new Piave near the estuary.

In October 1918 an Italian offensive on a large scale was launched on the Piave front with British and French support. This offensive culminated at the end of the month in the decisive defeat of the Austrians at the Battle of Vittorio Veneto (*q.v.*). (G. Kh.)

PIAZZETTA, GIOVANNI BATTISTA (1682–1754), one of the outstanding Venetian painters of the 18th century, was born at Venice on Feb. 13, 1682. He began his career in the studio of his father, Giacomo, a mediocre wood-carver. Soon after assisting the latter to carve the still-surviving bookcases of the library of SS. Giovanni e Paolo at Venice, he abandoned the family profession and began to study painting under Antonio Molinari (1665–after 1727). About 1703 he went to Bologna, where he worked in the studio of G. M. Crespi. He was back in Venice by 1711, and continued to work there until his death on April 28, 1754. From Molinari, and the study of Bolognese painting (especially Guercino's work), he learned the heavily shadowed manner which he henceforth adopted; Crespi probably awakened his interest in genre painting. The caravaggesque lighting effects at which he aimed have become emphasized with time, for his olive-grey and brown colours have darkened and the deep red ground on which he invariably painted has become more prominent.

Little is known of the dating of Piazzetta's works, especially those of his youth. "St. James carried off to Martyrdom" (in S. Stae) is dated 1717; at this period he was a powerful influence on the young G. B. Tiepolo. About 1725–27 he undertook his only ceiling painting, the "Glorification of St. Domenic" for the chapel of the Sacrament in SS. Giovanni e Paolo, in which the reverse influence of the now mature Tiepolo on Piazzetta is apparent. The "Ecstasy of St. Francis" (Vicenza), perhaps his finest religious work, dates from about 1732, and some three years later he was commissioned to execute an "Assumption" for the elector of Cologne (museum, Lille). The celebrated "Fortune Teller" (Accademia, Venice) is dated 1740. "The Pastoral" (Chicago) and the "Idyll by the Seashore" (Cologne, copy in Dublin), both in the same rococo-pastoral vein, must have been painted about the same time or a little before. In his last years he carried out a number of large-scale decorations with subjects taken from classical history.

In 1727 Piazzetta had been elected a member of the Bolognese Accademia di S. Luca and, on the foundation of the Venetian Academy in 1750, he was made its first director and teacher of drawing from the nude. He produced many works for private patrons, especially half-lengths of single saints, biblical subjects, and studies of peasants, soldiers, or adolescents, and a few portraits. He was a very slow worker and in spite of his popularity was compelled to produce innumerable drawings for sale to eke out a penurious existence for his large family. He also carried out many designs for book illustrations, mostly for his friend the publisher G. B. Albrizzi, the edition of T. Tasso's *Gerusalemme Liberata* (1745) being among the finest illustrated books of the 18th century.

Piazzetta had many pupils of whom the most important are Giulia Lama, Giuseppe Angeli (1710–98), Francesco Daggiù (known as "il Capella"; 1714–84), Domenico Fideli ("il Maggiotto"; 1713–93), Antonio Marinotti ("il Chizzotto"; 1719–90), and Francesco Polazzo (1683–1743). Their works are frequently confused with their master's.

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PIAZZI, GIUSEPPE (1746–1826), Italian astronomer and discoverer of the first minor planet Ceres, was born at Ponte in the Valtellina, July 16, 1746. In 1780 he was appointed professor of higher mathematics at the Academy of Palermo. Later, with the aid of the viceroy of Sicily, he founded the observatory of Palermo. There he produced his great catalogue of the positions of 7,646 stars, a work notable for its high accuracy and for the large number of objects listed. There also, on Jan. 1, 1801, he discovered and named Ceres. He died at Naples, July 22, 1826.

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PIBUL SONGGRAM, LUANG (1897–), field marshal and former prime minister of Thailand, was born near Bangkok on July 14, 1897. After completing his education in France, he returned to Thailand in 1927 and became a captain in the army. Five years later he took a leading part in the bloodless revolution which obliged King Prajadhipok to grant a constitution. From 1932 until 1938 Pibul and his civilian associate, Pridi Phanomyong (also known as Luang Pradit), wielded the power behind the throne. In domestic affairs, they established democratic forms of government and inaugurated strong economic policies of industrialization and nationalization. In foreign affairs, they nursed long-standing grievances against both the United Kingdom and France and adopted an independent course toward aggressive Japan.

Pibul became prime minister in 1938 and guided Thailand's destinies through World War II. He ruled by a series of totalitarian decrees and allied himself with Japan. He declared war on the Western powers, and, when defeated, stepped aside and obliged his political adversaries to sue for peace.

After the war Pibul faded temporarily into the political background but he reemerged as prime minister in 1948. In an environment of chaos, he was accepted as a pillar of anti-Communist strength. With his henchmen in control of important posts in the army, the police, and the state economic enterprises, he reestablished government by cabal. He survived several attempted *coups d'état* only to be ousted in 1957 by some of his disgruntled colleagues. After being forced out of office, he took up residence outside of Thailand. (C. A. B.)

PICABIA, FRANCIS (1879–1953), French painter, illustrator and editor associated with the Cubist, Dadaist and Surrealist movements, was born in Paris on Jan. 22, 1879. He came into contact with modern art through Impressionism and the influence of Alfred Sisley. In 1909 he moved on to early Cubism

and became a member of the *Section d'Or* ("Golden Section") Cubist group that met at the studio of Jacques Villon. During 1912–13 he went through his period of Orphism or colour orchestration, gradually adopting proto-Dada names for these works, *e.g.*, "Catch as Catch Can." In 1913 he exhibited at the Armory show in New York and at the famous Alfred Stieglitz gallery, contributed to the proto-Dadaist review *291*, contributing also to the Stieglitz *Camera Work* magazine where he promulgated Amorphism, a satire on current art trends. In 1917, with Walter Arensberg, Picabia launched the periodical *391* and with Marcel Duchamp, Marius de Zayas and Man Ray he also organized a semi-Dadaist group. Later he was active as a Dadaist in Barcelona, Paris and Zürich, where he worked with Tristan Tzara. In 1918 he collaborated on the third issue of *Dada* magazine in Zürich; in Paris in 1920 he began to publish a review called *Cannibale*. For many years thereafter Picabia continued to exhibit in Paris, where he died on Nov. 30, 1953.

See Marie De La Hire, *Francis Picabia* (1920); Robert Motherwell (ed.), *Dada Painters and Poets* (1951). (B. S. Ms.)

PICARD, CHARLES ÉMILE (1856–1941), French mathematician, whose theories did much to advance researches into algebraic geometry, was born in Paris on July 24, 1856. In 1878 he was appointed lecturer at Paris University; in 1879 he became professor at Toulouse University; from 1881 to 1898 he held various positions at the university and the École Normale Supérieure, Paris; and in 1898 he became professor at Paris University. In 1917 he was elected permanent secretary for the mathematical sciences in the Paris Academy of Sciences.

One branch of Picard's work was concerned with Fuchsian and Abelian functions, and with the allied theories of discontinuous and continuous groups of transformations. This work led to a study of the algebraic manifold now known as the Picard variety, which plays a fundamental role in algebraic geometry. In 1879 Picard proved the theorem known by his name, that an integral function of the complex variable takes every finite value, with one possible exception; this theorem initiated many important investigations. Picard also created a theory of linear differential equations, later extended by his pupil E. Vessiot, analogous to the Galois theory of algebraic equations. His study (inspired by N. H. Abel and G. F. B. Riemann) of the integrals attached to algebraic surfaces, and the related topological questions, developed into an important department of algebraic geometry, with varied applications to topology and function theory. Picard's researches in this field were expounded in the treatise he published with G. Simart, *Théorie des fonctions algébriques de deux variables indépendantes* (two volumes, 1897, 1906). Picard died in Paris on Dec. 12, 1941. (L. R.)

PICARD, JEAN (1620–1682), French astronomer who first accurately measured the degree of a meridian, was born on July 21, 1620, at La Flèche, Anjou. After acting as prior of Rillé, Anjou, he became professor of astronomy at the Collège de France, Paris (1655), and was admitted to the Academy of Sciences in 1666. Picard's measurement of the earth, which chiefly established his reputation, was used by Sir Isaac Newton to verify his theory of gravitation. In 1671 Picard went to the island of Hven (Ven) to determine the exact position of Tycho Brahe's observatory Uranienborg and returned with copies of the originals of Brahe's principal work. Picard is also given credit for the introduction of telescopic sights and the use of pendulum clocks as contributions to greater precision in astronomical observations. In 1675 he made the first recorded observation of barometric light (*q.v.*). Picard founded *La Connaissance des Temps* in 1679 and edited it until his death in Paris on July 12, 1682. *See* also GEODESY: *Ellipsoidal Era of Geodesy*.

PICARDY, the conventional name for a region of northern France lying between Normandy and the historic Netherlands and north of the Île-de-France and Champagne; its core forms the modern *département* of Somme (*q.v.*) and the northern part of Aisne, but parts are now in Pas-de-Calais or in Oise. Because Picardy was never unified in the feudal period, its boundaries are disputable. In the first place, Picards, whose speech was a form of the *langue d'oïl* distinct from that of the Île-de-France (*see* FRANCE: *The People: Languages*), are mentioned specifically from the beginning of the 12th century and were recognized as a "nation" in the organization of the University of Paris from the middle of the 13th; but the linguistic "Picardy" includes Artois, Cambrésis, Tournésis, and parts of Flanders and Hainaut and so has a far greater northward extension than the conventional Picardy. Secondly, Picardy may be considered ecclesiastically as embracing not only the medieval dioceses of Amiens, Noyon, and Laon but also the northern parts of those of Beauvais and of Soissons. Finally the province of Picardy from the 16th century to the end of the *ancien régime* comprised (1) the Somme basin from Saint-Quentin to the Channel, with Péronne, Corbie, Amiens, and Abbeville along its axis and with the adjacent country between the Authie River in the north and the Bresle River (which marked the frontier of Normandy) in the west, as well as Montdidier and the basins of the Noye and Aure tributaries of the Somme in the south; (2) the basins of the Serre and of the upper Oise, with La Fère, Marle, Vervins, and Guise, as well as the Thiérache country between the Oise and the source of the Sambre; and (3) Montreuil on the Canche beyond the Authie. To this province Boulogne and the Boulonnais and even the Pays Reconquis (Guînes, Calais, and the coastal area as far as Gravelines) were sometimes added.

Picardy was occupied by the Salian Franks in the 5th century A.D. In the feudal period it was divided. Apart from the countships of Boulogne and of Montreuil, the west formed the countship of Ponthieu (Vimeu being the tract between Bresle and Somme). The countships of Amiénois and of Vermandois occupied central Picardy; and to the east was Laonnois. Philip II Augustus of France gradually united Amiénois and Vermandois to his domain (from 1185); but Ponthieu was held by the English as a fief almost continuously from 1279 to 1360 and then as an outright possession till 1369; and the dukes of Burgundy, having obtained Flanders, Artois, and the Boulonnais, acquired Ponthieu, the Somme towns, and Montdidier under the Treaty of Arras in 1435 (*see* PHILIP the Good, duke of Burgundy). Reconquered for France by Louis XI in 1477, Picardy was thereafter a frontier area many times invaded from the Habsburg Netherlands till the French acquisition of Artois and southern Hainaut in 1659. Some of the bloodiest fighting in World War I (*q.v.*) was in Picardy: *see* particularly SOMME, BATTLES OF THE.

PICARESQUE NOVEL, THE. The picaresque novel, which may be defined as the prose autobiography of a social parasite, real or fictitious, who in describing his experiences satirizes the society he has exploited, developed in Spain in the 16th century as a special form of the *roman d'aventures* (the type of medieval romance in which the chief interest of the narrative centres in the adventures of the hero). Although the picaroon, or rogue hero, had made his appearance in literature in such early works as the *Satyricon* of Petronius Arbiter (*q.v.*), and had persisted in such popular medieval works as the fabliaux (*q.v.*) and the *Roman de Renart* (*see* REYNARD THE FOX), in its final form the picaresque novel (*novela picaresca*) was a Spanish invention. The word *picaro* is first found in texts of 1525 (*picaro de cozina*), and, in its present sense of rogue or rascal, from about 1545. The etymology generally accepted would derive it from *picar* (to nibble, pick up); a related synonym *picaño* goes back to the 14th century. *Picardo* (a native of Picardy, with which region Spanish soldiers in the Low Countries had many contacts) has also been advanced, *picardía* being the action of a *picaro*. The term applied to a character in fiction first occurs in *Guzmán de Alfarache* (1599) by Mateo Alemán (*q.v.*), a work long known simply as *El picaro*. But a genuine *novela picaresca* existed in Spain before the word had become generally current.

In Spain.—The earliest specimen is *La vida de Lazarillo de Tormes y de sus fortunas y adversidades*, an anonymous tale in seven brief *tratados* telling of Lázaro's experiences with as many masters, alternately lay and clerical, which was long attributed to Diego Hurtado de Mendoza (*q.v.*). Three editions appeared in 1554 (one in Antwerp) and three more before 1559, when it was placed on the Index for its implied attacks on the clergy. An also anonymous *Segunda parte de Lazarillo de Tormes* (1555) completely misinterpreted the irreverent wit of the original. Juan de

Luna wrote another, more estimable, sequel published in 1620. The Inquisition meanwhile gave up the attempt to suppress the first part, and in 1573 authorized an expurgated edition. Not until 1599 did a second work of the kind appear, Mateo Alemán's *Primera parte de Guzmán de Alfarache,* the feigned autobiography of the son of a ruined Genoese moneylender. The subtitle *Atalaya de la vida humana* added to the second part, like the copious moralizings which threaten to swamp the story in sharp contrast to the laconic cynicism of the *Lazarillo de Tormes,* proclaim it one of the most characteristic works of the Counter-Reformation; but it is richer than the *Lazarillo* in invention, variety of episode, and presentation of character, and enjoyed extraordinary popularity. A Valencian, Juan Martí, published a *Segunda parte* (1602) under the pseudonym of Mateo Luján de Sayavedra; in 1604 Alemán brought out the true continuation. A third part, written in Spanish by the Portuguese Felix Machado da Silva, was first printed in 1927. The *Viaje entretenido* (1603) of Agustín de Rojas (1572–*c.* 1618), while not fiction in the accepted sense, has some claim to inclusion here. A realistic account of the writer's experiences as strolling actor and playwright, it is at once an invaluable contribution to Spanish stage history and a graphic record of contemporary low life.

Next in date is Francisco López de Úbeda's *La pícara Justina* (1605), the story of a woman picaroon who deceives lovers as the *pícaro* does masters, which has acquired a reputation for indecency; its real defects are affected diction and want of originality. To philologists it is a mine of verbal eccentricities. Cervantes (*q.v.*) in several of his works (*Pedro de Urdemalas, Rinconete y Cortadillo, El coloquio de los perros*) presents a brilliant panorama of picaresque existence, if without the cynical pessimism characteristic of the kind. In the *Viaje del mundo* (1614) Pedro de Cevallos interpolates amusing tales of what befell him in the slums of Andalusia before he fled from justice to America. The *Relaciones de la vida del escudero Marcos de Obregón* (1618) of Vicente Martínez Espinel (*q.v.*) is a baffling compound of fact with fiction that was much drawn on by Le Sage in *Gil Blas. La desordenada codicia de los bienes ajenos* (1619) by Carlos García reports the life story of a garrulous jailbird and appends a glossary of thieves' slang. Every kind of picaroon is portrayed with intelligent sympathy by Alonso Jerónimo de Salas Barbadillo (1581–1635) who, while commonly described as a picaresque novelist, constantly neglects the recognized conventions of the kind. Thus *La hija de Celestina* (1612) abandons the autobiographical form, *El subtil cordobés Pedro de Urdemalas* (1620) alternates between dialogue and verse, and in *El necio bien afortunado* (1621) the chief character is rather a cunning dolt than a successful scoundrel. Antonio Liñán y Verdugo seeks ostensibly in his *Guía y avisos de forasteros que vienen a la corte* (1620) to warn against the temptations of the capital, but there is in most of his tales more entertainment than decorum. Serious intention underlies equally Jerónimo de Alcalá Yáñez y Ribera's *Alonso, mozo de muchos amos* (1624–26), in which the repentant *pícaro,* now a lay brother, relates his past to the monastery superior.

The adventures of the ex-nun Catalina de Erauso (1592–*c.* 1625), who fled from her convent to America dressed in man's clothes, enlisted and was promoted 2nd lieutenant, as told in the *Historia de la monja alférez doña Catalina de Erauso, escrita por ella misma,* were first published in 1829 and are clearly not wholly authentic; their interest is unquestionable. No suspicion attaches to the *Vida* of Alonso de Contreras, printed in 1899, though the ex-captain judges his past with unnecessary harshness. This subtle form of vanity also pervades the *Comentarios del desengañado de sí mismo* of Diego Duque de Estrada, a rakish soldier and inferior dramatist whose autobiography, begun in 1614 and continued over many years, remained in manuscript till 1860. A higher order of talent distinguishes the *Capitulaciones de la vida de la corte y oficios entretenidos en ella,* a bitterly unsparing review of picaresque life by the great satirist Francisco Gómez de Quevedo y Villegas (*q.v.*). These thumbnail sketches were preparatory studies for the *Vida del buscón don Pablos* (1626), the cleverest and most repellent book of its class, in which, allied to profound psychological artistry, may be seen a deep concern with moral values. After *El buscón* the picaresque novel declined insensibly into the novel of adventure, with an increasing predominance of narrative over description. The *Varia fortuna del soldado Pindaro* (1626) added nothing to the established reputation of Gonzalo de Céspedes y Meneses (*q.v.*). Alonso de Castillo Solórzano (*q.v.*) wrote *La niña de los embustes, Teresa de Manzanares* (1632), the *Aventuras del bachiller Trapaza* (1637), and, as sequel to this, *La garduña de Sevilla* (1642). But the style no longer evoked the old enthusiasm in Spain. The *Bachiller Trapaza* was continued in Portugal by Mateo da Silva Cabral and exploited in France by Alain René Le Sage (*q.v.*), who likewise utilized in his novel *Gil Blas* episodes from *El siglo pitagórico* (1644) of Antonio Enríquez Gómez. The primitive rogue returns in the allegedly autobiographical *Vida y hechos de Estebanillo González* (1646), of whom nothing else is known. Le Sage drew upon him in the *Histoire d'Estevanille Gonzalès.*

Outside Spain.—Meanwhile, the rogue had made his way into other European literatures. The Antwerp edition and spurious continuation of *Lazarillo de Tormes* brought the work to the notice of northern readers: Jean Saugrain translated it into French in 1561, and an anonymous Dutch version appeared in 1579. David Rowland's English version is dated 1586 (there may have been a 1576 edition), and numerous reprints (1599, 1639, 1669–70, 1672, 1677) indicate its popularity. Thomas Nashe (*q.v.*) wrote the first picaresque novel in English, *The Unfortunate Traveller, or, The Life of Jacke Wilton* (1594). Interest was kept alive by James Mabbe's admirable version (1622) of *Guzmán de Alfarache;* by *The Son of the Rogue, or the Politic Thief* (1638), an anonymous translation, done through the French, of *La desordenada codicia;* and by another anonymous translation (1657), likewise through the French, of Quevedo's *Buscón.* One result was *The English Rogue Described in the Life of Meriton Latroon, a Witty Extravagant* (1665), by Richard Head and Francis Kirkman. There is a female picaroon in *Moll Flanders* (1722), conceivably suggested by the *Picara Justina,* since the author, Daniel Defoe (*q.v.*), read Spanish. The satirical spirit lacking in *Moll Flanders* is abundantly present in another of Defoe's works, *Colonel Jack* (1722), which bravely aims at exhibiting "vice and all kinds of wickedness attended with misery." The picaroon, naturalized henceforth in English literature, is notably reincarnated by Henry Fielding (*q.v.*) in *Jonathan Wild* (1743) and by Tobias Smollett (*q.v.*) in *Ferdinand, Count Fathom* (1753).

The 1579 Dutch translation of *Lazarillo de Tormes* did not cause the picaresque novel to take root in Holland, yet from it derives one of the best Dutch comedies, *De Spaanschen Brabander* (1617) by Gerbrand Bredero (*q.v.*). A German version of *Guzmán de Alfarache* by Aegidius Albertinus appeared in 1615; one of the *Picara Justina,* anonymous, in 1627; and in 1617 versions of both *Lazarillo* and *Rinconete y Cortadillo* by Niclas Ulenhart. Martin Freudenhold wrote a continuation of *Guzmán de Alfarache* in 1626, but the only original picaresque novel of real value in German is *Der abenteuerliche Simplicissimus* (1669) by H. J. von Grimmelshausen (*q.v.*). Attempts to acclimatize the kind in Italy failed completely. French translations of *Guzmán de Alfarache, Marcos de Obregón, La desordenada codicia,* the *Buscón,* and the *Pícara Justina* were printed in 1600, 1618, 1621, 1633, and 1635 respectively. Paul Scarron (*q.v.*) takes his *Précaution inutile* from *Guzmán de Alfarache,* while *Les Hypocrites* (1655) is merely a translation of Salas Barbadillo's *Hija de Celestina.* The *Roman bourgeois* (1666) of Antoine Furetière (*q.v.*), generally described as picaresque, is concerned rather with the foibles of the middle class. The Spanish picaroon lives again in *Gil Blas* (1715–35) in which, with rare dexterity, Le Sage fuses materials unearthed from forgotten and seemingly worthless Spanish quarries. Gil Blas is a creation of the gentler, sunnier French spirit; like Beaumarchais's Figaro he is a Spaniard born, reared and humanized in Paris, and these two are the only picaroons whose relative refinement has not been gained at the cost of verisimilitude. The original type reappeared in Restif de la Bretonne's portentously dull sequel to the *Buscón* (*Le Paysan perverti,* 1776); he was deliberately rejected by Théophile Gautier in *Le Capitaine Fracasse* (1863). Yet Gautier conscientiously provides a Spanish atmosphere in this, the

last important book to continue the picaresque tradition. In Spanish literature elements of that tradition survived in the 19th century, and may still be met with in the novel. José María de Pereda (*q.v.*) in *Pedro Sánchez* (1884) touched the old theme with the accent of modernity; and the *pícaro* flourished afresh in such novels of Pío Baroja (*q.v.*) as *La busca* (1904).

In Latin-American literature the earliest novel, *El periquillo sarniento* (1816) by José Joaquín Fernández de Lizardi (1776–1827), is a genuine romance of roguery on the Spanish pattern.

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(J. F.-K.; W. C. An.)

PICASSO, PABLO RUIZ (Y) (1881–), Spanish painter, the initiator of Cubism and probably the paramount influence on the art of the 20th century, was born on Oct. 25, 1881, at Málaga. His father was an artist and professor at the Academy of Fine Arts at Barcelona, and under him Picasso received his first lessons in art. After many visits to Paris, he settled there in 1903. Though a Catalán by birth, he developed his art in France, where he became one of the leaders of the Postimpressionist school.

Picasso's early work displays his gift as an illustrator of somewhat sentimental character. Like Toulouse-Lautrec he chose the subject matter of his pictures from the life of the circus and from the morbid side of life in a big city, and he rendered with feeling the strained and sad look of young soubrettes, acrobats and harlequins. His contours were clear; his modeling in cool, bluish-gray tones was almost monochrome, but assumed rose tones after 1905. He thus, from the beginning, followed a line distinct from that of Matisse and his Fauvist following, who took pleasure in colour and flat patterns as such and who never entirely broke with the traditions of Impressionism.

To this early period belong "La Famille Soler" (1903), a rhythmically composed group; "L'Aveugle" (1903), archaic in the delineation of form; "La Tragédie" (1903), three gaunt, huddled figures by the illimitable sea; "La Boule" (1905), two acrobats; "La Toilette"; and a portrait of Gertrude Stein (1905–06) of the "rose period."

BY COURTESY OF THE MUSEUM OF MODERN ART, MRS. SIMON GUGGENHEIM FUND, 1949

"THE THREE MUSICIANS" BY PABLO PICASSO, 1921

The Cubistic formula was evolved by Picasso and Georges Braque between 1906 and 1910, while studying the composition of still-life groups. It was Braque who first introduced into his designs bits of printed paper, delighting in the harmonious distribution of black letterpress on white paper. Picasso then added pieces of wood and other tangible objects, which led to a form of art in which sculpture and painting were combined.

During Picasso's earlier Cubist period the surfaces of his canvases were delicately toned in brown or gray by dots in pointillist fashion, displaying some constructive design, mainly abstract, though here and there realistic fragments of recognizable objects were introduced. The gradations of light and dark suggested shading and space. At a later period this three-dimensional element disappeared; colour notes were introduced and the design formed a purely two-dimensional pattern.

The artist did not seek to imitate form but to create it. As opposed to the Impressionist preoccupation with the rendering of ever changing and superficial appearances, he wished to express his reaction to external objects. Following his convictions, he discarded resemblance to natural form and endeavoured to create a language of form—a visual music.

After 1918 Picasso returned mainly to traditional paths and based his pictures on natural form. His paintings became magnificently plastic and monumental. Then he changed again. Much of his work after 1925, in its fantastic and visionary character, suggested sympathy with surrealism. His large mural composition entitled "Guernica" (1937) presented the tragedy of the civil war in Spain as a nightmare. Although anti-Nazi, he remained in Paris during the German occupation and continued his work. After the liberation of Paris Picasso announced that he had become a Communist, and in 1949 the Paris Communist World Peace conference adopted a dove created by Picasso as the symbol of the various Communist peace movements.

Picasso's inventive gift, which led him from one experiment to another, inspired many followers. Painters such as Metzinger, Gleizes, Léger and Villon, and sculptors such as Archipenko and Lipschitz, to name only a few, followed in his wake. He was one of the first to appreciate the expressiveness of Negro sculpture; his style led to an appreciation of "significant form" and of constructive design in all branches of art. He became the outstanding influence in modern art among his contemporaries.

Picasso's influence was also felt on the stage. He produced a series of designs for curtains, scenery and costumes for several Russian ballets. The history of his collaboration with Jean Cocteau and Erik Satie in the ballet *Parade* (1917) is told by Cocteau in *Le Coq et L'Arlequin* (English trans., 1921). His work is represented in many galleries in the United States and Europe.

Picasso's clear, incisive outline drawings are executed with forcible directness and with rigid economy of means. He etched some plates and illustrated several books, notably André Salmon's *Le Manuscrit Trouvé dans un chapeau*, Ovid's *Metamorphoses*, Balzac's *Le Chef-d'oeuvre inconnu* and Pepe Hillo's *Tauromaquia*. He executed portrait drawings of contemporary writers and musicians such as I. Stravinsky, J. Cocteau, M. Jacob, G. Apollinaire, A. Salmon, P. Valéry, etc. He also wrote a play, *Le Désir attrapé par la Queue* (1945; English trans., *Desire*, 1948).

See also PAINTING: *Cubism; School of Paris;* PORTRAIT PAINTING: *19th and 20th centuries;* also references under "Picasso, Pablo Ruiz (y)" in the Index.

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PICCARD, a family of scientists and explorers who designed and used a number of unique vehicles for investigations in the stratosphere and the depths of the oceans.

AUGUSTE PICCARD (1884–1962), Swiss physicist and educator who, at different times, held the world's altitude record and the

record for the deepest descent into the ocean, was born at Basel, Switz., on Jan. 28, 1884. With his twin brother Jean, Auguste in 1913 made a 16-hour balloon flight across France and Germany and in 1926–28 performed various experiments in balloons. In May 1931 he gained the attention of the world when he and Paul Kipfer ascended from Augsburg, Ger., in a free balloon and set a new world's altitude mark of 51,775 ft. This flight, which lasted 16 hours and ended on a glacier in Austria, was the first instance of the use of a pressurized cabin for manned flight. In August of the following year Piccard, accompanied by Max Cosyns, made a second flight, this time ascending from Zürich. After having reached an altitude of 53,153 ft., another record, the balloon landed near Garda, Italy.

From 1937, the year of his last flight, Auguste Piccard devoted his time to studying the problems of designing a vehicle to be used in submarine exploration. After being interrupted by World War II, work was resumed in 1946 on his bathyscaphe, which was based on ballooning principles. The craft consisted basically of buoyancy tanks and a chamber for the crew. The first model was a failure, but a second model took Piccard and his son Jacques to a depth of more than 10,000 ft., more than three times as deep as William Beebe, the previous record holder, had been able to go in his bathysphere. A third bathyscaphe, the "Trieste," was sold in the late 1950s to the U.S. Navy. (*See* DIVING APPARATUS: *The First Bathyscaphes.*) Piccard died at his home in Lausanne, Switz., on March 24, 1962.

JEAN FELIX PICCARD (1884–1963), twin brother of Auguste, took his degree in chemical engineering (1907) and, like his brother, was awarded a doctorate in natural science (1909). With his wife, Jeannette (Ridlon) Piccard, he ascended in a balloon in 1934 to an altitude of 57,579 ft., traveling from Dearborn, Mich., to Cadiz, O. Jean Piccard later experimented with cellophane and plastic balloons, helping design the polyethylene Skyhook series of high-altitude balloons with which the U.S. Air Force sent manned flights to altitudes in excess of 100,000 ft. He died at Minneapolis, Minn., on Jan. 28, 1963.

JACQUES PICCARD (1922–), only son of Auguste, assisted his father in designing, building, and testing the bathyscaphe. On Jan. 23, 1960, he and Lieut. Don Walsh of the U.S. Navy set a new submarine depth record by descending 35,800 ft. into the Mariana Trench in the Pacific Ocean using the bathyscaphe "Trieste."

DONALD LOUIS PICCARD (1926–), youngest son of Jean, aided in his father's balloon experiments and in the 1950s designed a balloon shaped like a milk bottle. Using 12 of these, with an improved valving system, he made a flight which tended to prove the feasibility of his father's idea of a practical multiple-balloon aerostat.

See also BALLOON.

PICCINNI, NICCOLÒ (1728–1800), Italian opera composer, one of the outstanding representatives, with G. Paisiello and D. Cimarosa, of the Neapolitan school, who wrote in both the comic and the serious styles but who, in the century following his death, was chiefly remembered as a rival of Gluck. Born at Bari on Jan. 16, 1728, he received his early musical education in Naples. In 1754 his first *opera buffa, Le donne dispettose,* was produced there. He remained a prolific composer until the end of his life, writing about 140 operas, many of which achieved great popularity. His first *opera seria, Zenobia,* was given in Naples in 1756. Two years later he achieved a triumph in Rome with the opera *Alessandro nell' Indie,* but the masterpiece of his early years was *La buona figliuola,* also known as *La cecchina* (Rome, 1760), on a libretto of C. Goldoni based on Samuel Richardson's *Pamela.* This was the most successful comic opera of the period preceding Cimarosa's *Il matrimonio segreto* (1792).

In 1773 intrigues were created in Rome by Pasquale Anfossi, the first of Piccinni's many rivals, with the result that he left for Naples and later for Paris, where he was invited in 1776 by the supporters of Italian opera. Piccinni was thus condemned to play a role in a continuation of the "Guerre des Bouffons" (*see* OPERA). Though he was by nature a peaceful man, appreciative of the radically different qualities of his contemporaries, Piccinni was throughout his life drawn into the fiercest battles with contemporary figures. Before long his French operas *Roland* (1778) and *Atys* (1780), both on librettos of P. Quinault which had earlier been set to music by Lully, were held up for comparison with the operas of Gluck. Piccinni maintained the traditional sequences of arias and recitatives whereas Gluck, challenging this formal structure, was laying the foundations of an operatic reform. In order to incite controversy both composers were commissioned to write operas on the subject of *Iphigénie en Tauride.* Gluck's famous opera was given in 1779 but Piccinni's work was not given until two years later; at the second performance the singer in the principal part appeared on the stage in a state of intoxication. "C'est Iphigénie en Champagne," echoed the audience in derision. Far from being humiliated by a comparison with his rival, Piccinni continued to admire the art of Gluck and in the journalistic war waged on behalf of the two composers did nothing to encourage his own partisans. When Gluck left Paris in 1779 Piccinni was faced with another rival, Antonio Sacchini, whose *Renaud* (1783) was to be dwarfed by Piccinni's *Didon* of the same year. This became Piccinni's first popular French opera and continued to be given frequently in France during the first quarter of the 19th century. Deprived at the time of the Revolution of his post at the École Royale de Musique, he returned to Naples. He was in Paris again in 1798 and died at Passy, near Paris, on May 7, 1800.

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PICCOLO, in full *flauto piccolo* (Italian, "small flute"), denotes the highest woodwind instrument of orchestras and military bands. In some printed music for military bands "D♭ piccolo" indicates an obsolete six-keyed piccolo pitched a semitone above the ordinary piccolo to facilitate playing in flat keys. *See* FLUTE.
(A. C. BA.)

PICCOLOMINI, an Italian noble family, prominent in Siena and Tuscany since the early 13th century. They appear to be descended from members of the feudal landed gentry, who dominated Siena during the first 100 years of the city commune (12th century). But they were also among the noble Sienese families who took to trade and banking in the 13th century and acquired great wealth, in spite of being twice expelled from the city for the Guelph allegiance. They had counting houses in Genoa, Venice, and other Italian towns, as well as in France and England.

The Piccolomini invested their profits in land and lordships, with the result that they avoided disaster in the sudden crisis which crippled Sienese business at the end of the 13th century, and were able to take their place beside the great patrician families of late medieval Siena and its territory. In 1458 they were created counts palatine by the Holy Roman emperor Frederick III. Members of the house distinguished themselves as ecclesiastics, generals, and statesmen. Two became popes, Pius II and Pius III (*see* PIUS, popes).

See A. Lisini and A. Liberati, *Genealogia dei Piccolomini di Siena* (1900). (P. J. J.)

PICCOLOMINI, OTTAVIO, PRINCE (1599 or 1600–1656), general and diplomatist in the service of the Habsburg powers throughout the Thirty Years' War (*q.v.*), was born at Pisa in Tuscany, a scion of the Pieri branch of the noble Sienese family of Piccolomini. From 1616 onward he served the house of Habsburg, first in the Spanish, later in the Austrian Army, campaigning in Italy, Bohemia, Hungary, and northern Germany. From 1627 he was closely associated with Wallenstein (*q.v.*), whose bodyguard he commanded and who procured for him a superior post in the direction of the War of the Mantuan Succession (1628–31): here Piccolomini showed himself an able diplomatist as well as a sound general. He was instrumental in bringing about Wallenstein's reappointment as generalissimo by the Holy Roman emperor Ferdinand II (1632) and played an important part in the Battle of Lützen, which he nearly turned into an imperial victory.

Wallenstein continued to entrust Piccolomini with major military tasks in Bohemia and Silesia (1633) and seems to have considered him a faithful supporter of his political schemes. Piccolomini, however, remained unswervingly loyal to the emperor and,

together with Matthias Gallas, took the lead in the generals' conspiracy which led to the deposition and murder of the generalissimo (Feb. 25, 1634). Piccolomini received large donations, including the estate of Nachod in northeastern Bohemia, but the supreme command of the imperial army went to Gallas. Piccolomini therefore entered the service of Spain and operated with great success from the southern Netherlands against the French, who had declared war on Spain in 1635: he won a brilliant victory at Thionville on June 7, 1639, for which Philip IV created him duke of Amalfi. Piccolomini then reentered the Austrian service, but was disappointed in his hope that Ferdinand III would appoint him imperial generalissimo in succession to Gallas. Under the nominal command of the inept archduke Leopold William, he was severely defeated in the second of the Battles of Breitenfeld (November 1642). Thereafter he returned to the Spanish service and was richly rewarded. At last, in 1648, he was appointed imperial lieutenant general and thus conducted the last campaign of the Thirty Years' War.

As leader of the imperial delegation to the Congress of Nürnberg (1649), which was to clarify the issues left unsettled by the Peace of Westphalia, Piccolomini displayed great diplomatic skill, in recognition of which Ferdinand III made him a prince of the empire (1650). He died in Vienna in August 1656. His nephew and adopted son, Joseph Silvio Piccolomini, had been killed in the Battle of Jankov (1645).

See O. Elster, *Piccolomini-Studien* (1911). (S. H. S.)

PICENES, Early Iron Age inhabitants of the Adriatic coast of Italy from Rimini to the Sangro River, a territory considerably larger than Picenum (*q.v.*). Unlike the Villanovans (*q.v.*), Comacines, and Atestines (*see* ARCHAEOLOGY: *The Iron Age in Europe*), the Picenes' burial rite was inhumation. The dead were laid on the side, knees drawn up (a position common among primitive people), in a simple trench. Men and women dressed in wool; men wore armour, weapons, and ornaments of bronze or iron; women had numerous fibulae, torques, bracelets, girdles, and ornamental pendants. These pendants, characteristic of Picenum, were exported to the Comacines. Much amber was also worn by both sexes, probably as amulets.

Two main centres, one at Novilara in the north, and another around Belmonte and Fermo farther south, show notable differences. At Novilara swords are generally iron-bladed, broad, and short; the hilt is canted back at an angle from the blade (which is edged only on the inside). This is a Balkan weapon, found with pots of Balkan shape. To the south, the typical sword is long, straight-hilted, and of Greek type. Although inscriptions from the two regions are written in an Etruscan alphabet, they are in different languages (neither fully deciphered in the 1960s, though both contain Indo-European elements). Genetic connections of the Picenes remained obscure; they may descend from old Neolithic stock, with an Illyrian element in the southern group.

Long before the founding of the Greek city of Ancona (*q.v.*), *c.* 390 B.C., the Picenes had traded extensively with the Greeks. Proto-Corinthian Greek vases from Belmonte date from the 7th century B.C., and handsome Greek bronzes of the late 6th and 5th centuries are not uncommon in the south. In contrast, there is little evidence of trade with Etruria, except at the inland site of Fabriano. The evidence suggests that Picenes were primitive, warlike, with little artistic ability of their own, but wealthy enough to sustain a flourishing trade. In 286 B.C. their territory was annexed by Rome.

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PICENUM, a district of ancient Italy between the Apennines and the Adriatic Sea, bounded on the north by the tribe Senones and on the south by the Vestini. Its chief towns included Asculum (modern Ascoli Piceno), Firmum (Fermo), Falerio (Falerone), Auximum (Osimo), Ancona, and in the south Hadria (Atri) and Interamnia Praetuttiorum (Teramo). The southern part was held by the Praetuttii, whose name survives in the modern Abruzzi (Aprutium in the 7th century A.D.).

In early times Picenum formed a distinct cultural area with close linguistic and archaeological links with the opposite coast of Illyria. For the civilization of this warlike population, perhaps formed by Illyrian penetration among the descendants of the early Neolithic inhabitants, *see* PICENES. Conquered by the Romans in 268 B.C., the area was divided among Roman settlers by the *Lex Flaminia* (232). It was at Asculum that the Social War (the war of the *socii,* or allies, against Rome) broke out in 90 B.C.; thereafter Picenum received Roman citizenship. Under Augustus it formed the fifth region of Italy; it was reached from Rome by the Via Salaria and the Via Caecilia.

About the end of the 3rd century A.D. Picenum was joined to the northeastern part of Umbria (known as Flaminia after the Via Flaminia) to form the province of Flaminia et Picenum (sometimes simply called Picenum), which extended as far north as the Po River. This was later divided into Flaminia et Picenum Annonarium in the north and Picenum Suburbicarium in the south. In the late 6th century the Lombards conquered Picenum Suburbicarium, but the Pentapolis Maritima, including Ariminum (Rimini), Pisaurum (Pesaro), Fanum Fortunae (Fano), Sena Gallica (Senigallia), and Ancona, became part of the exarchate of Ravenna (*see* ITALY: *History*).

PICHEGRU, CHARLES (1761–1804), the general of the French Revolutionary Wars (*q.v.*) who was first the protégé of the Jacobins, then a national hero, and finally the agent of the antirevolutionary forces, was born at Les Planches, near Arbois in Franche-Comté, on Feb. 16, 1761, of a peasant family. Sent by Franciscans to their college at Brienne, he taught mathematics there when it became a military academy. He joined the artillery, however, in 1780 and was sergeant major in 1789. With commissioned rank in 1792, he resigned from the army to take up politics in Besançon but was unexpectedly elected lieutenant colonel of a volunteer battalion. Introduced to the minister of war, Noël Bouchotte, in August 1793, he was promptly promoted general; and in October, despite his acknowledged inexperience, was given command of the Army of the Rhine in Alsace. While he and Lazare Hoche, commander of the Army of the Moselle, defeated the Austrians, the two pairs of *représentants en mission* with the French armies quarreled over the merits of the generals; Saint-Just (*q.v.*) and P. F. J. Lebas wanted all credit to go to Pichegru.

In 1794, with the Army of the North and at first with authority also over the Army of the Ardennes, though the real conduct of the campaign was not left to him, Pichegru began operations in April and took Ypres in June and Antwerp in July; but his mentor Saint-Just then perished in the Thermidorian Reaction in Paris. In the autumn Pichegru launched his invasion of the Dutch Netherlands: after his passage of the frozen rivers, Amsterdam fell in January 1795 and Holland was conquered.

Back in Paris, hailed by the Convention as the saviour of his country, Pichegru was put in command of the armed forces there to suppress the Jacobin-inspired rising of 12 Germinal (April 1, 1795). Next he went, in the summer, to command the Army of Rhin-et-Moselle. The campaign was a fiasco, Mannheim fell to the Austrians, and Pichegru signed an armistice for his front on Dec. 31. From August, he had been in contact with agents of the French *émigrés* and of the British government; but Pichegru's treason was distinguished by inactivity.

Pichegru resigned his commission in March 1796. In 1797 he was elected to the Council of Five Hundred as deputy for the Jura *département.* President of the Council, he supported the right-wing opposition to the Directory; and in the government's *coup d'état* of 18 Fructidor (Sept. 4, 1797) he was arrested and deported to Guiana. Escaping in a small boat to Dutch territory (June 1798), he made his way to England and then to Germany, where he acted as a royalist agent. Having fled to England again in 1801, Pichegru went secretly to France in January 1804 in the hope of contacting J. V. Moreau (*q.v.*) for action with Georges Cadoudal and others against Napoleon but was arrested in Paris on Feb. 28. He was found strangled with his cravat in the Temple prison on April 5, 1804. It is not certain that he killed himself.

PICHINCHA, a province of north central Ecuador. Area 6,474 sq.mi. Pop. (1962) 587,835. Most of the population is concentrated in the high Andean plateau and the temperate valleys. Because of its geographical characteristics—mountains, plains, valleys, forests—Pichincha is rich in natural products. It has deposits of lime, gypsum, silver, sulfur and marble. Noted for a variety of fruits and cereals, the province also produces potatoes, sugar cane, cacao, coffee and rice. Its tropical forests are sources of fine woods. Although agriculture and cattle raising are the main occupations, thriving industries—textile mills, processing plants—and flour mills contribute to its economic progress. Cerro Pichincha, an Andean volcano, was the site of a decisive battle in the Latin-American wars of independence, fought May 24, 1822, on its lower slopes between the victorious patriot forces under Gen. Antonio José de Sucre and the Spanish royalists. Quito (*q.v.*), now the provincial capital, was occupied the following day. (C. R. J.)

PICKERING, EDWARD CHARLES (1846–1919), U.S. physicist and astronomer best known for his work in celestial photometry. He was born in Boston, Mass., July 19, 1846. He was graduated in 1865 from the Lawrence Scientific School of Harvard, where for the next two years he was a teacher of mathematics. Subsequently he became professor of physics at the Massachusetts Institute of Technology, where he established the first U.S. laboratory in which students were instructed by actual contact with physical instruments and measurements. In 1876 he was appointed professor of astronomy and director at the Harvard College Observatory. In 1877, when most observatories were devoting themselves to the old "astronomy of position," Pickering, who was a physicist rather than an old-school astronomer, chose as his particular field of labour the photometry of the stars, thus presaging the trend of the new astronomy along lines of physics. He invented the meridian photometers (*see* PHOTOMETRY, CELESTIAL), with which the brightness of more than 45,000 stars was measured at Cambridge and Arequipa (Peru) observatories, and the resulting system was generally adopted as an international standard. Pickering himself made more than 1,500,000 photometric settings.

Through the establishment of an observatory at Arequipa (1891), it became possible, after two years of study, to include measurements made on the stars throughout the southern heavens within the scope of the Harvard College Observatory's work. The work of the observatory under Pickering included photometry; a scale of photographic magnitude; a system of classification of variable stars; and a system of stellar spectroscopy which was universally adopted. He died at Cambridge, Mass., Feb. 3, 1919.

PICKERING, TIMOTHY (1745–1829), officer in the American Revolution, cabinet member under Presidents Washington and Adams, and leader of the New England Federalists, was born in Salem, Mass., July 17, 1745. After graduating from Harvard College in 1763, he studied law, was admitted to the bar, and took an active part in the resistance movement against Great Britain. During the Revolution he served successively as colonel of militia, adjutant general to George Washington, member of the board of war, and (1780–85) quartermaster general. In 1786, after taking up residence in Philadelphia, he was sent by the government of Pennsylvania to organize Luzerne County and to resolve the dispute with Connecticut settlers over claims to the Wyoming Valley (*q.v.*). During the next three years, though terrorized and even kidnapped, Pickering succeeded in bringing order to the valley and helped develop the town of Wilkes-Barre, which became the county seat.

During Washington's administrations Pickering served with distinction as Indian commissioner (1790–95), postmaster general (1791–95), and secretary of war (1795–96). In August 1795 he took charge of the Department of State on an interim basis, and in December he reluctantly became secretary of state. Although ill-suited for this post, he was reappointed to it in 1797 by President Adams. Pickering strongly supported the foreign policy views of Alexander Hamilton, including the maintenance of friendly ties with England and the support of a strong army and navy. These views brought him into conflict with Adams, who dismissed him from office, May 12, 1800. During the administrations of Jefferson and Madison, Pickering led the Federalist opposition in Congress, serving as senator from Massachusetts (1803–11) and as a member of the House of Representatives (1813–17). He helped to block Jefferson's assault on the judiciary and helped bring about the repeal of the Embargo Act in 1809. Remaining friendly to England and fearing the power of Napoleon, he bitterly opposed the War of 1812. Following his retirement from Congress he devoted himself to agricultural experimentation and education. He died in Salem, Jan. 29, 1829.

See Octavius Pickering and Charles W. Upham, *The Life of Timothy Pickering,* 4 vol. (1867–73); H. P. Prentiss, *Timothy Pickering as the Leader of New England Federalism, 1800–1815* (1934). (E. H. PH.)

PICKERING, WILLIAM HENRY (1858–1938), U.S. astronomer and discoverer of the ninth satellite of Saturn. He was born in Boston, Mass., on Feb. 15, 1858, and in 1879 graduated from the Massachusetts Institute of Technology. In 1891 he joined his brother Edward C. Pickering in establishing the Arequipa station of the Harvard Observatory in Peru. He also established a meteorological station at an altitude of 16,650 ft. upon Mt. Chachani, and accomplished the ascent of El Misti, 19,167 ft. He surveyed and determined the altitude of many other Peruvian mountains and returned to the United States in 1893. In 1894 he erected the observatory and telescope for Dr. Percival Lowell (*q.v.*) at Flagstaff, Ariz., and in 1900 erected a station for the Harvard Observatory at Mandeville, Jamaica, in the West Indies. In 1899 he discovered Phoebe, ninth satellite of Saturn, and noted its contrary revolution. His announcement of a tenth satellite in 1905 remains unconfirmed; but he correctly predicted (1919) the existence of a trans-Neptunian planet, later named Pluto. Pickering died in Jamaica, Jan. 21, 1938.

PICKETING: *see* STRIKES AND LOCKOUTS; LABOUR LAW.

PICKETT, GEORGE EDWARD (1825–1875), U.S. and Confederate army officer, known for "Pickett's Charge" at the Battle of Gettysburg, was born at Richmond, Va., Jan. 25, 1825. After graduating from the U.S. Military Academy at West Point, N.Y., in 1846 he served with distinction in the Mexican War. As a captain, he later played a notable part in the Northwest boundary controversy (1859). He resigned his commission in June 1861 and entered the Confederate Army, being made brigadier general in February 1862. In the Peninsular Campaign he led his Virginians effectively until he was severely wounded at Gaines's Mill. Late in 1862 he became major general. At Gettysburg on July 3, 1863, three brigades of his division (4,300 men) constituted somewhat less than half of the force in the climactic attack since known as "Pickett's Charge." The attack was actually under the command of Gen. James Longstreet. Its bloodily disastrous repulse at "High-water Mark" is often considered the turning point of the American Civil War. (*See* GETTYSBURG.) Pickett's conduct at this time has been adversely criticized, even to charges of cowardice; such charges are, however, refuted by Lee's retention of him in divisional command, throughout the Virginia Campaign of 1864. On April 1, 1865, his division was almost destroyed at Five Forks while Pickett was at a shad-bake. He remained with the army, though without a command after April 8, until Lee's surrender. After the war he was engaged in the insurance business in Norfolk, Va., where he died on July 30, 1875.

See Walter Harrison, *Pickett's Men* (1870); D. S. Freeman, *Lee's Lieutenants* (1942); G. R. Stewart, *Pickett's Charge* (1959).
(G. R. ST.)

PICKFORD, MARY (GLADYS MARY SMITH) (1892–), U.S. motion-picture actress noted for her roles as an ingénue, was popularly known as "America's sweetheart." Born at Toronto, Ont., April 8, 1892, she made her first stage appearance at the age of five; at eight she went on tour. She went to New York under the auspices of David Belasco, creating the part of Betty Warren in *The Warrens of Virginia.* Her first motion-picture work, as an extra at the age of 15, was undertaken with D. W. Griffith; but she returned to Belasco, taking the part of Juliet in *A Good Little Devil* at the Republic theatre in New York. In 1913 she turned permanently to the screen, rising to first rank with Famous Players company. In 1916 the Mary Pickford Film corporation was organized, and three years later Miss Pickford was prime mover in forming the United Artists corporation. She married Owen Moore

in 1911 (divorced, 1919), Douglas Fairbanks in 1920 (divorced, 1936), and Charles Rogers in 1937.

PICKLING is a general term meaning to preserve in salt, acid, sugar, or any combination of the three. The word appears to be an adaption of the Dutch *Pekel*, "brine, pickle" (*cf.* Ger. *Pökel*). The term is applied to the preservation of wood by treating it with creosote, copper or zinc sulfate or similar solutions. Certain kinds of steel are pickled in sulfuric acid; the term may also refer to processes in metal casting and leather manufacturing.

The greatest use of pickling is in the food industry where it is one of the four most commonly used methods of preserving food. (Canning, freezing and dehydrating are the others.) In the preparation and preservation of fish, meat, especially pork, and meat products such as bologna, wieners, sausages, etc., a brine made of salt (sodium chloride), sodium nitrite and sodium nitrate is widely used. Eggs are sometimes pickled in limewater (calcium hydroxide) or in water glass (sodium silicate).

Fruits, nuts and vegetables are pickled in a variety of ways. Crab-apples, peaches, pears and watermelon rind are pickled in a solution of vinegar, spices and sugar. Unripe walnut meats are pickled in salt, sugar and acid. Onions, cauliflower and mango peppers are pickled in strong (20%–24%) salt without fermentation. Other vegetables, such as cabbage (2% salt), green tomatoes and certain kinds of peppers (*e.g.*, banana, finger and tomato peppers [5%–10% salt]), undergo a lactic fermentation and are preserved by a combination of acid and salt.

Cucumber pickles are by far the most popular kind of pickles in the United States. Two varieties of cucumbers are used: the white spine, which has a thick, smooth, dark green skin and is the produce variety used for slicing; and the smaller black spine, which has a thin, warty, light green skin and is grown especially for pickling. All types of fresh cucumber pickles are made by placing fresh, washed cucumbers (whole or sliced) in glass jars, adding salt, acetic acid, sugar, turmeric, alum and spices, and then pasteurizing; other processes are used for salt stock and for fermented cucumber pickles. *See* also references under "Pickling" in the Index.

(F. W. Fn.)

PICO, a Portuguese island in the Atlantic Ocean, forming part of the Azores (*q.v.*) and separated from its neighbour Faial by a channel. Area 167 sq.mi. (432 sq.km.). Pop. (1960) 21,750. The island is dominated by the cone-shaped Pico volcano (7,713 ft. [2,351 m.]). Whaling, still practised in small boats, and cattle raising are important industries. The once-famous wine industry, interrupted by the destruction of vines by disease in 1852, was being restored in the mid-1960s with the use of American roots. The chief town is Lajes do Pico (pop. 2,508). (J. Ao.)

PICO DELLA MIRANDOLA, GIOVANNI, Conte (1463–1494), Italian philosopher and scholar who was next in importance to Marsilio Ficino (*q.v.*) as an exponent of Renaissance Platonism and is still admired as a representative of Renaissance learning. He was born on Feb. 24, 1463, the youngest son of Giovanni Francesco Pico, prince of Mirandola, a small territory not far from Ferrara. Pico, who was a precocious child, received a thorough humanistic education at home and subsequently studied canon law at Bologna and Aristotelian philosophy at Padua. He also visited Florence and Paris and learned Hebrew, Aramaic, and Arabic. Introduced by his Hebrew teachers to the Cabala, Pico was the first Christian scholar who tried to use Cabalistic doctrine in support of Christian theology. In 1486 he proposed to defend in a public disputation in Rome 900 theses drawn from diverse Greek, Arabic, Hebrew, and Latin thinkers, and composed for that occasion his famous *Oration* on the dignity of man; but 13 of the theses were declared heretical by a papal commission, and the disputation was prohibited by Pope Innocent VIII. Pico tried to defend the theses in an *Apologia* and fled to France. On the request of Lorenzo de' Medici, he was allowed to settle in Florence where he was connected with the famous Platonic Academy. There he spent the rest of his life except for short trips to Ferrara. He was absolved from the suspicion of heresy by Pope Alexander VI in 1493.

Pico published an exposition of Genesis under the title *Heptaplus* (Florence, no date); worked on a harmony of Plato and Aristotle, of which the completed treatise *De Ente et Uno* was part; and began a treatise against the enemies of the church, which included his famous and influential work against the astrologers. Toward the end of his life he came under the influence of Girolamo Savonarola. He died in Florence on Nov. 17, 1494.

Although his early death prevented Pico from working out his philosophy, his writings contain significant and influential ideas. He found elements of truth in all the different schools and thinkers known to him and defended the merits of the medieval scholastic philosophers against Ermolao Barbaro. In exalting the dignity of man, he denied that man occupies any fixed place in the universal hierarchy, but asserted that he determines his place and nature through his own free choice.

Pico's critique of astrology was based on religious rather than on scientific considerations and failed to gain general acceptance at the time, but it contained a good deal of weighty detail and influenced Johannes Kepler in the 17th century.

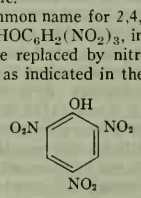
Bibliography.—The first great collection of Pico's writings was the *Commentationes Joannis Pici Mirandulae*, ed. with a biography by his nephew Giovanni Francesco Pico, 2 parts (1495–96); a modern edition was started by E. Garin in 1942. Some of the letters and the biography were translated by Thomas More (1510?). *See* further E. Garin, *Giovanni Pico della Mirandola* (1937); E. Anagnine, *G. Pico della Mirandola* (1937); P. Kibre, *The Library of Pico della Mirandola* (1936); A. Dulles, *Princeps Concordiae* (1941); J. Blau, *The Christian Interpretation of the Cabala in the Renaissance* (1944); S. Samek Ludovici, *Catalogo della mostra delle opere di Giovanni Pico della Mirandola* (1963), for the fifth centenary of Pico's birth. (P. O. K.)

PICRIC ACID (Trinitrophenol), a yellow crystalline solid that has been used as a military explosive, a yellow dye, and an anesthetic. The name picric acid, introduced by J. B. A. Dumas, derives from the Greek word *pikros*, meaning bitter, thus indicating the extremely bitter taste of its yellow aqueous solution, from which it can be crystallized in yellow scales, plates, or needles, depending on the concentration of the solution. It melts at 122.5° C, sublimes with slow heat, but explodes with rapid heat. Explosion also can be caused by percussion. It was first obtained in 1771 by P. Woulfe by treating indigo with nitric acid and was used as a yellow dye, initially for silk, beginning in 1849.

The once great importance of picric acid as an explosive dates from 1886, when the French began using it under the name of melinite as a bursting charge for shells. In 1888 Great Britain adopted its use under the name of lyddite and in Japan it was referred to as shimose. By the time of the Russo-Japanese War, picric acid was the most widely used military explosive. Its use was greatly reduced, however, after World War I because of its highly corrosive action on the metal surfaces of shells, which causes the formation of highly sensitive metal picrates. But one of its salts, ammonium picrate, is used in modern armour-piercing shells because it is insensitive enough to withstand the severe shock of penetration, thus making it possible to delay the explosion until the shell has completed its penetration.

Picric acid shows antiseptic properties and is incorporated with Butesin, a surface anesthetic, into burn ointments in the amount of 1%. It is also used for the determination of creatinine in urine. Like all aromatic nitro compounds (*i.e.*, ring structures including at least one NO_2, or nitro, group), it is a blood poison and its vapours are toxic.

Picric acid is the common name for 2,4,6-trinitrophenol, a compound of the formula $HOC_6H_2(NO_2)_3$, in which three hydrogens of the benzene ring are replaced by nitro groups and one by a hydroxyl (OH) group, as indicated in the structural formula



In one industrial preparation method, phenol, upon being heated with sulfuric acid at 120° C, is converted to phenolsulfonic acid, *i.e.*, $C_6H_5OH + H_2SO_4 \rightarrow HOC_6H_4SO_3H$, which on further treatment with 70% nitric acid, first at 0° C and then at 100° C, yields the trinitrophenol as an oily liquid that solidifies on cooling. The

crystals are washed with water until free of acid and are further purified by boiling in water in the proportion of 15 g. to the liter.

Another, more economical, method starts with chlorobenzene, which is converted with a mixture of concentrated nitric and sulfuric acids to 2,4-dinitrochlorobenzene. Hydrolysis of the latter with aqueous sodium carbonate to 2,4-dinitrophenol, *i.e.*, $ClC_6H_3(NO_2)_2 + Na_2CO_3 + H_2O \rightarrow HOC_6H_3(NO_2)_2$, and subsequent treatment with nitric acid gives picric acid.

Picric acid is a much stronger acid than phenol; it decomposes carbonates and may be titrated with bases, sodium alizarinsulfonate being used as an indicator. Neutral lead acetate produces no precipitate, but in basic medium a bright yellow lead picrate is obtained. The crystalline salts that it forms with organic bases are often used for their isolation and identification. It forms coloured molecular addition complexes of varying stability with many aromatic hydrocarbons, particularly with those containing a number of rings, such as naphthalene, anthracene, phenanthrene, etc. The stable complexes are utilized in the isolation of hydrocarbons from reaction mixtures, and in their purification and identification. The regeneration of the hydrocarbons from the complexes is often achieved by chromatographic adsorption. A benzene solution of the complex is passed through a tower packed with activated alumina powder. The picric acid is adsorbed more strongly by the alumina and the hydrocarbon appears first in the filtrate. (H. F.)

PICRITE, an intrusive igneous rock of ultrabasic composition somewhat similar to peridotite (*q.v.*). The name, given by Australian mineralogist Gustav Tschermak von Seysenegg in 1866, is derived from the Greek word for bitter, because of the high percentage of magnesia (bitter earth) these rocks contain. The picrites are dark, heavy rocks largely composed of olivine and augite, a pyroxene, with a small but variable amount of plagioclase feldspar. Hornblende and biotite may also be present. The picrites usually occur in sills or sheets, and seldom in large plutonic masses (unlike peridotites). Varieties include augite, enstatite and hornblende picrite. The term picrite-basalt is reserved for feldspar-poor basalts rich in olivine.

The minerals of picrites are very frequently decomposed. Serpentine (*q.v.*) partially or wholly replaces olivine, while hornblende (pilite), talc and chlorite appear as secondary products after the same mineral. Augite passes into hornblende or chlorite, and the essential feldspar is often represented by epidote, prehnite and white mica. In some picrites, as in the peridotites, a lustre mottling is given by the inclusion of unoriented grains of olivine in large crystals of augite or hornblende. In the porphyritic varieties a residual brown glass may be present. Such rocks are known as picrite-porphyrites.

Many picrites clearly possess alkaline affinities. Thus the augite picrites of the Midland valley of Scotland and of the type locality in Moravia contain interstitial analcite and are closely related to the teschenites with which they are associated (*see* THERALITE). Other picrites are more clearly calc-alkaline, being associated with diorites or diabases. The hornblende picrites of Caernarvonshire and Anglesey, Wales, and other places belong here. In the Devonian rocks of the Fichtelgebirge and Nassau picrites accompany diabases, as they do also in Cornwall and Devon. (C. E. T.)

PICROTOXIN, a respiratory stimulant used as an antidote in poisoning caused by central nervous system depressants, such as the barbiturates. Picrotoxin occurs in the fruits of *Anamirta cocculus*, a shrub indigenous to Malabar and the East Indies. The fruits are called fishberries because they are used by the natives to poison fish. The dried berries are known pharmaceutically as *cocculus indicus*.

Picrotoxin, whose formula is $C_{30}H_{34}O_{13}$, is a compound of picrotin and picrotoxinin, the latter representing the active part. Its effects are somewhat similar to those of strychnine, except that the action of strychnine is predominantly on the spinal cord while that of picrotoxin is on the cortex and medulla. In small doses it stimulates and in larger doses depresses the central nervous system, so that the sequence of events in picrotoxin poisoning are convulsions, confusion, and unconsciousness. In picrotoxin poisoning, barbiturates, chloral hydrate, or chloroform are indicated.

PICTOGRAPHY, in the widest sense, includes all human expression and communication by means of pictures, which are drawn, painted, scratched or incised. It includes primitive attempts at purely aesthetic expression; drawings with a communicative aim, which may be classified as the forerunners of writing; and full systems of writing utilizing pictures as basic forms. In a narrower sense, the term is applied only to primitive drawings on rocks, called petrograms if they are drawn or painted, and petroglyphs if they are incised or carved. It is in its restricted sense, as applied to the primitive forerunners of writing, that pictography is discussed in this article. (Full systems of writing, utilizing pictures for signs, such as Egyptian or Hittite, are often called hieroglyphic and are discussed in the articles HIEROGLYPHS; LOGOGRAM AND SYLLABARY; and WRITING.)

Primitive Drawings.—If writing is defined as a device for expressing linguistic elements by means of conventional visible marks, then it is no more than 5,000 years old. But even tens of thousands of years ago man felt the urge to draw pictures on walls and rocks. Primitive man is similar in this respect to a child, who no sooner learns to crawl than he begins to scribble on the wallpaper or to draw crude pictures in the sand. All over the world, man has left traces of his imaginative powers in rock drawings dating from Paleolithic to modern times. They usually depict man, deity and animal in various relations to each other. The faithful reproductions of animal figures left by Paleolithic man in Europe and the graceful paintings of the South African Bushmen are well-known examples. An immense number of rock drawings and carvings have been found in North America, especially in the mountainous regions.

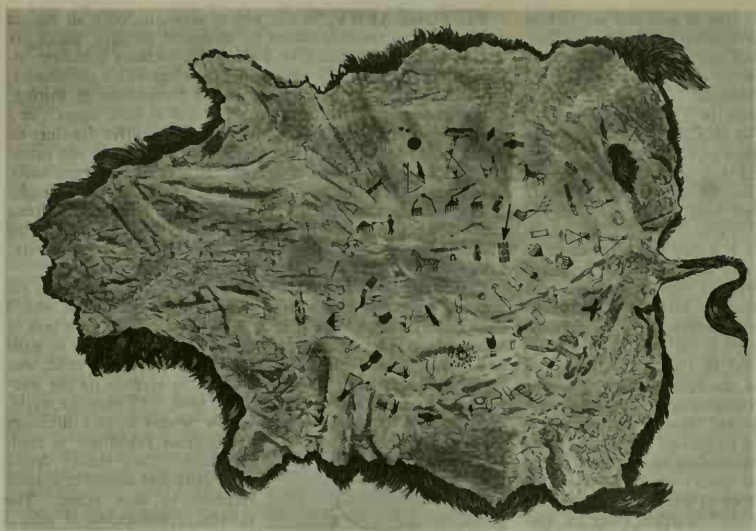
INDIAN ROCK DRAWING FROM NEW MEXICO

In most cases it is very difficult to ascertain the purpose of a picture, since the circumstances of its execution are not known. The picture may be a manifestation of magic, religious or aesthetic expression, and several impulses may have been at work at the same time in its origin. The depiction of a successful hunt or military expedition, though it may have been essentially pictorial, may also have served as a monument to commemorate past experiences. It could also have had the magical purpose of securing another good hunt or a successful razzia in the future. Such pictures do not constitute writing because they do not form part of a conventional system of signs and can be understood only by the man who drew them and those who knew of the event.

Although the underlying aims of a picture cannot be established, certain differences in the form of execution may be discerned between pictorial art and drawings made for purposes of communication. The latter attempt to communicate a certain message in a way that can be understood by the people for whom the message is intended. Since they are drawn for communication and not for aesthetic expression, they are characterized by stereotyped execution and by omission of all details (background, mountains, trees, etc.) not necessary for the expression of the communication.

Pictography and Ideography.—The basis of all writing is the picture. Among primitives, a picture satisfies, in a crude way, the needs fulfilled among literate people by writing. In the course of time the picture developed in two directions: (1) toward pictorial art, in which pictures continued to reproduce more or less faithfully the objects of the surrounding world in a way independent of language; and (2) toward writing, in which signs, whether they retained their pictorial character or not, ultimately became symbols for linguistic elements. Ideography represents an intermediate stage between pictorial art and writing.

The term ideography includes the various forerunners of writing, which convey ideas or meanings directly and have a very loose connection with the elements of language. Both ideography and pictography are applied to the same kinds of forerunners of writing, but while pictography refers to the pictorial character of the



BY COURTESY OF THE SMITHSONIAN INSTITUTION

WINTER COUNT, PAINTED ON BUFFALO ROBE, OF LONE DOG, OF THE YANKTONAI DIVISION OF THE DAKOTAS

This calendar (called "winter count" because the Dakotas count their years by winters) was begun about 1800 with the sign (*see* arrow) in the middle of the robe, and continues in a spiral to the left. Each sign acts as a mnemonic device, signifying an outstanding event in the band's life during that year

symbols, the term ideography denotes inner, structural characteristics of the system, such as the fact that the individual symbols, called ideograms, stand for certain ideas or meanings.

A simple example of ideography is the communication "no thoroughfare," in a rock drawing near a precipitous trail in New Mexico. The design, representing a mountain goat standing upright and a horse and rider upside down, is intended to warn horsemen that, while a mountain goat could climb up the rocky trail, a horse would tumble down. This drawing employs no more detail than is necessary to indicate the two animals and the rider, and there is no indication whatever of a background.

The ideographic communication is somewhat different from a work of art and is completely independent of language. A person who is only slightly acquainted with the communication habits of American Indians is able to understand the message just described, even though he is ignorant of the language of the person who drew it. This stage of the forerunners of writing is called the descriptive-representational stage.

Another forerunner of writing, used more for recording rather than for communicating, is called the "identifying-mnemonic" device. Certain signs or combinations of signs are used as aids for memorizing songs, proverbs, dates or the like. The Ojibwa Indians record their ceremonial songs in this way by means of drawings on birch bark; the Ewe Negroes of Togo, in Africa, record proverbs in a similar manner. In all cases the individual drawings do not reproduce pictorially the verse or proverb but only give a suggestion of it. Thus, among the Ewe a drawing of a threaded needle does not reproduce the proverb "the thread follows the needle" (resembling in its meaning the English "a chip off the old block") but is a device to help recall it.

The pictorial character of all the symbols used as forerunners of writing can generally be recognized. But even in their earliest stages these systems use symbols that do not look like real objects but rather like simple linear, geometric designs composed of strokes, squares and circles. Most of these symbols are not abstract forms but are schematic developments from real pictures. Some signs which are geometric in form may owe their origin to imitation of signs in gesture language. In the systems used by American Indians, the sign for "all," which is drawn in the form of a circle, may go back to a gesture sign made by a circular motion of the hand.

The main object of writing, namely, efficiency of communication, is achieved through the omission of all details not necessary for the understanding of the symbol. One such economizing measure is the *pars pro toto* convention, found so frequently in American Indian writings. By this device an object, usually a man or an animal, is indicated by a picture of only a part of it, very often the head.

Meaning can also be conveyed by various auxiliary devices based on the use of colour, position and context of situation. American Indians, for example, have frequently employed coloured signs. Thus, among the Cherokee white is used for peace or happiness, black for death, red for success or triumph, blue for defeat or trouble.

The importance of position can be visualized in modern mathematical systems as, for instance, in "32" and "3^2"; meaning is here expressed by conventional positions of the signs in respect to each other. The principle of position may be illustrated by many examples used among the American Indians. Drawings of a hawk and a person may represent the two words individually, but a hawk directly above the head of a person indicates, by convention, the name of the person; namely, "Hawk." A drawing of a person facing in one direction conveys "coming," in contrast to a drawing of a person facing in the opposite direction, which conveys "going away."

The principle of context of situation, a term introduced by B. K. Malinowski in his study of the problem of meaning in preliterate societies, may be exemplified by the query "where is the pen?" The question is usually perfectly understandable, even though the word pen may mean a writing instrument, a play pen or a different type of small enclosure, depending on the circumstances in which it is asked. In American Indian conventions, a drawing of a panther in one case may represent or imply a panther; in another case, the name of a person, especially if it is drawn above the person's picture; in still another case, at the end of a message, it serves as a sort of invocation to the panther, symbol of force, asking for help in a military expedition.

Forerunners of writing may be divided into several classes. In the primary class, objects and beings are represented by pictures of those objects or beings. The second, the associative class, includes signs that express ideas connected with the drawing by association of meanings. While a picture of the sun expresses "sun" by the primary device, it can also have the meanings "day," "bright," etc., by the associative device. Another device, phonetization or the rebus principle, plays a paramount role in all the fully developed writings, such as Sumerian, Egyptian, Chinese, etc., but is hardly ever attested among the forerunners of writing. Among the very rare examples is the Dakota writing of the name of the Indian tribe Hohe, which means "the voice" in the Dakota language; it is a drawing of the vocal organs.

Pictography is most widely used among the American Indians, and the Indians reached a level of systematization and standardization of symbols far above other comparable systems. One peculiarity of the Indian drawings is that, within each tribal system, every Indian draws in precisely the same manner. By contrast, in the drawings of the African Negroes the different local styles can be readily recognized.

Ideography and Logography.—Ideography, as used in this

article, denotes a system of visual communication which conveys ideas, thoughts and contents but not linguistic elements. The term has often been confused with logography or word writing. Because of the double meaning of ideography, the term semasiography (from the Greek *sēmasía* "meaning," "signification" and *gráphein* "to write") is sometimes used in its place.

The difference between the ideographic and fully developed systems of writing may be illustrated by analyzing the method in which a communication such as "the king killed a lion" is expressed in the two systems. This message would be expressed in an ideographic system by a scene showing a man with some insignia of royalty, such as a crown or a sceptre, depicted in the process of attacking a lion with a weapon. In any of the fully developed writings, such as Sumerian or Egyptian, the same communication would be expressed not by a scene but by a sequence of signs, each standing for one word of the communication. Instead of a scene composed of two parts (man with a weapon facing a lion), three separate signs would indicate the three main words of the communication; namely, the signs for king, killing and lion. It should be noted that even the fully developed writing systems are not capable in their earliest stages of indicating such morphological features of the language as the definite and indefinite articles and the distinction in tense. Later Sumerian, Egyptian and other similar writings are, of course, capable of indicating any linguistic nuances.

Another illustration of the different methods used in ideography and logography can be seen in the way a communication "five lions" would be recorded. In ideography it would be expressed by five separate pictures of lions, while in logography this would be accomplished by only two signs, corresponding to the two words of the language. The plural mark *s* would be omitted in the early stages of logography.

Another important characteristic of logography is that the order of the signs follows the order of the spoken words; in ideography, the meaning is conveyed without any convention regarding order. The third important distinction pertains to the choice of symbols or signs in ideography and logography. In ideography, the sign for sun conveys "sun" and related ideas, such as "bright," "light," "clear," "shining," "pure," "white," "day," or even "the sun is shining," "the day has come"; in logography, the sign has only as many meanings as there are words which are habitually and conventionally associated with it. Thus, in Sumerian, the sun sign expresses at least seven words related to the basic meaning of "sun," but in Chinese the sun sign stands only for "sun" and "day," while the word *ch'ing* "pure," "clear" is expressed by a combination of the sign for "sun" with the sign for "colour"; the word *ming* "bright," "shining" by that of "sun" and "moon"; and the word for "white" by a sign of unknown interpretation evidently having no connection with the sun. Similarly, in Egyptian, the words for "sun," "day," "white" and "light" are expressed by the picture of the sun, but the word $\underline{i}^{r}h^{r}n^{r}$ "shining" is written by a sign different from that for the sun. There are no logographic systems in which a sign can stand for a certain idea with all of its related ramifications, just as there are practically no signs in these systems which are not intended to correspond to words of language. Almost all cases claimed to be ideography turn out, upon investigation, to be false. When a writer intends to express a word by a word sign that stands for many words, he will usually try to make sure that the reader will read only the intended word. Semantic and phonetic indicators, the principle of position and context of situation are devices for the purpose of achieving this aim.

The oldest systems of writing, such as the Sumerian and Egyptian, being fully phonetic, employ conventional signs with definite word or syllabic values. Even in these fully phonetic writings, however, the meaning is sometimes expressed not by conventional signs but by descriptive-representational drawings. In Egyptian, in a written context describing the victories of Ramses II over foreign lands, Pharaoh's honorary title, "he who binds the foreign peoples," is expressed not by individual hieroglyphs but by a scene depicting the Pharaoh binding the foreign king with cords. In another written context, the formula, "an offering which the king gives," is expressed by a picture of a king holding a mat with a loaf of bread. The meaning is conveyed in these two scenes in a form which is known from the earliest periods of Egyptian writing, as found, for example, on the Narmer palette.

Even in modern usage there are signs which have no conventional speech forms. For instance, an arrow on a sign along a road may mean "follow the direction of the arrow," but at the entrance to a cave it may mean "enter here." Such examples as there are of this sort of symbolism have many parallels in the semasiographic stage of writing in which meanings, rather than words or sounds, are suggested by signs. As part of a phonetic system of writing, an arrow sign would in time develop one or two unequivocal speech meanings, such as "go (there)" or "follow."

Certain symbols in comic strips are also generally understood even though they have no conventional counterpart in speech. Such symbols, called "sublinguistic ideographs," include: a balloon encircling print, signifying that a character is speaking; footprints, signifying that he is going; sawing wood, for snoring or sleeping; a light bulb with rays, for an idea; and]/!*§§="), for profanity.

Also outside normal phonetic systems are the conventions of mathematics, logic and science. Although each sign of a formula has or can have an exact correspondence in speech, the meaning is conveyed by the order and form of the signs, which do not follow the conventions of phonetic writing.

See also references under "Pictography" in the Index.

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PICTON, SIR THOMAS (1758–1815), British lieutenant general who served throughout the Peninsular War and at the Battle of Waterloo, was born at Poyston, Pembrokeshire, in August 1758. He was gazetted an ensign in the 12th Foot Guards in 1771, when he saw service in Gibraltar, but transferred to the 75th Foot in 1778, and was promoted captain. The disbanding of his regiment in 1783, following the Treaty of Versailles, led to a riot which Picton subdued by arresting the ringleader. After the outbreak of the war with revolutionary France in 1793, he resumed his military career in 1794, joining the staff of the commander in chief of the West Indies. He took part in the capture of the islands of St. Lucia and St. Vincent in 1796 and of Trinidad in 1797. In the same year he was appointed governor of Trinidad, where he built roads, increased trade, and established an efficient but severe administration. In 1803 enemies at home accused him of tyrannical government and he resigned in protest. He saw more service in the operations which led to the recapture of St. Lucia and the seizure of Tobago before returning to England in October 1803 to face the serious charges against his administration in Trinidad. He was found guilty in 1806 but this verdict was rescinded at a second trial in 1808. The inhabitants of Trinidad showed their support for him by subscribing £4,000 to help in the cost of his defense, a sum which he later donated to the relief of the sufferers from the fire at Port-of-Spain, Trinidad.

In 1810 Picton was appointed to the command of the 3rd division of Wellington's army in Portugal and first showed his powers of leadership at Bussaco (1810) and at Fuentes de Oñoro (1811). With his division he took a leading part in the assault on Ciudad Rodrigo (1812), and at the battle of Badajoz (1812), his capture of the castle brought about the fall of the town after the main assault on the breaches had failed. In August 1812 Picton was invalided home to England with fever. He was knighted in February 1813, and returned to Spain where he was appointed lieutenant general and fought in the battle of Vitoria (June 1813), where his division, the 3rd, was engaged more fiercely and suffered heavier losses than any other in the army. He had a prominent share in the battles in the valleys of the Pyrences and, in the operations in France in 1814, at the battles of Orthez and Toulouse. His service in the Peninsular War established his reputation as a first-class leader of troops and as a competent and reliable subordinate, without any great pretensions to capacity for independent command.

He rejoined the army at the Waterloo campaign (1815) and as commander of the 5th division he repelled a series of French attacks at Quatre Bras, where he was severely wounded. He was

killed on June 18 at the Battle of Waterloo and was buried in London at St. George's, Hanover Square, on July 3, 1815. Picton possessed great courage and was a warm friend and a stern enemy, with brusque manners and a rough tongue; as a soldier he was a rigid disciplinarian and an outstanding leader of men.

See H. B. Robinson, *Memoirs of Lieutenant General Sir Thomas Picton*, 2 vol. (1836). (E. W. Sh.)

PICTS (Latin *Picti*, "painted"; Irish *Cruithin;* Welsh *Prydyn*), an early people inhabiting Scotland, whose language undoubtedly contained pre-Celtic and non-Indo-European elements. (*See* Celtic Languages.) They are first mentioned in A.D. 297, and their name may be derived in both its Latin and native forms from the habit of tattooing. They proved to be one of the most bitter groups of raiders upon the Roman province, particularly from 367 onward, and came to form a vigorous northern kingdom. In 685 the Picts defeated the Northumbrians at Nechtanesmere. In the 8th century the Pictish kingdom extended from Caithness to Fife and is associated with the carved memorial stones and crosses of which the finest collections are in the National Museum of Antiquities of Scotland, Edinburgh, and the museum at Meigle in Perthshire. The round stone towers known as brochs or "Pictish towers" and the underground stone houses called weems or "Picts' houses" are both earlier than the historical Pictish kingdom. Christianity had reached them in the late 6th century. About 843 the kingdom was united with the rest of Scotland under Kenneth I MacAlpin.

The relationship between the Picts and the Cruithin of Ireland (*see* Ireland: *History*) is a matter of dispute.

See F. T. Wainwright (ed.), *The Problem of the Picts* (1955). For the relation between *Cruithin* and *Picti* and the language of the Picts, *see* also T. F. O'Rahilly, *Early Irish History and Mythology*, esp. pp. 341 ff., 358 ff., 444 ff. (1946).

PICUS, the Latin woodpecker. As the woodpecker was sacred to the god Mars (*q.v.*) it was widely reverenced in ancient Italy and developed into a minor god. As a deity Picus is agricultural (not unlike Mars) and is associated particularly with the fertilization of the soil with manure; thus we find him at times called son of Sterculius (Stercutius or Stercenius, the dung god). Since the woodpecker was an important bird in augury, Picus is not only rustic but prophetic.

Later rationalizations made him an early king of Italy. Virgil (*Aeneid* vii, 45–49, 187–191) makes him son of Saturn, father of Faunus and grandfather of Latinus (*qq.v.*). His bride, Circe, for reasons of unrequited love, changed him into a woodpecker. Ovid (*Metamorphoses* xiv. 320 ff.), perhaps inventing the story, relates that his wife was the beautiful nymph Canens ("Singer") and out of faithfulness to her he spurned the love of Circe and thus suffered the metamorphosis. According to others it was Pomona who was his beloved.

As son of Saturn he came to be identified with Zeus, and because of the similarity of their names is confused with another rustic deity, Picumnus. Picus and Faunus are associated in a story told by Ovid (*Fasti* iii, 291 ff.) where Numa captures the two by rendering them drunk and forces their assistance to avert a disaster.

His earliest representations were as a wooden pillar mounted with the image of a woodpecker. In more sophisticated form he is a youth carved of marble with a woodpecker on his head.

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PIDDOCK, several species of highly specialized marine bivalve mollusks (*see* Mollusk) belonging to the family Pholadidae. They are adapted for boring into rock, shells, peat, hard clay or mud. The name was first applied to *Pholas dactylus*, a rock borer occurring in western Europe, but its use has been broadened to include species in various genera throughout the world. All of the species are characterized by having accessory plates in addition to the bivalve shell. The young stages have an anterior gape for the protrusion of a large muscular foot which aids in boring. The anterior portion of the valves is armed with rows of strong imbrications with which the animal abrades the substratum in the process of boring. In some groups the anterior gape is closed by a covering or callum when the animal has stopped boring. Some species bore to a depth only slightly more than the length of the shell, but others, which have extensible siphons, may bore to depths several times the length of their shell. Many of the deep borers have additional shelly or chitinous plates (the siphonoplax) for the protection of the siphons. The accessory plates on the dorsal surface of the valves are for the protection of the anterior adductor muscle, which has migrated to the outer surface of the shell. The alternate contraction of the anterior and posterior adductor muscles produces a rocking motion of the valves, pivoting on the dorsal and ventral condyles. It is this motion which brings the denticles of the anterior portion of the valves in contact with the substratum during boring.

FROM RUTH D. TURNER, "JOHNSONIA," VOL. 3, NO. 33; A PUBLICATION OF HARVARD UNIVERSITY

PIDDOCK (ZIRFAEA CRISPATA), SHOWING (FAR LEFT) EXPANDED FOOT; (CENTRE LEFT) THE EXTERNAL ANTERIOR ADDUCTOR MUSCLE; AND (RIGHT) EXTENDED SIPHONS

Piddocks, like most bivalves, feed on minute organisms in the water. Food particles are brought into the mantle cavity through the incurrent siphon, and excretory products are carried out through the excurrent siphon. The late embryonic stage of all species is a free-swimming larva. The larva is microscopic in size and is very similar in appearance to the young of most clams, but when it settles on the substratum, it attaches itself by a single self-secreted filament (byssus thread) while the shell modifies its surface and becomes an efficient boring tool. Boring begins within a few hours after the attachment of the larvae.

Piddocks are world-wide in distribution; most species are found in the intertidal zone, and only a few extend into deeper water. The most famous species, *Pholas dactylus,* not only bores into gneiss, probably the hardest rock into which any pholadid can bore, but it is also the only known luminescent species (*see* Bioluminescence). A number of species belonging to several genera including *Penitella, Parapholas* and *Zirfaea* are found on the west coast of North America. *Penitella penita* occasionally damages the cement jackets of pilings. The most destructive group is the wood-boring *Martesia,* which causes considerable damage to wharves and other water-front structures in warmer waters. The genus *Xylophaga* includes deeper-water species which may damage underwater cables. Species of two genera, *Diplothyra* and *Penitella,* bore into the shells of other mollusks, particularly oysters and abalones. *Pholas dactylus* was at one time highly esteemed as food and was sold in European markets. Though it is occasionally eaten today it is no longer seen on the market. *Pholas chiloensis* is considered a delicacy by natives of Chiloé Island, Chile.

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PIDGIN is a term applied to a number of varieties of speech which have grown out of English and other languages, and which have been used in various parts of the world since the 17th century. These languages are often termed "bastard jargons," "mongrel lingos" or the like; but in fact they are languages like any others, and can be accurately delimited and described. Before doing so, however, it is necessary, in order to facilitate discussion, to define three terms clearly: lingua franca, pidgin and creole. When a language is used as a means of communication between persons having no other language in common, *e.g.,* French in 19th-century diplomacy, it is a lingua franca (written with lower-case

initials to distinguish it from the original Lingua Franca, *cf.* the next paragraph). A lingua franca which is native to none of those using it, and with a sharply reduced grammar and vocabulary, is called a pidgin. (Defining pidgin thus eliminates both the broken English of, say, a beginning learner, and the skillful but non-native use of English in such countries as India.) When a whole speech community gives up its former language and comes to use a pidgin as its mother tongue, the pidgin has become a creole language (is creolized).

During the expansion of Europe since the middle ages, a number of pidgins and creoles have arisen on the basis of various European languages. The first known pidgin was the Lingua Franca, or "westerners' language," of the medieval levant and the Barbary coast, based chiefly on Italian. When Englishmen first came into contact with North American Indians in the 17th century, they developed a pidgin language; later in the same century, other varieties of pidgin English grew up as a result of English commercial contacts in China (where the word "pidgin" is said to have originated, from the English word "business") and slave-trading activities in west Africa. The establishment of plantation economies in the Caribbean area, with large groups of Negro slaves from different language backgrounds in west Africa, led to the development of a number of pidgins based on English, French, Spanish and Portuguese. Many of these have survived as creoles, *e.g.*, Gullah (*q.v.*) in South Carolina, the Negro English of the Antilles and the Taki-Taki of Dutch Guiana, all based on English; the French-based creoles of Louisiana, Haiti and the Lesser Antilles; and the Papiamento of Curaçao, an outgrowth of pidgin Spanish and Portuguese. Early contacts between settlers and natives led to the formation of pidgins in Australia and New Zealand, whereas the pidgin English of the South Seas ("Beach-la-Mar") grew out of the activities of whaling, trading and blackbirding (recruiting native labour). Pidgin English is extinct in New Zealand and the Carolines, and moribund in Australia, but is still flourishing in Melanesia (New Hebrides, Solomons, New Guinea) and has become creolized in Hawaii. One variety, that of the Rabaul area (New Britain), has become the widespread and indispensable lingua franca of the Territory of New Guinea, due to the official sanction given its use under German rule (1883–1914), and later Australian administrations.

Pidgin languages grow out of the initial, non-intimate contacts between speakers of different languages, when quick comprehension is more highly valued than correctness in grammatical usage or the differentiation of fine shades of meaning. As contacts grow closer, normally one group learns the other's language more fully, and pidgins survive the stages of initial contact only under special circumstances. In many instances, pidgins have been perpetuated where a dominant group regarded another as childlike or incapable of using anything but a simplified version of the "superior" language, as in the relations between Europeans and American Indians, West Africans or South Sea natives. On plantations and in other situations where European masters were in permanent contact with native servants or labourers, pidgins have served as status languages, as in New Guinea. Caste distinction, however, is not a necessary function of a pidgin, as is shown by the instance of Russonorsk, a reduced language used by Russians and Norwegians as equals in the arctic at the beginning of the 20th century. Chinese pidgin English survived for three centuries, not only in master-servant relations but also in use between English merchants and Chinese dignitaries, primarily through the desire of each side to keep the other at arm's length. Slaves on Caribbean plantations, New Guinea natives in newly formed multilingual villages, and others who have come to live together, marry and raise children, with no language in common save a pidgin, have used the pidgin as the customary language of the group. In such instances, the resultant creole has usually re-expanded its structure and vocabulary by more or less heavy borrowing from the language of a culturally dominant group, *e.g.*, Haitian creole from French, Taki-Taki and Papiamento from Dutch, and Melanesian pidgin from English.

In its original function, as a lingua franca among unlettered folk, a pidgin language is a medium of purely oral communication, as also are creoles in their initial stages. Only later, and usually in connection with missionary or other educational programs, are spelling systems devised for pidgins or creoles. Speakers of European languages have often applied the orthographical conventions of their own languages, as when the Melanesian pidgin sentence for "Why did you hit this policeman?" is written *Belong what name you fight 'im dis fellow police boy?* Such a spelling embodies all the inconsistencies that characterize English orthography, and is therefore difficult to learn; it distorts the structure of pidgin; and it confirms the naïve European or American in his belief that pidgin is only a ridiculous reduction of English. Those who have devised orthographies for ease of learning, accuracy in representing linguistic structure, and emphasis of the independent status of the language, have used phonemically based systems. The most effective orthographies of this type use the letters available on typewriters or in print shops, but consistently and predictably. Thus, the Melanesian pidgin sentence just quoted would be written, in the orthography of the Alexishafen mission: *Bilong wonem yu faitim disfela plisboi?* In the following discussion, pidgin forms are cited only in this type of transcription.

The simplification which characterizes pidgin extends to all aspects of linguistic structure (sounds, forms, constructions) as well as vocabulary. In some varieties (*e.g.*, Melanesian pidgin, from which our examples will be taken unless otherwise stated), stress has come to be automatic on the first syllable of every word: *e.g.*, *bikos* "because," *máshin* "machine." A minimum of five distinctive vowels is necessary, those represented in Latin or Italian pronunciation by *a* ("ah"), *e* ("eh"), *i* ("ee"), *o* ("oh"), *u* ("oo"), as in *antap* "up," *em* "he," *winim* "defeat," *kot* "coat," *tu* "also." The vowel sound *a* ("ah") combines with *i* ("ee") and *u* ("oo") in the basic diphthongs *ai* (English "i") and *au* ("ow"), as in *dai* "cease" and *nau* "now." Some, but not all, speakers make further distinctions, *e.g.*, between the *e* of *em* "he" and the *ei* ("ay") of *neim* "name." In almost all varieties of pidgin English, the two consonant sounds represented by Eng. *th* have merged with *t* and *d* respectively: *saut* "south," *disfela* "this." Many speakers of Melanesian pidgin also merge *ch* and *sh* with *s*, as in *tumas* "very" (from Eng. "too much") and *masin* or *mashin* "machine." Users of pidgin often carry over habits of sound production from their native languages: for instance, many Melanesian languages have *mb, nd* as variants of *b, d* between vowels, and Melanesians therefore often pronounce *tabak* "tobacco" as *tambak*, and *sidaun* "sit" as *sindaun*.

Grammatical categories, such as number, gender, case, person, tense, mood, voice—are almost wholly absent from pidgin and creole languages, as well as from many other languages of the world. Pidgin is not, however, "devoid of grammar," as is often asserted. Melanesian pidgin, for example, has three inflected parts of speech: pronouns, adjectives and verbs. The suffix *-fela*, added to pronouns, makes plurals, in *mi* "I, me" versus *mifela* "we, us" and *yu* "you" (sing.) versus *yufela* "you" (pl.). Another suffix *-fela* serves as a marker for adjectives of one syllable, demonstratives, indefinites and numerals: *maisfela* "pretty," *disfela* "this," *samfela* "some," *wanfela* "one." Verbs having a direct object (expressed or implied) take the suffix *-im*, and verbs without this suffix are intransitive or passive: cf. *rausim* "eject, remove" versus *raus* "be out, come out." Other parts of speech—nouns, prepositions, adverbs, conjunctions—are invariable, but are distinguished by the types of combinations in which they occur. In other varieties of pidgin English, the specific criteria for distinguishing classes of linguistic forms are different, but the basic structure is similar. Chinese pidgin nouns and pronouns, for example, can take the locative suffix *-said*, as in *doksaid* "at the dock(s)," *maisaid* "at my house," and the verb suffix *-em* forms, not transitives, but passive participles, as in *dis tri blong spoilem* "this tree is rotten."

The basic types of combinations—phrases and clauses—found in pidgin are the same as those of English; here again, however, many details of syntax are different. Melanesian pidgin nouns are followed, not only by possessive phrases (*haus bilong mi* "house of me, my house"), but also by modifying nouns (*haus pepar* "house [for] paper, office"), verbs (*haus kuk* "house for cooking,

kitchen"), adverbs (*man nogud* "evil man," *nogud* being an adverb meaning "undesirably"), and clauses (*man mi lukim em* "the man I saw"). In Chinese pidgin, pronouns simply precede nouns to indicate possession (*hi fes* "his face"), and relative position is shown by a noun preceding an adjective (*Ning-Po mo far* "further than Ning-Po"). With third person subjects, Melanesian pidgin predicates are normally preceded by the predicate-marker *i-*: *ol i-singaut* "they call"; *balus i-no kamap yet* "the plane hasn't yet arrived." Melanesian pidgin has the clause type called "equational" (also found in other languages, *e.g.,* Russian and Hungarian) in which no verb is present: *disfela kaikai i-gudfela* "this food (is) good." Chinese pidgin, on the other hand, has the copulative verb *blong* "be" with nouns and adjectives in the predicate (*e.g., yu fut blong plenti sor* "your foot is very sore"), but uses no verb with an adverb in the predicate indicating location: *tumachi dast tebal tapsaid* "a lot of dust (is) on the table."

Since vocabulary is restricted (about 700 words in Chinese pidgin, 1,500 in Melanesian), each word necessarily has a greater range of meaning than its English counterpart. The central meaning of Melanesian pidgin *sori* is not "sorry," but "emotionally moved," as shown by its extension to "sympathetic, grateful, glad"; similarly, *dai* means "cease" ("die" is *dai tru* "stop for good") and *stap* is "be located; remain; continue." For many concepts, pidgin uses phrases rather than single words: with *skru* "screw; joint" are formed *skru bilong arm* "elbow," *skru bilong leg* "knee," etc. Some pidgin words belong to different parts of speech from their English counterparts, *e.g.,* the Melanesian pidgin preposition *bilong* "of" and the Chinese pidgin copulative verb *blong* "be" from Eng. "belong." Non-English meanings of pidgin words often reflect native social structure, as when *papa* means "uncle," since a boy's maternal uncle, rather than his father (*papa tru*) is primarily responsible for his upbringing in New Guinea. Speakers of English are often naïvely amused or shocked by the disregard of some of our society's taboos evident in certain shifts of meaning, as when *ars* "buttocks" is extended to mean "bottom (of anything), foundation, reason, cause, source," for example, *ars bilong diwai* "the base of the tree," or *God i-ars bilong olgedar samting* "God is the source of all things." It must be realized, however, that in the context of native society and attitudes, these concepts are not taboo and no stigma attaches to the words or their use.

In the structural reduction from English to pidgin, the main grammatical characteristics have been kept (the part-of-speech system, the dichotomy between subject and predicate, the use of phrases taking the place of single words), though often with different identifying features. The various kinds of pidgin English are definitely English and Indo-European, not (as is often said), "native languages spoken with English words." Nevertheless, there have been extensive carry-overs from non-English structural patterns, because speakers of native languages have translated their own constructions into pidgin, especially in the early stages of its formation. For instance, in Chinese a numeral modifying a noun must be accompanied by a special word indicating a measure of quantity, called a "numeral classifier," as in *sān ge rén*, literally "three piece man." This type of combination was reflected in older Chinese pidgin *tufela man* "two men," *forpisi naif* "four knives," etc., with *-fela* for animate objects, *-pisi* for inanimate objects. However, in modern Chinese pidgin, *-fela* has not survived, and *-pisi* has lost its independent status and become simply a numeral suffix, as in *tupisi man* "two men." Similarly, the presence of separate pronouns for "we" (excluding the hearer) and "we" (including the hearer) in Melanesian languages has led to the establishment in Melanesian pidgin of a parallel contrast between *mifela* "we" (but not you) and *yumi* "we" (including you).

The proportion of vocabulary elements in pidgin English derived from non-English sources is small, both in relation to the popular myth that pidgin is a "weird mixture of tongues" and in comparison to the non-Germanic element in English itself. Of the approximately 1,500 words in Melanesian pidgin, not over 20% are of non-English origin. Of these, perhaps half are Melanesian (that is, *kiau* "egg; bomb," *diwai* "tree," *malolo* "rest," *balus* "pigeon; aeroplane") and one quarter were borrowed from German, such as *mark* "shilling," *tais* "pond," *langsam* "slow" and *beten* "pray." The remaining 5% are from various languages—a few from Malay (that is, *karabau* "water buffalo") and three from Romance sources: *save* "know," *pikinini* "child" and *pato* "duck." The percentage of non-English elements in Chinese pidgin is even smaller, hardly over 5%.

With the coming of modern civilization and technology to New Guinea and similar areas, the use of pidgin has posed a problem, especially with regard to its use as a medium of instruction in elementary education and technical subjects. The use of pidgin has been opposed by some, partly on puristic grounds and partly because it is alleged to be ineradicably tainted by connotations of colonialistic exploitation. In answer, it is pointed out that pidgin and creole languages are not "corruptions," but normal linguistic developments; it has even been suggested that the Germanic languages (and hence English) may have arisen from a creolized variety of Indo-European. In New Guinea and the Solomons, pidgin is no longer a status language, nor imposed on the people by white colonialists, but is the people's own lingua franca, indispensable for communication, and easier for a Melanesian to learn than English, which is both more complicated and more foreign to him. If skilfully used, pidgin can serve both as a medium of instruction and as a bridge to English. In this connection, it has been suggested that new names, without pejorative connotations, be given to these languages, *e.g.,* Neo-Melanesian to the pidgin used in New Guinea, and Neo-Solomonic to that used in the Solomon Islands. *See* also BASIC ENGLISH; LINGUA FRANCA.

BIBLIOGRAPHY.—For Melanesian pidgin English, a complete bibliography to 1955 is given in R. A. Hall, Jr., *Hands Off Pidgin English!* (1955); for Chinese pidgin English, *cf.* R. A. Hall, Jr., *Journal of the American Oriental Society*, LXIV, 95–113 (1944), with bibliography of preceding work. For Gullah, *see* L. D. Turner, *Africanisms in the Gullah Dialect* (1949). (R. A. HA.)

PIEDMONT (PIEMONTE), a region of northwestern Italy, is composed of the provinces of Alessandria, Asti, Cuneo, Novara, Turin (Torino), and Vercelli. Area 9,807 sq.mi. Pop. (1961) 3,949,006. To the south, west, and north it is surrounded by the vast arc of the Ligurian Apennines and the Maritime, Cottian, Graian, and Pennine Alps. The core of the region is the Po Valley, open to the east and consisting, especially in its eastern portion, of some of the best farmlands in Italy. South of the Po are the low and intensively cultivated hills of Monferrato and of the Langhe. In the foothills of the Alps are Lakes Maggiore and Orta. The Po and its tributaries, the Dora Baltea, Dora Riparia, Sesia, Tanaro, and Scrivia, provide ample water for agriculture.

The alpine arc of Piedmont plays a vital part in the power production of the region and of north Italy as a whole; its hydroelectric plants provide energy for industry, transportation, and domestic use. The forests provide lumber; the alpine and subalpine meadows afford excellent pasture for cattle as the base of a prosperous dairy industry. The lowlands produce wheat and rice, vegetables and fruit, milk and cheese; the hills south of the Po are noted for some of Italy's highest quality wines, both of the sparkling (Asti) and still (Barbera) variety. Piedmont is part of the great industrial triangle of north Italy (Turin-Genoa-Milan), and its industries are characterized by their variety as well as by their important output. Turin (*q.v.*), the largest city and the leading industrial centre, is the location of one of Europe's largest automobile plants, as well as of printing, textile, and machine industries. Ivrea, northeast of Turin, is the headquarters of one of the leading makers of office machinery in Europe. Textiles, chemicals, and glass are among the other important Piedmontese industries.

Through Piedmont passes the principal rail connection between France and Italy, the Turin–Mt. Cenis Tunnel–Paris line, while to the north the Simplon Tunnel leads to Switzerland. An excellent network of roads and expressways ties all parts of the region closely together; Genoa, easily reached from Piedmont, is its port. Development projects in the 1960s include an all-weather road between France and Italy, passing through a long tunnel under Mont Blanc, thence through the Valle d'Aosta to Turin and Milan.

In Roman times Piedmont played a role of importance because its passes served as connections between Italy and the transalpine provinces of the empire. After periods of Lombard and Frankish rule, the house of Savoy emerged as the most important feudatory of northwest Italy. This dynasty first became powerful as successor to the marquesses of Ivrea and of Turin, but after 1400 its control of both slopes of the Alps, ruling over what is now French Savoy (Savoie) and over Piedmont, gave it undisputed sovereignty over much of the region. After 1700 practically all of Piedmont passed under Savoyard domination, while the addition of Sardinia to its territories provided it with still wider interests. During the Italian Risorgimento it was Piedmont that led the attempts of 1848, 1859, and 1866 to unite all Italy, and Victor Emmanuel II, originally king of Piedmont, became modern Italy's first king in 1861.

See also references under "Piedmont" in the Index. (G. KH.)

PIEDRAS NEGRAS, formerly Ciudad Porfirio Díaz, a northern frontier city of Mexico in the state of Coahuila, 840 mi. north by west of Mexico City, on the Rio Grande del Norte, 720 ft. above sea level, opposite the city of Eagle Pass, Tex. The population in 1960 was 44,992. An international bridge connects the two cities, and the Mexican National railways have a northern terminus at this point. The city has an important transfer trade with the U.S. and is the centre of a fertile district devoted to agriculture and stock raising. Coal is found in the vicinity; silver, zinc and copper are also mined. In 1958 a superhighway was opened between Piedras Negras and Mexico City via Saltillo and Querétaro. (J. A. CW.)

PIER, in architecture, usually denotes a vertical support in masonry, brickwork or concrete which carries an arch or superstructure. In this sense it is applied both to those portions of a structure which are visible above ground and to isolated or detached supports underground described as foundation piers. The term is sometimes applied to the solid parts of a wall between windows or voids, and also to the isolated masses of brickwork, masonry or concrete which support bridges or those to which gates are hung. (*See* also CAISSON; FOUNDATIONS, STRUCTURAL.) Projecting jetties and landing stages are also called piers, as are the open promenades carried out over the sea on supporting wooden or metal piles at seaside resorts.

PIERCE, FRANKLIN (1804–1869), 14th president of the United States, was born at Hillsboro, N.H., Nov. 23, 1804. His father, Benjamin Pierce (1757–1839), served in the American Revolution, was a Democratic member of the New Hampshire legislature (1789–1801), and was elected governor of the state in 1827 and 1829. Franklin graduated from Bowdoin College, Brunswick, Me., in 1824, studied law, and was admitted to the bar in 1827.

Entry into Politics.—Entering politics as a Democrat, Franklin Pierce became a member of the New Hampshire House of Representatives in 1829, and was speaker of that body in 1831 and 1832. The following year he entered the national House of Representatives, where he supported the policies of the Jackson administration. During his first term in Congress he married Jane Means Appleton, daughter of the president of Bowdoin College. In 1837 he entered the U.S. Senate. Being its youngest member, he was overshadowed by a galaxy of older and more prominent men such as Thomas Hart Benton, Henry Clay, and Daniel Webster. Before his term expired he resigned his seat (1842) and returned to the practice of law at Concord, N.H., where he became federal district attorney. In 1846 he was offered an appointment to fill an unexpired term in the U.S. Senate and the position of attorney general in Polk's cabinet; but he rejected both, declaring that he had permanently retired from political life.

Service in Mexican War.—Shortly after the outbreak of the war with Mexico in 1846 Pierce enlisted as a private at Concord, but soon became colonel of the 9th Regiment, and later a brigadier general of volunteers. He was with Gen. Winfield Scott in the advance toward Mexico City. During the Battle of Contreras he was thrown forward on his horse and received painful injuries; he insisted on continuing the fight and in the course of the battle he fainted. This fact, variously interpreted, was used both for and against him when he was later a candidate for the presidency. At the close of the war he returned to his law practice.

Election to Presidency.—Pierce became the Democratic nominee for president in 1852 as a "dark horse." The leading candidates for the nomination were Lewis Cass, Stephen A. Douglas, and James Buchanan, but, because of factional rivalries, none of these proved to be acceptable. A few politicians, including some of Pierce's fellow generals in the Mexican War, foreseeing a deadlock, had prepared him for the place. At the convention in Baltimore in June his name was first brought forward by the Virginia delegation on the 35th ballot, and on the 49th ballot he received an almost unanimous vote. William R. D. King was nominated for vice-president. Both the Democrats and the Whigs were too badly split for any real issues to appear in the campaign. The chief question in the public mind was the finality of the Compromise of 1850 (*q.v.*), and while both parties declared themselves in favour of it the Democrats were more thoroughly united in its support. As a result Pierce swept the country in the November election, receiving 254 electoral votes against 42 for his opponent, Gen. Winfield Scott. He took office on March 4, 1853.

Presidential Administration.—The youngest man to have been elected to the presidency as of that date, Pierce was handsome, genial, and possessed of a certain superficial brilliance. The Eastern element of the Democratic Party, which he directly represented, was inclined for the sake of harmony and prosperity to oppose antislavery agitation and generally to placate Southern opinion. It was hence pro-Southern as a matter not only of political strategy but also of business expediency. Thus in the selection of his cabinet, as in both domestic and foreign policies of his administration, Pierce represented a coalition of Southern planters and Northern businessmen. The Democratic Party was badly torn into factions, and Pierce attempted to reunite it by using the patronage to bring together all shades of opinion. In his inaugural address he interpreted his election as a popular mandate to maintain the Compromise of 1850 and bury the slavery controversy. He also forecast an aggressive but honourable foreign policy; he would "not be controlled by any timid forebodings of evil from expansion." In fact "the acquisition of certain possessions" (doubtless referring to Cuba in particular) was deemed essential to the country's safety and commerce.

Foreign Policy.—Pierce endeavoured to buy Cuba. In order to secure the influence of European financiers upon the Spanish government, he ordered Pierre Soulé, the U.S. minister to Spain, to hold a conference with James Buchanan, minister to Great Britain, and John Y. Mason, minister to France, at Ostend, Belg., as a result of which they issued, on Oct. 18, 1854, what was called the Ostend Manifesto (*q.v.*). This was misinterpreted as advising that if the United States were unable to obtain Cuba peacefully, "by every law, human and divine, we shall be justified in wresting it from Spain if we possess the power." In the storm of controversy that followed, the administration disclaimed responsibility for the document and recalled Soulé. The following year a U.S. adventurer, William Walker, conducted a notorious filibustering expedition into Central America with the purpose of establishing a proslavery government to be brought under the control of the United States. He established himself as military dictator, then as president, of Nicaragua, and his regime was recognized by the Pierce administration. More permanent results came from the expedition that had been sent out by Millard Fillmore in 1853 under Commodore Matthew C. Perry to Japan. In 1854 Pierce received the commodore's report that his expedition had been successful and that U.S. ships would have limited access to Japanese ports. The administration also effected a reorganization of the diplomatic and consular service and the creation of the U.S. Court of Claims.

Domestic Policy.—Among the domestic policies of the Pierce administration were preparations for a transcontinental railroad and the opening up of the Northwest for settlement. It was in order to open the way for a southerly route to California through the lowest mountain passes that the Gadsden Purchase (*q.v.*) of 29,640 sq.mi. of territory was made from Mexico in 1853 at a cost of $10,000,000. It was mainly to stimulate migration to the Northwest and facilitate the construction of a central route to the

Pacific that the Kansas-Nebraska bill was enacted in 1854, receiving the president's sanction. This act opened two new territories for settlement and provided that the slavery question should be settled in each by popular vote. The indignation aroused by the repeal of the Missouri Compromise incorporated in this bill and conflict over slavery in the territories were the main causes of the rise of the Republican Party. Pierce's ineptness in handling Kansas made him unacceptable as a candidate for a second term.

Save for a three years' tour in Europe, he spent the rest of his life at Concord, where he died on Oct. 8, 1869.

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(R. F. N.)

PIERO DELLA FRANCESCA: *see* FRANCESCA, PIERO DELLA.

PIERO DI COSIMO (PIERO DI LORENZO) (1462–1521), Florentine painter, noted for his mythological paintings, was born in Florence in 1462. He derived his name from that of his master, the painter Cosimo Rosselli, and he participated in this artist's frescoes in the Sistine Chapel in the Vatican (1481). Thereafter, he worked exclusively in Florence, where, according to G. Vasari, he died in 1521.

Piero di Cosimo's highly individual painting style was influenced successively by Luca Signorelli, Hugo van der Goes, and Leonardo da Vinci. His most notable religious paintings are a tondo of the "Adoration of the Child" in the museum of art, Toledo, Ohio; an altarpiece for the Pugliese Chapel in the Innocenti, now in the Spedale degli Innocenti, Florence; a "Visitation" in the National Gallery of Art, Washington, executed for the Camponi Chapel in Santo Spirito, Florence; and an "Immaculate Conception" in the Uffizi Gallery, Florence.

However he is best known for his mythological paintings, which combine a close study of nature with a romantic fantasy that is found in no other Renaissance artist. These include two large paintings of the "Fall of Vulcan" (Wadsworth Atheneum, Hartford, Conn.) and "Vulcan and Aeolus" (Ottawa). Along with two panels in the Metropolitan Museum, New York, and the "Forest Fire" in the Ashmolean Museum, Oxford, illustrating a Vitruvian program of the early history of man, these may have formed part of a cycle of paintings executed for Francesco del Pugliese, which is described by Vasari. A cycle of bacchanals, also mentioned by Vasari, was commissioned by Giovanni Vespucci; from this, two panels at Worcester, Mass., and in the Fogg Art Museum, Cambridge, Mass., survive.

Piero di Cosimo's late style may be seen in scenes from the legend of Andromeda in the Uffizi Gallery, Florence. The "Death of Procris" in the National Gallery, London, is perhaps his most celebrated painting. Two remarkable portraits of Giuliano da Sangallo and Francesco Giamberti are in the Mauritshuis at The Hague.

Vasari supplies what is no doubt a well-founded account of the painter's eccentricities and observes that Piero's "works betray a spirit of great diversity distinct from those of others, for he was endowed with a subtlety for investigating curious matters in nature, and executed them solely for his delight and pleasure in art."

See R. Langton Douglas, *Piero di Cosimo* (1946); E. Panofsky, *Studies in Iconology* (1939). (J. W. P.-H.)

PIERRE, the capital city of South Dakota, U.S., the seat of Hughes county, is on the Missouri River in almost the exact centre of the state. The town was first named Mahto, the Sioux word for "bear," when it was started in June 1880 as the western terminal of the Chicago and North Western railway. It became the county seat in November and on Dec. 16, 1880, was officially named Pierre (locally pronounced "Peer") for Pierre Chouteau, an early fur trader. For the next six years it was the railhead for the tremendous freighting by ox team on which the Black Hills mining industry depended. Located between three Indian reservations and on the edge of a farming country to the east and cattle country to the west, the town had varied interests and was the trade centre of a large area. In 1885 the territorial legislature selected Pierre to replace Bismarck as capital but the governor vetoed the act; in 1889, when South Dakota became a state, Pierre was named the temporary capital and in elections in 1890 and 1904 was chosen the permanent capital. The state capitol building was erected (1905–10) on an attractive 30-ac. tract overlooking the Missouri River. Later additions include a war memorial building, housing the State Historical Society and Museum (1930); the governor's mansion (1936); a state office building (1951); and a state highway building (1955); as well as a 7-ac. artesian-fed lake.

Pierre's population has fluctuated with the economy of the farm-ranching country in which it is located and for years it held the dubious distinction of being the nation's smallest state capital, with a population of 1,776 in 1895 and 5,715 in 1950. Thereafter the population increased considerably, stimulated by the construction of Oahe Dam, starting in 1948 and continuing for several years. The dam, located 5 mi. above Pierre, is a power, irrigation and flood-control project, creating a 200-mi. lake along the Missouri.

Pierre is the site of a government Indian school (1891) and of St. Mary's Hospital. Five miles downriver is Farm Island State Park, a 1,800-ac. recreational area, with public golf course, swimming beach and other facilities.

The site of Pierre was for 400 years prior to 1800 the capital of the Arikara Indian nation; archaeological remains of it, as well as of many villages, are still to be seen. The Lewis and Clark Expedition of 1804–06 brought news of the vast trade potential of the Missouri River and for the half century following 1817 Fort Pierre, across the river from Pierre, was the fur-trade capital of the northwest. With the decline of the fur trade and the coming of the railroads it decreased in importance although, like Pierre, it experienced an increase in population after 1950.

For comparative population figures *see* table in SOUTH DAKOTA: *Population.* (W. G. R.)

PIERROT (PEDROLINO): *see* COMMEDIA DELL'ARTE.

PIETERMARITZBURG, the capital city of Natal Province, S.Af., lies between the Umsindusi (Umsunduze) River and the Dorp Spruit, 53 mi. NW of Durban by road and 71 mi. by rail. Pop. (1960) 90,077, including 37,991 Europeans. Founded by the Voortrekkers in 1839 after a victory over the Zulus, Pietermaritzburg was named in honour of the dead leaders, Piet Retief and Gerrit (Gert) Maritz. It played a leading role in the development of the Rand gold mines and was proclaimed a city in 1853, becoming the capital of Natal three years later.

The city, 2,200 ft. above sea level, nestles in a valley surrounded by tree-covered hills. The main thoroughfare, Church Street, more than a mile long, passes through the commercial centre. Among the imposing buildings are the city hall, the modern provincial government headquarters, and the Anglican (St. Saviour's) and Roman Catholic (St. Mary's) cathedrals. Ft.

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"DEATH OF PROCRIS," BY PIERO DI COSIMO

Napier overlooking the city from the southwest was established (1843) by a British garrison. Natal University is situated at Scottsville, a suburb, and there are also a teachers' training college, a technical institute, more than 30 schools (both European and non-European), two museums, a municipal art gallery, 12 ac. of rock gardens in Alexandra Park, a 110-ac. botanical garden and Queen Elizabeth Park, headquarters of the Natal Parks Board.

Pietermaritzburg is a centre of industry and agriculture, and there has been much development since World War II. Large factories manufacture a variety of products, including wattle extract, chocolates, furniture, and aluminum and rubber goods, and the city is the largest exporter of shoes in the republic. There is a big rice mill. The Royal Agricultural and Industrial Show is held every June. There are main road and rail communications with Durban, Johannesburg, Bloemfontein, and other cities in the republic. The aerodrome is capable of handling medium-sized cargo and passenger aircraft. (D. N. E. K.)

PIETISM, a Protestant religious movement stressing the "practice of godliness." It began in the 17th century, continued in its original form during the first half of the 18th century, and remained influential well into the 19th. The words pietism and pietist were first used as nicknames in Leipzig in 1689 in the course of an altercation concerning A. H. Francke (*see* below), but the movement itself goes back to the beginning of the 17th century in England. A distinction must be drawn between this Reformed pietism, which grew up in England, Holland, and northwestern Germany, and the Lutheran pietism, on the whole confined to Germany, which is the main subject of this article. Whereas it used to be thought that pietism was directly dependent on mysticism, such as that of Miguel de Molinos (*q.v.; see* also QUIETISM), and that it criticized the catholicizing features of its devotion, modern scholars tend to stress more strongly its connection with the reformed Lutheranism of the 17th century, an example being the apparently decisive impetus received by P. J. Spener from the theological faculty at Strasbourg when he was an undergraduate there. This reformed Lutheranism was at pains to counteract the rigidity of the church organization and to further a genuine devotion.

Reformed Pietism.—Reformed pietism was a comparatively self-contained entity; only its radical groups, influenced by enthusiastic ideas, led a separate existence. Those who contributed chiefly to its development were the Puritans Lewis Bayly (author of *The Practise of Piety*), Richard Baxter, John Bunyan, Thomas Goodwin, and John Owen, who have been called "pietists before pietism." Religious exiles, among them William Ames, took the new piety from England to the Netherlands, where it was further developed by Willem Teelinck and his son Johannes, and Gisbert Voet (Gysbertus Voetius) and his pupil Jodocus van Lodenstein. From the Netherlands it was brought, after the separation of Jean de Labadie, to northern Germany, where it was chiefly established on the lower Rhine and in Bremen.

History of Lutheran Pietism.—Five separate groups of Lutheran pietists are to be distinguished.

P. J. Spener's Circles.—Pietism in Lutheran Germany started with the publication of *Pia desideria* (1675) by Philipp Jakob Spener (*q.v.*); its program is first stated there. Pietism took up Spener's six demands for reform as well as his idea about the grievances of all classes and the need to meet them. In many places private devotional gatherings were established, based on the *collegia pietatis* that Spener had already founded in Frankfurt chiefly for Bible study. Yet soon radical influence appeared, which aroused the first opposition from the orthodox Lutherans. Unlike Francke and Zinzendorf, Spener neither founded nor directed a movement. He exerted a great influence through his extensive correspondence, but he remained more a counselor and spiritual adviser of individuals. He always declined the role of a "reformer after the reformation" that was thought as early as his own period to be his destiny.

A. H. Francke's Circle at Halle.—Pietism first entered the consciousness of the public in 1689, when controversy began in the faculty of theology at Leipzig over the *collegia biblica* founded by A. H. Francke. Not only the students but also the ordinary inhabitants were seized by pietism. Although Francke together with his friends at first depended on Spener, he soon became the centre of a movement which surpassed Spener's. Inspired by his "experience of conversion" (1687) in Lüneburg, Francke introduced into pietism an activist note which the cautious Spener always lacked. After moving to Halle, where he held the double office of vicar and of professor of oriental languages in the new university (1692), Francke became the centre of an influence which not only spread throughout Germany but also extended to England, Scandinavia, Russia, India, and North America, the last chiefly after his death, in accordance with the plan contained in his so-called *Grosse Aufsatz* ("Great Essay"). Though Spener had kept in touch, mainly by letters, with a large circle of pietists, Francke's influence was far wider, particularly on the young theologians trained in Halle and on the pupils in his institutions, who were all marked by pietism and regarded themselves as its emissaries. By this period the close link of German Lutheran pietism with the aristocracy had already been forged, and whole courts were imbued with pietism. Francke's charity school ("Armenschule") at Halle persisted when the ascendancy of pietism in Halle and in Prussia (where in particular King Frederick William I was its patron) was lost through the Enlightenment. Pietism at Halle gradually decreased until at the beginning of the 19th century it was confined only to a small group. (*See* also FRANCKE, AUGUST HERMANN.)

Graf Zinzendorf's "Brüdergemeine" at Herrnhut.—Nikolaus Ludwig, Graf von Zinzendorf (*q.v.*), was educated at Francke's school (the *Pädagogium;* 1710–16) at Halle and Spener was his godfather. These two facts show the influence on him of both groups of pietism and their leaders, but he and his followers were in fact more influenced by mysticism and the desire to dispense with the external features of religion (*e.g.*, Bible, sacraments) in a confrontation of the individual soul with God, elements which at first were in danger of getting out of control. Only after overcoming several crises did the *Brüdergemeine* ("Brotherhood") reach its final form, in which separatism was overcome and the positive elements of this type of pietism were able to have a fruitful influence on the whole church. (*See* also MORAVIAN CHURCH.)

Württemberg Pietism.—Pietism in Württemberg was from the start much more strongly influenced by Spener than by Francke and Zinzendorf, and was closely united with the church, relying more heavily on Luther than did Zinzendorf's group. Here the danger of separation was overcome at the start by making the Bible classes part of church life. The chief names in Württemberg pietism are J. A. Bengel, F. C. Oetinger, and J. M. Hahn, the peasant theologian and founder of communities.

Radical Groups of Seceders.—Pietism has always been in danger of radicalism, which infected all the above-mentioned groups. As early as Spener's first activity in Frankfurt, radicalism separated one group from the official church, which was regarded as "Babel" in which no one could be saved. Both Spener and Francke were rather perplexed and helpless when such outbreaks of enthusiasm took place. In general, radical pietism, which was basically influenced by mysticism and by individual spirituality, tended vehemently to reject the church or at least to regard it with indifference. The persecuted separatists found an asylum in the Wetterau district northeast of Frankfurt, where their community gathered round the Berleburger Bible (J. H. Haug's revision of Luther's version, 1726–42). The best-known names in this group are the church historian Gottfried Arnold, the alchemist J. K. Dippel, and the mystic G. Tersteegen. Women were particularly important among the inspired members.

Teaching and Influence.—Common to all branches and groups of Lutheran pietism was the insistence that the true faith must be not merely possessed but must also have a lively effect on the life of the individual and of the congregation, and that the Reformation was not a past event, completed once and for all, but an ever-present challenge to the church. Yet the different groups described above should be regarded as independent of each other, although closely interrelated, and as originating independently of Reformed pietism. Formerly it was thought that Reformed pietism gave birth to Lutheran pietism, through the influence of the French Reformed pietist Jean de Labadie (*q.v.*) on Spener,

but in fact Lutheran pietism's close connections were with the reformed Lutheranism of Germany. All the radical pietist groups, however, were closely interconnected by the mystical ideas which they held in common and which led them to ignore confessional barriers.

From the beginning pietism in all its groups met with vehement opposition, as the quantities of polemical treatises of the period testify. Orthodox Lutheran theology, together with the churches it controlled, frequently misunderstood the new movement and was offended by the degeneration of radical pietism as well as by the narrowness of pietism in general. But the opposition was chiefly caused by the basic beliefs of pietism and in particular by its theology. Although pietists did publish works on dogmatic questions, this was chiefly in order to defend themselves against the reproach of deviating from the teaching of the church. Their chief interest was in biblical theology, which was studied in those theological faculties that were imbued with pietism. The Tübingen faculty of theology was strongly influenced by pietism, and Halle was completely governed by it, though other influences were at work, such as the jurist Christian Thomasius and the philosopher Christian Wolff; Giessen and Jena in particular among the German universities were also influenced by the movement. (Only Wittenberg stood out against it after a fierce struggle.) Scriptural exegesis was clearly central to these pietistic faculties, in contrast to those of orthodox Lutheranism, but it was an exegesis that placed in the foreground the duty of devotion and the problems of Christian life. Church history made great strides forward through the work of the pietists, especially G. Arnold.

The practical demands of pietism had their outcome in pastoral theology. No department of life remained unaffected by the advances of pietism. Enthusiasm for works of charity led at home to the care of the poor and abroad to foreign missions. Pietist missionaries went as far afield as India, Greenland, and Labrador. Francke's group sent about 60 and Zinzendorf's more than 220.

The German pietists also had a considerable influence on evangelicals in foreign countries: Swedish prisoners of war in Siberia and the evangelicals in Russia, and the German settlers in North America. Martin Boltzius and Israel Christian Gronau were active in Georgia, and above all in Pennsylvania, during 1742–87, and Henry Melchior Mühlenberg, the patriarch and organizer of American Lutheranism, in the 18th century (*see* MUHLENBERG). All three (and a group of helpers with them) were from Halle. Moreover, Zinzendorf was in North America during 1741–42, where he tried to form *Brüdergemeine* as in England, Russia, and elsewhere.

The zenith of pietism was over by the middle of the 18th century, but the movement continued to exist and still survives, though not extensively, in certain parts such as Württemberg and northern Germany. Zinzendorf's group, the *Brüdergemeine*, maintains a widespread circle of members, extending far beyond the boundaries of Germany, in the Moravian Church. The religious revival movements of the 19th and 20th centuries were connected directly or indirectly with pietism, which in its turn received stimulation from them.

See also references under "Pietism" in the Index.

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PIETRO DELLA VIGNA (PETRUS DE VINEA) (*c.* 1190–1249), the jurist and man of letters who before his tragic end held high offices under the Holy Roman emperor Frederick II (Frederick I of Sicily), was born at Capua, on the Italian mainland of the Sicilian kingdom. After studying law at Bologna, Pietro was, in 1221, presented by the archbishop of Palermo to the emperor, who appointed him notary of the Sicilian chancery. By 1225 he was judge of the Sicilian *magna curia* (high court). After Frederick's return from the crusade, Pietro became one of his closet counselors and was also employed on diplomatic missions; thus he repeatedly acted as imperial envoy to Pope Gregory IX and in 1234 went to England to negotiate the marriage between Frederick and Isabella, sister of Henry III. Though he had not the title of chancellor, he was virtually head of the chancery long before Frederick II appointed him, probably in 1247, protonotary of the imperial court and logothete of the kingdom of Sicily. Suspected, doubtless wrongly, of conspiracy against the emperor, he was arrested at Cremona in February 1249. He was found guilty of corrupt practices and was blinded; in April he committed suicide in prison, at San Miniato near Pisa. The question of the guilt of the man who, in Dante's words, "held both keys to the heart of Frederick," greatly exercised contemporaries; Dante defends him in *Inferno*, xiii.

Pietro della Vigna was one of the most prominent exponents of the *ars dictaminis* (technique of composition) in the 13th century and had a decisive influence on the literary form of Frederick II's letters, manifestos, and decrees. His Latin style was greatly admired and had a lasting effect on the development of official letter writing in the European chanceries. His poems, in Latin and Italian, secure him a place in the Sicilian school of poetry.

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PIEZOELECTRICITY is the generation of electric charge in a substance by a mechanical stress that changes its shape, and a proportional change in the shape of a substance when voltage is applied. The prefix piezo comes from the Greek verb meaning "to press." The phenomenon occurs only in material of electrically polar nature, especially in single crystals of polar symmetry.

Piezoelectricity is a means of converting mechanical energy into electrical energy and vice versa. The technique is particularly effective at high frequencies. Its principal applications are in the field of electroacoustics, including phonograph pickups, underwater sound signaling and ranging (sonar) and in the frequency control of electric circuits by the use of the very stable mechanical resonance frequencies of crystal plates, notably those cut in exactly specified orientations from quartz crystals. High-precision, quartz-controlled circuits are a key element in communication systems used in space exploration.

History.—Piezoelectricity, as distinct from contact and frictional electricity, was discovered at the Sorbonne in 1880 by Pierre and Jacques Curie. Pierre, who 18 years later collaborated with his wife in the discovery of radium, was 21 years old, Jacques 24, when the brothers first demonstrated the piezoelectric effect. In her biography of Pierre, Marie Curie pointed out that the youthful discovery was not an accident but the product of extensive theoretical and experimental study of the symmetry of crystalline matter. Crystallographic and mathematical relations governing piezoelectricity were developed in the few years following the discovery. Crystals studied in this early period included quartz, tourmaline and Rochelle salt (sodium potassium tartrate), which were to become technically important 50 years later.

Piezoelectric quartz crystals found some use in electrostatic measurements in connection with studies of radioactivity by Pierre and Marie Curie. The first step toward an engineering application was taken about 1916 in France by Paul Langevin, who constructed an underwater ultrasonic source consisting of a piezoelectric quartz element sandwiched between steel plates; this device was to serve for submarine detection. While piezoelectricity did not become practical for this purpose until many years later, experimentation started during World War I led Walter G. Cady of Wesleyan university (Middletown, Conn.) to recognize the reaction of the mechanical resonance of a vibrating crystal on its electric behaviour, and hence to the invention of frequency control by quartz crystals. Crystal frequency control soon became essential for the growing broadcasting and radio communication industry. During World War II the United States alone used about 50,000,000 quartz crystal elements (*see* QUARTZ).

The closely related use of piezoelectric crystals in wave filters for multichannel telephony was largely developed in the Bell Telephone Laboratories beginning about 1925.

Yet another result of the search for ultrasonic generators in 1917–18 was the observation of the unusually high dielectric

(*q.v.*) constant and dielectric hysteresis in Rochelle salt. This behaviour was soon reeognized to be a dielectric analogue to ferromagnetism. Since Rochelle salt is known in Europe as Seignette salt, after its discoverer P. Seignette, the phenomenon was termed Seignette electricity by Soviet researchers, who led in its study in the early 1930s. After 1945, however, the term ferroelectricity was generally accepted. The ferroelectricity of Rochelle salt is the cause of its very high piezoelectric effect, which led to a wide use in microphones and phonograph (*q.v.*) pickups. Growth of these applications came about largely through the efforts of the Brush Development Company in Cleveland, O., beginning in 1930. (*See* MICROPHONE; TARTARIC ACID.)

Extensive studies were undertaken in the early 1940s to find water-soluble crystals which would approach Rochelle salt in piezoelectric effect without its dielectric anomalies and limited operating temperature range. These efforts were partly successful, as indicated by the introduction of ammonium dihydrogen phosphate, primarily for sonar applications. Major progress came, however, from an unexpected direction.

About 1940, a dielectric constant in excess of 1,000 was found in a refractory material, barium titanate ($BaTiO_3$). The ferroelectric nature of this compound was recognized by Arthur von Hippel and co-workers at Massachusetts Institute of Technology. Soon afterward it was discovered that treatment in a strong electric field can permanently reverse the direction of polarity in the crystallites of a ceramic, polycrystalline barium titanate body, and thereby render it strongly piezoelectric. This discovery opened the way for the development of piezoelectric elements comparable with Rochelle salt in sensitivity and with quartz in chemical stability. Ceramic preparation methods made possible shapes and sizes which were unattainable with single crystals.

Barium titanate is ferroelectric and piezoelectric only below 120° C. This limitation was overcome in the 1950s by the discovery of piezoelectric effects in ceramic lead metaniobate, $PbNb_2O_6$, and lead titanate zirconate, $Pb(Ti,Zr)O_3$, which are usable at least to 250° C. By the late 1950s barium titanate and the newer ceramics were dominant in the electroacoustic field in the United States, and novel applications as electric circuit elements were indicated. For frequency control and highly selective electric wave filters, quartz crystals remained unchallenged; dependence on high-quality natural quartz crystals, a near-monopoly of Brazil, however, was alleviated by the development of an industrial process for growing quartz crystals, and crystals of this type became commercially available in 1958.

In the 1960s development of the laser (*q.v.*) brought about a new demand for piezoelectric crystals (*e.g.*, ammonium and potassium dihydrogen phosphates) for modulating light at high radio frequencies and for mixing coherent light beams emitted by the laser. The intrinsic electric polarity that makes these crystals piezoelectric also governs their ability to mediate this interaction between electromagnetic signals. During these years the advancing technology of compound semiconductors (*see* ELECTRICITY, CONDUCTION OF) made available a number of crystals similar in structure to zinc blende (*see* SPHALERITE). Among these, cadmium sulfide and zinc oxide show piezoelectric constants about five times higher than zinc sulfide (Table 1). A substantial interaction between elastic waves and electric currents is found in these piezoelectric semiconductor crystals.

THEORETICAL CONSIDERATIONS

CRYSTALLOGRAPHIC AND MOLECULAR CONSIDERATIONS

Symmetry and Piezoelectric Effect.—Solid matter consists of electrically charged particles disposed in space, the positive and negative charges being in exact balance in an electrically uncharged body. The development of electric surface charges by mechanical deformation is therefore not unexpected. Considerations of symmetry, however, severely limit the conditions under which such charges can appear. The state of mechanical stress or resulting geometric deformation (strain) at any point in a solid is described by a tensor, which does not distinguish between opposite directions, whereas electric polarization and electric field are described by vectors which specify the sense of direction. If a mechanical stress is to produce an electric polarization, a directional quality must therefore be inherent in the body. Conversely, in an isotropic material (*i.e.*, a body without inherent directional quality) mechanical stress or strain caused by an electric field must be equal for opposite directions of the field; this implies a quadratic dependence on the field. This quadratic effect, known as electrostriction, is substantial only in materials of very high dielectric constant, notably ferroelectric materials. A necessary condition for the occurrence of the piezoelectric effect, including the converse linear dependence of stress or strain on electric field, is the absence of a centre of symmetry. Twenty-one of the 32 crystal symmetry classes (*see* CRYSTALLOGRAPHY) lack this symmetry element, and crystals in all but one of these classes can exhibit piezoelectricity. A qualitative test for presence of piezoelectricity is therefore useful in crystal structure determination.

Piezoelectricity has been observed by qualitative tests in about 1,000 crystal species, while more or less complete quantitative data have been taken on about 100 crystals. Sulfates, phosphates, tartrates and various sugars and their derivatives contribute heavily to the latter number.

The combination of symmetry planes and axes that is characteristic of any crystal class determines which components of stress and of electric polarization may be linked by piezoelectricity. It must be emphasized, however, that crystallographic symmetry merely states what effects are forbidden; the magnitude of the allowed effects is a matter of empirical observation or of calculation from atomic structure and atomic dynamics. While some principles of such calculations were outlined as early as 1920, the quantitative data available during the 1960s were almost entirely derived from measurements.

A Molecular Model.—Symmetry as well as the molecular approach can be illustrated by the simplest crystal structure capable of piezoelectricity. This is the cubic modification of zinc sulfide (ZnS) noted above as sphalerite or zinc blende. A unit cell of this structure is shown in fig. 1. It contains only two different atoms, each atom of one kind surrounded by four atoms of the other kind placed at the corners of a tetrahedron. The symmetry class is $\bar{4}3m$ in the international designation. Compressional stress (stress = force per unit area) applied parallel to an edge of the unit cell will not produce an electric moment since the sulfur atoms (negative) lie in planes halfway between the zinc atoms (positive), and there is nothing in the nature of the applied stress to disturb this symmetry.

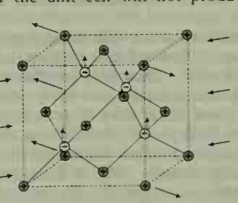


FIG. 1.—UNIT CELL OF CUBIC ZINC SULFIDE CRYSTAL WITH POSITIVE ZINC AND NEGATIVE SULFUR ATOMS

Long arrows indicate applied shearing strain, short arrows the associated displacement

If, however, a shearing stress is applied in the horizontal plane, resulting in the shearing strain (displacement per unit length) indicated by long horizontal arrows in fig. 1, then tetrahedral symmetry of the four zinc atoms around each sulfur atom (and vice versa) is disturbed and the sulfur atom is displaced toward the two zinc atoms which have moved apart. The amount of displacement is calculated readily by postulating that the distance between nearest neighbour atoms remains constant. For a shearing strain of $\frac{1}{1.0}\frac{1}{0.0}$ (angle of distortion about $\frac{1}{2}0°$) the displacement of the sulfur atoms against the zinc atoms in the direction perpendicular to the plane of the shear is $\frac{1}{1.0}\frac{1}{0.0}$ of the unit cell dimension. The resulting electric polarization is the product of this displacement with the number of sulfur atoms per unit volume and the electric charge per atom. To obtain agreement with the observed piezoelectric effect it is necessary to place a negative charge of one-fourth of an electron on the sulfur and the same positive charge on the zinc. This is in accord with the partially polar character of zinc sulfide. A quantitative theory would have to consider also the distribution of electric charge within each atom.

Piezoelectricity in Various Crystal Classes.—In zinc sulfide and all other piezoelectric crystals of cubic symmetry, the piezo-

electric effect of any mechanical stress can be expressed in terms of the single piezoelectric constant relating electric polarization parallel to a cubic axis to strain in the plane perpendicular to this axis. In crystals of lower symmetry, a number of independent piezoelectric constants are needed to describe all possible piezoelectric effects. For the triclinic asymmetric crystal class there are 18 independent coefficients. Fortunately, the most important piezoelectric crystals belong to classes having several symmetry elements, and are characterized by only two or three piezoelectric constants. If, starting from class $\bar{4}3m$, one of the three axes is made different from the other two, the tetragonal crystal class $\bar{4}2m$ results, of which ammonium dihydrogen phosphate is an important example. This class has two independent piezoelectric constants.

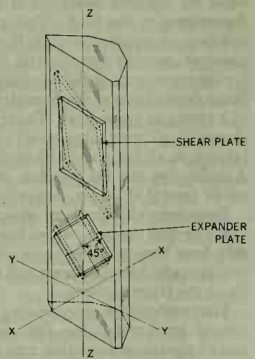


FIG. 2.—ROCHELLE SALT CRYSTAL

Ferroelectric and highest piezoelectric effects are connected with electric field in X direction. Crystal plate cut parallel to Y and Z axes deforms in shear when field is applied in X direction. Plate cut at 45° to Y and Z axes expands along one edge and contracts along the other edge

If all three axes are different, the orthorhombic crystal class 22, which includes Rochelle salt, is obtained.

The trigonal crystal system includes two very important piezoelectric crystals, quartz and tourmaline (*q.v.*). Quartz has three twofold axes of symmetry in addition to the threefold, principal axis; the crystal class is 32, characterized by two piezoelectric constants, one relating compressional stress parallel to a twofold axis with an electric polarization in the same direction, while the second constant relates shearing stress in the plane perpendicular to a twofold axis with polarization parallel to that axis. Tourmaline, crystal class $3m$, has three planes of symmetry intersecting in the threefold axis. Its most important piezoelectric constant relates polarization parallel to this axis to compressional stress in the same direction.

It is in the general nature of stress and strain (*see* ELASTICITY) that a shearing stress or strain can be resolved into compression or expansion if related to rotated axes. Thus it is possible to obtain piezoelectric response to compressional stress in crystals of class $43m$, $\bar{4}2m$ and 22 if the crystal plates have sides inclined to the crystal axes. The optimum angle is 45°; in this case the effective piezoelectric coefficient for compression is one-half that of the shear coefficient for the original axes. Fig. 2 illustrates this for plates cut from a Rochelle salt crystal. Hydrostatic pressure, however, does not contain an element of shear in any co-ordinate system and cannot cause a piezoelectric effect in crystals of the three classes mentioned. Response to hydrostatic pressure is also absent in quartz due to a compensation of the effects on the three twofold axes. A piezoelectric effect of hydrostatic pressure is found only in crystals having a single polar axis. These are exactly the same crystals which show true pyroelectric effects. Strong electric response to hydrostatic pressure is found in tourmaline and lithium sulfate monohydrate (monoclinic, class 2).

NUMERICAL EXPRESSION OF PIEZOELECTRIC EFFECTS

Basic Equations.—Piezoelectricity connects an elastic variable, stress or strain, with an electrical variable, electric polarization or electric field. Piezoelectric constants may be defined to connect either of the two elastic variables with either electric variable. The most useful piezoelectric constants (usually designated by the letter d) relate electric polarization to the stress causing this polarization. It is found from the requirement of conservation of energy that then the same constant also gives the strain caused by an applied electric field. The vector component of electric field or polarization is indicated by subscripts 1, 2 and 3 for the X, Y and Z axes. The tensor components of stress or strain are indicated by 1, 2 and 3 for compressional components along the axes, while 4, 5 and 6 designate shear in the planes perpendicular to the axes. Thus for a crystal of class $\bar{4}3m$ (for example, zinc sulfide) the following relationships are shown:

$$P_1 = d_{14}T_4;\ P_2 = d_{14}T_5;\ P_3 = d_{14}T_6$$
$$S_4 = d_{14}E_1;\ S_5 = d_{14}E_2;\ S_6 = d_{14}E_3,$$

where T and E are components of applied stress or electric field, while P and S are components of resulting polarization or strain. For Rochelle salt, class 22, these relationships exist:

$$P_1 = d_{14}T_4;\ P_2 = d_{25}T_5;\ P_3 = d_{36}T_6$$
$$S_4 = d_{14}E_1;\ S_5 = d_{25}E_2;\ S_6 = d_{36}E_3.$$

The threefold symmetry of quartz makes the compressional piezoelectric constant d_{11} also responsible for a shear effect as expressed in the following system of equations:

$$P_1 = d_{11}T_1 - d_{11}T_2 + d_{14}T_4;\ P_2 = -d_{14}T_5 - 2d_{11}T_6$$
$$S_1 = d_{11}E_1;\ S_2 = -d_{11}E_1;\ S_4 = d_{14}E_1;\ S_5 = -d_{14}E_2;$$
$$S_6 = -2d_{11}E_2.$$

The strain component S_6 describes a shear in the horizontal plane of fig. 3.

The equation indicates that this strain is excited by an electric field in the Y direction. By this relationship, an electric field applied between the surfaces of a quartz plate cut perpendicular to the Y axis will cause a shearing deformation of the side facets of such a plate.

Examples.—The units to be used for expressing piezoelectric constants derive from the units employed for elastic stress and electric polarization. For consistency, the electric and elastic units used must lead to the same unit of energy. Preference is given to the metre-kilogram-second system with rationalized electric units. With this choice, the unit of the piezoelectric d-constant becomes the coulomb/newton or metre/volt. Here 1 coulomb = 1 amp. × second and 1 newton = 1 kg.-mass × metre/second^2 = 0.225 lb. = 102 gr. force. The two units are equivalent since 1 newton × metre = 1 joule = 1 volt × coulomb (*see* PHYSICAL UNITS).

The values of the piezoelectric coefficients are found to be numerically so extremely small that they are best expressed as multiples of 10^{-12}. In Tables I and II this is expressed by giving the unit as micromicrocoulombs ($\mu\mu$C.) per newton. The dielectric constants are relative, and are to be multiplied by the permittivity of empty space ϵ_0 or 8.85 micromicrofarads ($\mu\mu f.$)/m.

The meaning of the figures in Table I can be explained by a few practical examples:

1. A force of 10 lb. is exerted on the major face of a quartz plate 1 in. square and 0.1 in. thick cut with its major face perpendicular to an X axis (fig. 3, X-cut). The generated charge is:

d_{11} × area × stress = d_{11} × force
= 2.3 × 10/0.225 = 102 $\mu\mu$C.
Capacitance = dielectric constant × area/thickness = 4.5 × 8.85 × 0.0254/.1 = 101 $\mu\mu f.$
Generated voltage = charge/capacitance = 102/10.1 = 10.1 v.

2. A plate of Rochelle salt 1 cm. long, 2 mm. wide and 0.5 mm. thick, mounted at one end, is subjected to shearing stress by application of 10 grams of force in the width direction at the free end.

The generated charge is:

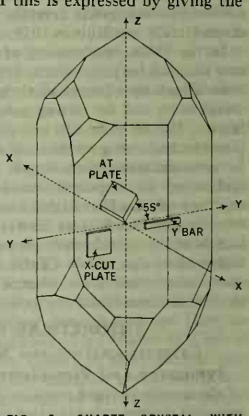


FIG. 3.—QUARTZ CRYSTAL WITH THREE MOST IMPORTANT PIEZOELECTRIC ELEMENTS

X-cut is used for expansion or contraction in thickness direction on application of electric field in X direction; Y bar expands and contracts in length direction when field is applied in X direction. AT shows shear in side faces when field is applied in thickness direction; it excels in low temperature variation on resonance frequency

$d_{14} \times$ area $\times$ stress $= d_{14} \times$ force $\times$ length/thickness $=$
$350 \times 10 / (102 \times 0.05) = 700\ \mu\mu C.$
Capacitance $= 550 \times 8.85 \times 0.01 \times 2/.5 = 200\ \mu\mu f.$
Voltage $= 700/200 = 3.5$ v.

3. A voltage of 1,000 is applied to an ammonium dihydrogen phosphate plate 1 cm. square and 1 mm. thick, with its major face perpendicular to the Z axis. The resulting shear deformation (change in angle between the X and Y axes) is:

$S_6 = d_{36}$ voltage/thickness $= 0.000048$ radians $= 0.16$ minutes.

TABLE I.—*Piezoelectric Crystals*

Crystal	Piezoelectric constants*	Dielectric constants†
Rochelle salt (30° C.)	d_{14} + 550	350
	d_{25} − 54	9.2
Quartz	d_{14} + 12	9.5
	d_{11} + 2.3	4.5
	d_{14} − .7	4.5
Ammonium dihydrogen phosphate (ADP)	d_{14} − 1.5	56
	d_{36} + 48	15.5
Potassium dihydrogen phosphate (KDP)	d_{14} + 1.3	42
	d_{36} + 21	21
Tourmaline	d_{14} + 3.6	6.3
	d_{25} − 0.3	6.3
	d_{31} + 0.3	7.1
	d_{33} + 1.8	7.1
Zinc blende (ZnS)	d_{14} − 5.2	9
Barium titanate crystal	d_{31} − 34	170
	d_{33} + 86	170
	d_{15} + 392	2,900
	d_{31} − 78	1,700
Barium titanate ceramic	d_{33} + 190	1,700
	d_{15} + 260	1,450

*Unit is micromicrocoulomb/newton. †Relative to air.

These typical examples show that the electric charges generated are quite small but the voltages very substantial. Conversely, mechanical displacements caused by piezoelectric effects are minute, but due to the high elastic stiffness of crystals the forces created can be large.

FERROELECTRICITY

Ferroelectric Crystals.—Inspection of Table I shows Rochelle salt to be superior to the other listed crystals in the value of its piezoelectric constant d_{14}. At the same time, the dielectric constant is also in the order of 100 times higher than that of ordinary solids. The high values of these two constants are a result of the ferroelectricity of Rochelle salt. This term designates a dielectric phenomenon analogous to ferromagnetism in magnetic materials (*see* MAGNETISM). The basic condition for either phenomenon is a co-operative molecular effect. In magnetism it involves the electron spins associated with certain metallic elements, while in the dielectric case it involves electric dipoles which may be permanent or may be induced by local electric fields. Consideration of the value of the electrical charge and typical interatomic distances indicates that ferroelectricity should be a more widespread phenomenon than ferromagnetism. Extensive studies of dielectric properties of a number of solids have indeed produced numerous examples of ferroelectric materials, especially among organic salt type compounds, but none of these have been found to approach Rochelle salt in piezoelectric effects.

Characteristic of ferroelectrics is the formation of domains; *i.e.*, regions within each crystal which have a spontaneous electric polarization. Under the influence of an applied electric field these domains may reverse their orientation; this effect can contribute substantially to the dielectric constant. In most ferroelectrics a characteristic temperature, the Curie point, is observed above which domain structure disappears. The dielectric constant reaches particularly high values near this temperature. In the case of Rochelle salt, the Curie temperature occurs at 24° C., and thus a very high dielectric constant is found in the room-temperature range. This high dielectric constant may be said to enhance the piezoelectric effect, the origin of which, in Rochelle salt, as in other crystals containing asymmetrical organic molecules, is inherent in the molecular structure.

Barium Titanate.—Barium titanate ($BaTiO_3$) and related compounds including lead titanate ($PbTiO_3$), calcium titanate ($CaTiO_3$) and lead zirconate ($PbZrO_3$) belong to a simple crystal structure type, the perovskite type, which is cubic and has a centre of symmetry in the ideal case. This cubic symmetry is actually found for barium titanate above 120° C.; below this temperature barium titanate is tetragonal with a polar symmetry, class *4mm*. The transition from cubic to tetragonal near 120° C. is a Curie point with a peak dielectric constant as high as 10,000. Below this temperature a barium titanate crystal is found to consist of domains with electric polarity in different directions but always parallel to a cube axis. Each of these domains is a true tetragonal crystal with definite piezoelectric coefficients. The multidomain crystal is, in crystallographic terms, a multiple twin. The piezoelectric properties of such a crystal will depend on the domain distribution; reproducible data are found only if uniform domain orientation is induced by a maintained external electric field. Domain reversal may be caused by such moderate applied fields as 100 v./mm. This phenomenon has been applied in electric data storage.

Domain reversal by applied electric fields makes it possible to induce a resultant over-all polarization in polycrystalline ceramic masses of barium titanate crystallites. Due to forces acting between the crystals, the electric polarization of the ceramic is more stable than that of the single crystal. Barium titanate and ceramics of related structure have thus become major practical piezoelectric materials.

Ferroelectric Ceramics.—In barium titanate and other ferroelectric ceramics that have been rendered polar by treatment in a strong electric direct-current field, such as 50,000 v. per inch, is found an over-all symmetry comprising a polar axis and all planes intersecting in this axis. This leads to three independent piezoelectric constants, d_{33}, d_{31} and d_{15}. It is usually found that a compression parallel to the 3-axis causes electric polarization opposite to that originally applied in the poling process, while compression at right angles to this axis causes the polarization to increase. The effect of axial compression is predominant so that a decrease of polarization also results from hydrostatic pressure. The shear piezoelectric constant d_{15} has values even larger than d_{33}, but this shear effect does not have such wide applications.

In the ferroelectric oxide ceramics the phenomenon of ferroelectricity does not merely enhance the piezoelectric effect, but is its basis. No piezoelectric effects are present above the Curie point. The asymmetry of the single crystal below the Curie point

TABLE II.—*Piezoelectric Transducer Materials*

Material	Upper temperature limit* (° C.)	Field direction	Force direction	Effective piezoelectric constant (d) (coulomb/newton)	Young's modulus (Y) (newton/m.²)	Dielectric constant (K)	Electro-mechanical coupling factor (k)	Density (kg./m.³)	Elastic wave velocity (m./sec.)
Quartz	550	X	X	2.3×10^{-12}	8.0×10^{10}	4.5	.10	2.65×10^3	5,400
		X	Y	2.3×10^{-12}	8.0×10^{10}	4.5	.10		5,400
Ammonium dihydrogen phosphate (ADP)	120	Z	45° XY	24×10^{-12}	1.9×10^{10}	15.5	.29	1.80×10^3	3,250
Rochelle salt (30° C.)	45	X	45° YZ	290×10^{-12}	1.8×10^{10}	350	.68	1.77×10^3	3,200
	45	Y	45° ZX	27×10^{-12}	1.0×10^{10}	9.2	.30		2,400
Barium titanate ceramic	100	Z	Z	190×10^{-12}	10.6×10^{10}	1,700	.52	5.7×10^3	4,300
		Z	X	78×10^{-12}	11.0×10^{10}	1,700	.22		4,400
Lead titanate zirconate (45/55)	300	Z	Z	140×10^{-12}	7.1×10^{10}	450	.60	7.6×10^3	3,100
		Z	X	57×10^{-12}	8.7×10^{10}	450	.26		3,400
Lead strontium titanate zirconate	300	Z	Z	250×10^{-12}	6.7×10^{10}	1,200	.64	7.5×10^3	3,000
		Z	X	105×10^{-12}	8.1×10^{10}	1,200	.30		3,300
Lead metaniobate	500	Z	Z	80×10^{-12}	6.0×10^{10}	225	.42	6.0×10^3	3,200
		Z	X	11×10^{-12}	6.0×10^{10}	225	.04		3,200

*Practical upper limits set either by approach to Curie point or chemical decomposition.

which permits piezoelectricity is a direct result of ferroelectricity. Further, the possibility of rendering a ceramic polar depends on reversal of ferroelectric domains.

High-Temperature Ferroelectrics.—Substantial variations in the properties of barium titanate ceramics have been obtained by modification of their composition. In some cases this has involved solid solution formation, with such elements as calcium and strontium replacing barium, or zirconium replacing titanium. A principal effect of such substitutions is a shift in the Curie point. More subtle changes in electric properties are obtained by additives, such as rare-earth oxides, from other columns of the periodic system. Additions in the range of 1% may destroy the ability of barium titanate ceramics to accept permanent polarization, but advantageous dielectric properties for capacitor applications have resulted. Solid solutions of lead titanate and lead zirconate, also of the perovskite structure type, are found to possess piezoelectric properties generally similar to those of barium titanate.

Lead titanate zirconate compositions, in addition to having high Curie points (300° to 400° C.), have a higher electromechanical coupling than barium titanate. A wide range of electric properties can be achieved by the controlled variation of composition in the preparation of lead titanate zirconate.

Further perovskite-type ferroelectrics of potential technical interest are obtained by partial substitution of potassium or lead for sodium in sodium niobate (columbate, $NaNbO_3$). Lead metaniobate ($PbNb_2O_6$) is of promise for high-temperature applications in view of its high Curie point (570° C.) and is of theoretical interest as a prototype of a new crystal structure.

Preparation and Measurement

Preparation of Crystals.—The manufacture of useful piezoelectric bodies from piezoelectric crystals involves the services of the geologist and mineralogist in locating suitable high-quality single crystals of the minerals quartz and tourmaline. In the case of quartz the absence of crystallographic twinning is essential. This requirement once limited the supply of commercial piezoelectric quartz notably to Brazil and the Malagasy Republic. Water-soluble crystals such as Rochelle salt and ammonium dihydrogen phosphate are grown from their solutions, under closely controlled conditions of temperature, with the use of seed crystals of definite shape and orientation. The art of crystal growing has been extended also to quartz. The solvent in this case is water with the addition of an alkali under supercritical conditions such as a temperature of 400° C. and a pressure of 1,000 atmospheres. Fig. 4 shows a large quartz crystal as grown in a seed-holding fixture.

To obtain the desired piezoelectric action, piezoelectric elements have to be cut from the natural or grown crystal to close tolerances of dimensions and orientation in regard to the crystal axes. In case of quartz crystal oscillators for precision frequency control, dimensional stability may have to be more than 1/1,000,000,000 of an inch and dimensional accuracy closer than one minute of arc. The methods for cutting and finishing quartz oscillator plates are akin to those used in the manufacture of precision optics.

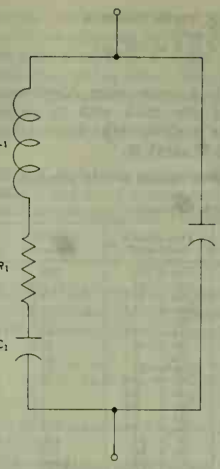


FIG. 5.—EQUIVALENT CIRCUIT OF PIEZOELECTRIC CRYSTAL ELEMENT NEAR A RESONANCE

C_0 is electrical capacitance; L_1, C_1 and R_1 are mechanical mass, compliance and damping load reflected in electrical behaviour through piezoelectric effect. Resonance frequency is $1/(2\pi\sqrt{LC})$

Preparation of Ceramics.—Piezoelectric ceramics are obtained by methods generally applied in preparing electric insulator ceramics, but closer control over impurities usually is required. The addition of fluxes can affect the electric properties undesirably. After a ceramic firing process the ferroelectric bodies are given closely adhering electrodes, usually in the form of a fired-on silver preparation, and subjected to high direct-current voltage for a period of time that may be as long as one hour. Usually this takes place at an elevated temperature, preferably close to the Curie point.

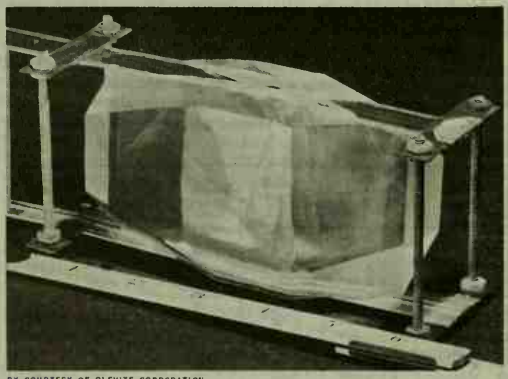
Direct Measurement Methods.—The most direct method of determining the piezoelectric effect of a crystal body is the measurement of the electric charge generated upon application or removal of a mechanical force. Such measurements are convenient on piezoelectric ceramics that show high piezoelectric effect and good insulation resistance. The method requires considerable skill when applied to piezoelectric crystals of only moderate piezoelectric effect. In such cases application of an oscillatory force of known magnitude and amplification of the resulting alternating-current piezoelectric signal may be employed.

Other methods depend on the converse piezoelectric effect. A static method uses strain gauges to study the deformation resulting from an applied high direct-current voltage. Small oscillatory displacements resulting from the application of alternating voltage may be detected as frequency modulation if the vibration is applied to the plate of a tuning condenser in a high-frequency circuit.

Resonance Measurement Methods.—The most accurate measurements of piezoelectric constants depend on the electric effects in piezoelectric bodies vibrating near their principal mechanical resonance frequencies. Applied to small crystals or crystal fragments, resonance is employed in the most sensitive test for presence of piezoelectricity, the click test. In this the tester listens to the transients occurring in an oscillator circuit when it is swept over resonances of the crystals.

When electrical impedance of a crystal is measured as a function of frequency, it is found that the apparent capacitance increases to very high values as the resonance is approached. At this point the impedance is a pure resistance, then becomes inductive. With a further increase of frequency, the impedance becomes once more a pure resistance but at a much higher resistance level, and then it again becomes capacitive. This behaviour can be represented by an equivalent electric circuit (fig. 5). In this circuit, C_0 represents the capacitance of the crystal if the piezoelectric effect were suppressed. L_1 and C_1 are related to the mass and elastic compliance of the crystal, multiplied by a factor representing the piezoelectric effect. R_1 represents the mechanical damping of the crystal. The ratio of the inductive impedance to R_1 is given by the mechanical quality factor which is the reciprocal of the mechanical damping factor.

This quality factor may be as high as 1,000,000 in practical quartz crystal oscillators. The ratio of capacitances C_1/C_0 is a direct measure of the strength of the piezoelectric effect involved



BY COURTESY OF CLEVITE CORPORATION

FIG. 4.—QUARTZ CRYSTAL, WEIGHING 1½ LB., GROWN FROM SODIUM CARBONATE SOLUTION AT PRESSURE OF 6,000 LB. PER SQUARE INCH AND TEMPERATURE OF 360° C.

in the elastic resonance under study. It is found to be related to the piezoelectric d-constants by equations of the type

$$C_1/C_0 = fd^2Y/K\epsilon_\sigma$$

ϵ_0 is the dielectric permittivity of empty space and f is a numerical where Y is Young's elastic modulus, K is the dielectric constant, factor related to the amplitude distribution of the elastic mode; it is near 0.8 for typical fundamental modes. This capacitance ratio represents the amount of sharing of electric and elastic energy through the piezoelectric effect. The square root of the capacitance ratio is proportional to the electromechanical coupling factor k defined by

$$k = d\sqrt{Y/K\epsilon_\sigma}.$$

The most convenient way of obtaining the coupling factor and hence the piezoelectric constant is by the measurement of the two frequencies at which the impedance of the crystal is a pure resistance. The frequency of low resistance is the resonance frequency and the frequency of high resistance is the antiresonance. For an elongated bar the product of the fundamental resonance frequency and length is one-half the elastic wave velocity. Extremely accurate values of the elastic modulus, Y, are obtained by the relation

$$\text{wave velocity} = \sqrt{Y/\text{density}}.$$

Table II lists the important piezoelectric operating parameters of some crystals and ceramics. The data for ceramics are only representative, since small variations in composition or processing, either intentional or fortuitous, can cause substantial changes in operating parameters. Only piezoelectric effects of compression or expansion forces, as distinct from shear forces, are considered. The table comprises cases where the electric field and force are parallel as well as those where they are at right angles. For quartz, the same coefficients hold for both cases since $d_{12} = -d_{11}$.

Young's modulus is much lower for the water-soluble crystals than for ceramics or quartz, but for calculation of wave velocity this is largely compensated by the lower density of the soluble crystals. The enormous spread in the piezoelectric d-constants is somewhat balanced by the analogous spread of dielectric constants, so that the listed electromechanical coupling coefficients are comprised within one order of magnitude. It is noteworthy that electromechanical coupling coefficients in excess of 0.5 have been found only in ferroelectric materials. The ideal piezoelectric would approach the value 1 for this coefficient.

APPLICATIONS

Mechanical Measurements.—The crystals and ceramics listed in Table II are those which have found major application. Minor but continuing use in measurement instruments is made of tourmaline and lithium sulfate. Ethylene diamine tartrate (EDT) and neutral potassium tartrate (DKT) crystals were produced in sizable quantities about 1950 but failed to establish themselves on a competitive basis. Potassium dihydrogen phosphate has found some application for an electrooptic effect closely related to piezoelectricity.

All the methods of observing the piezoelectric effect have become the basis of applications of this effect in the field of electromechanical measurement, electroacoustics, electric voltage sources and frequency controlling devices. The most immediate application is in the measurement of force or pressure. Here, however, a major limitation is encountered as a result of the electric leakage current which gradually neutralizes the voltage generated by application of a force. Piezoelectric effects are therefore not suitable for measurement of constant or slowly changing pressures such as barometric pressure. The compactness and high mechanical resonance frequency of piezoelectrics gives them, however, unique advantages for dynamic pressure studies, as in blast gauges and accelerometers for the analysis of rapidly changing states of motion.

Phonograph Pickups.—Devices translating electric energy into mechanical energy and vice versa are known as electromechanical transducers. Most transducers involve compressional rather than shear piezoelectric effects. The largest use of piezoelectric elements in terms of units manufactured is in phonograph pickups. In these, the piezoelectric element transforms the mechanical energy picked up by the phonograph needle into an electrical signal. In the period from about 1938 to 1958 Rochelle salt phonograph pickup elements supplied approximately nine-tenths of the whole phonograph industry of the United States. Beginning in the early 1950s ceramic piezoelectric elements became increasingly important. They are free of temperature and atmospheric humidity problems and are well adapted to light-weight construction.

Major requirements for a phonograph pickup element are high mechanical compliance and high voltage output. In both these respects lead titanate zirconate offers considerable advantage over barium titanate.

In a widely used arrangement, two piezoelectric plates are combined into a sandwich which is subjected to bending forces. The piezoelectric effect used links the field in the thickness direction to elastic stress along the length. The size may be as small as $0.5 \times 0.06 \times 0.02$ in. for the sandwich, and the standard voltage output is typically one volt for five to ten grams stylus pressure. The two component elements may be connected either in series or in parallel. In either case connections are made so that the outputs of the two elements add when one is compressed and the other is expanded as occurs in bending. An alternative arrangement, in which torque is applied to a combination of two shear-sensitive elements, has been very successful with Rochelle salt but is not feasible with piezoelectric ceramics. Such a torque-type phonograph pickup cartridge is shown schematically in fig. 6. Torque in the crystal sandwich is caused by the lateral movement of the stylus.

A vertical stylus movement in the same arrangement causes bending of the crystal sandwich. This has been used in one type of stereophonic crystal pickup which contains a sandwich of one Rochelle salt shear plate and one expander plate (*see* fig. 2). Separate electrical connections from the two plates carry signals proportional, respectively, to the horizontal and vertical excursions of the record groove. (*See* also HIGH-FIDELITY SOUND SYSTEMS; LOUD-SPEAKER.)

Acoustics and Ultrasonics.—Other applications of piezoelectric transducers are in the fields of sound transmission and reception. They have been especially successful in acoustic underwater sound devices because piezoelectric solids are much better matched acoustically to water than to air. Thus, comparatively simple matching structures or none at all are required for piezoelectric underwater transducers. While much of the use of piezoelectric crystals has been for military underwater sound purposes, increasing peacetime uses of sound energy in liquids developed after about 1950. Ultrasonic cleaning devices, operating at frequencies from 10 kc. to 100 kc., have been particularly successful. For this frequency range, resonating bars have convenient lengths of 0.5 to 5 in. To obtain reasonably large values of capacitance, bars with the electric field perpendicular to the length direction are usually preferred even when, as in the case of the ceramics, the piezoelectric effect for lengthwise mechanical action is the weaker one. For frequencies above 100 kc. per second, thickness resonance of plates with mechanical and electrical action in the thickness direction is preferred. Fig. 7 shows ceramic thickness vibrators operating about 500 kc. per second. The curved shapes have their electric axes at all points in the radial direction and produce focused compressional waves in the surrounding liquid. This would be very difficult to achieve with piezoelectric single crystal elements which have their axes in parallel directions at every point,

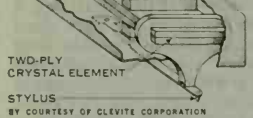
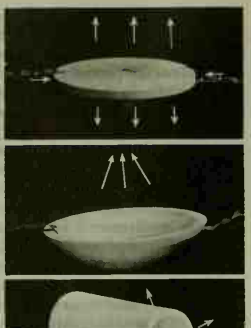


FIG. 6.—ROCHELLE SALT PHONOGRAPH PICKUP

When each half of two-ply element is a shear plate (fig. 2), combination is sensitive to torque (lateral stylus movement). Substitution of expander plate gives response to bending stress (vertical motion)

The conditions for elastic vibrations of bars and plates are different; the data of Table II refer to bars and are only approximately applicable to plates in thickness vibration.

Piezoelectric generators and receivers of sound waves in the megacycle frequency range are used for the input and output of acoustic delay lines employed in many computers. The principal materials used in underwater sound transducers are ammonium dihydrogen phosphate, barium titanate and lead titanate zirconate. (*See* also Ultrasonics; Sounding.)



FROM "INDUSTRIAL AND ENGINEERING CHEMISTRY" (1950); REPRODUCED BY PERMISSION OF AMERICAN CHEMICAL SOCIETY

FIG. 7.—BARIUM TITANATE CERAMIC TRANSDUCERS

Electric drive of transducers at mechanical thickness resonance produces ultrasonic waves in direction of arrows. Bowl concentrates radiation near a point, cylinder along axis

Frequency Control.—The major application of piezoelectric quartz crystals is for electric frequency control. Quartz combines exceptional chemical and mechanical stability with very unusual elastic properties. While most materials show a steady decrease in the elastic moduli with temperature, some of the elastic moduli of quartz show the opposite trend. By cutting plates from quartz crystals at certain orientations and dimensions, a high degree of compensation for these temperature coefficients can be obtained. The piezoelectric coupling of quartz, while not very large, is entirely adequate to cause a reaction of the quartz crystal on the electric driving circuit. This reaction can force the circuit to oscillate at an exact frequency determined by the quartz crystal. Quartz crystal oscillators have been built to operate at frequencies from 1 kc. per second or less to approximately 100 mc. The largest number are in the communication range from five to ten megacycles. For this range the most important type of quartz crystal oscillator is the AT cut (*see* fig. 3). By applying an electric field in the thickness direction, this plate is excited to transverse vibrations traveling in the thickness direction. To obtain fundamental resonance (one-half standing wave) at eight megacycles, the thickness should be about 0.008 in. The orientation of the AT cut is chosen so as to minimize the temperature dependence of the resonant frequency over a wide operating range, such as $-55°$ to $+90°$ C. Stability within 0.005% may be obtained without temperature control of the crystal.

A frequency constant to 1 part per 1,000,000,000 over many months has been obtained through the use of extremely carefully prepared quartz oscillators, maintained at constant temperature. Liquid helium boiling at constant pressure is especially suitable, because at such very low temperatures any gradual changes in elastic properties are suppressed. Such quartz clocks are more constant than the rotation of the earth itself (*see* Clock: *Quartz Crystal Clocks;* Time Measurement).

Wave Filters.—Closely related to frequency control is the mechanical wave filter application of piezoelectric crystals. In this case the remarkable impedance properties of the crystal near a resonance point are used to provide passage of an electric signal that falls within a prescribed band of frequencies, while other frequencies are rejected. The width of the frequency pass-band is related to the range of frequency at which the crystal impedance is inductive and thus to the capacitance ratio (C_1/C_0) (*see* above, *Resonance Measurement Methods*). In quartz crystals, unless associated with additional inductors, this pass-band is limited to the order of 1% of the centre frequency of the band. Nevertheless, quartz crystal filters are of great importance in separating the voice channels in multichannel telephony, in which carrier frequencies range from 65 to 200 kc. per second. Piezoelectric ceramics are intrinsically less stable than quartz. Nevertheless, modifications of barium titanate and lead titanate zirconate have been found which combine a high piezoelectric coupling coefficient, and hence a high band width, with sufficient stability for intermediate frequency filtering—usually at 455 kc. per second—in radio receivers.

The search for new and improved piezoelectric materials is part of the expanding field of solid state physics. Its practical aim is the development of devices and circuit components of smaller size, greater ruggedness and increased temperature and frequency operating range.

See also Solid State Physics.

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(Ha. J.)

PIG, a common name given to the swine of any age. Hog is used collectively with much the same meaning as pig, hog being generally used in the U.S. to indicate pigs being used for fattening but in England generally referring to the castrated male. The term gilt is applied to female pigs up to the weaning of their first litter. Swine is applied to any hoofed animal of the family Suidae (*see* Swine).

The pig reproduces by multiple birth, farrowing around 4 to 6 pigs in the wild state, and 8 to 12 pigs in the domesticated state. Pigs are rotund-bodied, short-legged, even-toed, hoofed mammals of omnivorous habits, having thick skin from which grow short, coarse bristles, a long mobile snout, small tail, and feet with two functional and two nonfunctional digits. A mature pig has 44 teeth, carries its head low, and eats, drinks, and breathes close to the ground.

Fossil remains of the pig which have been found in Europe and India, although not on the American continents, date back to the Neolithic period. Bones have been found with those of cattle, sheep, and dogs and indicate pigs were first domesticated at this period. Present-day breeds have been evolved from the heavy shouldered, rough European wild boar that was crossed with the finer, smaller Chinese pig. The black Neapolitan pig was an offset of the latter. Modern European pigs have evolved from these types, while domesticated breeds in the Americas, Africa, and Australasia have either been imported as such or have been evolved from animals taken there by earlier settlers.

In the ancient world, pigs were a symbol of fertility and an embodiment of the corn spirit, for instance in Greece where they were sacred to Demeter, in Egypt where pork was eaten one day a year in honour of Osiris, and in India. In Northern Europe the pig was killed and eaten in the autumn and the remains buried with the seed in the spring. The boar's head carried in procession at medieval feasts and eaten at Christmas—the winter solstice—may be a relic of this custom. Pigs are still considered sacred in New Guinea, while in Japan there are shrines in honour of boars whose progeny has been outstanding in improving the national herd.

Since the pig was sacred, ritual cleansing was necessary for those in contact with pigs, and swineherds were shunned in ancient Egypt. From this stemmed the idea that the pig was unclean in the ordinary sense. The flesh of the pig is forbidden food to Jews and Muslims. Though the pig is not naturally a dirty animal (see *Care and Management* below) "pig" and "swine" symbolize degradation in Christian parables, and derivatives from these words (*e.g.,* "roadhog") are universal terms of abuse.

The pig makes a frequent appearance in folklore and nursery rhyme in Europe and America, sometimes as half-remembered myth and sometimes as a familiar domestic animal.

Boar hunting with dogs and spears has been a popular sport from classical times. The sport has practically died out in Europe, though it continues in India (*see* Pigsticking). Pigs have also been used in England to point for game and in France to root for truffles.

WORLD PRODUCTION AND TRADE

For the five-year period ending with 1950, the average annual world pig population was estimated at about 250,000,000 and represented substantial recovery from the devastation of pigs along with other livestock in much of Europe, the U.S.S.R., China, and Southeast Asia and many of the islands of the Southwest Pacific during World War II. Following 1950 world production steadily increased, reaching an all-time high of more than 500,000,000 in the 1960s. Asia produces the largest number of pigs, followed by Europe, North America, the U.S.S.R., and South America. Substantially smaller but important numbers are produced in Africa and Oceania. In many countries pigs constitute the principal source of meat in addition to poultry and fish. In many rural and village economies throughout the world, and especially in the tropics, pigs are not only an important source of sustenance but the sale of live pigs in local markets is a critical source of cash income.

In world trade, pigs, except for breeding purposes, are not shipped long distances because of the excessive shipping space required and the costs involved. Consequently, most hog products entering world trade are shipped either in fresh or frozen carcasses, or cured or processed, at much cheaper costs. China normally exports the most live hogs, followed by such countries as Poland, Yugoslavia, and Hungary. The greatest total trade in live hogs imported for slaughter is carried on by West Germany, Austria, El Salvador, and Italy. (J. H. Z.)

BREEDS AND BREEDING

Domestic pigs differ from their wild ancestors and even among themselves with regard to general conformation, colour, size, disposition, and other characteristics. Breeds of pigs have been developed to meet certain geographical conditions and to satisfy particular economic wants. The importance of the Asiatic breeds was recognized in the use of Chinese and of "Siamese" hogs from Southeastern Asia in the improvement of early European and North American breeds and is reflected in the name of the Poland China, which in turn has been used as a foundation breed for the Beltsville No. 1 and Minnesota No. 2.

Basically pigs can be classified as either lard, bacon, or pork type. Lard pigs tend to be large-framed and to be concentrated in areas where there are good supplies of fattening food, such as corn (maize). Bacon pigs are somewhat smaller and produce a long carcass weighing about 150 lb. Fresh pork is eaten from pigs of widely differing weight, but a pork pig is generally considered to be one giving a mature lean carcass weighing about 100 lb. dead weight. The increased world demand for lean meat has seen development from these three types of breeds or strains possessing a high lean meat content. (*See* also BACON; PORK; HAM; and LARD.)

There are over 300 breeds of pigs or local varieties throughout the world. A brief description follows of the better known commercial breeds that have figured prominently in improving breeds and upgrading domestic breeds and crosses throughout the world. No attempt has been made to assess the economic performance of any breed because of differing production methods and methods of selecting breeding pigs. White pigs are generally associated with some form of intensive management, coloured pigs, which are resistant to sunscald, being preferred for extensive production and crossing.

The *Berkshire* is a black pig with white on its face, legs, and tip of tail. It has a short dished face with erect ears pointing slightly forward. It originated in England where in the early 19th century the name "Berkshire" became synonymous with improved pig strains of differing origin and type. The establishment of a herdbook in 1885 fixed current strains. Berkshires are used for fresh pork production in England and Japan, but a larger bacon type has been evolved in Australia and New Zealand. The breed is also found in both North and South America.

The *Chester White* is white with a pink skin similar in type to the Large White or Yorkshire, but fatter. It originated in the United States, in Chester County, Pa., hence its name. The Chester White is very prolific, has a quiet disposition, matures early, is a good grazer, a good feeder, and possesses good carcass qualities. The breed is of the lard type and is restricted to the United States and Canada.

The *Duroc* is a red pig. It was developed in 1822–77 from the Old Duroc pig of New York and the Red Jersey pig of New Jersey, thus the earlier name Duroc-Jersey. It proved particularly suitable for feeding in the American Corn Belt and has been extensively used in the Argentine, Canada, Chile, and Uruguay. The Duroc, which is a lard pig, although of less importance since the demand for lean meat has increased, has probably produced more pigs than any other pure breed.

The *Essex* pig is black with a white saddle on the shoulder and forelegs, and with white on the nose, hind legs, and tip of the tail. It was evolved in England by crossing the Black Suffolk with Neapolitan pigs (which may have included the Siena Belted, the oldest saddled breed). It is mainly used commercially for crossing with a boar of one of the white breeds and is of bacon type.

The *Gloucestershire Old Spots* is a white lop-eared pig with black spots, current policy being to select breeding pigs on the absence of pigment in the skin. It was evolved in England in Gloucestershire from material similar to some of the original Berkshire strains, although it has had no connection with the latter breed for many years. It is of bacon type but is normally used for crossbreeding only.

The *Hampshire* derives from an importation of Wessex Saddleback type pigs from England to North America in 1825 and is identical in appearance to that breed. It is of bacon type.

The *Hereford* is red with a white head and was given this name because of its similarity to Hereford cattle. It was developed in the early 20th century in Missouri by crossing other American breeds. The Hereford is of pork type.

The *Iberian* pig is usually coloured red, black, or pied and possesses short semierect ears. Of little commercial importance outside Spain and Portugal where it grazes forests, it is of academic interest as it closely resembles the type of pig found in Europe in medieval times.

The *Landrace* is a white lop-eared pig found in most countries in Central and Eastern Europe, local varieties having in particular been developed in Denmark, Germany, the Netherlands, and Sweden. World attention was first drawn to the Landrace by Denmark where since 1890 by progeny testing (the selection of boars for breeding on the basis of the scientific assessment of their progeny) a superior pig, designed for Denmark's export trade in Wiltshire bacon to England, has been produced. Denmark will not permit the export of Landrace for breeding. Sweden also has progeny tested from Landrace stock but for a shorter period. Pigs from Sweden were first exported to England in 1953 when prices of up to £1,000 per pig were paid. This resulted in a worldwide Landrace explosion, and most major pig-producing countries have since taken stock.

The *Large Black* or *Cornwall* is an all-black pig with lop ears. The breed was developed in England by the fusion of black breeds found in Devon and Cornwall with similar breeds of Essex and Suffolk pigs. Of bacon type, the breed is normally used for the production of crossbred litters.

The *Mangalitza* breed is white or brownish black with a white belly. It was developed in Serbia in the late 18th century and is confined to the Balkan states. Used primarily for fat production, it is of declining importance.

The *Middle White* is a white pig similar in body conformation to the Large White but much smaller and with a dished face. Coming from lines identical to those of the Large White, it contains a greater proportion of Chinese blood. It is of pork type. Originating in England, it is used extensively in Japan.

The *Pietrain* is a lop-eared breed characterized by exceptional fleshing which arises from genetic causes which produce double muscling. It is a dirty white in colour with black spots. The breed was produced in Belgium in 1920 and since 1960 has attracted interest because of the demand for lean meat. It is also found in the Netherlands and France and has been introduced experimentally to Denmark and England but has not been released for general use.

The *Poland China* pig is black with a white face and feet and a white tip on the tail; the ears droop. The breed originated between 1835 and 1870 in Butler and Warren Counties, O., by a fusion of Polish pigs and "Big Chinas." It is of lard type and is found in the United States and Chile.

The *Spotted Swine*, or *Spots*, formerly known as the Spotted Poland China, developed in the United States, resembles the black Poland China except for numerous white spots over the body. It was produced in Indiana from a local spotted pig, Poland Chinas, and Gloucester Old Spots that were imported from England in 1914. It is of lard type and largely restricted to the United States.

The *Tamworth* is a golden red pig with a long snout and erect ears. Originally indigenous in Staffordshire, it is a descendant of the Old English forest pig. Tamworths are of bacon type but are used extensively for crossing. They are also found in Australia, Canada, and New Zealand.

The *Welsh* is a breed of white lop-eared pig virtually identical in appearance to the Landrace breed. Up to 1950 they were little found outside Wales but since then have been developed by a controlled and limited introduction of Landrace blood which has produced a pig similar to the Landrace and which retains its original hardiness. It is of bacon type. The Welsh pig has been exported to Africa, France, Poland, and the U.S.S.R.

The *Wessex Saddleback* is native to England and is popular in Australia. It is a black pig similar to the Essex but with a white saddle only; it remains a separate breed. This breed is of bacon type but is used mainly for crossing with white boars. The Hampshire breed can be traced to identical stock, but Wessex Saddlebacks have been introduced into the United States as a separate breed.

The *West French White* is a white lop-eared pig found only in France where it was produced by fusion of the Craon, Normandy, and Flemish breeds. It is of pork type.

The *Yorkshire* or *Large White* is a white pig with erect ears. It was produced in the 18th century by crossing the large indigenous white pig of North England with the smaller, fatter, white Chinese pig thus producing a better fleshed animal. Further intensive selection took place during the 18th century. Although primarily a bacon breed, strains are used for lightweight pork. The boar is used considerably as a sire of crossbred litters out of coloured dams. The breed is found in the majority of countries and is probably the most widely distributed breed of pig in the world.

Pig Breeding.—Commercial pig production is based to a large extent on the crossing of two established breeds, although there are notable exceptions to this rule, such as Denmark, where the whole pig industry rests on purebred Landrace lines. Crossbreeding gives improved performance in the resulting litters as a result of hybrid vigour. By mating boars of extreme commercial type with matronly sows of another breed, a compromise is secured between the meat requirements of the butcher and the good mothering quality required by the breeder. Pure breeds have been developed by the mating of similar types. Inbreeding is not normally undertaken, but line breeding to an outstanding sire is common.

Experimental work in the United States with corn (maize), whereby two inbred strains were eventually outcrossed to give an improved yield of 20%, was copied with pigs by the University of Minnesota and elsewhere from 1937. Inbred lines of Tamworth and Landrace were mated to produce the Minnesota No. 1 line. Subsequently the Minnesota No. 2 line (Canadian Yorkshire × Poland China) was produced, and the two breeds have thereafter been crossed commercially. Analogous work has been undertaken elsewhere in the United States to produce the Beltsville, Maryland, Montana, and Palouse breeds and in Canada to produce the Lacombe. Little comparable work has been undertaken in other countries.

While the pig has been known for centuries, the founding of pure breeds of swine did not take place until the 18th and 19th centuries. Early breeders kept a private record of their breeding operations. As the number of animals increased, types became fixed, well-defined characters established, and exchange of animals between breeds increased; it then became necessary to protect the purity of breeding stock as well as interests of purchasers of purebred hogs.

The registration of purebred swine varies in different countries. Separate herdbooks are published by separate breeder associations in some countries, by national pig-breeder associations recording the breeds within a country, or under the direction or control of a government agency created for that purpose.

Certain well-defined rules are generally applicable to data for the pedigree. The sire and dam of the animal to be recorded must be purebred and registered. Date of birth, number of pigs farrowed and weaned in the litter, name of the owner of the ancestors at time of mating, and identification of pigs are required before a pedigree certificate can be issued.

From a breed improvement standpoint, a pedigree is good or bad according to the individual it represents. Regardless of pedigree an animal should not be retained as a breeder unless it meets certain standards, not only of type and conformation as judged by the eye, but also of the individual's inheritance or ability to transmit desirable characters to its offspring. Thus prolific sows that farrow and raise large litters of pigs, that make rapid and economical gains in the feedlot, and that produce carcasses of suitable quality are a credit to any breed, or breeding program.

The swine industry of Denmark has led the world in record-of-performance testing for improvement of swine. Record-of-performance testing of swine was begun in the United States in 1926 and in Canada in 1928. The majority of swine associations conduct some form of record-of-performance tests for the improvement of their respective breeds. Outstanding animals that meet high standards of production merit are given special notation on the pedigree. That the program is a success is attested to by the fact that the demand by breeders for animals of tested strains has greatly exceeded the supply. (J. H. Z.; AL. J.)

CARE AND MANAGEMENT

Sanitation is essential to good health, rapid growth and development, and profitable pig production. Contrary to general opinion, the pig is a clean animal if given sanitary surroundings. Many pigs are forced to live in an unsanitary environment.

The raising of pigs does not require expensive equipment. The principal needs are: (1) good practical houses that provide protection from the elements, freedom from drafts, and proper ventilation; (2) dry bedding; and (3) prevention of dust to avoid respiratory troubles. Where natural shade is not available, artificial shade is useful to prevent overheating from the sun.

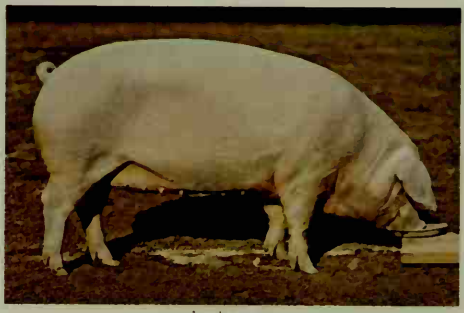
In the selection of purebred animals for the foundation breeding herd, attention needs to be given to strains that are prolific, gain rapidly, and utilize feed efficiently. Other considerations are uniformity of type and similarity of colour, markings, and conformation. Sows are desired which show quality, length of body, femininity, and a well-developed udder, having two rows of teats with at least six teats in each row, and capable of suckling large litters of pigs. The boar should possess quality, masculinity, good disposition, and ability to sire strong, vigorous pigs. A young, well-developed boar may be bred at eight months of age and mated to 20 or 30 sows during the first breeding season, whereas an aged boar may be mated to 40 to 60 sows during a season.

The period of estrus (or heat) in the sow is about three days, and mating with the boar should take place the second or third day. If not pregnant, the sow comes in heat every three weeks. The average gestation period is 114 days. Much of the success of pig raising depends on the care and management during this period. Suitable feed and ample exercise are important during pregnancy. When practicable, sows and gilts are sorted and fed in separate groups. Gilts may be bred at 8 to 8½ months of age to farrow their first litter when one year old. After that, two litters a year may be produced and the sow retained as long as her usefulness continues. The amount of feed is regulated to have the animal in good condition at farrowing time, but not too fat. Accurate breeding dates should be maintained and sows and gilts removed to a cleanly prepared individual farrowing pen three

Hampshire boar

Hampshire sow

Landrace boar



Landrace sow

Yorkshire boar

Yorkshire sow

BREEDS OF PIG

PHOTOGRAPHS: J. C. ALLEN AND SON

PIG

Berkshire boar

Berkshire sow

Chester White sow

Chester White boar

Poland China boar

Poland China sow

BREEDS OF PIG

BY COURTESY OF (CENTRE LEFT, RIGHT) THE CHESTER WHITE SWINE RECORD ASSOCIATION; PHOTOGRAPHS, (OTHERS) J. C. ALLEN AND SON

Tamworth boar

Tamworth sow

Wessex Saddleback boar

Wessex Saddleback gilt

Palouse boar

Palouse sow

BREEDS OF PIG

BY COURTESY OF (BOTTOM LEFT, RIGHT) WASHINGTON STATE UNIVERSITY PHOTOGRAPHS, (TOP LEFT, RIGHT) W. RICHARDSON; © ENCYCLOPÆDIA BRITANNICA, INC.; (CENTRE LEFT, RIGHT) JOAN PITT, © ENCYCLOPÆDIA BRITANNICA, INC.

PIG

Minnesota No. 1 gilt

Minnesota No. 1 boar

Minnesota No. 2 boar

Minnesota No. 2 gilt

Montana No. 1 boar

Montana No. 1 gilt

BREEDS OF PIG

BY COURTESY OF (TOP LEFT, RIGHT, CENTRE LEFT, RIGHT) UNIVERSITY OF MINNESOTA; PHOTOGRAPHS, (OTHERS) COFFRIN STUDIO

lays before they are due to farrow. Providing pens with guard ails helps prevent sows from crushing their young. The use of n electric pig brooder furnishes warmth and prevents chilling f young pigs. The ration of the sow needs to be reduced several lays before farrowing, then gradually increased after farrowing o as not to disturb the digestive system of the newborn pigs. Special attention should be given to prevent loss of pigs during he first two weeks of life, when most losses occur.

Newborn pigs depend on the milk of their mothers for the first hree weeks. After that they eat supplementary feeds in addi- ion. Pigs are weaned from their mothers at 6 to 10 weeks of ge. They should then be well fed and cared for during the rowing and fattening period to produce rapid and economical ains. One or a combination of several methods of feeding may e followed, namely, hand feeding, limited feeding, self-feeding, r hogging-down crops.

Nutritive Requirements.—The pig is an economical con- verter of feed into body tissue, the products of which furnish meat nd fat for human consumption (*see* PORK). Unlike other classes f livestock the pig has a small stomach and requires its food n concentrated form. Pigs grow more rapidly than any other class of farm animals in relation to their weight. Under good feeding and management, an average of 300 to 350 lb. of feed is required to produce 100 lb. of gain in growing and fattening pigs. One hundred pounds approaches the market weight throughout much of Asia; in Malaysia, for example, the usual market weight is about one picul (about 133⅓ lb.), reached at about 9–10 months.

The daily ration of the pig should be properly balanced with respect to proportions of carbohydrates, proteins, minerals, and vitamins. Energy which is needed for body maintenance and for gain is furnished primarily by carbohydrates and fat in the ration. Energy is also derived in part from protein metabolism. The ex- cess energy above maintenance requirements is stored as fat in the body. Energy requirements for maintenance vary with atmos- pheric temperature, increasing as temperature decreases below a critical point. The principal sources of carbohydrates are the grains commonly grown on the farm, namely, corn, wheat, barley, oats, sorghums, and rye.

Proteins are essential for growth of muscle, bones, and the vital organs, and for body repair. As the pig grows the demand for pro- tein decreases, while relatively larger amounts of carbohydrates are used for fat production. The proportion of protein to carbohy- drates may vary from 1 to 4 for 50-lb. pigs to 1 to 7 for pigs weigh- ing 300 lb. Although the grains contain proteins, the latter are not present in sufficient quantity or quality with respect to amino acid makeup, to promote rapid growth. High-protein feeds that possess the essential amino acids necessary to supplement the grain part of the ration are milk, tankage, fish meal, soybean meal, lin- seed meal, alfalfa meal, and similar feeds. Combinations of two or more of the protein-rich feeds improve the quality of the ration.

Mineral and vitamin requirements can be met under ordinary conditions by the proper selection of feeds without recourse to special supplements. Calcium and phosphorus are the two most important mineral elements needed for bone development. Other elements required in small amounts are iodine, zinc, magnesium, cobalt, manganese, potassium, sodium, chlorine, copper, and iron. Pasture and hay crops furnish proteins, minerals, and vitamins that help correct the deficiencies of these elements in the grain ration. The vitamins known to be needed for the health and growth of the pig are vitamins A, D, and the B group: thiamine, riboflavin, niacin, pantothenic acid, and pyridoxine. Supplement- ing swine diets with vitamin B_{12} and certain antibiotics usually increases growth rate and feed efficiency of pigs.

Water is essential to efficient use of feed. The amount of water consumed at will may increase from about 3.3 lb. daily for a 25-lb. pig to 12 lb. daily for a 200-lb. pig.

The requirements for the constituents of the ration will vary with the different functions performed, such as growth, fattening, reproduction, and lactation. For example, young pigs to 100-lb. weight require a high level of protein in the ration; pigs from 100 to 150 lb. and sows during gestation and lactation require a medium level of protein; whereas pigs weighing from 150 to 225 lb. make efficient gains on a lower level of protein intake. (J. H. Z.)

Diseases.—The most devastating disease of swine, the world over, is hog cholera (swine fever; *q.v.*). This contagious malady affects swine of all ages and breeds and is caused by a virus. Other species are not susceptible.

The virus is present in the blood and excretions even before symptoms appear and may be spread to susceptible swine from these sources either directly or indirectly by man, birds, or flies. Feeding uncooked swill, or garbage, that contains infected pork, and purchasing unvaccinated pigs from public markets are espe- cially hazardous.

Methods of prevention include the hypodermic injection of graduated quantities of live attenuated hog cholera virus with or without antiserum, killed virus vaccines without antiserum, and virulent virus with antiserum. In England, all herds in which swine fever occurs are slaughtered.

Hog cholera should not be confused with African swine fever, another virus disease, although the two appear similar. African swine fever has spread to Spain and France.

Erysipelas is a bacterial disease prevalent in Europe and the United States. The acute form appears much like swine fever; the chronic form is characterized by heart valve lesions, arthritis, un- thriftiness, and necrosis of the skin, tail, and ears. Some other species, including man, are susceptible, but are less frequently af- fected. However, in turkeys the disease may cause high mortality. For immunization, live cultures of the virulent or attenuated or- ganism, *Erysipelothrix rhusiopathiae*, are used with specific hyper- immune antiserum or killed cultures without antiserum. The serum has considerable therapeutic value, and penicillin is highly effective in treating the acute disease.

Enteritis causes considerable losses in swine. The most wide- spread and serious form is attributed to *Salmonella choleraesuis*, which commonly occurs with swine fever. Hemorrhagic dysentery, caused by *Vibrio coli*, is another form of infectious enteritis. Transmissible gastroenteritis in baby pigs, caused by a virus, spreads very rapidly and mortality is high. Additional deaths in unweaned pigs may arise from poor sanitation, improper nutrition, chilling, parasitism, and genetic weaknesses.

Tuberculosis is contracted by swine from chickens, cattle, and man. The chief loss from the disease results from condemnation of heads because of localized lesions in the lymph nodes found dur- ing meat inspection. Successful control or eradication depends chiefly upon preventing exposure.

Brucellosis, caused by *Brucella suis*, is characterized by abor- tions and localized infections, chiefly in the vertebrae, joints, and testes. The disease spreads almost exclusively from pig to pig. It may be detected by periodic blood tests. Treatment is ineffec- tive. Man develops a severe form of undulant fever from *Brucella suis*.

Influenza, virus porcine pneumonia, swine pox, icteroanemia, and atrophic rhinitis in swine over ten weeks of age, and nutritional anemia in suckling pigs also cause death losses or impaired health in swine.

The incidence of foot-and-mouth disease must be reported to the police in England and herds where outbreaks occur are slaughtered. In some European and South American countries control is by vaccination though this method is mainly confined to cattle. The disease is highly contagious (*see* FOOT-AND-MOUTH DISEASE).

Anthrax (*q.v.*) occurs in pigs occasionally. It is caused by a bacillus, and its presence is usually associated with sudden death.

Pseudorabies (Aujezky's disease, or mad itch) is found in the United States and Europe but is rare in England. Affected ani- mals go off their food and convulsive fits may be experienced. In young pigs the mortality rate can be high. Survivors evince restlessness and irritability of the skin, with scratching.

Rhinitis (atrophic rhinitis) is an inflammation of the membranes that line the nasal cavity and is due to several causes. Affected animals show sneezing and a nasal discharge. If complications develop, some deaths may occur. If the disease persists, deformity of the snout and upper jaw can result, making eating difficult. Formerly a reportable disease in England, rhinitis is mainly found in North America and Scandinavia.

Leptospirosis is caused chiefly by *Leptospira pomona*, although other species are incriminated in certain areas of the world. Pregnant sows may abort or farrow small, weak, or dead pigs. Swine other than pregnant sows usually have a mild or inapparent infection, and mortality is low. The chief source of infection is carrier animals which pass leptospirae in the urine for several months. The disease can be diagnosed by blood tests or finding the organism in the urine. A bacterin made from killed organisms successfully immunizes swine, and antibiotics are effective in treatment. The disease is transmissible to man.

Good swine husbandry emphasizes good breeding, proper nutrition, and strict sanitation, all of which help to control diseases.

(M. S. Sn.; V. L. S.; Al. J.)

Parasites.—The most serious parasites of swine are roundworms, although protozoa and mange mites may sometimes be of considerable importance.

Ascaris suum is the most injurious roundworm of swine. The adult worms are found in the small intestine, where they compete with their host for food. Even more serious are the effects caused by the migration of the larvae. The females lay eggs, which pass out of the body. Infective larvae develop inside the eggs on the ground. These embryonated eggs are very resistant to the effects of heat, cold, sunlight, and chemicals, and may remain alive in the soil for more than four years. When they are swallowed by a pig they hatch in the intestine, and the larvae migrate to the liver and lungs, where they undergo some growth. They are then coughed up and swallowed, and finally become adults in the small intestine. The migrations of the larvae damage the liver and lungs, causing pneumonia, difficult breathing, stunting, and even death.

Control consists in following a system of sanitation known in the U.S. as the McLean County system, first extensively tested in 1920 in McLean County, Ill. Briefly, the system consists in worming and washing the sows before farrowing and placing them in thoroughly cleaned and disinfected farrowing quarters. After farrowing, the sows and pigs are kept in the houses until the pigs are from two to four weeks old, and are then hauled—not driven—to a clean pasture, where adequate shelter and feed are provided. Even better sanitation can be obtained if the pigs are raised on concrete throughout their lives. With due attention to the details of the system, a high percentage of the pigs which are farrowed can be raised, and the pigs can be marketed four to eight weeks earlier than if kept under average conditions. In addition, the system saves feed and controls many other parasites and infectious diseases.

Piperazine is the drug of choice for removing the adult worms. A number of other compounds have also been used, but they are either less satisfactory or more toxic than piperazine. In treating pigs, this compound is ordinarily mixed with the feed.

Lungworms are also injurious. They live in the bronchial tubes, where they cause pneumonia and unthriftiness. In addition, they may transmit the virus of swine influenza and probably also that of hog cholera. Lungworms require earthworms as intermediate hosts before their larvae can develop to the infective stage. Pigs become infected by eating infected earthworms.

Another roundworm is *Trichinella spiralis*. The tiny adults are found in the intestine, while the larvae occur in the muscles, where they cause the painful and sometimes fatal disease, trichinosis. This disease is serious in man, but swine seldom show symptoms. Swine become infected largely through eating pork trimmings in uncooked garbage or slaughterhouse offal, or by eating dead pigs, rats, or other animals which harbour the encysted larvae. Man ordinarily becomes infected by eating uncooked or improperly cooked pork. Human infection can be prevented by cooking pork thoroughly. Infection of swine can be largely prevented by cooking all garbage fed to them. (*See* also Trichinosis.)

Other injurious roundworms of swine include whipworms, which attach themselves to the wall of the caecum, and kidney worms, which injure the liver, kidneys, and other organs.

The large thorny-headed worm, *Macracanthorhynchus hirudinaceus*, attaches itself to the wall of the small intestine, causing a nodule to form. Its intermediate host is the white grub, which is the larval stage of the May beetle; pigs become infected by eating infected grubs or beetles.

Swine normally are not infected with adult tapeworms. They are, however, intermediate hosts of the pork tapeworm of man, *Taenia solium*. The larva of this parasite occurs in the heart and muscles of swine, and man becomes infected with the adult worm by eating inadequately cooked pork.

Flukes are relatively unimportant but may be encountered in some parts of the world, especially the Orient. Three of these, the large intestinal fluke, *Fasciolopsis buski;* the lung fluke, *Paragonimus westermani;* and the blood fluke, *Schistosoma japonicum*, also occur in man, and swine may spread them unless proper sanitary precautions are observed. Lice can be eradicated effectively by dipping or spraying with DDT, methoxychlor, Delnav or lindane; by spraying with Co-Ral, malathion, toxaphene or ronnel (Korlan); or by dusting with DDT or lindane. Mange mites can be eradicated effectively by dipping or spraying with lindane. Certain precautions should be used with almost all these insecticides.

Swine have many intestinal protozoa. Some are harmless, but others cause disease. Coccidiosis is a diarrheal disease caused by *Eimeria debliecki* and related protozoa. They invade and destroy the epithelial cells of the intestine. The ciliate, *Balantidium coli*, is found in about two-thirds of all swine and also occurs rarely in man. It is usually harmless, but may occasionally invade intestinal lesions started by other microorganisms. *See* also references under "Pig" in the Index. (N. D. L.)

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(M. S. Sn.; V. L. S.)

PIGEON, which brings to mind the awkward, strutting, wheeling birds that live in the midst of cities, is the name applied generally to all birds of the worldwide family Columbidae, found throughout the tropical and temperate zones. There are about 290 species, including the doves, which cannot be distinguished from pigeons either by size or by scientific classification. They are gentle, plump, small-billed birds with a skin saddle (cere) between bill and forehead; their feathers are easily pulled out. All pigeons strut about with a characteristic bobbing of the head. Because of their long wings and powerful flight muscles, they are strong, swift fliers. Pigeons are monogamous; *i.e.*, they mate for life and the survivor accepts a new mate slowly. The female lays two glossy white eggs in a flimsy nest that barely holds them. The female generally incubates by night, the male by day. The incubation period is 14 to 19 days, but the young are cared for in the nest for another 12 to 18 days. For about a week after hatching,

the young are fed by pigeon "milk," a secretion rich in protein and fat, and proliferated from the glandular walls of the crop in both sexes.

Although the well-known street pigeon (*see* below) is often drab, the majority of pigeon species are tropical and highly colourful. These belong to the fruit pigeon subfamily, Treroninae. The green fruit pigeons (*Treron*) of Africa, Asia, and Malaysia are pale green with black flight feathers. The fruit doves (*Ptilinopus*) of the South Pacific islands are more colourful; the superb fruit pigeon (*T. superbus*) is green with pink and purple on the head and neck. Fruit pigeons and doves are flocking in habit, continually moving about in search of figs and berries. The very large nutmeg pigeons (*Ducula* species) are arboreal and solitary. The green imperial pigeon (*D. aenea*) is lavender below, metallic coppery-green above, with dark chestnut under the tail and with red feet.

WILLIS PETERSON

DOMESTIC PIGEON OR ROCK DOVE (COLUMBA LIVIA)

The largest pigeons (chicken-sized) are the crowned pigeons (*Goura* species, subfamily Gourinae) of New Guinea's sago swamps; they have maroon body plumage and a large, lacy head crest of blue-gray.

The doves and pigeons of the subfamily Columbinae are seed and fruit eaters. They are found in tropic, temperate, and even in boreal regions. To this group belong the street pigeons, composed of a bewildering array of cross breeds of domesticated strains, all of them ultimately traceable to the wild rock dove (*Columba livia*). The rock dove is typically dull in colour—gray and white rump and two large black wing bars; this Eurasian species nests above 5,000 ft. in Asia. It has been domesticated and selectively bred since 3000 B.C. with production of numerous colour variants and about 200 named strains—show pigeons, racing pigeons, and large food types. Pouters have a large, inflatable gullet; carriers, a long bill; runts, a massive bill and body; barbs, a short bill. Fantails may have 42 tail feathers; owls have diverging throat feathers; frillbacks, the feathers reversed; jacobins, hoodlike neck feathers. Tumblers tumble backward in flight.

The snow pigeon (*C. leuconota*) breeds at 15,000 ft. in rock crevices on Mt. Everest. Ringdoves or turtledoves (*Streptopelia*), the size of rock doves or smaller, range throughout the Old World to Australia; they are gray and buff with a checkered collar. The name turtledove is also used for the North American mourning dove (*Zenaidura macroura*), with violet and pink on the sides of the neck and a long, pointed tail. The Inca dove (*Scardafella inca*), gray with a strong scaly pattern, is found in the American tropics with the white-fronted dove (*Leptotila verrauxi*), which ranges north to Texas. The bleeding-heart pigeon (*Gallicolumba luzonica*) of the Philippines has a splash of red in the middle of the white breast. The European stock dove (*Columba oenas*) breeds in holes in the trunks (stocks) of trees. The wood pigeon (*C. palumbus*), up to 16 in. long, is the largest European species.

The passenger pigeon (*Ectopistes migratorius*) of North America, extinct since 1914, with the passing of the last survivor in the Cincinnati (O.) Zoo, was colonial and formerly numbered billions. It took only a few years for market hunters to reduce the population to the point at which recovery was impossible. The demise of the passenger pigeon is a classic case of the destruction of a species by man.

See also references under "Pigeon" in the Index.

See W. M. Levi, *The Pigeon* (1957); Charles R. Darwin, *The Variation of Animals and Plants Under Domestication*, 2 vol. (1868).

(W. J. Be.; X.)

PIGEON FLYING. Of the many varieties of pigeons man has developed for utility, sport and pleasure, the homing pigeon is a specialized variety developed through selective crossbreeding for maximum distance and speed in directed flight. Distinct strains of these pigeons are usually named after fanciers who have succeeded in selecting desirable traits of performance and appearance. Pigeon fanciers usually separate their birds into two classes, one for breeding and the other for racing, though the latter are permitted to breed within limits.

History.—The earliest record of the domestication of pigeons is from the fifth Egyptian dynasty (about 3000 B.C.). The sultan of Baghdad established a pigeon post system in 1150. Genghis Khan used such a system as his conquests spread. Pigeons were widely used for messenger service during the French Revolution of 1848, and the messages found popular acceptance in both French and Belgian newspapers. In 1849 pigeons were used to carry messages during interruptions in telegraphic service between Berlin and Brussels.

Pigeons were used as emergency message carriers in war well into the 20th century. The record flight for a United States army signal corps pigeon was a flight of 2,300 mi.; flights of 1,000 mi. are routine.

Belgium is credited as the home of racing pigeons as a sport. In 1818 the first long-distance race of over 100 mi. was held, while in 1820 a race took place between Paris and Liège, and in 1823 from London to Belgium. The sport gained prominence in the latter part of the 19th century in Great Britain, the United States and France. Nowhere, however, did it match the popularity enjoyed in Belgium where nearly every village had a Societe Columbophile (pigeon club). The annual Belgian Concours National, a race of about 500 mi. from Toulouse to Brussels, was inaugurated in 1881; during the same year the first regular races in Great Britain, from Exeter, Plymouth and Penzance to London, took place.

Training and Feeding.—All homing pigeons except those reserved for breeding purposes may undergo training continuously from the time they are 28 days of age. This training consists of teaching them to enter the loft through the trap, exercising around the loft and returning to the loft when given liberation at points distant from the loft. The pigeon's desire to return to the loft is a phenomenon not thoroughly understood.

The speed and reliability of the bird's return are reflections of its breeding strain, physical condition, training and treatment. Fog, extremes of heat and cold, rain and adverse winds, or conditions that reduce visibility or oppose the flight of the pigeon, decrease its efficiency. The strength of the bird is improved both by exercise flights within the loft and by training flights that are distant from the loft.

A healthy bird requires proper diet, clean drinking water, adequate ventilation and sanitary loft conditions. The diet includes leguminous seeds, cereal grains, green foods and grit. The seeds and grains are fed in a feed mixture.

Racing.—At the start of a race the competing birds are banded with a rubber countermark; they are then liberated together by a starter who records the time of release. The birds ascend rapidly, become oriented and head directly toward their loft usually following the line of least resistance.

As the birds enter their home lofts, the countermark is removed from the leg and placed in a pigeon timer that indicates the time of arrival. The distance of the pigeon's flight is divided by the time consumed to determine which pigeon has made the fastest speed. A bird is not considered to have arrived "home" until actually through the trap of its loft.

The training of pigeons for use as a means of communication is similar to training for racing. Messages are attached to the pigeon's leg or back by means of specially designed capsules.

See Carl A. Naether, *Book of the Racing Pigeon* (1950); A. N. Hutton, *Pigeon Racing* (1958). (H. L. McN.)

PIGEON HAWK: *see* Merlin.

PIGEONITE: *see* Pyroxene.

PIG IRON. Crude cast iron, run from the blast furnace directly into molds. The molds originally were of sand formed in a way which suggested a nursing litter of pigs. *See* Iron and Steel Industry; Blast Furnace.

STRUCTURAL COLOURS

Tyndall blues in skin about head and neck of turkey (top left) and in the feathers of a blue jay (bottom) is caused by striations and ridges scattering the reflected light. Blue colour in the wing of *Morpho* butterfly (top right) is caused by iridescent interference

FROM PHOTO RESEARCHERS, INC. (TOP LEFT) RUSS KINNE; (TOP RIGHT) BRADLEY SMITH; (BOTTOM) STEPHEN COLLINS

PIGMENT, ANIMAL. The vast realm of colour in living forms has, from man's earliest days, incited his wonder and active curiosity. Aside from the universal aesthetic appeal of colour for mankind through the ages, pigmentation holds special attractions for all biologists. Moreover, chromatology (the study of colours) finds applications in medicine, agricultural science, numerous arts and industries and certain military operations.

The physician is often aided in his diagnosis and treatment of diseases by following the visible signs of various metabolic processes as reflected by the colours of tissues and body fluids. The grower has long recognized seasons of ripening or reproductive maturity by viewing the changes in kind or intensity of pigmentation in his products. And the geneticist, pursuing colour expression in successive generations, is in reality studying heritable biochemical operations within the organism. The comparative metabolism of coloured molecules is indeed one of the important realms of investigation in the wide field of biochemistry.

Animal coloration is achieved in two entirely different ways: (1) chemically, by natural pigments (biochromes), coloured molecules which reflect and/or transmit visible light; and (2) physically, by colourless architectural structures (schemochromes), submicroscopic ridges, striations, facets and layers which break up light rays into their component colours. Pigment colours are not substantially changed by physical methods such as grinding or crushing; structural colours, however, are altered and sometimes completely destroyed by such operations. If, for example, a blue feather of a jay is crushed, it appears black: the blue is a structural blue, resulting from the scattering of ordinary light by the delicate organization of a colourless horny subsurface layer; black pigment that lies beneath the scattering layer shows through when this layer is disrupted.

It will be well to consider briefly the schemochromic sources of coloration before discussing the biochromic or molecular origins of true pigmentation. While biochromy, being of molecular foundation, may find conspicuous expression quite independently of the presence of any special minute, optically effective structural units, the reverse is not quite true, for the schemochromic colours are greatly reinforced and intensified by the presence of pigment, whether in underlying or in superimposed strata or occurring within the colour-producing structural layers.

STRUCTURAL COLOURS (SCHEMOCHROMES)

The physical principles of total reflection, interference, scattering and to some extent, diffraction, all familiar in the inanimate world, are encountered also among tissues and tissue products of animals.

Reflection.—Total reflection of light, imparting whiteness to animal structures, often arises from the separation of finely divided structural materials by air spaces just as whiteness is conferred upon snow. Examples of this are seen in white feathers, fur and hair, and in the wings of certain butterflies. Secretions or deposits in animal tissues may also contribute to the whiteness of total scattered reflection, examples being colloidally dispersed fatty or lipoid materials, calcium carbonate in the skeletons of numerous mollusks, crustaceans, corals, echinoderms and protozoans, silica in sponges, proteinaceous materials in various serous

membranes, deposits of white pterins in the wings of pierid and other butterflies and silvery aggregates of crystalline guanine or other purine materials (*see* below) in the covering of numerous invertebrates and in scales of fishes.

Interference.—Disintegration of white light into its spectral components occurs in animal structures chiefly through interference: the incident light penetrates and is reflected back through successive thin-layered films to give striking iridescence, even in diffuse light. Sir Isaac Newton discussed the principle as applying to soap bubbles and other thin films in his book *Opticks* (1704). The elder and the younger lords Rayleigh between 1919 and 1923, applied Newton's principle to the manifestation of iridescence by various structures of numerous beetles and other animals.

Iridescent interference colours are common in certain animal structures, including: the wing scales of *Morpho* and other butterflies; the brilliant rainbow hues observed in the feathers of hummingbirds, peacocks, pheasants, etc.; the wing covers of many beetles; the outer skin of reptiles; and nacreous surfaces of pearls and molluscan shells. The lustre of human or other mammalian hair and its iridescent appearance in direct sunlight is due to the same phenomenon, the light being reflected in its disintegrated components by minute transparent scales which surround each individual hair. Pure prismatic refraction of light in animals is probably rare and limited to cases wherein direct beams of light encounter certain microcrystalline deposits. Diffraction by natural gratings or regular fine parallel striations is not uncommon among certain insects, and is conspicuous only when a direct beam of light strikes such structures at an angle. Studies with the electron microscope have confirmed the presence of such natural diffraction gratings in the wing coverings (elytra) of certain iridescent beetles.

Scattering and Diffraction.—Also common in animals is the display of blue colours, arising less frequently from blue pigment than from the scattering of reflected light by finely dispersed colloidal systems above dark layers of melanin deposits. Examples of these structural, so-called Tyndall blues (after John Tyndall, the British physicist who discussed the general phenomenon in 1869) are very numerous. Blue eyes, in which the cloudy tissue of the iris overlies the dark membrane or uvea, may be simulated by placing disks of agar gel or dried collodion film upon a black surface. The blue skin about the head and neck of turkeys, cassowaries and other such birds, or upon the face, buttocks and genital parts of certain primates derives its colour from the scattering of the blue to violet fractions of light by colloidally dispersed materials within the tissue, overlying an absorbing layer of melanin in the dermis. The blues of feathers and of many fishes and reptiles could be added to the many other examples of structural blue.

Two types of structural coloration may act in combination; *e.g.*, diffraction and interference. In other instances, structural and pigmental layers are superimposed. Most of the greens found in the skins of fishes, amphibians and reptiles do not arise from the presence of a green pigment (although there are exceptions to this), but are the result of the emergence of scattered blue light through an overlying layer of yellow pigment. Similarly, the purple hues seen between red and blue areas in the naked skin about the neck and face of cassowaries or turkeys, or in that over the buttocks or genital regions of certain baboons and other primates, are derived from the complementary colour effect of blue-scattering and red hemoglobin.

PIGMENTS (BIOCHROMES)

Chemistry and Physiology.—The visible range of light is selectively affected by reflection from or transmission through particles whose size or whose vibrational frequencies lie between 3,000 and 7,000 Å (angstrom units; 1 Å = 10^{-8} or $\frac{1}{100,000,000}$ cm.). Those physical structures in the biological world which may fractionate white light have already been mentioned: namely, very thin, finely spaced laminations, ridges or striations, all yielding spectral effects; and minute colloidally dispersed particles which scatter incident light, reflecting only the most refrangible rays; that is, blue and violet. The colour of a chemical compound depends upon the selective absorption of light within definite wave lengths, the unabsorbed rays being reflected or transmitted to the eye. This capacity to absorb visible light is due, in turn, to varying kinds and degrees of chemical unsaturation in colour-carrying groups (chromophores) within the molecule. These areas of special molecular activity arise from reduction in the relative speed or frequency of motion of one or more pairs of the compound's many rapidly vibrating electrons. Indeed, sufficient modification in the speed of electronic vibration imparts to the entire molecule a degree of special vibratory motion or chemical resonance. This phenomenon, in the modern view, is the basis of colour manifestation.

If the molecular resonance involves short rapid waves, the shorter visible light waves will be absorbed (*i.e.*, those of the violet and the blue spectral regions) and the compound will therefore appear yellow. Red substances, having slightly longer resonance values, similarly absorb light in the blue and green regions. Blue or green compounds result from cancellation of light in the red or orange realm. Black substances absorb all light equally and completely.

The colours of most chemical compounds are not of spectral purity, but include all of the visible light excepting the absorbed fraction; the commonly observed colour of a substance depends upon the dominant wave length or that of maximum transmission.

There is good ground for the view that colour and chemical reactivity, and hence the potential metabolic value of a pigment to an organism, are parallel expressions of the same underlying molecular property of unsaturation. This is a reason for the careful consideration of the physicochemical attributes of biochromes or pigments and for continued researches regarding their metabolic position in the living organism.

The more important pigments of animals may be arbitrarily grouped into classes whose molecules are without combined nitrogen and others which contain this element.

Of the nonnitrogenous pigments, by far the most important, conspicuous and widely distributed, both in animals and plants, are the carotenoids or polyenes. Chromolipoids, naphthoquinones, anthraquinones and flavones represent other nitrogen-free pigments which occur in animals, but these are limited in distribution, and little is known of their physiological attributes.

In the nitrogenous group are several pigments of most diverse chemical nature and metabolic position. The tetrapyrrolic pigments include both the porphyrin class, present in the blood of many animals, and the bile pigments, occurring in many secretions and excretory products; the dark melanins occur in skin, hair and other parts and represent metabolic end products. Several purines, while usually white or silvery in appearance, are included as pigments because they contribute to the total colour of numerous lower animals; similarly the pterins, which are derivatives of pyrimidine, are frequently white, but may often be yellow or other colours; the lyochromes or flavins, detectable in the tissues of all or nearly all living organisms, are identified with certain important biocatalysts; finally the indigoid derivatives, which are somewhat limited in distribution, are, like the melanins, purines and pterins, end products of metabolism.

In the following treatment are outlined the chemical configuration, colour, source and metabolic features (insofar as the latter are known) of some representative animal pigments.

Carotenoids.—This group of red, orange or yellow pigments, whose number of known compounds is constantly increasing, is of almost universal distribution throughout the living world. Carotenoids are insoluble in water, but may be readily dissolved in alcohol, ether, chloroform and various other organic fat solvents. They are crystalline and in solution exhibit usually two or three absorption bands (but in some cases only one), characteristically in the violet to blue, sometimes extending into the green region of the visible spectrum. They are readily bleached by light and by exposure to atmospheric oxygen, and are unstable also in the presence of mineral acids, their chloroform solutions giving blue coloration upon treatment with concentrated sulfuric acid.

These pigments occur in plant organisms ranging from bacteria, fungi and algae, to the most highly evolved flowering forms. Ani-

mals from Protozoa to the highest mammals, including man, contain carotenoids, although the tissues and blood sera of a number of mammals are almost or entirely devoid of these pigments. The livers of some of these species often yield carotenoids, and it is known that the animals depend upon a supply of β-carotene (*see* fig. 1) or its metabolic derivative, vitamin A. Carotenoids are

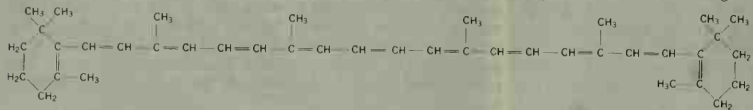


FIG. 1.—β-CAROTENE

relatively more concentrated in ovaries or eggs, some testes, liver (or liverlike analogue in invertebrates), skin, eyes and milk. Carotenoid pigmentation may be seen in the legs, body fat and eggs of domestic poultry; in similarly coloured wing covers of many insects; and in the milk fat of cattle. In some animals a high degree of specificity exists for the absorption of either the hydrocarbon (carotene) class or the oxygenated (alcoholic or xanthophyllic) type of carotenoid. The horse, for example, absorbs through the intestine only carotenes, from green food containing an ample supply of both kinds of carotenoid. The hen, on the other hand, stores only members of the xanthophyll class; many fishes and marine invertebrates likewise store only xanthophyllic carotenoids, rejecting in the feces or otherwise totally disposing of the carotenes. Other animals, including the frog and man, assimilate and store both classes in depot fat.

Striking displays of carotenoids are found in the skins of many fishes, amphibians and marine invertebrates including sea stars and brittle stars, mollusks, sea squirts, crustaceans, anemones and corals and many marine worms. The blue, green, gray, chocolate, violet and near-black pigments of certain crustaceans, naked mollusks and sea stars are in many instances due to carotenoids in chemical conjugation with protein. Denaturation of the protein by immersion of the specimen in boiling water or in alcohol frees the carotenoid involved and unmasks its colour; hence the familiar red colour of boiled lobsters. Marine animals commonly derive their rich supplies of carotenoids directly or indirectly from the countless microscopic plants or larger seaweeds. Even carnivorous fishes and flesh- or mud-eating invertebrates from the dark depths frequently exhibit rich pigmentation, derived from supplies of carotenoids long since generated in lighted waters above them.

A yellow condition of the skin known as xanthosis, carotenemia or artificial jaundice, may follow excessive eating of carotenoid-rich foods such as carrots or oranges. The condition, less common in adults than in children, is unaccompanied by pathological symptoms and disappears when excessive carotenoids are withheld from the diet. Hens and female fish mobilize body carotenoids to their eggs during laying (or spawning) season, with an evident loss of the yellow pigment from the skin. Males, however, may continue to exhibit the pigmentation. Derivatives of yellow carotenoids are responsible for the striking red colours observed in the exposed skin covering the legs and toes of the American flamingo (*Phoenicopterus ruber*), the leg joint of the Chilean species (*P. chilensis*) as well as for the pink colours in the plumage of flamingos, roseate spoonbills (*Ajaia ajaja*) and scarlet ibises (*Guara rubra*). Captive animals of such species gradually lose their pigmentation, both from the skin, which fades, and through the seasonal feather molt, unless a generous supply of carotenoid material is included in the diet.

Naphthoquinones.—These compounds, occurring in many plants, are yellow, orange, red and purple in colour. They are soluble in various organic solvents, and have found considerable use as dyes for fabrics. Their occurrence among animals was long believed to be limited to the sea urchins and sand dollars (echinoids), whose spines, shell and thin skin are often coloured red, purple and, in some instances, green by echinochromes. (*See* fig. 2.) Some pigments of this class occur also in certain red crinoids or sea lilies. The skull, teeth and other skeletal parts of the sea otter (*Enhydra lutris*) assume a pink to purple coloration as a consequence of the animals' having consumed, over some periods of time, large numbers of sea urchins in their natural habitat. The echinochrome recoverable from the otter's skeleton is chemically similar to the compound obtained from its prey.

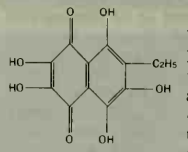


FIG. 2.—ECHINOCHROME

Echinochromes, like quinones generally, are mildly oxidizing and lose their colour when treated with chemical reducing agents. They assume different colours also according to the acidity or alkalinity of their surroundings. The purple colour of sea urchins is consistent with the faintly alkaline condition of the tissues and calcareous shell. The antihemorrhagic factor, vitamin K, is a naphthoquinone of yellow colour. Echinochrome is believed by some investigators to act as a respiratory stimulant for sea urchin eggs, to activate the spermatozoa of certain species of echinoids and to attract the sperm to the eggs. Studies of crystalline melting point, absorption spectra and other properties confirm the existence of a number of chemically different echinochrome compounds. The diverse coloration of various structures of some echinoid species is attributable to the presence of mixtures of several different echinochromes in varying proportions.

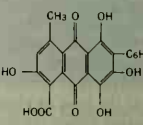


FIG. 3.—CARMINIC ACID

Anthraquinones.—A large number of brilliantly coloured compounds which have found wide application as dyes and chemical indicators of acidity or alkalinity are included in this group. Like the naphthoquinones, with which they share a common chromophoric structure, they may be chemically reduced by certain substances.

Cochineal (*q.v.*) is the potassium salt of carminic acid, a red pigment occurring within cells of the fat body of the female cochineal insect, a scale insect that lives upon certain cacti in Mexico and Central and South America. (*See* fig. 3.) Other species of scale insect store the same or a closely related pigment.

The dye is not confined exclusively to the fat body but is present also in the eggs and in cells of the larvae. It may constitute a considerable proportion of the weight of the adult female insect but is present in lesser amounts in the males.

Carminic acid, chemically extracted from the powdered insect material, imparts a permanent red colour to mordanted wool or silk. Cochineal, largely replaced by aniline dyes, is still applied, however, to the dyeing of certain fabrics, inks and confections.

(LEFT) CY LATOUR; (RIGHT) WILLIS PETERSON

BIOCHROMIC COLORATION

The naphthoquinone compound echinochrome is manifested in the purple colour of sea urchins, left. Carotenoid pigmentation is revealed in the red plumage and orange-yellow leg skin of flamingos

Kermesic acid, a red dye popular in ancient Greece and Rome, is extracted from the female kermes scale insect (*Lecanium ilicis*), which thrives upon certain kinds of oak found in Spain, Portugal and Morocco. Yellow-red in water, violet-red in acidic solutions, kermesic acid is employed as a dye, as is carminic acid to which it is chemically allied.

Laccaic acid is isolated from lac dye or lac-lac, the solid exudation or resinous secretion covering the female bodies of certain lac insects living on various plants of southeast Asia (*see* LAC).

While these conspicuous anthraquinones are in all probability derived by the insects from the plants upon which they feed, no information is yet available as to the manner in which the compounds are metabolized, or concerning their possible physiological significance. Anthraquinone pigments have been discovered in red crinoids of the genus *Comatula*, notably *C. pectinata*, thus recalling the assimilation of certain related naphthoquinones by other sea lilies (*see* above).

Flavones.—These compounds occur in a wide variety of plants and in a few insects feeding upon such plants. They impart yellow colours to flowers. The chemical properties of a yellow biochrome isolated from the wings of the butterfly *Melangaria galatea*, correspond closely with those of the plant pigment quercitin. (*See* fig. 4.)

Flavonelike pigments have been reported in the hypoderm of some strains of the larval silk moth (*Bombyx mori*) and in the cocoons of the Verdi strain. Early studies revealed similar pigments in the hypoderm of a number of true sucking bugs, including not only those parasitizing plants, such as the box elder bug (*Leptocoris trivittatus*) and the small milkweed bug (*Lygaeus kalmii*), but also the Philippine assassin bug (*Eulyes illustris*) which sucks the blood of other insects.

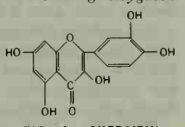


FIG. 4.—QUERCITIN

While most of the relatively few animals storing flavones derive the pigment directly from the plant hosts, the carnivorous forms, such as the assassin bug, must obtain their flavones from preying upon herbivorous or perhaps omnivorous species.

The chemically related anthocyanins, the red, violet and blue compounds often seen in blossoms, fruit and leaves of plants, are occasionally encountered in larval and adults of flies and true bugs. None of these classes of pigments has been shown to fulfill a particular physiological function in these animals, though they are believed to be involved in certain biochemical oxidations in the plants which synthesize them.

Tetrapyrroles.—*Porphyrin Compounds.*—Porphin is the parent compound of the class of biologically important nitrogenous, water-soluble pigments called porphyrins. (*See* fig. 5.) They are represented in the green photosynthetic chlorophylls of plants and in animal hemoglobins (*see* BLOOD: *Blood Pigments*).

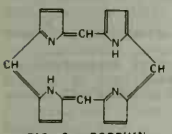


FIG. 5.—PORPHIN

Hemoglobins are present in the red blood cells of mammals, birds, reptiles, amphibians and fishes and in the circulatory fluids of many invertebrates, notably annelid worms and some arthropods, echinoderms and mollusks. These compounds have the unique capacity to combine with atmospheric oxygen in lungs, gills or other respiratory surfaces of the body, and to release it to the tissues. Hemoglobins are responsible for the pink to red colours observed in combs and wattles of birds and in the skin of man and other primates; particularly prominently coloured are portions of the face, buttocks and genital regions of baboons. Hemoglobins are conspicuous also in the blood and muscles of many polychaete worms; they impart red or pink colours to the mouth musculature operating the radula or filelike rasping tongue of many marine snails, also to the mantle, foot, adductor muscle, brain and gills of at least one bivalve—the common edible Pismo clam (*Tivela stultorum*).

The sea cucumbers *Cucumaria miniata* and *Molpadia intermedia* were found by Frederick Crescitelli in 1945 to carry hemoglobin in their red blood cells. H. M. Fox and his associates discussed,

EDWARD VAN BAERLE, © ENCYCLOPÆDIA BRITANNICA

COLORATION DUE TO TETRAPYRROLES

Hartlaub's touraco owes the red colour in its wing feathers to turacin, a water-soluble copper salt of a uroporphyrin; the greenish feathers contain an oxidized derivative of turacin

in the 1940s and after, the presence of hemoglobins in species of *Daphnia* and other freshwater crustaceans; in certain aquatic insects, notably the midge *Chironomus riparius;* in the pond snail *Planorbis corneus;* and in the echiurid worm *Thalassema neptuni.* Fox emphasized the variability of hemoglobin content in certain *Daphnia* species, depending partly upon the aeration of the habitat, *i.e.*, fading somewhat in aerated waters, but increasing conspicuously in redness in oxygen-poor waters. This ability to elaborate fresh hemoglobin under conditions of unfavourable oxygen supply suggests an important physiological adaptation toward survival. Similar conditions apply to the brine shrimp (*Artemia salina*).

Some parasitic animals seem to derive their supply of the blood pigment from their hosts. This applies to certain copepods that parasitize the gills of fishes and to nematode worms that infest swine and horses. Other examples are the larva of the botfly *Gastrophylus*, parasitic in the stomach of the horse, and the blood-sucking bug *Rhodnius prolixus.*

A singularly interesting discovery in the 1940s was that hemoglobin is present in the bacteria- (*Rhizobium*) harbouring root nodules of peas, beans and other leguminous plants. It is believed that hemoglobin may, in this extraordinary instance, serve as a catalyst for the chemical fixation of atmospheric nitrogen, long known to occur within the root nodules. (*See* also BACTERIOLOGY.)

Other pigments chemically allied to the heme compounds are: cytochrome, the red oxidation enzyme which occurs in minute concentrations in nearly all cells; catalase, an enzyme of similar distribution which accelerates the breakdown of hydrogen peroxide; pinnaglobin, a brown compound which serves as a respiratory aid in the mollusk *Pinna squamosa;* chlorocruorin, a green pigment that plays a similar role in the blood of tube-building annelid worms; helicorubin, a red compound encountered in the liver and gut of some snails; and actiniohematin, responsible for some of the beautiful red colours of sea anemones. The physiological functions, if any, of the last two pigments have not been clarified.

Many invertebrates display porphyrin pigments, some showing fluorescence, in their skins or shells. The worm *Thalassema lankesteri*, like its relative *Bonellia*, possesses a bluish-green pigment in its skin and mucus. In acetone solution, the pigment is green and exhibits fluorescence in ultraviolet light; it resembles bonellin in chemical properties and in its absorption spectrum.

Like *Rhodnius*, certain parasitic worms presumably derive their characteristic porphyrin pigments from the heme of their vertebrate hosts. *Tetrathrydium*, a cestode parasite of the hedgehog; *Eustrongylus*, a red nematode in the dog; and *Taenia solium*, infesting the muscles of the pig, are believed to store porphyrin derivatives.

Uroporphyrin and conchoporphyrin have been recovered from the shells of many mollusks, and coloured oyster-pearls yield traces of free- and metalloporphyrins. Higher proportions of metallo-

PHOTOGRAPHED ESPECIALLY FOR ENCYCLOPÆDIA BRITANNICA BY JAMES LARSEN

BILICHROME COLORATION

Biliverdin and allied pigments in the dark-green shell of an emu egg

porphyrins, apparently involving lead or zinc, in ratio to metal-free porphyrins, seem to apply to green pearls, whereas pink pearls have been found to possess both less total porphyrin and lesser proportions combined with metallic elements.

Various porphyrins occur in secretory and excretory products of animals, and some kinds, prominently so-called phorbides derived from plant chlorophylls, have been extracted from ancient natural deposits such as coal, petroleum and muds from long-buried strata of the ocean floor. Oöporphyrin is responsible for the red flecks upon the eggshells of plovers and other birds. The remarkable African touraco (*q.v.*) secretes a copper salt of uroporphyrin III into its quill feathers. This red pigment (turacin) is readily leached from the feathers by water containing even traces of alkali, giving a magenta red solution. Neutralization or mild acidification precipitates the pigment. The green plumes of the same bird owe their colour to the presence of turacoverdin, an oxidized derivative of turacin. There is some ground for the belief that in various lower animals certain porphyrins may be involved in activating pituitary hormones, including those concerned with the period of sexual heat.

Bilins.—Among the metabolic breakdown products of heme or allied pigments is a series of yellow, green, red or brown nonmetallic tetrapyrroles typified by the simplest member, a colourless synthetic called bilane (*see* fig. 6). Small quantities of the red compound bilirubin ($C_{33}H_{36}O_6N_4$), its green oxidation product biliverdin ($C_{33}H_{34}O_6N_4$) and various other chemically homologous compounds occur in normal tissues and may be conspicuous in excretory and secretory materials under some circumstances.

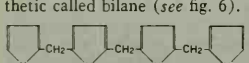


FIG. 6.—BILANE

The bile pigments, though first identified in mammals, are by no means confined to them. Various members of the bilichrome series are encountered in invertebrates and among lower vertebrates.

Pterobilin is a blue pigment observed in the wings of many pierid butterflies and other insects, and their larvae exhibit or excrete allied compounds. Certain leeches nourished by the blood of vertebrates, contain blue-green, red or brown bile pigments in their blood, probably as a result of the breakdown of ingested hemoglobin. A violet bilichrome, haliotiviolin, has been recovered from the shell of the abalone *Haliotis cracherodii*. Two related bilichromes, aplysioviolin and aplysiorhodin, occur in the purple ink of the sea slug *Aplysia punctata*. And the blue coral *Heliopora caerulea* yields a blue pigment, helioporobilin.

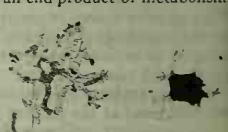
Many fishes, notably among the needlefishes and sculpins (Cottidae), bear strikingly blue-green skeletons. The green pigment in the bones and scales of the needlefish *Belone belone* is closely related to or identical with biliverdin. The California needlefish (*Strongylura exilis*) likewise owes the blue-green colour of its skeleton to a very similar bile pigment and, among the mackerels and tunas (Scombridae), commercial catches of the skipjack *Katsuwonus pelamis* yield rare individuals whose endoskeletons, particularly the skull and vertebrae, are green or blue-green, because of the presence of an insoluble salt of a pigment closely resembling biliverdin in its chemical and spectral properties. Contrary to the impressions of some commercial dealers, the green colours persistent in the bones of some species do not reflect the presence of copper or another poisonous substance.

Oöcyan, a pigment responsible for the blue or blue-green colours in the eggshells of gulls and various other wild birds, is regarded by R. Lemberg to be biliverdin. The dark green pigment of the emu egg has been proved to involve biliverdin, accompanied by minor amounts of bilirubin.

A green bilichrome once called uteroverdin, originating outside of the liver and found in hemorrhagic placental areas in dogs, is also biliverdin. The conspicuous yellow colour of horses' blood plasma arises in part from relatively high concentrations of bilirubin, which pertain after the animal fasts but which return to average values after it feeds.

Although the bilin pigments are in all probability derived largely from the metabolism of heme precursors, there is evidence that bilirubin, accompanied by iron salts, promotes the synthesis of new hemoglobin when injected into humans, dogs or rabbits afflicted with secondary anemia.

Melanins.—Dark colours, indicating the presence of melanin pigment, are observed in feathers; in mammalian hair and eyes; in the skin and scales of numerous fishes, amphibians and reptiles; in the ink of cephalopods; and in various tissues of invertebrates. Melanin is also found in skin moles of man and in black tumorous growths of many vertebrates. It is an end product of metabolism, formed as a result of oxidation and polymerization of tyrosine (*see* fig. 7) or similar phenolic compounds. This oxidation by dissolved atmospheric oxygen is catalyzed by a copper-containing enzyme tyrosinase. Chemically reversible yellow, orange or red stages in the successive oxidation are followed, if uninterrupted, by an intensely black end product.



A B

FROM HEWER IN "PROC. ROY. SOC. LONDON" (1923)

FIG. 8.—FROG MELANOPHORES (A) expanded (skin is darkened green); (B) contracted (skin becomes pale)

Some white or albino animals may lack the power to elaborate either the enzyme tyrosinase in its active form or some intermediate compound necessary for pigmentation. Completely white or red variants of the sea anemone *Metridium senile*, for example, fail to develop melanin in their tissues as do brown variants of their species. But upon death or upon grinding of the tissues of such an albino animal, the macerated material blackens rapidly with the formation of melanin.

Pale yellow, tawny, buff, ruddy, brown and black colours of hair are due to melanin in various phases of formation or in relatively finely divided condition. That dark, light-absorbing sub-

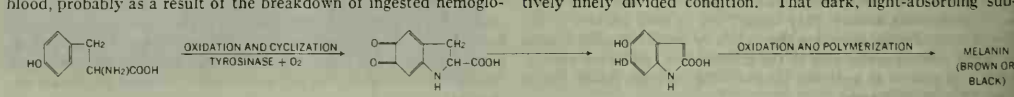
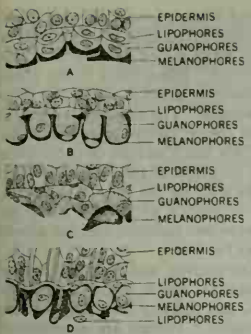


FIG. 7.—TYROSINE (COLOURLESS) CONVERTED TO MELANIN PIGMENT



FROM W. J. SCHMIDT IN "ARCH. MIKR. ANAT." (1920)

FIG. 9.—DIAGRAM SHOWING SKIN OF TREE FROG DURING COLOUR CHANGE
As cells of component layers expand and distribute pigment, skin colour changes from (A) bright green to (B) dark green to (C) lemon yellow to (D) gray

layers of melanin intensify structural blues or iridescent colours has been mentioned.

Many fishes, lizards, amphibians, cephalopods (octopus, squid) and shrimps possess in their skin dark melanoid pigment in specialized cells called melanophores (fig. 8). Within the boundaries of these cells the pigment granules may become dispersed, making the skin dark, or may aggregate into a small mass at the centre, rendering the skin pale. (*See* fig. 9.) These pigmentary changes may be induced by certain chemicals or by physical stimuli; when alarmed, such animals often display colour changes adapted to concealment.

In at least one of the crestfishes, *Lophotus*, much melanin is stored within a special glandular sac, from where it may be expelled in forcible jets through a postanal opening by muscular contractions.

Black or brown melanins or melanoproteins are to be observed in many invertebrate animals. Certain of the worms, many crustaceans and many classes of mollusks exhibit melanism in the skin.

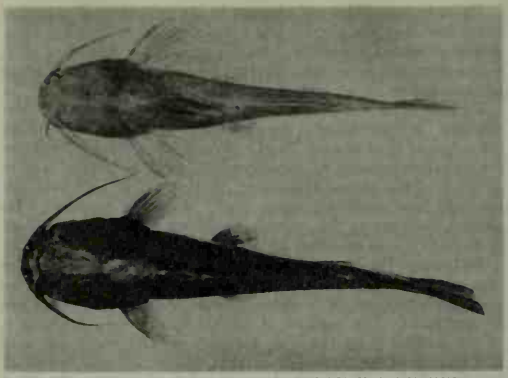
The red intermediate compound, formed during the transformation of tyrosine to melanin (*see* fig. 7) is hallachrome, which is encountered also in the marine worm *Halla parthenopaea*. It is green in alkaline solution. Hallachrome may be reversibly oxidized and reduced. Its original precursor may be either tyrosine or tryptophane.

Red or yellow uranidines, found in sponges, corals, jellyfishes, sea cucumbers, annelid worms and tunicates, are believed to be chemically related to the melanins. Urochrome, the principal yellow pigment of urine, is considered to be a modified melanin. In certain diseases, melanin precursors cause urine to darken as oxidation occurs on standing (melanuria, alkaptonuria).

Black melanin recovered from the wool of hybrid Downs-Dorset sheep was originally assigned by R. A. Gortner the empirical formula $C_{105}H_{173}N_{23}SO_{38}$, but there are variations in the elementary composition of melanins from different sources. They are extractable in very dilute alkali, soluble also, when fresh and undried, in very dilute acid solutions. Melanin, soluble in cold ethylene chlorhydrin, is bleached by such oxidants as hydrogen peroxide (which indeed is often applied to growing hair to create a blond effect), chlorine, chromate or permanganate.

The degree of melanization depends upon relative concentrations of copper and of the copper-containing enzyme tyrosinase. Dark mammalian hairs contain higher traces of combined copper than do pale hairs. Minimal traces of copper are required for melanistic pigmentation of the hair (*e.g.*, of rats); should the daily intake of copper fall substantially below the threshold value of a fraction of a milligram per animal per day, the new pelages emerge successively less dark.

In an individual strand of human hair, the cortex, beneath the outer layer of cuticular cells, surrounds the central medullary column or pith. Ellipsoidal or spherical microgranules of melanin are randomly distributed within the dried cortical cells, imparting pale buff, brown or black colours, depending upon relative numbers, sizes and depth of hue of the individual microgranules. Melanin occurs in the medulla of some mammalian hairs; this medullary melanin may assume the status of a colloidally dispersed stain rather than microscopically identifiable particles. Human red hair, unlike other hair, human or nonhuman, yields a unique, iron-rich pigment. A similar substance has been obtained from red poultry feathers, and is reminiscent of certain reddish melanin derivatives.



FROM A. S. ROMER "THE VERTEBRATE STORY," THE UNIVERSITY OF CHICAGO PRESS

FIG. 10.—COLOUR CHANGE IN CATFISH PRODUCED BY DIFFERENT ENVIRONMENTS
(Above) fish taken from light container; (below) fish from dark container

All human skin, except in albinos, contains greater or lesser amounts of melanin. In fair-skinned races the corium or deeply lying skin layer contains but little of the pigment, whereas in the darker races, dermal deposits of it are heavy and are fortified by numbers of smaller melanocytes in the upper skin layer or epidermis. Samples of human skin, photographed by electron microscopy have been found to contain minute particles of melanin pigment in the form of microspherules (0.2 to 0.3 μ in diameter) or rodlets (from 0.1 × 0.4 μ to 0.18 × 0.6 μ). On exposure to sunlight, man's epidermis undergoes gradual tanning, or increase of melanin pigment, which helps to protect underlying tissues from injurious sunrays. *See* also SKIN.

Amphibians and fishes, maintained for protracted intervals upon black backgrounds, have been found to augment greatly the numbers of melanophores in the epidermis. Animals thus darkened gradually lose their integumentary melanin after transferral to containers with pale inner surfaces. (*See* fig. 10.)

There are some remarkable instances of rapid darkening of the skin through melanization. The relatively sudden appearance and rapid enlargement of black skin moles, which are actually malignant, melanotic areolae, is well known. Among the fishes, the Tasmanian whitebait (*Lovettia sealii*) was observed by M. Blackburn in 1950 to exhibit rapid integumentary blackening upon entering the postspawning stage. There is a great increase in numbers of melanophores with successive stages of sexual ripeness, notably in the males; and individuals of both sexes, after spawning, show extensive darkened areas of the skin. In dying individuals the skin may become completely black.

In the very young downy chick of the American flamingo, the pudgy little legs are covered with delicate, naked skin, bright red or pink in colour due to the rich supplies of blood hemoglobin. It has been observed by Étienne Gallet (1950) and by D. L. Fox (1957, 1958) that the colour of the chick's leg skin deepens gradually, becoming black at the end of about the eighth day, when the chick is ready to leave its nest for the first time, no longer to be protected from direct sunlight by the hovering parents.

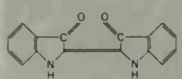


FIG. 11.—INDIGO

Indigoid Derivatives.—Like melanins, the indigo compounds are excretory products of certain animals, but in contrast to melanins, their distribution as pigmentary compounds is relatively limited. Unlike the dark, sombre melanins, many indigoids are red, green, blue or purple.

Indigo.—Also called indigo-blue or indigotin, this occurs as a glucoside in many plants of Asia, the East Indies, Africa and South America. (*See* fig. 11.) It has long been used as a blue dye. While the pigment itself does not occur in the tissues of healthy animals, certain chemical derivatives of it are found in secretory and excretory products.

Hallachrome.—This red pigment in the epidermis of a marine worm has been discussed. The compound, as well as the chromogen of human melanuria, which is probably a derivative of 5, 6-dihydroxy indole, may be generated from the breakdown of either of the common amino acids, tyrosine or tryptophane.

Tyrian Purple.—A purple of the ancients, Tyrian is 6,6′-dibromindigo. It is generated in the presence of light, probably through the influence of an enzyme, from a colourless precursor secreted by the so-called adrectal or hypobranchial gland in several species of snails of the genera *Murex* and *Purpura*. This red-violet dye has long been employed commercially in certain countries. Its physiological use to the animals producing it is obscure; in all probability it is an excretory product.

Purines.—The purine compounds are hardly to be classed as true pigments, since they are usually white crystals. They often contribute, however, to the colour scheme of lower vertebrates and invertebrates. The position of purines as excretory products is amply illustrated by the large amounts of solid white uric acid and guanine in the excrement of birds, and of uric acid in that of reptiles. Uric acid has also been found in the yellow sheets of mucus excreted by sea anemones, and urates are present in small amounts in the urine of man and of the higher apes. (Pathological deposition of sodium urate in the joints is a factor responsible for gout [*q.v.*].)

The brilliant whiteness of some anemones, notably the white variant of *Metridium senile*, results partly from microcrystalline deposits of uric acid in the tissues. These crystalline aggregates are especially noticeable in the mesenteries. Other purines, such as xanthine, have been reported as occurring in the wings of pierid butterflies. Mention has already been made of the notable deposition of guanine crystals in the leucophores or iridocytes of fishes, contributing a whiteness or often a brilliant silvery appearance to extensive areas of the skin. Purine compounds constitute part of the complex nucleic acids which abound in the nuclear material of all cells; it is therefore presumed that they play an indispensable part in cell metabolism. The purine compound hypoxanthine exercises a specific stimulating and accelerating effect upon the growth of embryonic tissues of the chick.

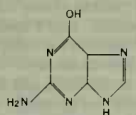


FIG. 12.—GUANINE

Some fishes vary the quantities of deposited guanine (fig. 12) in proportion to the lightness of the background upon which they are living. Studying the effects of the albedo (ratio of reflected to incident light) upon the black and white pigmentation of fishes' skins, F. B. Sumner in 1944 demonstrated that the greenfish or opaleye (*Girella nigricans*) kept in white-walled containers became very pale during a four-month period. These fishes stored about four-fold the quantity of integumentary guanine as did the skins of fish kept in black-walled aquariums. The skins of the fish in the latter group, intensely black in colour, yielded more than twice the total quantity of melanin. This was a unique demonstration of two alternative, very different biochemical reactions, catalyzed in opposite ways by the total light entering the eyes of the fishes, *i.e.*, high albedo stimulating the deposition of guanine while depressing the formation of the end product melanin; and low albedo exerting the opposite effects. (*See* fig. 10.)

Pterins.—Closely related to the purines, and formerly classed among them, are the so-called pterins, which derive their name from their notable appearance in, and primary chemical isolation from, the wings of certain butterflies. Pterins are encountered as white, yellow, orange or red granules in association with the wing material. They contribute the yellow colour to the body-covering of many wasps.

Pterins are soluble in aqueous solutions, often more so in the presence of ammonia, and insoluble in the usual organic solvents. Leucopterin is a white compound obtained from the white butterflies *Pieris brassicae* and *P. napi*, and has been found accompanied by other pterins in other species. Xanthopterin (fig. 13) is a yellow pigment responsible for the yellow colour in the wings of *Gonepteryx rhamni* and other butterflies, and in the abdominal skin of wasps (*Vespa* species). It occurs also in human urine, and therefore has been called uropterin. This compound has been effective in preventing nutritional anemia in rats and in young salmon.

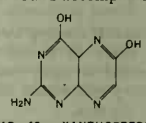
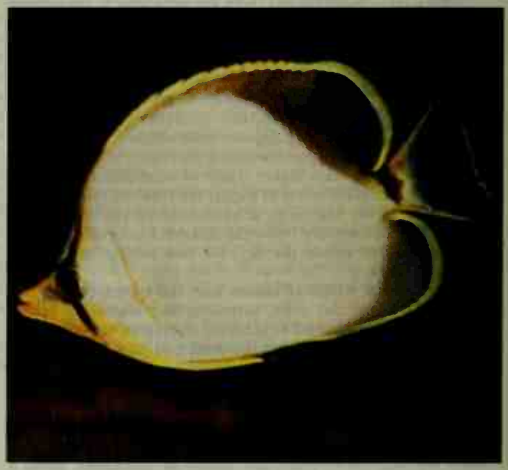


FIG. 13.—XANTHOPTERIN

In butterflies, the colourless compounds guanopterin and mesopterin may be accompanied by chrysopterin, an orange compound, or by a red homologue, erythropterin; the latter imparts conspicuous red colours to the wings of several species. A red pigment in the eyes of the fruit fly *Drosophila melanogaster*, of great interest and usefulness to geneticists, is believed to be related to the pterin class. Fluorescyanin, a blue-fluorescing pterin in the scales of many fishes, biochemically resembles some of the B vitamins.

Certain pterins and their derivatives are believed to deter the growth of some tumours (in experimental mice), while others have reportedly been effective in reducing pain, whether induced experi-



FROM PHOTO RESEARCHERS, INC. (LEFT) STEPHEN COLLINS; (RIGHT) RUSS KINNE

COLORATION DUE TO CRYSTALS OF PURINES AND PTERINS

Yellow granules of pterin give colour to the yellow jacket (left), and a purine, guanine, gives the silvery appearance to the yellow-headed butterfly fish (right). Melanin pigment imparts the blackish colour

mentally or incidental to neoplastic diseases.

Lyochromes (Flavins).—This class of yellow, greenly fluorescent, water-soluble pigments is widely distributed in plant and animal tissues, although their presence in but very small amounts usually renders their colour inappreciable in animals. Although synthesized by bacteria, yeasts and green plants, the lyochromes, notably lactoflavin (riboflavin), identical with vitamin B_2, is not manufactured by animals, which thus depend upon plant material for their ultimate supply of this important factor. Lactoflavin (fig. 14) is an enzyme capable of combining with molecular oxygen,

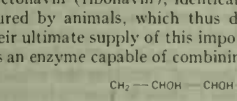


FIG. 14.—LACTOFLAVIN

whereupon the yellow colour develops. It may then release oxygen for intracellular oxidation processes, with simultaneous loss of colour. The colour is restored by fresh supplies of oxygen.

Blood, milk, eggs, liver, kidney and muscle contain appreciable quantities of lactoflavin. A nutritional lack of this enzyme leads to impairment of cellular respiration, retardation of growth of young mammals, and cataract development in mice, chickens and monkeys. The compound is not stored in quantity and is a normal excretory product. It has been encountered in somewhat concentrated amounts in the Malpighian tubules of insects, which obtain it from fresh vegetable material. The larvae of mosquitoes responsible for carrying yellow fever fail to develop normally, or to complete their metamorphosis if deprived of flavin and purine.

MISCELLANEOUS PIGMENTS

There are many animal colouring matters whose constitutions remain unknown. Of these, only a few of the more conspicuous examples will be mentioned.

Chromolipoids.—These are yellowish, reddish or brown fat soluble pigments often encountered in the fat droplets of eggs and other cells and in other lipoid-rich tissues. They have often been mistaken for both melanins and carotenoids. Chromolipoids are believed to be derived from partially oxidized fatty acids, phospholipids or other lipoid compounds, perhaps in ways similar to those in which commercial fats may gradually become discoloured on being heated or after long standing in air.

Hemocyanin.—This compound is the respiratory catalyst encountered in the plasma of molluscan and crustacean blood. It is colourless in the reduced condition, but assumes a blue colour upon exposure to oxygen, with which it combines. During the circulation of the blood, the oxygen carried in combination with hemocyanin is released to the tissues requiring it. Chemically, hemocyanin is composed of a large protein complex bound to copper, whose presence is responsible for the blue colour of the oxidized molecule.

Wide differences in molecular weight have been found in hemocyanins from the blood of various species; in certain crustaceans, the value has been given as 360,000 and represents lower limits. *Limulus*, the horseshoe crab, carries a hemocyanin having a molecular weight of about 1,300,000; *Octopus* 2,000,000; and the land snail *Helix* as high as 5,000,000.

The blue oxyhemocyanins of various mollusks and arthropods commonly exhibit a broad spectroscopic band of light absorption in the yellow to orange region. The fact that hemocyanins possess only about one-fourth the oxygen-combining capacity of the commoner hemoglobins explains in part why species endowed with hemocyanin are subject to relatively depressed metabolic activities, *e.g.*, as in certain bottom-dwelling snails, or are extremely sensitive to asphyxia as are squids.

Hemerythrin.—Hemerythrin is an iron-containing proteinaceous pigment present in the blood of certain bottom-dwelling marine worms and of the brachiopod *Lingula*, serving as a reversible oxygen carrier as do hemoglobin, chlorocruorin and hemocyanin. The blood containing hemerythrin is pale in the reduced condition, becoming red or reddish-brown when oxygenated.

Vanadium Chromogen.—This compound is the pale-green pigment within the blood cells (so-called vanadocytes) of sea squirts belonging to the families Ascidiidae and Perophoridae. The vanadocytes are rounded, mulberry-shaped cells, varying but little in shape or size among different species. The diameter is about that of the disc-shaped red blood cells or erythrocytes of mammals, about eight microns. Within each vanadocyte are about eight to ten relatively large, apple-green bodies containing the pigment.

Actiniochrome.—This red or violet pigment in the tentacle tips and mouth opening of various sea anemones is not to be confused with either the carotenoid or the heme classes of pigment. Insoluble in ether, chloroform and in most other common fat solvents (except acetone) it may be extracted from the fresh tissues with glycerol, to which it imparts its red colour with the display of several characteristic absorption bands; one of these has its maximum in the yellow region, another is located in the blue range. The physiological significance of actiniochrome is unknown.

Adenochrome.—This red pigment, occurring in high concentrations in the branchial heart tissues of *Octopus bimaculatus*, is readily soluble in dilute ammonia or other alkalis, conferring thereto a wine-red colour. Even dilute acidification causes complete precipitation of the coloured material as purple flocs. Adenochrome, insoluble in alcohol, ether, chloroform, dioxane and glacial acetic acid, dissolves slightly in trichloroacetic acid or in dilute pyridine. Readily precipitable from aqueous alkaline solutions by the addition of alcohol and subsequently dried, the resulting mauve or purple powder fails to melt at 300° C., but chars at higher temperatures.

Aphin.—The hemolymph of numerous coloured species of aphids yields a series of yellow, orange and red compounds, referred to by A. R. Todd and his associates as aphins. Fresh insects treated with hot water yield protoaphin, a water-soluble pigment crystallizable as pale-yellow needles. This protoaphin is convertible, through the action of oxidizing enzymes in freshly crushed insects, into a secondary, yellow derivative, xanthoaphin, which, on further oxidative changes is altered to yield chrysoaphin; and this, in turn, is similarly convertible to erythroaphin. Each of these aphins exhibits a characteristic crystalline habit, colour and fluorescence corresponding with successive phases of oxidation.

The aphin molecule is without combined nitrogen, halogens, sulfur or methoxy groups. Erythroaphin seems to possess phenolic hydroxyl groups; its ready chemical reduction and its reoxidation by atmospheric oxygen suggest the likelihood of a quinonoid structure.

Although protoaphin, the primary pale-yellow water-soluble aphin, is easily and extensively oxidizable through an enzyme in the hemolymph, this compound's potential physiological significance in the insect's system remains yet to be clarified.

Other Pigments.—Numerous coelenterates exhibit brilliant pigmentation, the chemical nature of which is as yet imperfectly known. For example, the lasting red pigment in skeletons of red coral (*Corallium rubrum*) and organ-pipe coral (*Tubipora musica*) and the red, orange and yellow colouring matters of many other alcyonarian coral skeletons are chemically obscure.

The large, colourful, poisonous jellyfish *Pelagia noctiluca panopyra* exhibits several pigments. Blue (noncarotenoid) intracellular chromoproteins are present in the heavy, pendulous lips, the exumbrella, gonads and gastric filaments; brown pigments occur in the outer skin of the umbrella and a magenta-coloured chromoprotein is recoverable from the noncellular mesogloeal jelly. Studies on the magenta suggest a melanoid character.

The function of colours in animals and plants is covered in the articles ANIMAL COLORATION and PLANT COLORATION. *See* also references under "Pigment, Animal" in the Index.

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tural Colours (1953) and "Pigments of Fishes" in *Physiology of Fishes,* ed. by M. E. Brown, vol. II, ch. 7, pp. 367–385 (1957); R. H. Thomson, *Naturally Occurring Quinones* (1957). (D. L. F.)

PIGOT, GEORGE PIGOT, Baron (1719–1777), English East India merchant and governor of Madras who was arrested and deposed by his council in 1776, was born in London on May 4, 1719. Entering the service of the East India Company in 1736, he became governor and commander in chief of Madras in 1755. He stoutly defended Madras against the French in 1758–59, and after the capture of Pondicherry by Lieut. Col. (afterward Sir) Eyre Coote in 1761 he occupied the town on behalf of the company. Resigning his office in November 1763, he returned to England and was made a baronet in 1764. Member of Parliament for Wallingford (1765–68) and Bridgnorth (1768–77), he was created an Irish peer as Baron Pigot in 1766. Returning to Madras in 1775 to resume his former offices, Pigot was involved in a quarrel with his council, in which a majority backed by Paul Benfield, a notorious East India trader, opposed Pigot over his proposed restoration of the raja of Tanjore (Thanjavur). Pigot was arrested by his opponents on Aug. 24, 1776, and died at Fort St. George, Madras, on May 11, 1777, while still a prisoner. The case was discussed in Parliament in 1779, and four of those responsible for his arrest were tried and fined £1,000 each.

PIGOU, ARTHUR CECIL (1877–1959), one of the most eminent British economists of the 20th century, was born at Ryde, Isle of Wight, Eng., Nov. 18, 1877, and was educated at King's College, Cambridge, of which he became a fellow in 1902. In 1908 he succeeded Alfred Marshall (*q.v.*) in the chair of political economy at Cambridge, from which he retired in 1943. His most significant and influential work was *The Economics of Welfare* (1920). Based on a carefully guarded set of utilitarian premises, using the techniques of marginal analysis characteristic of neoclassical economics and ordered round the concept of the national income, it inquired into the respects in which the pursuit of individual self-interest may not produce the best results for society as a whole, thus affording scope for various forms of state intervention. In other works Pigou applied his outstanding powers of analysis and construction to many problems, including those of tariff policy, industrial fluctuation, unemployment, and public finance. He served on the Royal Commission on Income Tax (1919–20) and on two committees on the currency (1918–19 and 1924–25). He died at Cambridge on March 7, 1959. (D. H. R.)

PIGSTICKING (Hog-Hunting), the chase and spearing of wild boars from horseback, was an Indian sport adopted enthusiastically by British cavalrymen early in the 19th century. It is believed that the boar was originally merely a substitute target for the bear when that animal became scarce. A further impetus was given pigsticking in 1816 when England armed the 9th, 12th, 16th and 23rd light dragoons with the lance. Soldiers stationed in India began testing this weapon on wild boars of the *kadirs* (dry river beds) and rapidly acquired hog-hunting fever. Near Poona, about 1830, a few officers even tried killing pigs with a sabre.

It has been claimed that the short jobbing or thrusting spear was also introduced in 1830, yet colour plates in Capt. Thomas Williamson's *Oriental Field Sports,* engraved in 1807, indicate much earlier familiarity with the jobbing technique. With this type of spear, no longer thrown, many thrills were had chasing bad-tempered beasts standing 40 in. at the shoulder and weighing up to 358 lb. Equipped with razor-sharp lower tusks, the Indian boar has been known to overturn mounted men to attack them. Reaching his prime at 8 years, a boar may live to be 20. Pigs of the jungle average larger than those of the grassy plains and any under 28 in. in height are not considered fair game.

Because of the pig's trick of "jinking" (zigzagging) a good hog-horse has to be agile as a polo pony. Arabs, Australian Walers and native Indian ponies proved the best mounts for the sport. A speedy horse might overtake a boar within less than one mile provided the horse had not broken a leg in a porcupine hole, impaled itself on the concealed stake of a cut-down *jhow* (tamarisk), or cut its throat on the cactus fences of Guzerat.

Most hog spears have a shaft of male bamboo and a Bodraj head with oval blade tapering to a point. The Bengal spear, under 6 ft. in length, is weighted with lead at one end and is used overhand for jobbing. The longer Bombay spear is wielded like a lance, an attacking pig being encouraged to spit itself on the point. The Calcutta Tent club fined any member a case of champagne for spearing a boar on his near side or killing a sow. By tradition the head and tusks go to the rider claiming "first spear."

Expert pigsticking requires strong nerves, keen sight, a firm seat, light hands, a cool head and a lot of luck. The four major methods of hunting include beating a cover, beating on a line ("spears" riding with the line), "ghooming" (riding quietly alone looking for game) and "pugging" (tracking the animal from its feeding grounds). *Wuh jata* ("There he goes!") is the cry when a boar is sighted.

The Kadir cup competition, established in 1869, was long considered the highest achievement for a hog-hunter.

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PIKA, a small, essentially tailless, rabbitlike mammal inhabiting mountainous regions in parts of western North America and high deserts and mountains in Asia, one species barely ranging into eastern Europe. In North America the name cony, or coney, is sometimes ambiguously applied to these animals as well as to the unrelated hyraxes (*see* Hyracoidea).

Pikas belong to the genus *Ochotona* and to the order Lagomorpha, which includes the hares and rabbits. Their ears are rounded rather than elongate, and the soles of their feet are heavily haired. They are about the size of a guinea pig, reaching a length of approximately eight inches.

Most pikas live among rocks, especially talus slopes, but in Asia there are species that inhabit burrows in forests and even in the Gobi Desert. They do not hibernate. During the summer and autumn months pikas "harvest" vegetation, which they dry in the sun. This hay, stored under rocks or in other places where it will be protected from snow, provides a source of food during the winter. Unlike rabbits and hares, pikas are quite vocal, uttering a bleatlike sound, especially when danger approaches; and they are active only during the daylight hours. *See* also Lagomorph. (R. T. O.)

PIKE, ZEBULON MONTGOMERY (1779–1813), U.S. army officer and explorer, was born at Lamberton, N.J., Jan. 5, 1779. His father was an army officer and young Pike volunteered as a cadet when only 15 years of age.

In the summer of 1805 Pike, then a lieutenant, received instructions from Gen. James Wilkinson to lead an exploring party to the headwaters of the Mississippi. He was directed to discover the source of that stream, negotiate peace treaties with the Indian tribes and emphatically assert the legal claim of the United States to the area. With a company of 20 men, Pike started up the Mississippi river from St. Louis in Aug. 1805. Six months later, after traveling more than 2,000 mi. by boat and on foot through wooded marsh lands, the party reached Cass, Leech and Sandy lakes in northern Minnesota. Here they found British traders in undisputed possession of the region and British flags flying over Indian villages. Pike at once explained the American position to the Indians, stating firmly that they now owed allegiance to the United States. He also warned the British traders to respect the laws of the American nation, upon whose soil they were illegally operating. He recommended to the administration at Washington that government agents be appointed to regulate the fur trade and that military posts be erected at strategic sites. Pike erroneously identified Leech lake as the source of the Mississippi.

In July 1806 Pike was dispatched to the southwest with 23 men to explore the Arkansas and Red rivers and, if possible, to obtain information about the adjacent Spanish territory. The alarmed Spaniards attempted to intercept Pike's party but were unsuccessful and Pike pushed rapidly southward. Near the site of Pueblo, Colo., he erected a post and then proceeded to reconnoitre the Arkansas river, ascending that stream as far as Canon City and Leadville, Colo. After building a blockhouse at the eastern entrance of the Royal gorge and leaving two men to guard the horses, baggage and supplies left there, Pike and his men traveled

southward until they reached the Sangre de Cristo mountains. After crossing this range, the party emerged upon the vast tableland of northern New Mexico. Here the explorers were apprehended by Spanish officials on the charge of illegal entry into New Mexico. They were forthwith transferred to Santa Fe, N.M., and then to Chihuahua, Mex., for trial. The authorities confiscated Pike's maps, notes and papers, some of which were recovered a century later by the historian Herbert E. Bolton. After considerable delay the Americans were escorted across Texas to the Spanish-American border at Natchitoches, La., where on July 1, 1807, they were released. The Pike explorations were important because a mass of information about Santa Fe, noting particularly the military weakness of the capital and the lucrativeness of the overland trade with Mexico, was included in Pike's report published in 1810. This report created American interest in the southwest and undoubtedly stimulated the expansionist movement into Texas and the projection of the colourful Spanish-American trade over the Santa Fe trail. Pike saw active service in the War of 1812, attained the rank of brigadier general and was killed in action during the attack on York (now Toronto), Can., on April 27, 1813. A mountain that he saw and attempted to climb in what is now the state of Colorado was later named Pikes peak in his honour.

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PIKE, fresh-water fishes generally distributed over the rivers and lakes of Europe, northern Asia and North America. They form a small family (Esocidae) of soft-rayed fishes. Pikes, typified by the common or northern pike (*Esox lucius*), are recognized by their elongate, compressed body, which is olive or greenish-gray with lighter spots, and covered with small scales; a long

GENE HORNBECK FROM NATIONAL AUDUBON SOCIETY

NORTHERN PIKE (ESOX LUCIUS), COMMON TO TEMPERATE FRESH WATERS

head; long spatulate snout; and large mouth armed with strong and long teeth in the jaws and broad bands of smaller teeth on the palate and tongue.

The teeth, which point backward or can be depressed, offer no obstruction to any object entering the mouth, but prevent withdrawal. The dorsal and anal fins are placed far back on the tail, thus greatly increasing the propelling power of the fish. Although pikes lead rather a sedentary life, they are excelled by no other fresh-water fish in rapidity of motion when they dash upon their prey or dart out of reach of danger.

Pikes are the most voracious of fresh-water fishes. Although large specimens will seize muskrats or waterfowl, and are said to attack even foxes and small dogs, most of them subsist on small fish, insects and aquatic invertebrates. They are solitary hunters, finding their prey by lying motionless in the water or lurking in a clump of vegetation and, as soon as a victim comes within reach, making a sudden lunge and seizing it.

The common or northern pike occurs in North America from Alaska to British Columbia and eastward to New York, including the Great Lakes and the Ohio valley; it is the only old world species of pike known and is found in Europe north of Greece (but excluding Spain and Portugal) as far as Lapland and in northern Asia. North American waters are also inhabited by other species of the pike family, of which the largest (attaining a weight of over 100 lb.) is the muskellunge of the Great Lakes (*E. masquinongy*). Other smaller American pikes are generally called pickerels.

The spawning season of the northern pike varies according to the local climate. It generally occurs from late winter through the spring. Studies indicate the average length at one year of age to be about 20 in. and at five years, about 30 in., but specimens are known which have reached a length of more than 4 ft. and a weight of over 50 lb.

Commercial fishermen in North America catch about 100,000 lb. of northern pike a year, mostly with gill nets and pound nets. Anglers take pike by trolling or casting artificial lures, or by fly-fishing or still-fishing using small fish or frogs as bait.

(L. A. Wd.)

PIKE PERCH, fresh-water fishes of the perch family (Percidae) identified by having large, strong teeth standing between smaller, weaker ones. These excellent food fish resemble the pike in their elongate body and head, and are dangerous enemies to other fresh-water fishes. In Europe two species occur, the more celebrated being *Sander lucioperca*. It prefers the quiet waters of large rivers and clear, deep lakes, in which it reaches a weight of 25 to 30 lb. The second, *S. wolgensis*, is limited to rivers in southern U.S.S.R. and Hungary. In North America the walleyed pike (*Stizostedion vitreum*), of the same family, is sometimes called pike perch. It occurs at least as far west as Nebraska and northern Alberta, as far north as Labrador and as far south as Alabama and Georgia. It grows to a weight of 25 lb. (L. A. Wd.)

PIKES PEAK, a famous mountain of the Front range of the Rocky mountains in El Paso county, Colo., U.S. It ranks 32nd in altitude (14,110 ft.) among the 55 Colorado peaks of over 14,000 ft. It is, however, the most widely known mountain in the U.S. by reason of its commanding location and easy accessibility. On its southwestern side, in Teller county, is the famous Cripple Creek gold district, while directly at its eastern base lie Manitou Springs and Colorado Springs (*q.v.*). About 350,000 tourists annually ascend to the summit, a fairly level area of about 60 ac. Ascent may be accomplished by trail, by a cog railway (8.75 mi.) in operation since 1891, or by an automobile toll road (19 mi.) opened in 1916. An average snowfall of about 9½ ft. on the northern and 14 ft. on the southern slopes provides skiing and constitutes the major part of the water supply of Colorado Springs. Timber line is between 11,400 and 12,000 ft.; above it rises nearly 2,500 ft. of bare granite. The view from the summit, which is said to have inspired Katharine Lee Bates to write the familiar hymn "America the Beautiful" in 1893, is magnificent in all directions. Blanca peak (14,317 ft.) and the twin Spanish peaks are visible 100 mi. to the south; Longs peak (14,255 ft.) 100 mi. to the north; the many lofty giants of the Park and Collegiate ranges to the west. On the east is the vast sweep of the Great Plains.

Pikes peak was discovered in Nov. 1806, by Lieut. Zebulon Montgomery Pike (*q.v.*), who abandoned his attempt to climb it because of snow and inadequate clothing. It was climbed by Edwin James and two companions, J. Verplank and Z. Wilson, of Maj. Stephen H. Long's expedition on July 14–15, 1820—the first recorded ascent of a 14,000-ft. peak in the U.S. The mountain was named for James by Major Long but common usage had deservedly bestowed Pike's name upon it by 1859, when it became the focal point of the Pikes peak gold rush.

See Robert M. Ormes (ed.), *Colorado Mountain Club's Guide to the Colorado Mountains,* rev. ed. (1955); Harvey L. Carter, *Zebulon Montgomery Pike: Pathfinder and Patriot* (1956). (Hy. L. C.)

PILA (Ger. Schneidemühl), a town of Poland in Poznan *wojewodztwo* (province) and a district centre, lies about 65 mi. (105 km.) N of Poznan by road. Pop. (1960) 34,000. The town is on the Gwda River, a tributary of the Noteć, at the northern boundary of the *wojewodztwo*. It is on the Berlin–Danzig Railway and is connected with Bydgoszcz. Since World War II a heavy metal and machine industry has been developed, and there are railway repair workshops and sawmills. The potato export trade is important.

Pila, first mentioned in the 15th century, obtained town rights in 1513. After the first partition of Poland in 1772 it was seized by Prussia. Between 1807 and 1815 it was in the Duchy of Warsaw, then again passed to Prussia. It returned to Poland in 1945, much of the town having suffered war damage. (K. M. Wi.)

PILAR (Villa del Pilar), a city of the Ñeembucú department, Paraguay, lies 118 mi. (190 km.) S of Asunción, on the left bank of the Paraguay River opposite the mouth of the Bermejo. Pop. (1960 est.) 7,136. It is an important river port exporting the agricultural products of Ñeembucú department, between the rivers Paraguay and Paraná. Pilar has sawmills, distilleries, and textile mills, supplies being obtained by road from the northeast where it is linked to the main Asunción-Encarnación highway. Founded in 1778 by Pedro Melo de Portugal, it is the capital of Ñeembucú, which it was originally called. (G. J. B.)

PILATE, PONTIUS (d. after A.D. 36), Roman procurator of Judaea who passed the death sentence on Jesus Christ. His origin and early history are unknown, save that he was of equestrian rank. It is believed that he became a protégé of Sejanus, the favourite of the Roman emperor Tiberius. Sejanus succeeded in filling all provincial posts except Syria with his followers, so Pilate, whom he appointed (26) as procurator of Judaea (and therefore subordinate to the governor of Syria), was stationed at an exposed point. Jewish groups used this situation to make aggressive advances, and Pilate, protected by Sejanus' hostility to the Jews, handled the tricky problem of Roman-Jewish relations with little skill. After Sejanus' fall (31) he found himself in an embarrassing position, which the Jews may have used in obtaining a legal death sentence on Jesus (John 19:12). Pilate's attack upon the Samaritans, perhaps instigated by Caiaphas, caused his removal by the Syrian governor in the winter of 36/37. After being sent to Rome to answer for himself, he probably committed suicide, as related in Eusebius' church history. (*See* also Jews: *Greek and Roman Conquests.*)

In the New Testament Pilate is shown as unwilling to condemn Jesus, whom he found innocent, but finally driven to do so by fear of being accused of disloyalty to the emperor. Pilate's wife sent a message to him during the trial advising him to have nothing to do with "that just man" for she had suffered much in a dream about him, and Pilate after condemning Jesus washed his hands publicly of all responsibility for his death (Matt. 27:19, 24). His efforts to release Jesus made him almost a hero in some Christian traditions; in the Ethiopian Church, for instance, he is venerated as a saint on June 25. In Jewish tradition he is the anti-Semitic prototype.

The apocryphal Acts of Pilate, extant in Greek and in a Latin version, dates from the 4th century. It describes the trial, execution, and resurrection of Jesus and is followed in some manuscripts by an apocryphal account of Jesus' descent into hell. Both these works together are called the Gospel of Nicodemus. Nothing remains of the pagan Acts of Pilate, an anti-Christian work originating in the time of the emperor Maxentius (306–312), which are mentioned in Eusebius' church history.

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PILCHER, PERCY SINCLAIR (1866–1899), British engineer and aviation pioneer, was born in Jan. 1866. After six years in the Royal Navy, he qualified and practised as an engineer, and was in 1893 appointed assistant lecturer in naval architecture and marine engineering at Glasgow university. He took up the active study of heavier-than-air flight in 1895, under the influence of Otto Lilienthal, whom he twice visited in Germany. Pilcher built his first glider, the "Bat," in 1895, which he then modified after Lilienthal's ideas, and on which he made many successful glides. His second machine, the "Beetle," was also built in 1895, and his third, the "Gull," in 1896. It was with his fourth glider, the "Hawk" (1896), that Pilcher achieved his most productive flying. It was a monoplane, with rear fin and tailplane and wheeled undercarriage, and was controlled in the Lilienthal manner of swinging the torso and legs from a hanging position between the wings. After gaining valuable experience with this glider, he turned his attention seriously to the problem of powered flying in 1897. By 1899 he had almost completed his first powered machine—for which he had also built the engine—when on Sept. 30, 1899, the "Hawk" broke up in the air when Pilcher was gliding in it at Stanford Park, near Market Harborough. He died of his injuries on Oct. 2, 1899.

See *Aeronautical Journal*, vol. i, pp. 1–4 (1897), vol. xiii, pp. 87–89 (1909); P. Pilcher, "Gliding," *Aeronautical Classics*, no. 5 (1910). (C. H. G.-S.)

PILE. As a textile term, this word indicates the surface of a cloth composed of an infinite number of loops of warp threads, or else of an infinite number of free ends of either warp or weft (filling) threads that stand erect from the foundation or ground structure of the cloth. There are two general methods of distinguishing between such cloths: when the loops are uncut, the pile is usually termed looped pile; when the same or similar loops are cut, either in the loom during weaving or by a special machine after the cloth leaves the loom, the pile is termed cut pile.

Other names applied to such cut-pile fabrics in which the effect is formed by the warp threads are velvet (*q.v.*) and plush, the former being used to define short-pile fabrics and the latter to define long-pile fabrics. The word velveteen (*q.v.*) is used to distinguish the fabric when the pile is formed of weft or filling threads that have been cut.

Among the loop-pile fabrics may be mentioned Brussels tapestry and imitation Brussels carpeting, as well as Moquettes and the like. In some cases the surfaces of carpets, such as Wilton and Axminster, are formed of cut pile; and again, both looped (uncut pile) and cut pile appear on the surface of the same fabric. Imitation sealskins and several other kinds consist of monocoloured pile, whereas all the above-mentioned carpets have surfaces upon which decorative designs appear in both kinds of pile and in several colours. *See* Carpet Manufacture; Rug and Carpet. For pile in building *see* Foundations, Structural. (T. W.)

PILGRIMAGE, a journey to a saint's shrine or other sacred place, undertaken for a variety of motives: with the object of gaining supernatural help; as an act of thanksgiving or of penance; for the sake of devotion. Pilgrimages are characteristic of most of the higher religions.

Christianity.—There is a record of a pilgrimage by the Cappadocian bishop Alexander to Jerusalem about 212 (Eusebius, *Church History*, VI, 11). Western Christians soon followed him. In 333, a pilgrim from Bordeaux in Gaul left an account of his visit to the sacred places, while the travel memoir of the Spanish nun Etheria (*c.* 400) testifies to a system of guides and lodgings for those seeking the Palestinian sites (*see* Peregrinatio Etheriae). Yet, long before this date, Europe possessed its own places of devotion. The excavations of the 1940s at St. Peter's Basilica, Rome, unearthed a 2nd-century memorial to the apostle with numerous scratched inscriptions of the 2nd and 3rd centuries, evidencing acts of piety. The Roman liturgical calendar of the year 354 lists 29 local sanctuaries of the saints at which the faithful gathered annually. In Gaul, a vivid account of the mid-5th century describes the pilgrims thronging to Arles for the feast of St. Genesius on Aug. 25, and in Britain, Bede (d. 735) catalogues visits to the graves of SS. Alban, Oswald, Chad, Cuthbert, etc., from the 5th to the 8th century.

Motives for these undertakings varied. In 560, King Clotaire I journeyed to St. Martin's tomb at Tours in search of pardon. Visitors to St. Nicetius' sepulchre at Lyons in 590 carried away relics of the saint, but St. Willibald (d. 786) seems to have undertaken his pilgrimage of 722–730 to Italy and the Near East simply to satisfy devotion. In addition to such pilgrimages undertaken freely, the Middle Ages knew also the votive and the judicial pilgrimage. The votive form came about as the result of a pledge or vow and was normally expected to be kept, though provision was made for the possibility of ecclesiastical dispensation in the *Decretals* issued by Pope Gregory IX in 1234, and dispensation had in fact been granted as early as 1166. Judicial pilgrimages were imposed upon penitents as a satisfaction for sin or resulted from a sentence such as that decreed by the Inquisition at Albi against Guillermus Salavert in 1319. By this period, pilgrims were also enabled to secure indulgences, for Pope Boniface VIII, in proclaiming the first Holy Year of Jubilee on Feb. 22, 1300, alluded to the tradition (at least a century old) that indulgences could be gained by those visiting the Roman basilicas (*see* Indulgence).

The medieval pilgrim began his journey with the blessing by a

priest of his scrip and staff. His garb was recognizable, and upon his hat he would wear, on returning, the badge of the shrine visited (*e.g.*, the face of St. John Baptist if he had been to Amiens). Along the more traveled routes he would find hospices such as that at Maidstone for pilgrims going to Canterbury. By decree of Pope Celestine III (1191–98), the property of those seeking the Roman sanctuaries was placed under papal protection.

For Dante, writing *c.* 1293 (*Vita Nuova*, XL. 7), the Holy Land, Santiago de Compostela in Spain, and Rome were the chief attractions for pilgrims. Access to the Near East had been facilitated by the opening of the Danube route *c.* 1000; however, the obstacles put in the way of the devout by the Seljuk conquest of Jerusalem (1076–77) were to lead to the preaching of the First Crusade. Rome's appeal was due to the tombs of the apostles Peter and Paul, while Santiago's magnetism lay in its claim (most probably legend) to possess the remains of St. James the Greater.

While medieval pilgrim resorts were counted in the hundreds, not all were of international reputation. Italy, in addition to Rome, gloried in the Volto Santo at Lucca; the tomb of St. Francis (d. 1226) and the Porziuncola near Assisi; the tomb of St. Anthony (d. 1231) at Padua; and the reputed Holy House at Loreto. France prided itself on St. Martin's tomb (d. 397) at Tours, Mont-Saint-Michel, the Marian shrine at Le Puy, the alleged relics of the Madeleine at Vézelay, and, after 1206, the reputed head of the Baptist at Amiens. At Bruges, Belg., in the mid-12th century, was a vial alleged to contain the Holy Blood. In Germany, not only the authentic tomb of St. Boniface (d. 754) at Fulda but the reputed relics of the Holy Coat at Trier and of the Magi at Cologne were widely reverenced. In England, Durham claimed the transfer of St. Cuthbert's relics in 999; Canterbury was renowned for the tomb of St. Thomas Becket (d. 1170), while from the mid-12th century Walsingham was honoured as the chief Marian sanctuary. In Ireland, the tomb of St. Patrick at Downpatrick was a pilgrim resort, as in Poland after 1382 was the icon of the Virgin at Czestochowa.

Churchmen were not unaware of problems connected with pilgrimages. Caesarius of Arles in the 6th century warned against moral excesses, and Guibert of Nogent in the 12th questioned the authenticity of many relics (*see* RELIC). The 15th-century author of the *Imitation of Christ* observed: "they that go much on pilgrimage be seldom thereby made perfect and holy."

The attitude of the 16th-century Reformers found expression in 1530 in the Augsburg Confession, which portrayed pilgrimages as "childish and useless works," as well as in the destruction in 1538 of the shrines of St. Thomas at Canterbury and of St. Cuthbert at Durham. While modern Protestants visit Luther's grave at Wittenberg or the Wesleyan Memorial at Epworth, Eng., or the Museum of the Desert at Mas Soubeyran, France, these are not regarded as devotions. Among certain Anglicans, however, there has been a revival of pilgrimage to Walsingham.

For Roman Catholics, the Holy Year of Jubilee is essentially a pilgrimage to Rome (*see* JUBILEE, YEAR OF). On Feb. 11, 1936, the Sacred Congregation of the Council issued instructions requiring that pilgrimages be provided with spiritual directors, and on Sept. 8, 1953 (*Fulgens corona*), Pope Pius XII called for pilgrimages to the sanctuaries of the Virgin as one form of observance of the Marian Year (1953–54). Though many medieval centres still attract Catholic pilgrims, the more recent shrines of St. Francis Xavier (d. 1552) in Goa, India; of the Holy Shroud (1578) at Turin, Italy; of St. Anne de Beaupré (1658), Canada; of St. John Vianney (d. 1859) at Ars and of St. Thérèse (d. 1897) at Lisieux, both in France; and the Marian centres of Guadalupe (1531) in Mexico, of La Salette (1846) and Lourdes (1858) in France, of Pompeii (1876) in Italy, and of Fátima (1917) in Portugal have steadily grown in importance. (H. G. J. B.)

In countries of the Eastern Orthodox faith, worshipers commonly make pilgrimages to celebrated monasteries, to ask spiritual and practical help from the holy men (*startsi*). St. Seraphim (*q.v.*) of Sarov was sometimes visited by thousands of pilgrims in a single day. In *The Brothers Karamazov*, Dostoevski depicts the spiritual power and influence upon pilgrims of Zossima, an example of such a *starets*. (X.)

Islam.—Pilgrimage is a very ancient Semitic religious custom, and in pre-Islamic days the pilgrimage to 'Arafat at Mecca on the 9th day of Dhu 'l-Hijja was participated in by many and diverse tribes. Large commercial and cultural fairs were also associated with the pilgrimage. Certain striking parallels have been suggested between the 'Arafat pilgrimage and the Jewish Feast of Booths, revealing a common ancient Semitic tradition. When Islam became the religion of Arabia, this rite of pilgrimage was taken over and made a fundamental obligatory duty of a Muslim—the "fifth pillar" of Islam—by a koranic pronouncement in the year 2 A.H. (A.D. 623–624), necessary adjustments being made to remove all traces of a belief in gods. The pilgrimage is called *hajj* (or *hadj*), a word of uncertain etymology.

The condition that a person should be in sound physical and financial state to undertake the pilgrimage explains the fact that, although it is a duty devolving on every Muslim once in his lifetime, the number of pilgrims is relatively small. Even so, in the mid-20th century the annual average was around 80,000, and the *hajj* provides a unique occasion for strengthening international unity among Muslims and a genuine forum of discussion for Muslim religious and political leaders. For a description of the ritual of the *hajj*, *see* MECCA: *The Pilgrimage*; *see* also ISLAM: *Muslim Theology: The Five Pillars*. (F'U. R.)

Buddhism.—While there is no rule prescribing pilgrimage for the Buddhist, many places and shrines are centres of Buddhist pilgrimage. Four of these places, held in special regard, are in north India, where Gautama Buddha proclaimed the Buddhist Way of life leading to Nirvana; as the teaching of the Way is held to be the noblest charity, so a reverent gratitude for it is the primary motive of Buddhist pilgrimage.

In the Theravada tradition, this gratitude means a special veneration for places associated with the Buddha's life and teaching and for shrines where, it is believed, his relics are preserved, such as the Temple of the Tooth at Kandy, Ceylon, and the Shwe Dagon Pagoda at Rangoon, Burma. Shrines containing notable images of the Buddha, such as the beautiful temple of the Emerald Buddha in Bangkok, Thailand, also attract many pilgrims.

In Mahayana Buddhism, gratitude for the teaching of the Way is extended to include founders of sects. Thus in Japan, besides pilgrimage to the famous Buddha images preserved at Kamakura and Nara, pilgrims gather before the image of one of the great teachers of the Pure Land version of the faith, Shinran, at Hongwanji. In China some of the most popular mountain shrines are dedicated to the compassionate Bodhisattvas of the Mahayana tradition, including the temple of Mount Omei in Szechwan Province, which is dedicated to the Bodhisattva Samantabhadra.

A new interest in pilgrimage is one of the signs of resurgent 20th-century Buddhism. Pilgrimage is also encouraged by the pan-Buddhist movement, which seeks to bring Theravada and Mahayana Buddhists together. The Deer Park at Sarnath near Varanasi (Benares), where the Buddha gave his first instructions in the Way, "setting in motion the Wheel of the Law," and which the Maha Bodhi Society takes special interest in preserving, attracts Buddhists from all parts of the world. Buddh Gaya (*q.v.*), also in northern India, is especially venerated as the place where the Buddha attained enlightenment. Together with his birthplace in Nepal, and Kusinara, where he passed to Nirvana, these sites are commended as places of pilgrimage in the Pali scriptures; pilgrims who set out to visit any one of these four places are encouraged by the assurance that if they die on the way they will be reborn in a heavenly condition. In the Mahayana text, the "holy places of pilgrimage" are described as "ladders to heaven by divine sages and saints whose souls are intent on devotion." This is a reflection of Indian thought; the attitude to pilgrimage most characteristic of Buddhism associates gratitude to a teacher of the Way with thought of greater devotion to the Way which may come with such remembrance. (R. H. L. S.)

Hinduism.—As the sublime and the beautiful in nature are aids to contemplation, the Hindus chose hilltops, mountain slopes, river banks, and the seashore as sites for temples. Visits to temples are pilgrimages for the Hindu in search of peace of soul or the fulfillment of a long-cherished desire. Many thousand pilgrims

visit the Shiva temples at Rameswaram and Chidambaram in Madras and at Varanasi (Benares) and Kedarnath in Uttar Pradesh; the Vishnu temples at Trivandrum in Kerala and Srirangam in Madras, and temples at Pandharpur in Maharashtra and Vrindaban in Uttar Pradesh dedicated to Krishna, considered an incarnation of Vishnu; Rama temples at Ayodhya in Uttar Pradesh where Rama, the hero of the Ramayana, lived and ruled; Shakti temples at Cape Cormorin in Kerala, Madurai and Kancheepuram in Madras, Varanasi, Kalighat in West Bengal, and Kamakhya in Assam, Nabadwip in West Bengal where Chaitanya was born, Puri in Orissa where Krishna is worshiped, Dakshineswar near Calcutta, the scene of Ramakrishna's austerities, and the temple at Belur Math opposite Calcutta dedicated to his memory, also attract hundreds of thousands of people. "The holy ones impart sanctity to places of pilgrimage." To bathe in the seven rivers of India—the Ganges, Jumna, Godavari, Sarasvati (now dried up), Narmada, Indus, and Cauvary—is considered purifying, the Ganges being the holiest of them all. It is the ambition of every devout Hindu to bathe in the Ganges and visit the temple of Vishwanath (Shiva) in Varanasi. Seven cities—Ayodhya, Mathura, Hardwar, and Varanasi in Uttar Pradesh; Kancheepuram in Madras; Ujjain in Madhya Pradesh; Dwaraka in Gujarat—are said to possess the power to give salvation to visiting pilgrims. Manasarowar in Tibet is the most sacred of all lakes to the Hindu.

The *kumbha-mela, ardha-kumbha-mela,* and *purna-kumbha-mela,* which occur once in 3, 6, and 12 years respectively, are held in each of four places of pilgrimage—Hardwar and Allahabad in Uttar Pradesh, Ujjain in Madhya Pradesh, and Nasik in Maharashtra—by rotation. The *purna-kumbha-mela* draws millions of pilgrims.

Before leaving home the pilgrim resigns himself (or herself) to the will of God. He takes a minimum of baggage, including a rosary and a piece of carpet or deerskin on which to sit while meditating. On arrival at his destination, where he stays at least three days, he bathes, visits the temple twice, perhaps three times a day, arranges fruits, flowers, and sweets to be offered in the temple, gives some coins to the priests, tells his beads, reads a sacred book, avoids useless talk, and joins other pilgrims in attending recitals of religious music or expositions by a scholar in the afternoon or evening.

Pilgrimages have served to unite Hindus throughout India in a common cultural and religious consciousness, as well as to help the growth of commerce and industry. (S. GH.)

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PILGRIM FATHERS, the name given by posterity to those who settled the first permanent colony in New England at Plymouth, Mass., in 1620. These 102 settlers included 35 members of the English Separatist Church who had migrated to Leiden, Holland. They sought relief from the hard life in Holland and desired civil and religious autonomy within the English government. The remaining majority were a heterogeneous group from England, mostly of the Anglican Church, who came to America for various reasons. These first settlers did not become known as the Pilgrim Fathers until two centuries after their arrival. Contemporaries called them Old Comers while later generations referred to them as Forefathers, and during the colonial period the people of Plymouth celebrated Forefathers' Day in their honour. The celebration was revived in 1793, and at that time Rev. Chandler Robbins preached a memorial sermon in which he used a quotation from William Bradford's manuscript which he found copied into old church records. In this quotation, Bradford referred to the "saints" who left Holland as "pilgrimes" and this name struck a responsive chord. In 1819 the Pilgrim society was organized, its efforts dedicated to perpetuating the fame of the Forefathers. In this it was successful. The society promoted a bicentennial celebration in 1820 with Daniel Webster as speaker. His stirring address, which was later published, began: "We have come to this Rock to record here our homage to our Pilgrim Fathers . . . ." From this time on the Forefathers became Pilgrim Fathers in common usage. *See* also MASSACHUSETTS: *History.*

See William Bradford, *Of Plymouth Plantation 1620–1647,* ed. by Samuel Eliot Morison (1952); George F. Willison, *Saints and Strangers* (1945), (ed.), *The Pilgrim Reader* (1953). (B. K. B.)

PILGRIMS' WAY, a name that has remained for portions of the North Downs Ridgeway across the northern edge of the Weald of Kent, Eng. It is a prehistoric track used as the route between Kent and Wiltshire at the latest from the Iron Age. This ridgeway is still partially in use, surviving often as roads for light traffic or bridle paths which are marked "Pilgrims' Way" in the Ordnance Survey. The term "Pilgrims' Way" is often used misleadingly as if it were synonymous and coextensive with the whole ridgeway. Both a ridgeway proper and, on the southern slope of the downs, a terrace way can be traced, but the precise route of the prehistoric track cannot always be determined, since such tracks were not fixed ways but in varying weather conditions shifted over a belt of country which might provide passage.

The name Pilgrims' Way, though not attested before the 18th century, gained further currency from the theories of Hilaire Belloc, who in *The Old Road* (1904) posited a continuous prehistoric track from Winchester to Canterbury, revived after long disuse by pilgrims journeying thither to visit St. Thomas Becket's shrine. It is of course not impossible that pilgrims used the North Downs Ridgeway (although the route normally used was the London to Canterbury road celebrated by Chaucer); its survival for considerable stretches as a fixed way must be due to use in Saxon and medieval times, when it would have provided a passable route when the lower roads were bad. But Belloc's "Pilgrims' Way" does not coincide with the known prehistoric track until it reaches the Hog's Back (traveling eastward), and the route he makes it take from Winchester to the Hog's Back is based on conjecture. The evidence against him is, however, largely negative: for instance, the virtual absence of large towns and religious foundations along much of his proposed route.

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PILIBHIT, a municipal town, the headquarters of a district of the same name in Rohilkhand division, Uttar Pradesh, India, about 30 mi. (48 km.) NE of Bareilly. Pop. (1961) 57,527. It is a junction on the Northern railway and is connected with Bareilly by a metaled road. The main industry is sugar manufacturing. There is a great mosque on the western outskirts built by Hafiz Rahman Khan (*c.* 1775), the founder of Pilibhit.

PILIBHIT DISTRICT is on the border between India and Nepal, on the foothills of the Himalayas. Pop. (1961) 616,225. Area 1,352 sq.mi. (3,502 sq.km.). It is a gentle undulating plain intersected by numerous southward-flowing streams. The north and northwest are a continuation of the Tarai (*q.v.*); the eastern section has undeveloped forest tracts; and the southeastern part is a low lying belt of moist alluvial soil producing grass and tamarisk, with an inhospitable climate. The southern extremities of the dis-

trict have richer soil akin to that of the Ganges plains, more stable cultivation and a denser population. Among its ancient monuments is a fortress near the railway station of Shahgarh (Dhopap). Its main crops are wheat, rice, sugar cane, gram and barley. The only other town of any size in the district is Bisalpur. (B. St.)

PILKINGTON, FRANCIS (?–1638?), English composer of madrigals and lute songs of great charm. Pilkington took a bachelor of music degree from Lincoln College, Oxford, in 1595. In 1602 he was appointed "chaunter" in Chester Cathedral and about 1612 became a minor canon. He held various benefices in and near Chester until his death, which probably occurred in 1638. His *First Booke of Ayres* (1605) contains 21 songs, which can be performed either with four voices or with solo voice and lute, and a "Pavin for the Lute and Bass Viol." This book was followed by two sets of madrigals published in 1613 and 1624. A small number of attractive lute solos by Pilkington have survived in English manuscripts. (D. Po.)

PILLORY, an instrument of punishment which consisted of a wooden post and frame fixed on a platform raised several feet from the ground, behind which the culprit stood, his head and his hands being thrust through holes in the frame (as are the feet in the stocks [*q.v.*]) so as to be held fast and exposed in front of it. This frame in the more complicated forms of the instrument consisted of a perforated iron circle, which secured the heads and hands of several persons at the same time, but it was commonly capable of holding only one.

In the statutes of Edward I it is enacted that every pillory or "stretch-neck" should be made strong enough to hold offenders without peril to their bodies. It was customary in the case of men to shave the head and beard wholly or partially; the hair of female culprits was cut off and in extreme cases the head was shaved.

England abolished the pillory except for perjury and subornation in 1816, and the perjurer Peter James Bossy was the last to stand in the pillory at the Old Bailey for one hour on June 22, 1830; the pillory was finally abolished in 1837. In France the instrument, called *carcan*, was used until 1832. In Germany it was known as *Pranger*. The pillory was employed in the American Colonies, and the U.S. federal statutes provided for its infliction until 1839; Delaware, the last state to use the pillory, did not abolish it until 1905. (R. G. Cl.)

PILOCARPUS (Jaborandi), dried leaves of the *Pilocarpus jaborandi* or *P. microphyllus* of Brazil and Paraguay formerly used medicinally to induce sweating and as a miotic. About 0.5% of the constituents of the leaves are alkaloids, including pilocarpine, jaborine, and pilocarpidine. The leaves are the chief source of pilocarpine hydrochloride, which is used as a miotic and antidote for atropine poisoning.

PILON, GERMAIN (1535–1590), French sculptor of the Renaissance, was born in Paris in 1535. He was perhaps a pupil of Bontemps and more than once carried out designs by Primaticcio. Starting as a somewhat italianate, mannered sculptor he developed curiously enough in a more realistic (and in a sense, native) direction without, however, carrying French sculpture as a whole with him. The classic foundations had definitely been laid in France. Pilon was the author of the monument for the heart of Henry II (though the design was possibly by Primaticcio), in which the three Graces of marble that support the urn are of great elegance. Pilon was also employed on the tomb of Henry II in St. Denis, France (designed by Primaticcio). The greatest of his portraits is undoubtedly the kneeling figure of Chancellor de Birague (Louvre). Pilon apparently was also a medallist of distinction, although it is disputed whether he merely made the wax models or also cast the medals. Pilon died on Feb. 3, 1590.

See H. Vollmer, *Jean Goujon und die französische Renaisanceskulptur* (1923). (A. K. McC.)

PILOTAGE, in its modern aspect, may be described as the services rendered by a trained individual to a vessel entering or leaving a port, or to a vessel navigating waters for which national legislation requires that such vessel be under the control of a pilot specifically licensed to operate in them. A pilot serves as technical adviser to the master of the vessel; when both are on the bridge, the pilot's orders have the same effect as those of the master unless the latter disapproves. The master may control the actions of a pilot or even overrule him if he feels it necessary to assure the safety of his ship or to avoid imminent danger.

The present practice of pilotage is entirely different from the original concept. References to pilotage or pilots in the Bible, in Homer, and in Virgil indicate that in ancient days pilotage was the full-time service rendered to a vessel or vessels by a person skilled in navigation. Thus, the pilotage services rendered to an ancient or medieval vessel were analogous to the services rendered to a modern vessel by its full-time navigator.

Historical Development.—With the discovery of the New World and the accompanying period of exploration and conquest, pilotage assumed such importance that the nations seeking possessions in the Americas appointed individuals as chief pilot, pilot major, or grand pilot of the realm. For example, Spain appointed the Italian explorer and navigator, Amerigo Vespucci, as chief pilot in 1508. In this capacity, Vespucci was responsible for the preparation of charts for use by all other Spanish mariners. England followed this practice in 1549 with the appointment of Sebastian Cabot as grand pilot.

In addition to navigating their vessels safely over the oceans, pilots of that period were expected to accumulate hydrographic material during each voyage and thereafter transfer such material to nautical charts for the use of other navigators in both peace and war. However, as the maritime horizons of the world expanded with each new discovery or conquest, it became apparent that a vessel's safety while operating in strange harbours would be enhanced if, in addition to the regular ocean pilot, an individual learned in the currents, tides, and depths of the particular harbour or coast were engaged to assist the master in moving his vessel through such waters. Thus, there arose another phase of pilotage known as harbour, bay, or bar pilotage. In England as early as 1369 certain guilds or associations of pilots were established at principal maritime centres such as Newcastle, Kingston upon Hull, and Leith. Subsequently, there was established at such centres, by royal charter, a corporation which was to provide pilotage in and out of the ports under the jurisdiction of the corporation and to prevent unqualified persons from undertaking to pilot vessels. These corporations usually assumed the name of Trinity House of the port or district placed under their jurisdiction. Trinity House of Hull, for example, is believed to have been established in 1369 and was incorporated during the reign of Henry VIII (1541). The present pilotage system in England continues to be centred around Trinity House organizations.

The modern term "pilot" appears to have had its origin in the Netherlands. One authoritative source states that the word is derived from the Dutch words *pijl* and *lood*. The first word means "pole" and in Dutch connotes everything vertically straight, and the second word means "lead," as in sounding lead. Another source equally as authoritative also attributes the origin of the term to the Netherlands but holds that it is derived from the old Dutch word *piloot*, which specifically denotes one who works a vessel into a port, or over a bar, or through a channel or passage. The Netherlands is also the nation in which the first professional local pilotage system was established, in 1749. Franz Naerebout announced in that year that he was "a professional *pijl loods* ready to take sailing ships in and out of the harbours of Holland, the depths of which he had studied until he knew the location of every danger spot."

The available records of professional pilotage during the colonial period preceding the birth of the United States are sketchy at best and give only isolated incidents to indicate that an individual, or a group of individuals, was engaged in the profession of bar pilot. In New York, there is a record that the barge which conveyed George Washington from Elizabethtown to New York City for his first presidential inauguration was manned by 13 pilots. In Boston, Capt. John Gallop piloted the ship "Griffin," bearing the Rev. John Cotton and Thomas Ieveretti into Boston Harbour in 1633. There is another record that the keeper of the first Boston lighthouse, George Worthylalse, served also as a regular pilot of Boston Harbour in 1716. In the Chesapeake Bay area, Col. William Burges in 1676 employed a pilot for an expedition which was

sent from St. Mary's to the Nanticoke Indian territory. An additional record in this area reveals that the first act to improve navigation, passed by the Virginia House of Burgesses in 1660, had as its purpose the creation of a chief pilot for the James River.

Pilotage Laws.—One of the first acts of the First Congress of the United States expressly provided for the continuance and expansion of the state pilotage systems such as those established by Massachusetts and Pennsylvania. It appears that the Congress was fearful that the state systems would be eliminated under the commerce clause of the U.S. Constitution and passed the act to avert such a development. Substantiation that existing state laws were bodily adopted by the federal government is found in the decision of Chief Justice John Marshall speaking for the U.S. Supreme Court in the case of *Gibbons* v. *Ogden.*

The preservation of the state system of pilotage did not in itself establish a safe and adequate pilotage service for the major harbours of the United States. Monopolies by state pilot associations often resulted in pilots competing in a mad race at sea to gain the first incoming ships. In many instances pilots raced together for one ship while other ships, trying to ride out the storms and inclement weather, signaled frantically for a pilot to no avail. Two major marine casualties involving the packet ship "Mexico" and the barque "Bristol" were directly attributable to Sandy Hook pilots who not only refused to furnish pilotage to these vessels until a storm abated but would not allow New Jersey pilots to furnish this service. This unsavoury state of affairs received the attention of Congress in 1837 when it authorized the master of any vessel coming into or going out of any port situated upon waters which are the boundaries between two states to employ any pilot duly licensed or authorized by the laws of the states bounding on such waters to pilot the vessel to or from such port. In 1851 Congress required that all passenger-carrying steamboats be placed in the charge of federally licensed pilots. Since no exception was made permitting state pilots to operate if not federally licensed, some federal courts held that unless state pilots were federally licensed they could not operate on the navigable waters of the U.S. This view was set aside by the Supreme Court in 1864 when it decided that the act of 1851 was not intended to cover "port pilots."

Apparently, however, Congress had intended that all pilotage on the navigable waters of the U.S. be by federally licensed pilots, for on July 25, 1866, it passed an act requiring every United States seagoing steam vessel navigating the bays, inlets, rivers, and harbours of the United States to be under the control of a federally licensed pilot. The next year a congressional committee reviewed the effect of this legislation on national maritime safety and stated that the act of 1866 had virtually abolished state pilotage over U.S. vessels without providing any substitute, since the federal pilotage acts did not require an examination on knowledge of particular ports or harbours. The committee concluded, therefore, that until Congress should enact a general pilotage law, the state systems should be continued. Congress accepted this view and amended the act of 1866 by adding a proviso that the act should not be construed "to annul or affect any regulation established by the existing law of any State requiring vessels entering or leaving a port in such State to take a pilot duly licensed or authorized by the laws of such State, or of a State situated upon the waters of the same port." In 1871 Congress passed a new steamboat inspection law which required coastwise seagoing steam vessels not under registry to have a federally licensed pilot on board when under way, except on the high seas. When this act was drafted there was no exemption for registered vessels of the United States, and it was the apparent intention of the Steamboat Inspection Service to limit state or bar pilotage to foreign vessels. However, the original draft of the bill was changed in committee to restrict federal pilotage to licensed, or enrolled and licensed, vessels of the United States.

The deepening and expanding of the St. Lawrence-Great Lakes Seaway opened an entirely new phase of pilotage in the United States. Pilotage requirements were needed for all oceangoing vessels navigating U.S. waters of the seaway. Also, coordination with a regulated Canadian pilotage system was necessary. After several years of international consultation, the Great Lakes Pilotage Act of 1960 was passed. Under this act, no vessel that is required by any other national law to have in its service, and actually has in its service, pilots licensed by the U.S. Coast Guard for the navigation of the Great Lakes is required to employ the services of a Great Lakes registered pilot. Also, Canadian vessels of certain types may be navigated in United States waters without a pilot registered under the Great Lakes Pilotage Act as long as Canada permits enrolled vessels of the United States to be navigated in Canadian waters of the Great Lakes by their officers. All registered vessels of the U.S. and foreign vessels navigating those waters of the St. Lawrence and the Great Lakes designated in the presidential proclamation issued on Dec. 22, 1960, are required to have in their service a U.S. registered pilot or a Canadian registered pilot for the waters concerned. The administrative control over the registering of U.S. pilots for these waters is vested in the secretary of commerce. The secretary published extensive regulations on Jan. 30, 1961, covering those persons who were eligible for registration, the manner in which such registration could be suspended or revoked, and the rates, charges, and conditions for pilotage services.

In addition to the compulsory pilotage required on the St. Lawrence-Great Lakes Seaway, registered vessels of the United States and all foreign vessels, entering or leaving harbours of most states bordering on the Atlantic and Pacific oceans and the Gulf of Mexico, are required by state statute to employ a pilot licensed by a board of state pilot commissioners and to pay the fees established by state law for such services. If a vessel required by state law to have a state pilot aboard refuses or neglects to engage such pilot, most state laws authorize the collection of the full pilotage fee nevertheless. No vessel may transit the Panama Canal without having on board a pilot licensed by the Panama Canal Company. Foreign vessels operating on the navigable waters of the U.S., such as Long Island Sound or the Mississippi River, are not required either by national or state statute to be under the control of a licensed pilot. (F. K. A.)

PILOT FISH (*Naucrates ductor*), a pelagic fish of the jack or pompano family (Carangidae), well known to sailors from its habit of keeping company with ships and large fishes, especially sharks. It inhabits all tropical and subtropical seas, and in the summer the fish may also be found in temperate seas. It accompanies both ships and sharks for the waste food which it derives from them. The pilot fish does not attach to the larger object as does the remora (*q.v.*) but swims freely in the water. It is probable that, except in confinement, neither the pilot fish nor the remora is ever attacked by the shark. The pilot fish attains a length of one or two feet. A sharp keel runs along the middle of each side of the tail. The teeth are small, arranged on bands. Five to seven dark-blue or violet crossbands traverse the bluish body from back to belly. The pilot fish spawns in the open sea. *See* also FISH: *Mullets, Silversides, Barracudas, etc.* (C. HU.)

PILOT WHALE, the name given to whales of the genus *Globicephala*, which travel in large schools following a leader. They are valued for their meat and oil in the Faeroe Islands where the inhabitants capture them by driving schools ashore in the fjords. Also called caa'ing whale or blackfish, the pilot whale is one of the medium-sized toothed whales. It reaches about 25 ft. in length and is characterized by the blunt rounded profile of the forehead and slender, pointed flippers. The colouring is mainly black, with a lighter splash on the throat and chest. Pilot whales feed on squids and fish, and are found throughout the oceans of the world. *See* also WHALE: *Family Delphinidae.* (L. H. M.)

PILOTY, KARL VON (1826–1886), German painter, the foremost representative of the realistic school in Germany, was born at Munich on Oct. 1, 1826, the son of Ferdinand Piloty (d. 1844), noted as a lithographer. His picture of "Seni at the Dead Body of Wallenstein" (1855) gained for the young painter the membership of the Munich Academy, where he became professor. He executed a number of mural paintings for the royal palace in Munich, and for Baron von Schach he painted the celebrated "Discovery of America." In 1874 he was appointed keeper of the Mu-

nich Academy, being afterward ennobled by the king of Bavaria. Piloty was a successful teacher, among his pupils being Makart, Lenbach, Defregger, Max and Grützner. He died at Munich on July 21, 1886.

PILSEN: *see* PLZEN (Czech.).

PILSUDSKI, JOZEF (1867–1935), Polish revolutionary statesman and marshal, the chief restorer of his country's independence after World War I, was born on Dec. 5, 1867, at Zulow, in the Wilno (Vilnius) Province, the second son of an impoverished Polish nobleman. His mother, née Maria Billewicz, inspired him with hatred for the tsarist regime, which was treating the Poles with great harshness after their anti-Russian insurrection of 1863. On leaving school in Wilno, Pilsudski started studying medicine at Kharkov in 1885 but was rusticated in 1886. Returning to Wilno he consorted with young socialists and studied Karl Marx, though he was interested more in practical revolution than in theory. In 1887 he was arrested on a charge of plotting the assassination of the emperor Alexander III. Though innocent of the charge, he was banished for five years to eastern Siberia.

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JOZEF PILSUDSKI AS PRIME MINISTER OF POLAND IN 1930

Pilsudski returned to Wilno in 1892 determined to prepare an insurrection and, with the help of the Polish working class, to re-establish Poland's independence. He joined the newly founded Polish Socialist Party (PPS) and in 1894 became its leader. He started a clandestine newspaper, *Robotnik* ("The Worker"); but in February 1900 his press in Lodz was accidentally discovered, and he was arrested with his first wife, formerly Maria Juszkiewicz. Incarcerated in the Warsaw citadel, from which there was no hope of escaping, he feigned insanity so as to secure his transfer to a military hospital in St. Petersburg, from which, in May 1901, he escaped. He then settled at Cracow, in Austrian Poland. In winter 1905–06 he visited London.

Pilsudski knew that without external aid no Polish rising could succeed. When the Russo-Japanese War broke out, he went to Tokyo in July 1904 to solicit Japanese assistance. Roman Dmowski (*q.v.*) was already there; and Dmowski told the Japanese that Pilsudski's plan was impracticable. The two Poles agreed to disagree.

After returning to Cracow, Pilsudski passed back to Russian Poland to direct the revolutionary movement which at the end of 1904 was spreading throughout the Russian Empire. When the revolution was put down in 1905, a split occurred within the PPS: the left wing, which proposed to delete from the party's program the stipulation that its main aim was an independent Poland, broke with Pilsudski's group, who insisted on the stipulation.

Aware of the Russian Empire's structural weakness and foreseeing war between Russia and the Central Powers, Germany and Austria-Hungary, Pilsudski concluded that it was imperative to form a Polish military organization as the nucleus of a future national army. This he began secretly in Lwow in 1908 and continued legally, with the help of the Austrian military authorities, from 1910. To a few friends he confided his belief that the Central Powers would be victorious against Russia, but would finally suffer defeat in the west; and that consequently Poles should side with them during the first phase of the war and turn against them later.

World War I justified Pilsudski's prediction. Until 1916 the three brigades of the Polish Legion, technically under the Austro-Hungarian high command, distinguished themselves on the Russian front, with Pilsudski commanding the First Brigade. On Nov. 5, 1916, the Central Powers, short of manpower, proclaimed the independence of Poland, hoping that Polish divisions would occupy large sectors of the eastern front so that German divisions could be moved to the west. Pilsudski, appointed head of the military department of the Polish Council of State, accepted the idea of a Polish army on condition that it should be part of a sovereign Polish state. His position was unexpectedly reinforced by the Russian Revolution of March 1917. The German government, however, refused to bind itself as to Poland's future, demanding instead that the existing Polish units should swear "fidelity in arms with the German and Austrian forces." Pilsudski, refusing this, was arrested in July 1917 and imprisoned in Magdeburg.

Released on the German collapse in the west, Pilsudski arrived in Warsaw on Nov. 10, 1918, as a national hero. Four days later he was unanimously accepted as head of state and commander in chief of the Polish Army. From that moment he ceased to be the man of a party, though his main support came from the left and from the centre; the right saw its leader in Dmowski, who was then heading the Polish National Committee in Paris and was appointed by Pilsudski to be Poland's first delegate at the peace conference.

Pilsudski devoted himself to protecting Poland against the Red Army, which was trying to fight its way into Germany in order to consolidate the revolution there. He led the Polish forces far to the east, occupying large areas of historic Poland. These areas he proposed to bring into a federal state, whereas Dmowski argued that they should be annexed on the basis of pure and simple incorporation within the new Poland. In 1920 a counteroffensive by the Red Army forced the Poles to retreat almost to the suburbs of Warsaw; but Pilsudski, made marshal of Poland on March 19, conceived and directed a maneuver that in August brought victory to Polish arms. (*See* RUSSO-POLISH WAR.)

As head of state, Pilsudski visited Paris in February and Bucharest in September 1921. After the adoption of a new constitution and a new general election, he transmitted his powers on Dec. 14, 1922, to his friend Gabriel Narutowicz, the newly elected president of the republic, who two days later was assassinated. Stanislaw Wojciechowski, another of Pilsudski's old friends, was next elected president, Pilsudski agreeing to serve as chief of the general staff. When a right-wing government assumed power Pilsudski resigned his post (May 29, 1923) and went into retirement at Sulejowek, near Warsaw, with his second wife, née Aleksandra Szczerbinska, and his two daughters.

Pilsudski returned to power in 1926, at a time of economic depression and disillusion over the working of the parliamentary system: on May 12 he marched on Warsaw at the head of a few regiments, and on May 14 Wojciechowski and his government resigned. The National Assembly elected Pilsudski president of the republic on May 31, but he refused the honour, and his friend Ignacy Moscicki was elected instead. In the new government, formed on May 15, Pilsudski took the ministry of defense, which he held till his death.

From Oct. 2, 1926, to June 27, 1928, and again from Aug. 23 to Dec. 4, 1930, Pilsudski was prime minister. During that period he became bitter and intolerant. To "cleanse" political life, he had 18 members of the *sejm* arrested on Sept. 10, 1930, including Wincenty Witos (Polish Peasant Party), Wojciech Korfanty (Christian Democratic Party), and Herman Liberman (Polish Socialist Party). Thenceforward Pilsudski ruled as a dictator.

Always interested in foreign policy, Pilsudski actually controlled it from 1926: the two foreign ministers, August Zaleski and Jozef Beck, were his nominees. At a time of tension with Germany, a Polish-Soviet nonaggression treaty was signed (July 1932) on Pilsudski's initiative; and in 1933, when Hitler became German chancellor, Pilsudski ordered military moves, including the reinforcement of the Polish base at Westerplatte, on the territory of the Free City of Danzig. On Hitler's proposal a declaration renouncing all use of force between Germany and Poland was signed in Berlin in January 1934, but Pilsudski refused to meet with Hitler.

Pilsudski died of cancer of the liver in Warsaw on May 12, 1935. He was buried in a crypt of the Wawel Cathedral in Cracow, among the remains of Polish kings and other leaders. His writings, speeches and orders of the day were published in Warsaw in ten volumes (1930–36); selections in English appeared in 1931.

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PILTDOWN MAN (*Eoanthropus dawsoni*) was the name given to remains (brought to scientific notice in 1912) that had been artificially treated to simulate a primitive form of man. The forgery was sufficiently convincing to generate scholarly controversy that lasted about 40 years. Apparently fossilized fragments of cranium and jawbone were found in a gravel formation at Barkham Manor, on Piltdown Common near Lewes, Eng.; together with these were fossil remains of extinct animals, which supported an early Pleistocene dating of the site, and worked implements of bone and flint, the latter attributable to a very early human culture (pre-Abbevillian). In 1926 the gravels were found to be much less ancient than supposed and in 1953 and 1954, as an outcome of more recent discoveries of fossil man and intensive reexamination, the remains were shown to be skilfully disguised fragments of a quite modern human cranium and ape (orang) jaw fraudulently introduced into the shallow gravels, as were the implements and animal bones. These results confirmed the arguments and evidence, first put forward by J. S. Weiner of Oxford University, pointing to the fraudulent nature of the Piltdown materials.

Piltdown "man" was distinct from *Pithecanthropus* (Java man), Neanderthal, and modern man in combining a large modern-looking brain case, devoid of marked eyebrow ridges, and a chimpanzeelike jaw. Sir Arthur Smith Woodward's reasons for accepting this as an ancestral form of man were that all the remains were found very close together; the lower jaw and the brain case were of a similar brown colour and apparently in the same state of fossilization; and although the jaw itself was apelike, the molars were worn to a flatness expected in a human type and the canine tooth was worn in a way never found in modern apes.

Objections by British, U.S., and French anatomists who regarded the finds as the coincidental mingling of a fossil ape and a fossil man failed to refute these arguments. Nor could it be proved that the jaw would not fit the brain case, for the critical part of the mandible was missing. In 1915 a find at Sheffield Park, two miles away, again pointed to an association of simian jaw and *sapiens*-like cranium.

As long as the remains could be accorded a high antiquity, Piltdown man seemed a feasible alternative to *Pithecanthropus* (then known only from scanty remains) as an ancestor for modern man. From 1930, many more finds of *Pithecanthropus*, the discoveries of the still more primitive *Australopithecus*, and further examples of Neanderthal man (*see* MAN, EVOLUTION OF) left Piltdown man completely isolated in the evolutionary sequence. It was often supposed to have represented a specialized line that had failed to develop.

In 1949 K. P. Oakley showed, by means of the fluorine dating technique, that the remains were not of great antiquity but that jaw and brain case were of similar geological age. This provided a new reason for insisting on their association, but it made Piltdown man not only morphologically anomalous but also chronologically aberrant. To deny the association meant accepting the existence of a fossil ape at an improbable date and allowing the coincidence of fossil ape and man at two different sites.

This dilemma could only be resolved by supposing that the original discovery was a forgery. The bony remains and the associated fauna were therefore analyzed by anatomical and radiographic examination of the jaw, teeth, and cranial fragments and by chemical investigations of the bone and stone implements. The jaw and cranium proved to have differing contents of fluorine, nitrogen, uranium, organic carbon, and organic water, these differences all indicating that the jaw was of relatively recent date and the cranium somewhat older. Carbon-14 dating in 1959 confirmed these conclusions (*see* GEOCHRONOLOGY). Chemical tests revealed that the fragments had been deliberately stained, some with chromium and others with acid iron sulfate solution—neither chromium nor sulfate occur in the locality—and that although the associated remains were of genuine extinct animals they were not of British provenance. X rays demonstrated that the molar teeth were similar to those of the orang. The peculiar dental wear resulted from artificial abrasion to simulate the human mode of flat wear. One of the fragments from the second site was shown to belong to the first skull.

The outcome of this exposure has been to clarify the human sequence of evolution by removing the greatest anomaly in the fossil record. At the same time, a series of valuable new tests were developed for paleontological study.

For scientific papers dealing with all aspects of the exposure, see *Bulletin of the British Museum (Natural History)*, vol. 2, no. 3 and 6. For an account of the finds at Piltdown and for a discussion of the authorship of the deception and the tests carried out, *see* J. S. Weiner, *The Piltdown Forgery* (1955). (J. S. WE.)

PIMA, a tribe of American Indians concentrated in the 1960s (pop. about 7,500) on the Gila River and Salt River reservations in Arizona. They are closely related to the Papago (*q.v.*), their historic neighbours to the south, and to the Nevome (Pimas Bajos) in Sonora, Mex. They practised irrigation and lived in permanent though rudely built villages. In their territory are the adobe ruins of the prehistoric pueblo Casa Grande and miles of ancient ditches. Divided into five patrilineal totemic groups, they make fair pottery and excellent basketry. The Pima differed much from the other sedentary and agricultural natives of the Southwest, the Pueblo Indians (*q.v.*). Estimated at 2,500 in 1775, they were consistently friendly to the Europeans. The Pima long withstood the Apache courageously, fought back the hostile Yuman tribes, and sheltered those that took refuge with them.

Piman (Sonoran) speakers extended from Arizona to Jalisco, Mex., and, besides the Pima and Papago, included the Huichol and Cahita (*qq.v.*), Opata, Tarahumare, Tepehuane, Tepecano, Cora, and other groups. *See* also HOHOKAM.

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PIMPERNEL, the name for small plants of the genus *Anagallis*, primrose family (Primulaceae). The most widely known is the scarlet pimpernel (*A. arvensis*), called also shepherd's clock and poor man's weatherglass, native to Europe and widely naturalized in North America, often becoming a nuisance. It is a delicate annual with diffusely branching stems, with small, opposite, somewhat clasping leaves, black-dotted beneath. Its scarlet or white (rarely bluish) flowers, about one-fourth inch across, usually with a darker centre, close at the approach of bad weather, hence some of the popular names.

PIN, a peg or bolt of wood or metal used for fastening or support; more commonly a small pointed and headed piece of stiff wire used to secure clothing, papers, etc.

The earliest known pins were made of bronze. Ancient Egyptian tombs have yielded specimens ranging from two to eight inches in length and finished with gold heads or with decorative gold bands circling them at the top. Both the Greeks and Romans employed pins or brooches similar to the safety pin for fastening clothing such as the tunic and the chlamys.

In medieval Europe, early pins were skewers of wood, bone, ivory, silver, gold, and brass. Elaborate metal pins of this type were made by hand and were so costly that only persons of wealth could afford them. The wooden skewer remained the common pin of the poor until the middle of the 16th century.

Pins of drawn iron wire were made during the 15th century, and by the latter part of that century the manufacture of wire pins was well established, particularly in France. The best quality pins of this period were made of brass. Despite early restrictive legislation in England, the demand for pins in that country was met largely by French makers, a condition that prevailed until about 1626, when John Tilsby, of Gloucestershire, Eng., established domestic manufacture on a firm basis.

Pins of this period were commonly made by coiling a wire, somewhat thinner than that used for the pins, around a spit on a lathe and cutting it into sections of two coils each. These coils were annealed (softened), attached to the ends of pins cut to proper length, and pressed in a die to secure them to the pins. The head

was then soldered onto each pin and the other end was sharpened, after which the pin was straightened and blanched.

Machine-made pins were introduced during the early part of the 19th century. Pinmaking machines were patented in England and the United States, and in both countries mechanical production of pins was established on a profitable commercial basis in the 1830s. In the U.S., the improved machines of Dr. John Ireland Howe were the basis for a successful manufacturing company he founded at New York, while Daniel Foote-Taylen, of Birmingham, Eng., profitably applied the patents of Lemuel W. Wright.

Subsequently many machines for making pins were developed. In general, all functioned in the following manner: stiff pin wire was drawn into the machine from a hank wound on a drum and was straightened by rapidly revolving rolls. A pin-length of the wire was gripped by a set of jaws so that the end of the wire extended a little beyond the jaws. This pin-length was struck several times by a header-die to form the head of the pin, and the pin-length was cut off, carried along a shaft, and passed over a series of files or cutters to point the end of the pin. The completed pins were cleaned by being rapidly tumbled in sawdust and then treated to give them a thin coating of tin. A sticking device thrust the finished pins through crimped papers. These pinmaking machines were so efficient that advancement to completely automatic manufacturing methods required few innovations in function or design. (E. L. Y.)

PINACEAE, the pine family of conifers, composed of trees (rarely shrubs) of north temperate regions. Many members are of considerable economic importance, yielding timber, paper pulp, oils and resins and some are much cultivated for ornament. Modern classifications admit nine genera: *Abies* (fir), *Keteleeria, Pseudotsuga* (Douglas fir), *Tsuga* (hemlock), *Picea* (spruce), *Pseudolarix* (golden larch), *Larix* (tamarack, larch), *Cedrus* (true cedar) and *Pinus* (true pine). Fir and true pines extend into lower latitudes at higher elevations, with the latter reaching Central America. The Pinaceae are monoecious (having male and female organs in the same individual) and have needlelike leaves, solitary, in fascicles, or on specialized short branches. The staminate or pollen-bearing cones are solitary or clustered, and consist of numerous spirally arranged scales, each bearing two pollen sacs. The ovulate or seed-bearing cones are compound; the numerous spirally arranged scales are free from the subtending bracts and bear two inverted ovules on their upper side. In the true pines the bract disappears in the mature cone. The embryogeny of the Pinaceae is complex; only one of the many embryos formed survives to maturity. There are two to many seed leaves, or cotyledons.

See also CONIFERS. (R. W. H.)

PINAR DEL RÍO, a province and its capital city in the westernmost section of Cuba. The population of the province in 1962 was 503,987; area, 5,212 sq.mi. (13,499 sq.km.). Low ranges form the backbone of the long, narrow province. The sandy soils of the southern plain produce some of the world's best tobacco. Pine forests have been much exploited. Copper at Matahambre has been mined since 1913.

The city of Pinar del Río was founded about 1775 and was given the official name of Nueva Filipina in 1800 as the capital of the western jurisdiction of Cuba. Its importance dates from about 1830 with the development of the tobacco industry of the Vuelta Abajo region. The population of the town was 3,000 in 1865 and reached 9,000 in 1900. With completion of the railway from Havana, 110 mi. distant, came the development of the city as a commercial centre of a large rural area. In addition to high-quality cigar tobacco, the region produces sugarcane, rice, pineapples, coffee, and livestock.

The city is situated in the hilly pinelands at about 160 ft. elevation near the base of the Sierra de los Organos, whose steep sides of porous limestone give the appearance of giant haystacks. The city is bordered on the east by the Arroyo Yagruma, a tributary of the Guamá River. Industries include the manufacture of cigars, cigarettes, and furniture. Since the completion of the Central Highway in 1931 with Pinar del Río as the western terminus, the city's population grew from 20,000 to 38,885 in 1953 and an estimated municipal population of 121,510 in 1962. (D. R. D.)

PINCHBECK, a gold-coloured brass named after London clockmaker Christopher Pinchbeck who first introduced the alloy (a brass containing about 15% zinc) in 1732 for the manufacture of imitation-gold jewelry. The term came to be used for any flashy or imitation jewelry. *See* BRASS: *Colours of Brass.*

PINCHOT, GIFFORD (1865–1946), pioneer of U.S. professional forestry and prominent public official, was born at Simsbury, Conn., on Aug. 11, 1865. He graduated from Yale in 1889 and afterward studied at the École Nationale Forestière, Nancy, France, and for briefer periods in Switzerland, Germany, and Austria. Upon his return he began the first systematic forestry work in the United States, in the Vanderbilt Forest, at Biltmore, N.C., in 1892. In 1896 he was made a member of the National Forest Commission that worked out the plan of U.S. forest reserves, and in 1897 he became confidential forest agent to the secretary of the interior, to examine and report upon the reserves. In 1898 he was appointed chief of the division, later the Bureau of Forestry, and then the forest service in the Department of Agriculture, which office he held under presidents McKinley, Roosevelt, and Taft until 1910. During the period of his administration the entire forest service system and administrative machinery was built up, and Pinchot's enthusiasm and publicity work did much for the conservation movement in general. He also served as a member of the Committee on Public Lands, 1903, and the Inland Waterways Commission, 1907. In 1908 he became chairman of the National Conservation Commission, and in 1910 president of the National Conservation Association. He founded the Yale School of Forestry at New Haven, as well as the Yale Summer School of Forestry at Milford, Pa., and in 1903 became professor of forestry at Yale. His books on forestry included *A Primer of Forestry* (1899) and *The Training of a Forester* (1917, 4th ed. rev. 1937). He was appointed state forester of Pennsylvania in 1920 and began a systematic administration of the forest areas of that state. With Theodore Roosevelt he helped to found the Bull Moose Party in 1912. From 1923 to 1927 and from 1931 to 1935 he was governor of Pennsylvania, and in his first term forced a reorganization of the state government and the establishment of a budget system. He was also able, in 1923, to settle an important anthracite coal strike by arbitration. He died in New York, N.Y., Oct. 4, 1946. His autobiography is *Breaking New Ground* (1947).

PINCKNEY, CHARLES (1757–1824), U.S. political leader, diplomat and influential member of the convention that framed the U.S. Constitution, was born Oct. 26, 1757, in Charleston, S.C. After the American Revolution, during which he was captured and held prisoner by the British, Pinckney served in the Continental Congress (1784–87) where he opposed abandonment of the right of navigation on the Mississippi, supported a more effective revenue system and urged a convention to revise the Articles of Confederation. As a member of the Constitutional Convention of 1787 Pinckney proposed a detailed plan of government generally referred to as the Pinckney plan. Though the original Pinckney draft was not preserved, it is known to have contained 31 or 32 provisions that were incorporated into the new federal constitution. Pinckney probably had as large a share in determining the style, form and content of the constitution as any one individual. He supported the ratification of the constitution in South Carolina, presided over the convention (1790) which remodeled the South Carolina constitution and as governor (1789–92) guided the early steps of adjustment between the state and federal government.

Pinckney began his political career as a Federalist but (1791) transferred his allegiance to the Jeffersonian Republican Party. He served that party in the South Carolina legislature (1792–96, 1810–14), as governor of the state (1796–98, 1806–08) and as U.S. senator (1798–1801) and U.S. representative (1819–21). He supported amendments to the state constitution that gave greater representation to the back country and established white manhood suffrage. In 1798 he opposed Federalist policies, thus estranging his cousins Charles Cotesworth Pinckney and Thomas Pinckney (*qq.v.*). In 1820 he bitterly assailed the proposed restrictions on slavery in Missouri.

As U.S. minister to Spain (1801–05), Pinckney negotiated a

convention providing for a joint tribunal to settle spoliation claims and the restoration to U.S. shippers of the "right of deposit" (temporary storage of goods) at New Orleans. He also won Spain's reluctant consent to Napoleon's sale of Louisiana, but the incorporation of part of West Florida into a U.S. customs district brought failure to his mission.

Pinckney died at Charleston, S.C., on Oct. 29, 1824.

See A. J. Bethea, *The Contribution of Charles Pinckney to the Formation of the American Union* (1937). (F. M. G.)

PINCKNEY, CHARLES COTESWORTH (1746–1825), U.S. soldier, statesman, and diplomat who was a participant in the XYZ affair, was born in Charleston, S.C., Feb. 25, 1746. With his younger brother Thomas he was educated in England at Oxford university and the Middle Temple, and at the French military academy at Caen.

Pinckney entered public service in 1769 as a member of the South Carolina assembly. He served in the first South Carolina provincial congress in 1775, on the council of safety, as chairman of the committee that drafted the plan of government for the colony and later in both houses of the South Carolina legislature. During the American Revolution he served as aide to General Washington at Brandywine and Germantown, Pa., and later commanded a regiment at Savannah, Ga. He was taken prisoner in 1780 at the fall of Charleston, was sent to Philadelphia, Pa., and exchanged in 1782 and was promoted to brigadier general in 1783.

In the Constitutional Convention of 1787, where he served with his cousin Charles Pinckney (*q.v.*), he opposed religious tests for office, suggested 1808 as the date to end the slave trade and favoured senate ratification of treaties as a check on the executive. He was one of the ablest defenders of the constitution in the South Carolina ratification convention. He was the architect of the provision in the state constitution of 1790 that provided two seats of government, one at Charleston and the other at Columbia, S.C.

When appointed U.S. minister to France in 1796 he was refused recognition by the French Directory and fled to Amsterdam, Holland. He returned to Paris the following year as a member of a commission that included John Marshall and Elbridge Gerry. When one of the group of French negotiators (later referred to in the correspondence as "X, Y and Z") suggested that the U.S. representatives offer a gift, Pinckney is said to have replied, "No! No! Not a sixpence!" (*See* XYZ CORRESPONDENCE.). The mission was a failure and an undeclared war between France and the U.S. ensued. Pinckney returned home and was commissioned a major general.

The unsuccessful Federalist candidate for vice-president in 1800 and for president in 1804 and 1808, Pinckney spent his later years in successful law practice. He also aided in the establishment of the South Carolina college (1801) and served as president general of the Society of the Cincinnati (*see* CINCINNATI, SOCIETY OF THE) from 1805 until his death on Aug. 16, 1825.

See C. C. Pinckney, *Life of General Thomas Pinckney* (1895). (F. M. G.)

PINCKNEY, THOMAS (1750–1828), U.S. soldier, politician, and diplomat who negotiated the treaty of San Lorenzo el Real with Spain, was born Oct. 23, 1750, in Charleston, S.C. With his older brother Charles Cotesworth Pinckney he was educated in England at Oxford university and the Middle Temple, and at the French military academy at Caen. He was admitted to the bar in 1774 in South Carolina and entered military service at the outbreak of the American Revolution. He was engineer at Fts. Johnson and Moultrie and served in the Florida campaign. After being wounded at Camden, S.C., and captured, he was sent to Philadelphia, Pa., and eventually exchanged.

Pinckney's plantation home, Auckland, was burned by British troops in 1779 and his slaves and livestock were carried away. After the war, Pinckney turned to law to recoup his fortune. He served as governor of South Carolina from 1787 to 1789 and as president of the state convention that ratified the federal constitution in 1788.

Pinckney was U.S. minister to Great Britain (1792–96) and envoy extraordinary to Spain (1795). *Persona non grata* in Britain, he bombarded the foreign office with demands and protests that were generally ignored. Bold, persistent and yet tactful in dealing with Manuel de Godoy of Spain, Pinckney negotiated the treaty of San Lorenzo el Real (1795), or the Pinckney treaty, whereby Spain surrendered all claim to territory east of the Mississippi river and north of 31° N. latitude, granted freedom of navigation on the Mississippi, extended the "right of deposit" (temporary storage of goods) at New Orleans and agreed to a joint settlement of claims and restriction of Indian depredations.

Pinckney was the Federalist candidate for vice-president in 1796 and member of the U.S. house of representatives (1797–1801). State rights in his views, he voted against the Alien and Sedition laws. As a major general in the War of 1812 he saw little active service but was with Gen. Andrew Jackson at the war's end. A scientific planter, Pinckney built dikes to reclaim salt marshes for rice culture, and imported English and Italian cattle to improve his dairy cattle and work oxen. He was a frequent contributor to *The Southern Agriculturist*. He served as president general of the Society of the Cincinnati (*see* CINCINNATI, SOCIETY OF THE) from 1825 until his death on Nov. 2, 1828.

See C. C. Pinckney, *Life of General Thomas Pinckney* (1895). (F. M. G.)

PINDAR (*c.* 518–*c.* 438 B.C.), the greatest of the Greek choral lyrists, is a poet of high rank and of special importance in Greek literature because he stands outside the main Ionic-Attic stream of development and embodies in his work a vision of the world that is peculiarly his own.

A biography of Pindar transmitted with his works in ancient times survives in four versions, much altered and corrupted, in medieval manuscripts. The earliest authority quoted is Chamaeleon (*c.* 300 B.C.). Material came from various sources in addition to the poems themselves. The account of Pindar's musical training goes back to scholarly work on the history of music; information relating to Thebes and Delphi was preserved by local ciceroni; the story of his reward by Athens was probably a rhetorical topic. There was also, as was usual in ancient biography, a certain embroidering of the theme with legend and anecdote.

His *floruit* (it is not known on what evidence) was placed in 480, the year of the Persian invasion, which on the usual reckoning would place his birth in 520. The date given by the biography is the 65th Olympiad (520–517). Pindar himself (fragment 193), however, dated his birth in a Pythian year, which in the 65th Olympiad would be 518. In view of the uncertainty of the dating by *floruit* and the possibility that the Olympiad is a mere deduction from it, many scholars have felt it open to choose between the Pythian years 522 and 518.

Pindar was born at Cynoscephalae, a village near Thebes, and Thebes itself was his home. There his house was shown as late as the 2nd century A.D. and to it was attached the famous story of its sparing by Alexander the Great in the sack of 335. He was no doubt of good birth, but the view that he was a member of the family of the Aegeidae rests on an uncertain interpretation of his words in *Pythian* v. 76. To his youth is attached the pretty story of the bees who built their honeycombs upon his lips as he slept, and anecdotes tell of his relations as pupil or competitor with the Boeotian poetesses Myrtis and Corinna. He was taught music by Scopelinus and like other boys of his social class had a literary education in the poets, among them Hesiod, in whom Boeotia could already boast a poet of Panhellenic stature. The rich traditions of Thebes must have filled his mind; there Cadmus had sown the dragon's teeth, there Dionysus and Heracles were born and there belonged the epic story of the Seven against Thebes and the tragic tale of Oedipus.

The education begun at home was continued in Athens, which at the end of the 6th century was pulsing with new artistic life. Of the two musicians named as his teachers Agathocles is recorded as the teacher of Damon but Apollodorus is unknown. It may reasonably be conjectured that in Athens he made the acquaintance of Aeschylus, a kindred spirit and near contemporary. His only epinician odes to Athenians are *Pythian* vii in honour of Megacles the Alcmaeonid and *Nemean* ii in honour of Timodemus, but one of his most famous poems was the dithyramb (fragment 76) in honour of Athens the "violet-crowned," in gratitude for which the

Athenians are said to have given him 10,000 drachmas and made him their representative at Thebes.

Of the external events of his adult life the biographical sources have little to tell. He is said to have been married and to have had two daughters and a son, Daiphantus, whose name was probably known from the poems, and to have had close relations with Delphi, where later the seat on which he used to sing was pointed out by the guides and where his descendants enjoyed certain hereditary privileges. For the rest the modern scholar is dependent on what can be deduced from his works with such aid as is given by the ancient commentaries. These scholia, along with some external evidence, make it possible to establish a reliable chronology for the *Olympian* and *Pythian* odes (see *Works*, below), which serves as a framework for an account of his literary career.

Pindar's first dated poem, *Pythian* x, was commissioned in 498 by Thorax, chief of the Aleuadae of Larissa in Thessaly. It is difficult to detect in it any marked traces of youth; in vocabulary it already shows some of his favourite words and it shows also the self-respect which characterizes him in relation to his clients. In 490 he made his first contact with Sicily (*Pythian* vi, xii) and in these early years he first wrote for patrons in Aegina, a city with which he seems always to have felt the closest sympathy (*Nemean* v, vii). In 480 came the Persian invasion in which Thebes went over to the enemy and Delphi, too, played a dubious part. In a poem of this time (fragments 110, 109) Pindar seems to have warned his townsmen of the dangers of war and counseled them to peace and quietness. After the Greek victory Thebes narrowly escaped destruction and *Isthmian* viii, without being explicit, reflects his mood. A few years later, however, he spoke without reserve in *Pythian* i of the glorious battles for freedom at Salamis, Plataea and Himera, and the war and his equivocal position as a Theban had no apparent effect on his career, which now reached its climax in his Sicilian period. It has been generally held, though there is no direct evidence, that he visited Sicily (476–474) as guest of Hieron of Syracuse; the strong tone of personal feeling in some of the Sicilian odes is easier to understand on that assumption.

In the years that followed, he maintained connection with Sicily and wrote for clients in various states, including Rhodes (*Olympian* vii) and Corinth (*Olympian* xiii) in 464. It is of special interest that the formal ode for Xenophon of Corinth can be supplemented by fragment 122 which gives a rare glimpse of Pindar in a lighter vein, somewhat embarrassed, perhaps, at having the temple prostitutes of Aphrodite as the matter of his song. Already in 474 he had written *Pythian* ix for a Cyrenaean and in 462 he wrote *Pythians* iv and v in honour of the king Arcesilaus. *Pythian* iv was commissioned by a Cyrenaean exile as a peace offering, and once more Pindar plays the part of adviser to a monarch, but without the intimacy that marks his relations with Hieron.

By 460 the rise of Athens had brought the danger of subjection to many Greek states, including Aegina, and it threatened, also, ways of thought and life to which Pindar was attached. The battle of Oenophyta in 457 brought Boeotia itself under Athenian domination, and it was not till after the battle of Coronea (446) that it regained its freedom. Aegina remained tributary to Athens. Pindar's position as an international poet must always have been difficult in difficult times. According to one version of the story his fellow citizens had fined him for his dithyramb in honour of Athens, and there are traces in his work of an effort to assure them of his loyalty. His last dated poem is *Pythian* viii for an Aeginetan in 446. It contains no overt political statement, but it has been thought to convey a veiled allusion to Athenian *hybris*, and it concludes with a prayer for the freedom of Aegina with the blessing of Zeus and its heroes Aeacus, Peleus, Telamon and Achilles. The exact date of Pindar's death is uncertain. He is said to have died in the arms of his favourite, Theoxenus, in the gymnasium or the theatre of Argos; the story may be an invention based on his striking love-poem in honour of Theoxenus of Tenedos (fragment 123).

By the time of his death the art of choral lyric as practised by Pindar was already outmoded, but it is clear from the papyri that he continued to be read into late antiquity, and his works afforded a rich field of study for ancient scholars. When his poems became known in western Europe (first edition 1513), he attracted imitators, among whom Pierre de Ronsard was especially influential, and the fashion for "Pindaric odes" continued in the 17th and 18th centuries (*see* PINDARICS).

Works.—Pindar's career was that of professional choral lyrist. Choral performances combining words, music and dance go back to great antiquity in association with religious festivals and important social occasions such as marriages and funerals, but by the 5th century they had become less specific and functional, so that dithyramb and tragedy might have "nothing to do with Dionysus" and the boundaries of the genres were partly obliterated. The forms cultivated by Pindar according to the Alexandrian edition, which presented his poems in 17 books, were the hymn, the paean, the dithyramb, the prosodion (procession song), the partheneion (maiden-song), the hyporchema (song with mimic dance), the encomion (panegyric), the threnos (dirge) and the epinician ode. The four books of the epinicians, arranged according to the four great festivals as *Olympian*, *Pythian*, *Nemean* and *Isthmian*, have been preserved. The other works are known only from fragments, but some of these are substantial enough to give an adequate idea of content, structure and style.

The epinician ode is an ode of victory in honour of a winner in the games. It is not one of the older forms and took shape in the 6th century, particularly in the hands of Simonides. There was a basis in improvised celebration, but the form as it has survived is highly literary. Though the structure is not fixed, there is a certain uniformity in content and arrangement. The occasion demands a reference to the victor and the nature and place of his victory; to this may be added reference to victories by members of his family or a compliment to his trainer. The contests are not described in detail; Pindar does not give the impression of an expert and interested spectator. Generally, but not always, there is a myth more or less elaborate and more or less relevant to the occasion. There also is a gnomic element of wise sayings and reflections on life either from the poet's own store or backed by ancient authority. These elements constitute a "program" that can be applied on all occasions. The poet may also speak in his own person in passages which reflect his own personality and his relation to his theme. Reference to gods, heroes and abstract powers gives the whole a colour of religious solemnity.

A few poems are in stanza form, but the metrical structure is mainly "triadic"; the unit is a system of three elements, strophe with metrically corresponding antistrophe and epode of different form. This system may be repeated at will; the longest poem has 13 such groups. Though Pindar mainly confines himself to two types of metre, the so-called dactylo-epitrite and Aeolic (*see* PROSODY, CLASSICAL), each poem is a new and elaborate structure and the composition represents a remarkable tour de force as compared with monodic lyric, which is constructed by the repetition of a simple fixed stanza. The poet was responsible, also, for the music and the choreography which must have contributed much to the effect.

The dialect of the odes is an international literary dialect fitted to be understood from Asia Minor to Sicily. It is influenced by epic and because of the history of the genre has a Doric colour with some elements of Aeolic; there is little trace of Pindar's native Boeotian. The style, which seems to bear the mark of his own personality, appears fully formed at the beginning of his career and remains remarkably constant. It is designed not to convey an ordered system of ideas, but to give a uniform poetic colour and to secure a uniform poetic emphasis. Pindar is fond of certain emotive nouns and of some vaguely emotive adjectives, but, in general, he does make his adjectives tell. For his purpose nouns outweigh verbs, and he uses certain verbs to link his nouns with little regard to their specific meaning. The connection of sentences and clauses is loose; he has a simple apparatus of particles and sometimes uses none. A too prosaic subordination is avoided, and there are some violent uses of apposition. Within the sentence, to make the elements tell with greater force, he alters the natural order of words or holds a key word in suspense. The most pervasive general feature of his style is metaphor; he is metaphorical throughout and is sometimes betrayed into the grotesque.

Sequence of thought is not always easy to trace. Transitions

are made by loose association, particularly in passing from the "occasional" to myth, and the return is often abrupt. The gnomic and personal elements are sometimes obscure and the myth is sometimes hard to relate to its context. A certain lack of unity has been accepted by some critics as arising inevitably from the nature of the epinician ode; others have attempted, sometimes by forced or cryptic interpretation, to find everywhere a unifying train of thought. More success has attended those who, while accepting the absence of formal unity, have seen an inner unity in the poet's interpretation of his theme, which binds together the occasional, the mythical and the gnomic and finds a place for himself also. For the original audience the powerful psychagogic effect of the language, which gives the same brilliant colour to all parts of an ode, must, along with the music, have disguised any difficulty of structure.

There is evidence in the sources for Pindar's life of personal religious devotion and his work is permeated by religious feeling. The great games are not mere secular festivals and to have gained victory raises a man to a pinnacle of glory, makes him a benefactor of his city and brings him near to those heroes of his land who themselves once were men and whose worship proves that men may attain to something of the divine. In this context the myths are not mere ornament, though they differ greatly in their depth of meaning and in their degree of relevance. In *Pythian* vi the story of Antilochus is a simple example of filial piety, while the magnificent opening of *Pythian* i with its picture of divine harmony and of violence enchained is of deep symbolic significance.

In more elaborate myths various purposes can be combined as in *Pythian* iv, where the Argonautic story is a splendid ornament, but is also relevant both in relation to the foundation legend of Cyrene and in the lesson it conveys in the character of Jason. The myths were not transmitted as dogma, so that the poet feels free to recast what offends. In *Olympian* i he dismisses as the invention of "envious neighbours" the traditional story that Pelops was served up as a meal to the gods by his father Tantalus and partly eaten and substitutes his own version that Pelops was carried off by Poseidon as Ganymede was by Zeus. Divine homosexual love (a link between the divine and the human) was more acceptable to him than divine cannibalism. Similarly in *Pythian* iii the omniscient mind of Apollo perceives from afar the infidelity of his lover, where in the original story the evil tidings were brought by a "little bird," the crow which was turned black for its pains. A more radical re-thinking was alien to his nature. It would be a distortion to consider the myths only from the point of view of relevance or inner meaning. In them he has displayed his greatest art and created scenes of great beauty and wonderful evocative power.

Pindar shows a proud confidence in the inborn genius which raises him above his plodding rivals and a deep sense of his high vocation as poet. That great deeds will perish in oblivion without song and that only the wisdom of the poet can truly interpret them by elucidating the values that they enshrine is a conception to which he gave expression in the hymn to Zeus, when he described how the muses were created to celebrate the mighty works of Zeus himself and his ordering of the universe, and in a well-known passage of fragment 133 he joins the poet with "noble kings and men of fleetness and strength" in the special class of those who after re-incarnation become "holy heroes" in the eyes of men. This conception of function and status is illustrated on a grand scale in his relations with Hieron. On the one hand by poetic interpretation he links Hieron as ruler, conqueror of barbarians and city-founder with the divine and the heroic and invests him with something of the prestige of ancient royalty; on the other, as sage, he meets him on a footing of equality and reads him a lesson on the duties of a prince.

Pindar is not a writer who can be approached easily by a modern reader on the basis of common humanity or community of thought. The background of the epinicians is narrow and peculiarly Greek and his thought is neither historical nor philosophical. It is true that his ethical and religious values are not unfamiliar. They are those of an old-fashioned aristocracy which thought highly of physical prowess and was suspicious of the intellectual; which valued hereditary quality and family tradition; and which delighted in the opportunities of self-expression and display that were given by inherited wealth. This conservative attitude has its moral and religious aspects; success does not come without willing acceptance of toil, danger and high adventure, and power should be combined with magnanimity and courtesy and used in support of peace and order as by Zeus himself; however powerful and successful, man must recognize his human station and accept that vicissitude is his lot. It is less easy, though much has been done by sympathetic interpreters, to understand Pindar's vision of the human scene transfigured in a kind of splendour and made intelligible not by generalization and abstraction but concretely by myth. It is only by an effort that the reader can find his way into this world of archaic thought and not all readers like what they find there.

Even lovers of Greek poetry have felt for Pindar only an imperfect sympathy and have given him only qualified praise as a poet of high, but not of the highest, rank. The brilliance of his language, the strength of his personality and his sense of the poet's function are immediately obvious, but his thought does not satisfy because he attains his aim by a too facile transfiguration of reality and a too great readiness to disguise its harsher aspects by "turning the fair side outward." We are too well schooled in history to look at Syracuse with Pindar's eyes, and myth, even though we may learn to understand his use of it, may remain remote and unreal and fail to touch our emotions. *Pythian* ix is brilliant, but it has the brilliance of a religious picture in which we can admire the skill of the artist and yet, because the religion itself is alien, remain unmoved. But if Pindar cannot capture our minds and rarely touches our hearts, he can impress by his grandeur and he has helped to create for us by his art that Greece of the imagination which has sometimes had more power than the real—the ideal Greece of gods and heroes, and of athletes in the strength and beauty of youth.

See also references under "Pindar" in the Index.

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PINDARI, a word meaning an irregular horseman and plunderer, first applied to foragers attached to Muslim armies in India, who were allowed to plunder in lieu of pay. The word is Marathi, and probably derives from two words meaning "bundle of grass" and "who takes." The same men followed the Maratha bands who raided Mughal territory from the late 17th century. With the collapse of the Mughal Empire in the 18th century, these camp followers organized themselves into groups, each band being usually attached to one of the leading Maratha chiefs. As the Maratha chiefs themselves grew weak at the end of the century the Pindaris became largely a law unto themselves, conducting independent raids from hideouts in central India. The majority of the leaders were Muslims, but they were recruited from all classes.

When the regular forces of the Marathas had been broken up in the campaigns conducted by Sir Arthur Wellesley (later duke of Wellington) and Lord Lake (1803–04), the Pindaris made their headquarters in Malwa (*q.v.*), under the tacit protection of the rulers of the states of Gwalior and Indore, respectively the Sindhia and Holkar dynasties. They usually assembled annually in November to set forth over British territory in search of plunder. In one such raid upon the Masulipatnam coast they plundered 339 villages, killing and wounding 682 persons, torturing 3,600, and carrying off much valuable property. In 1808–09 they plundered Gujarat and in 1812 Mirzapur. In 1814 they were reckoned at 25,000 to 30,000 horsemen, half of them well armed. At last the evil became intolerable, and in 1816 the marquess of Hastings, as governor-general, obtained the consent of the East India Company to the organized campaign known as the Pindari War (1817–18). The Pindaris were surrounded on all sides by a great army, consisting of 120,000 men and 300 guns, which converged upon them from

Bengal, the Deccan, and Gujarat under the supreme command of Lord Hastings in person. Sindhia was overawed and forced to sign the Treaty of Gwalior (1817), consenting to aid in the extirpation of the Pindaris. The peshwa at Poona, the Bhonsla raja at Nagpur, and the army of the infant Holkar each took up arms, but were separately defeated. The Pindaris themselves offered little opposition. They ran hither and thither; most of the leaders surrendered and their followers dispersed. The most daring of them, Chithu, fell to a tiger in the jungle.

See Sir J. Malcolm, *Memoir of Central India*, vol. i, ch. 10 (1823); Sir J. F. G. Ross-of-Bladensburg, *The Marquess of Hastings* (1893). (T. G. P. S.)

PINDARICS, irregular rhymed odes in which length of line and of stanza are capriciously varied, so as to suggest, but not to reproduce, the style and manner of the odes of Pindar. Abraham Cowley's *Pindarique Odes* (1656) set a fashion for those who wished to escape for a time from the bondage of the heroic couplet. William Congreve, who confessed that he had been one of Cowley's imitators, in *A Discourse on the Pindarique Ode* (1706), condemned these poems as "a bundle of rambling, incoherent thoughts, expressed in a like parcel of irregular stanzas," and pointed to the triadic structure of the true Pindaric, which he now imitated in an *Ode to the Queen*. Thomas Gray's two Pindaric odes "The Bard" and "The Progress of Poesy" are similarly correct, but the majority of English poets continued to prefer Cowley's licence to the inhibitions of scholarship. The romantic poets, clamorous for liberty in all its guises, disported themselves in this metrical wilderness with even livelier enthusiasm. Pindar's song remains, as Cowley said, unnavigable, but the genuine imitations of Jonson, Congreve and Gray hardly surpass the spurious Pindarics of Dryden's "Alexander's Feast," Wordsworth's "Ode on Intimations of Immortality," Coleridge's "Dejection," Shelley's "Ode to Naples," and Tennyson's "Ode on the Death of the Duke of Wellington." (E. J. M. Bw.)

PINDEMONTE, IPPOLITO (1753–1828), an eloquent Italian poet of preromantic sensibility, was born at Verona, Nov. 13, 1753, the son of a nobleman. He was educated in the Collegio San Carlo, Modena, and after visiting various parts of Italy he settled in his native region (1784), where, inspired by the English landscape poets, he composed in 1785 a sequence of tender, melancholy verses known as the *Poesie campestri* (1788). He then went to Paris, the result of his experiences being the poem *La Francia* (1789) and a prose satire on the political conditions in Europe called *Abaritte* (1790). With the Reign of Terror Pindemonte lost faith in the French Revolution; and after living for a time in London, Berlin and Vienna, he returned to his villa and published the *Prose campestri* (1794), a companion volume to the earlier verses. Between 1805 and 1819 Pindemonte prepared his highly prized translation of the *Odyssey* (1822). His other works include the tragedy *Arminio* (1804), *I Sepolcri* (1808)—a reply to Ugo Foscolo's poem on the same subject—*Il colpo di martello del campanile di San Marco* (1820) and many verse *Sermoni* (1819). He died at Verona, Nov. 18, 1828.

His brother, Giovanni Pindemonte (1751–1812), poet, dramatist and politician, was born at Verona on Dec. 4, 1751. He held high office in the governments of Venice and Milan; but he also spent many years in exile. He wrote lyric poetry and tragedies, some of which, such as *Ginevra di Scozia* and *Lucio Quinzio Cincinnato*, were influenced by Shakespeare as well as by Vittorio Alfieri. He died in Verona, Jan. 23, 1812.

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PINDUS (modern Greek Píndhos), a range of mountains in northern Greece, running from north-northwest to south-southeast and forming part of the main backbone of the country. The chain extends for about 68 mi. from the Métsovon Pass in the north to the pass east of Karpenísion in the south (some modern writers extend the term to cover the whole central mountain system of the Greek peninsula). Its average width is about 20 mi. and its general height about 6,000 ft., but it rises to 7,595 ft. in Mt. Timfristós at its southern extremity. It consists generally of a gently undulating limestone surface, scored by abrupt and virtually impassable ravines, notably that of the Mégdhova River. The Pindus Range forms the traditional boundary between the districts of Thessaly (Thessalia) and Epirus (Ípiros), and within it are found the sources of the five principal rivers of northern Greece—the Aliákmon, Piniós, Akhelóös, Árakhthos, and Aóös. Its eastern edge, above the plains of Thessaly, is formed by a straight escarpment, but it sends off a number of spurs to the west. Despite ruthless felling, the Pindus Mountains still carry some of the finest forests in Greece, of silver fir and Corsican pine, with oak and chestnut on the lower slopes. After the snows melt in April, the plateaus above the tree limit provide rich summer pastures for the flocks of migrant Vlach shepherds. (Wm. C. B.)

PINE, the name of an English engraver and his two sons, both painters.

John Pine (1690–1756) operated a print shop in London, and thus was able to publish books illustrated with his own engravings. It is not known where he learned his art, although he may have studied under Bernard Picart. His first important publication, which is also one of the finest examples of his work, was a group of engravings of the ceremonies attending George I's revival of the order of the Bath (1730). His other productions include a copy of the Magna Carta; an edition of Horace and a part of one of Virgil; copies of the tapestries celebrating the defeat of the Spanish armada that hung in the house of lords; and several maps of London. In 1749 his friend William Hogarth depicted him as the friar in his painting "The Gate of Calais," and from that date Pine was known, to his considerable irritation, as Friar, or Father Pine. He died May 4, 1756.

Robert Edge Pine (1730–1788), his son, was born in London. In 1760 his painting "The Surrender of Calais" won for him first prize for historical subjects in the first exhibition held by the Society of Arts, and three years later he received the same award for his "Canute Rebuking His Courtiers on the Seashore." He became widely known as a painter of portraits, particularly those of contemporary theatrical personalities. His likenesses of David Garrick, painted during this period, are regarded as especially fine. About 1783 he went to the United States, planning to paint the portraits of the leaders of the American Revolution, as well as historical scenes of the important events of the war itself. The plan never materialized, although he did make portraits of a number of contemporary statesmen, including Francis Hopkinson, George Washington, Robert Morris, Benjamin Franklin and John Jay. Many of Pine's works went to the Columbian museum in Boston and were destroyed when that institution burned. He died in Philadelphia, Nov. 18, 1788.

Simon Pine (d. 1772), another son of John Pine, was a miniature painter at Bath.

PINE, a name given by the ancients to several resinous, cone-bearing trees. Modern botanists restrict the use of the term to members of the genus *Pinus* (Pinaceae), which differs from other pinaceous genera in featuring slender, needlelike leaves, borne in fascicles of two to eight (rarely solitary), growing from a basal membranous sheath. Each tuft represents an abortive branch which springs from the axil of a partially deciduous, scalelike leaf, the base of which remains closely adherent to the stem. The numerous staminate catkins are arranged in dense spirals about the bases of young shoots of the season; the two-celled sessile anthers release an abundance of pollen through longitudinal slits; the ovuliferous flowers are composed of several spirally arranged bracts each subtending a scale with two basal ovules. The fruit of the pines, a cone, requires two or rarely three seasons to mature. It is composed of numerous woody, armed or unarmed scales spirally arranged about a woody central axis, each bearing two-winged, or rarely wingless, seeds. The cones of several species open at maturity to release their seeds, others remain closed for several seasons; still others require the heat of a forest fire to open them in appreciable quantities. In such instances vast amounts of viable seed are accumulated through the years, which, when released, completely reseed burned-over areas.

The pines, which comprise about 90 species, are widely distrib-

uted over the north temperate zone, in the southern portions of which they are chiefly confined to the mountains. In Central America a few are found within the tropics. In more northern regions they frequently form extensive forests which are seldom invaded by other trees. One species, *P. sylvestris*, is native to Great Britain and about 55 are indigenous to North America. Pines are botanically soft woods, but commercially they may be designated as soft pines (easily worked) or hard pines (more durable and harder to work). Their soft or hard straight-grained, resinous and often durable woods are suitable for many purposes, and some are among the most esteemed of timber trees.

This article considers first North American pines and second Eurasian pines.

NORTH AMERICAN PINES

The 55 or more species and major varieties of pine native to North America, including Mexico, may be grouped in two sections, the soft pines and the hard pines.

Soft Pines

The soft pines have soft, close-grained wood, with thin, nearly white sapwood; the sheaths of the leaf clusters fall off early (deciduous); the leaves contain a single fibrovascular bundle, and, excepting those of the nut pines, are in five-leaved clusters. There are 17 species, only one of which, the eastern white pine, is found east of the Great Plains, the others occurring in the Rocky mountain region, on the Pacific coast and in Mexico.

American soft pines are divided into four groups whose botanical designations and features are set forth below.

Soft Pines

Group	Leaves	Cones
White pines *P. strobus* *P. monticola* *P. lambertiana*	in clusters of 5, 4″ to 6″ long	Long stalked, with thin, unarmed scales; seeds long winged
Stone pines *P. albicaulis* *P. flexilis* *P. ayacahuite*	in clusters of 5, about 3½″ long	short stalked, with thick, unarmed scales; seeds short winged or wingless
Foxtail pines *P. aristata* *P. balfouriana*	in clusters of 5, about 2″ long, persistent for many years	short stalked, the scales armed on the back with a small, often deciduous prickle; seeds long winged
Nut pines *P. cembroides* *P. quadrifolia* *P. monophylla* *P. edulis*	in clusters of 2 to 4, or solitary, about 2″ long	short stalked, few scales, the scales greatly thickened, unarmed, short winged or wingless

White Pines.—The eastern white pine (*P. strobus*), known also as Weymouth pine, because of its large size and the soft, even grain of its white wood, is one of the most valuable of North American timber trees. It once formed extensive forests from Newfoundland to Manitoba, from Minnesota to Maine and southward in the mountains to Georgia, but it has been cut intensively so long that by the second half of the 20th century very few old trees remained. On deep rich soil *P. strobus* may attain a height of 200 ft., and a trunk diameter of 4 to 6 ft. Its wood is durable for indoor use, especially when protected by paint, its smooth, easily worked grain rendering it a favourite wood for the carpenter and joiner. The western white pine (*P. monticola*) grows in the mountains of the northwestern United States and British Columbia, has light-brown wood and is extensively cut for lumber, especially in Idaho, the total cut in one year exceeding 188,000,000 bd.ft.

The sugar pine (*P. lambertiana*) of California is the largest of known pines, often 200 to 220 ft. tall and with a trunk diameter of 6 to 8 ft., or occasionally to 12 ft. Its crown is pyramidal, with horizontal or slightly drooping branches, and bears slender, bright-green needles 2 to 4 in. long. The pendent cones are 4 to 6 in. in diameter when open, sometimes to 24 in. long, and bear large, edible seeds. It is lumbered extensively, the cut after World War II exceeding 170,000,000 bd.ft. annually.

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WHITE PINE (PINUS STROBUS) FOLIAGE SPRAY WITH CLOSED CONES

Stone Pines.—Stone pines are typically timber-line species, and are more important as protectors of valuable watersheds than for the timber they produce. The whitebark pine (*P. albicaulis*), so called because of its chalky-coloured bark, extends along the mountains of the Pacific slope from British Columbia to the Sierra Nevada of California and eastward through Idaho to Montana and Wyoming. Limber pine (*P. flexilis*) is essentially a Rocky mountain tree. The Mexican white pine (*P. ayacahuite*) attains its northern limits in the southwestern United States.

Foxtail Pines.—This group attains its name from the fact that the leaves persist on the branches for 10 to 15 years or more and simulate the bushy aspect of a fox's tail. Bristlecone pine (*P. aristata*) is a tree of the southern Rocky mountains, while foxtail pine (*P. balfouriana*) is found on the coast and Sierra Nevada ranges of California. Both are small alpine trees. Needles of the former have superficial resin canals from which resin is exuded upon the surface of the leaf.

Nut Pines.—Some authorities recognize but one species, *P. cembroides*, and classify the other forms as varieties of this species. The single-leaf piñon (*P. monophylla*) features one and sometimes two needles in a fascicle. This tree occurs sporadically through northern Mexico and the southwestern United States. The Parry piñon (*P. quadrifolia*) is the four-needle piñon of southern California and northern Lower California. Nut pine (*P. edulis*), the most widely distributed tree of the group, like the Mexican piñon has needles in clusters of two and three. The seeds of the group are very large and tasty and are sold in the markets as "pine nuts."

Hard Pines

The hard pines have usually heavy, coarse-grained, mostly dark-coloured wood, with pale, often thick sapwood; the sheaths of the leaf clusters are persistent, except in the Chihuahua pine (*P. leiophylla*); the leaves have two fibrovascular bundles, and are arranged mostly in three-leaved and two-leaved clusters. There are some 24 species about equally divided in number between the region east of the Great Plains and the region extending from the Rocky mountains to the Pacific coast.

The group of yellow pines with the leaves ordinarily in three-leaved clusters includes several of the most valuable trees of North America. Among these are the longleaf pine (*P. palustris*), the slash pine (*P. caribaea*), the loblolly pine (*P. taeda*), the pitch pine (*P. rigida*) and the pond pine (*P. rigida* var. *serotina*) of the southern states, and the ponderosa or western yellow pine (*P. ponderosa*), the Arizona pine (*P. ponderosa* var. *arizonica*) and Jeffrey pine (*P. jeffreyi*) of the Pacific states. Other representa-

tives of this group are the Monterey pine (*P. radiata*), the knobcone pine (*P. attenuata*), the digger pine (*P. sabiniana*), and the Coulter pine (*P. coulteri*) of California and Oregon, and also the Chihuahua pine (*P. leiophylla*) of the Mexican border.

The group of hard pines with leaves usually in two-leaved clusters also comprises several important trees. Among these are the red or Norway pine (*P. resinosa*), the gray or jack pine (*P. banksiana*), the spruce pine (*P. glabra*), the shortleaf pine (*P. echinata*), the Virginia pine (*P. virginiana*), the sand pine (*P. clausa*) and the table-mountain pine (*P. pungens*), of the region east of the Rocky mountains. Here belongs also the lodgepole pine (*P. contorta* var. *latifolia*), found from New Mexico to Alaska. Another representative of the two-leaved group is the bishop pine (*P. muricata*). The rare Torrey pine (*P. torreyana*), confined to the California coast, is a five-needle pine, a condition rare among yellow pines.

Longleaf pine (*P. palustris*) is the most notable yellow pine of the southern states; it abounds on sandy soils from the Carolinas and Florida westward to Louisiana and Texas. The most marked feature of the tree is its long tufted foliage—the leaves, of a bright-green tint, springing from long white sheaths, being often a foot in length. The tall columnar trunk, sometimes 120 ft. high, furnishes one of the most valued pine timbers of the United States; close-grained and resinous, it is very durable and polishes well; it is largely employed in construction work, and large quantities are exported, especially to Great Britain and the West Indies. This tree is the chief lumber-producing pine of the southern United States; it also yields large quantities of tar and turpentine.

Loblolly pine (*P. taeda*), a tall tree with straight trunk and spreading top, covers great tracts of the pine barrens of the southern states, but also frequently spreads over deserted arable lands that have been impoverished by long and bad farming; hence, the woodsmen call it the "old-field" pine, while, from the fragrance of its abundant resin, it is also known as the frankincense pine. It is a fine species 80 to 100 ft. high, having sometimes a girth of 6 or 8 ft. The timber of this pine, though soft and brittle, is much used for lumber and pulpwood, but the forests of it are of no importance to the naval-stores industry because of the poor quality of the derived oils and turpentine. The shortleaf (*P. echinata*) and slash (*P. caribaea*) pines are two other very important timber trees in the south. The latter extends over the Florida keys to several islands in the Caribbean.

Ponderosa and Other Hard Pines.—Ponderosa, western yellow or bull pine (*P. ponderosa*), which grows from 150 to 200 ft. high, with a massive trunk 5 to 8 ft. in diameter, is noted for its soft, easily worked wood which is much softer than most other yellow pines; it is the most widely distributed American pine, being found in the mountain forests of western North America from British Columbia to South Dakota (Black hills) and south to Texas and Mexico. It is the chief lumber pine of the Pacific states where it is second in importance only to the Douglas fir (*q.v.*). The similar Jeffrey pine (*P. jeffreyi*) is confined to California and Lower California. The Coulter pine (*P. coulteri*) is remarkable for its enormous cones (sometimes 1 ft. long, 6 in. in diameter, and weighing more than 4 lb.); the scales end in long hooked points curving upward; the leaves are long, rigid and dark green. Closely related to this is the digger pine (*P. sabiniana*) of California, the cones of which are 7 to 9 in. long and 5 to 6 in. in diameter, also with hooked scales; the large nutlike seeds are eaten by the Indians; the tree sometimes attains a height of 80 ft. and a trunk diameter of 4 ft.

The beautiful Monterey pine (*P. radiata*), found sparingly along the California coast, is distinguished by the brilliant colour of its foliage. The Torrey pine (*P. torreyana*), with leaves 12 in. long, found only in a narrow strip some 8 mi. in length along the coast near San Diego, Calif., and on Santa Barbara Island, is the least widely distributed of all known pines.

The pitch pine (*P. rigida*), found from the coast of Massachusetts southwestward throughout the Appalachian region, is a tree of from 40 to 50 ft. in height, with rugged trunk, occasionally 3 ft. in diameter; the short dark-green leaves are in thick tufts, contrasting with the pale-yellowish, usually clustered cones, the scales of which are furnished with small curved spines. Large quantities of a low grade tar and pitch have been obtained from this species. The tree is one of the few that will flourish in salt marshes.

Pine Lumbering in the United States

The various native species of pine, several of which form forests of vast extent, constitute the chief source of softwood (coniferous) lumber produced in the United States. Commercially, the lumber cut from the various kinds of pine is known as white, yellow, ponderosa, sugar and lodgepole pine, and is classified under these descriptive names in the census of manufactures. White-pine lumber includes that produced from the eastern white or Weymouth pine, the western white pine, the gray or jack pine and the Norway or red pine, the two last named belonging botanically with the yellow pines. Prior to 1900 the eastern white pine was one of the chief lumber-producing trees in North America, but the original forests have become so depleted that the tree now contributes only a minor fraction of the lumber marketed as white pine. The lumber from the eastern white, the gray and the red pine is mostly cut in the northern border states from Maine to Minnesota. Western white-pine lumber is practically all produced in Idaho and Washington.

Yellow-pine lumber is cut mainly in the southern states; 70% of the total is produced in five states: Mississippi, Louisiana, Alabama, Texas and Georgia, which rank in the order named. The kinds of pine furnishing yellow-pine lumber all belong to the pitch-pine group, and include the longleaf, loblolly, shortleaf, sand, slash, pitch, spruce, pond, table-mountain and Virginia pine, the longleaf, shortleaf, loblolly and slash pines ranking among the most important.

Ponderosa-pine lumber, mainly cut from *P. ponderosa*, with some cut from *P. jeffreyi*, is produced chiefly in Oregon, California, Washington, and Idaho.

Sugar-pine lumber, cut from a single species (*P. lambertiana*) and produced commercially only in California (more than 95%) and Oregon, commands the highest average price at the mill of any pine lumber cut in the United States. Lodgepole-pine lumber is produced in small quantities in the Rocky mountain states: Wyoming and Colorado contributing about 90%; Montana and Utah, the remainder of the total footage.

EURASIAN PINES

P. sylvestris.—The Scots pine (*P. sylvestris*) of northern Europe is typical of the two-needled pines. When grown under optimum conditions it is one of the finest of the group and is a very picturesque forest tree. Attaining a height of 70 to 120 ft., it is conical in youth, acquiring a mushroom crown in maturity; has a straight trunk 2 to 4 ft. in diameter; fiery red-brown bark; and gnarled, twisted boughs densely clothed with blue-green foliage at the extremities. The leaves are rather short, curved and often twisted. In May or June the staminate cones fill the air with sulfurlike pollen and pollinate the purple carpellate cones, which are at first sessile and erect but become recurved on lengthening stalks. Fertilization occurs the next summer and the carpellate cones mature in the autumn of the following year. Scots pines seldom shed their seeds until the third year. *P. sylvestris* occurs in varying abundance from Finland and Sweden to the mountains of Spain and the higher slopes of Etna, and longitudinally from the shores of the North sea to Kamchatka, U.S.S.R. Abundant in the Scandinavian peninsula, it is the fir (*fur, furu*) of the old Norsemen, and still retains that name in Great Britain, although it is a true pine. It grows vigorously on lower ground in Lapland and occurs up to 3,000 ft. in south Norway. The great forests from which Norway-pine timber is chiefly derived are on the lower slopes of the southeastern dales; in the higher altitudes it dwindles to a mere bush. It furnishes the yellow deal of the Baltic and Norway. In Germany, both on the mountains and the sandy plains, woods of Scots pine (*kiefer*) are frequent and widely spread, while vast forests in the U.S.S.R. and Poland are chiefly composed of this species. In Asia it abounds in Siberia and on

the mountains of the Amur region, U.S.S.R.; in the European Alps it occurs at a height of 5,600 ft., and in the Pyrenees it is found at still higher elevations. In Great Britain natural forests of Scots pine of any extent are found only in the Highlands, chiefly on the slopes of the Grampians.

SCOTS PINE (PINUS SYLVESTRIS) FOLIAGE WITH CLOSED CONES

The heartwood of the finer kinds of Scots pine is of a deep brownish-red colour, abounding in the resin to which its durability is probably due. It is as lasting as oak, and is well adapted to both indoor and outdoor construction. The quality of the timber depends greatly on the soil and position in which the trees are grown. The rapidity of growth is still more variable: in Great Britain full maturity is attained in from 70 to 120 years, but in Norway the trunk increases much more slowly; H. Schübeler states that a tree felled in the Alta district (about 70° latitude), measuring 2 ft. 10 in. in diameter, showed 400 annual rings.

P. sylvestris is subject to many insect depredations: the pine chafer (*Hylurgus piniperda*) is destructive in some places, this beetle's larvae feeding on the succulent shoots, especially in young plantations; the fir weevil (*Hylobius abietis*) eats away the bark, and numerous lepidopterous larvae devour the leaves; the pine sawfly is injurious in some seasons. Removal of all dead branches from the trees and the ground beneath is recommended, as most of these insects lay their eggs in the decaying parts of the bark and among the dead leaves.

In common with other pines, *P. sylvestris* is subject to the attacks of various fungi. *Trametes radiciperda* attacks the roots and penetrates to the stem, causing rotting of the wood. The disease is difficult to eradicate, as the mycelium of the fungus travels from root to root in the soil. Rotting of the wood at the base of the trunk is also caused by *Agaricus melleus*, which spreads in the soil by means of its long, purple-black, cordlike mycelial strands known as rhizomorphs. Much damage is often caused by species of Peridermium, which often invade the soft portions of the inner bark to such an extent as to "ring" the stem or branch, or to cause an abnormal formation of turpentine which soaks into the wood and stops the upward passage of water.

Plantations in England are generally ready for final cutting in from 60 to 70 years, and many are cleared at a much earlier stage of growth, especially when protected from injury by pests. In England *P. sylvestris* is largely employed as a "nurse" for oak trees. Its conical growth when young affords protection from the wind while allowing sunlight to reach the seedling oaks. Its dense foliage renders it valuable as a shelter tree for protecting land from the wind; it stands the sea gales better than most conifers, but will not flourish on the shore like some other species.

This pine is planted for ornament and sparingly naturalized in the eastern United States. It has proved of value also in afforesting treeless areas, such as occur in western Nebraska.

Large quantities of turpentine are extracted from this pine in Sweden and the U.S.S.R. by removing a strip of bark, terminating in a deep notch cut in the wood, into which the pitch runs, and from which it is scooped as it accumulates; but the product is not equal to that of the silver fir and other species. Tar is prepared from *P. sylvestris*, chiefly obtained from the roots.

P. pumilia.—Closely allied to the Scots pine, and perhaps to be regarded as a mere alpine form of that species, is the dwarf *P. pumilio*—the *krummholz* or *knieholz* of the Germans—a recumbent bush, generally only a few feet high, but with long zig-zag stems that root occasionally at the kneelike bends where they rest upon the ground. The foliage much resembles that of the Scots pine, but is shorter, denser and more rigid; the cones are smaller but similar in form. Abounding on the higher slopes of the Bavarian and Tirolese Alps, it is a favourite shelter for the chamois; the hunters call it the "latschen," from its recumbent, straggling habit.

P. laricio.—*P. laricio*, the Corsican pine, is one of the noblest trees of this group, growing to a height of 100 or even 150 ft., with a straight trunk and branches in regular whorls, forming in large trees a pyramidal head; the slender leaves, of a dark-green tint, are from 4 to 7 in. long; the cones, either in pairs or several together, project horizontally, and are of a light-brown colour. This pine abounds in Corsica, and is found in more or less abundance in Spain, southern France, Greece and many Mediterranean countries. The tree is of very rapid growth, but produces good timber, much used in southern dockyards, and very durable, though less strong than that of *P. sylvestris;* the heartwood is of a brownish tint. In southern France it has been planted with success on the drift sands of the Bay of Biscay, though it does not bear the full force of the sea blast as well as the pinaster. *P. laricio*, closely related to the Austrian pine, is considered by some a subspecies of it.

P. nigra.—The black or Austrian pine (*P. nigra*) derives its name from the sombre aspect of its dark-green, sharp, rigid, rather long leaves. The tree, up to 100 ft. tall, displays a deeply fissured bark and light-brown branches. This species, widely cultivated for ornament, is native to Europe and western Asia.

P. pinaster.—The cluster or pinaster, a vigorous grower in coastal sand, has been cultivated extensively for the purpose of stabilizing sand drifts, especially on the dunes of the Bay of Biscay. Growing to a height of from 40 to 80 ft., the deeply furrowed trunk occasionally reaches a diameter of 3 ft. or more at the base, where, like most sand trees, it usually curves upward gradually, a form that enables the long taproots to withstand better the strain of the sea gale; when once established, the tree is rarely overthrown even in the loosest sand. The branches, with their thick covering of long, dark-green leaves, curve upward like the stem, giving a massive rounded outline to the tree; the ovate cones are from 4 to 6 in. long, of a light, shining, brown hue, with thick scales terminating in a pyramidal apex; they are arranged around the branches in the radiating clusters that give name to the tree. The pinaster grows naturally on sandy soils around the Mediterranean from Spain to the Levant. On the drift sands of France, especially in the Gironde, forests have been formed mainly of this pine; the seeds, sown at first under proper shelter and protected by a thick growth of broom sown simultaneously, vegetate rapidly in the sea sand, and the trees thus raised have, by their wind-drifted seed, covered much of the former desert of the Landes with an evergreen wood. These forests of pinaster, apart from the production of timber in a once treeless district, have a great economic value as a source of turpentine. In England the cluster pine has been largely planted on sandy districts near the sea, and has become naturalized in Purbeck and other wild tracts in the southern counties.

P. pinea.—This is the stone pine of Italy; its spreading, rounded canopy of light-green foliage, supported on a tall and often branchless trunk, forms a striking feature of the landscape in that country, as well as in some other Mediterranean lands. The reddish-brown, shining, roundly ovate cones with pyramidal scale apices have been prized from the ancient days of Rome for their edible seeds (pignons), which are still used for food. They ripen the fourth year and are kept in the cone until required; otherwise their abundant oil soon turns rancid.

P. griffithi.—Similar to *P. pinea* is *P. griffithi*, the Himalayan or blue pine, which differs chiefly in its longer cones and drooping, glaucous foliage. It grows in Kumaon, Bhutan and on some of the Nepal ranges at 7,000 to 12,000 ft., where it attains large dimensions; however, it is absent from the moist climate of the Sikkim Himalayas.

P. cembra.—*P. cembra*, the stone pine of central Europe and Siberia, abounds on the Alps, the Carpathians and the Siberian ranges, growing at altitudes of 4,000 to 6,000 ft. in Switzerland. The oily seeds, like those of *P. pinea*, are eaten by the inhabitants of the Alps and Siberia, and yield a fine oil used for food and in

lamps. *P. cembra* grows slowly, is remarkably even-grained and is used by the Swiss wood-carvers in preference to any other.

See also references under "Pine" in the Index.

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PINEAPPLE. Cultivated varieties of pineapple belong to the species *Ananas comosus*, a bromeliad (family Bromeliaceae) native to tropical and subtropical America but introduced elsewhere. Earliest written records of pineapple are references to it by Columbus, Gonzalo de Oviedo y Valdes and Sir Walter Ralegh (Raleigh) who found pineapple growing in the West Indies, where it was used for food and for wine making.

In a remarkably short time after it was first seen by Europeans, the pineapple was carried to many parts of the world. The Portuguese apparently were responsible for much of its early dissemination. They introduced it to St. Helena shortly after they discovered that island in 1502. Soon after they carried it to various parts of Africa and to Madagascar and by about 1550 to India. Before the end of the 16th century cultivation of the plant had spread over most of the tropical areas of the world, including some of the islands of the South Pacific. Crowns from fruits carried on board ship for food during voyages were probably the propagating material. These thick, succulent tufts can remain viable, even when detached for long periods, certainly for as long as those voyages required.

BY COURTESY OF DOLE HAWAIIAN PINEAPPLE COMPANY

A RIPE PINEAPPLE READY FOR PICKING

The pineapple plant resembles agave or some yuccas in general appearance. It has from 30 to 40 stiff succulent leaves closely spaced in a rosette on a thick fleshy stem. With commercial varieties, a determinate inflorescence forms about 15 to 20 months after planting on a flower stalk several inches in length. The originally separate lavender flowers, together with their bracts, each attached to a central axis core, become fleshy and fuse to form the pineapple fruit, which ripens five to six months after flowering begins. Fruits of commercial varieties range from three to six pounds in weight. Most varieties are self-incompatible and do not normally produce seed, though they will do so when crossed with certain other varieties.

There are many varieties of pineapple, but those of greatest commercial importance are the Smooth Cayenne in Hawaii, the Queen group in Australia and South Africa and the Red Spanish in Cuba and Puerto Rico.

When pineapple is planted on plantations, an asphalt-impregnated mulch paper is first laid on well-tilled soil in rows, with the edges covered to anchor the strips of paper. Mulch paper is commonly laid on five-foot centres and the pineapple propagating pieces are inserted through the paper into the soil, so spaced as to give a population of 15,000 to 20,000 plants per acre. In many areas the soil is fumigated with DD (a mixture of dichloropropene and dichloropropane) at the time the mulch paper is laid. Such fumigation is necessary to kill nematodes parasitic on the roots of the pineapple plants.

Pineapple culture, particularly in Hawaii, makes use of many agricultural chemicals. One of the important uses is in controlling weeds in the spaces between strips of mulch paper. Cultivation for weed control has been practically eliminated by the use of chemicals in many areas where pineapple is grown. Chemical insecticides like DDT and Malathion are used to control harmful insects.

Chemical fertilizers are employed and the kind, amount and timing of the application varies immensely with the soil and weather. On some of the plantations in Hawaii, need for fertilization is determined by frequent chemical analysis of representative plants in the field. By this method, even with fluctuating weather and differing soils, proper adjustments of fertilization to the measured needs of the plants permits a condition of balance in plant nutrition favouring the development of fruit of uniformly high quality.

Total world production of pineapples for all purposes ordinarily averages 1,750,000 tons annually, of which an estimated 45% is produced in the Hawaiian Islands. Other areas of substantial production include Brazil, Mexico, the Philippines, Cuba and Formosa. Hawaii also produces approximately 60% of the world's total supply of canned pineapple products, practically all sold in the other U.S. states. Other areas that produce substantial quantities of canned pineapple products for sale in the United States are the Philippines and Puerto Rico. Pineapple canned in Australia, Malaya and South Africa is exported principally to Great Britain.

Except in those countries where it is grown, trade in fresh pineapple is limited. Exceptions are the Azores, which produce fresh pineapple for export to the European continent and Great Britain; and Mexico and Puerto Rico, which export to the United States.

Since highest quality is not developed except when the pineapple fruit is allowed to become fully ripe on the plant, fresh-fruit quality is impaired by long shipment. For this reason, much pineapple fruit is processed so that it can be transported to parts of the world where it cannot be grown. Fresh, ripe fruits are peeled and cored, usually mechanically, and the cylinders are examined for freedom from blemishes. The most common style of cut for packing in cans is slices, but "chunks," wedge-shaped pieces about 1 in. by ½ in., and "tidbits," somewhat smaller than chunks, are also packed. All styles of cut are packed in cans by grades; sirup is then added and the cans are sealed and heat-processed. Some packers also preserve fruit in cans or in cartons by freezing. Shredded pieces of fruit, commonly called "crushed," are canned for use in flavouring ice cream and for pie mix.

Pineapple juice is canned for beverage use and may be either heat-processed or concentrated and frozen.

See J. L. Collins, *The Pineapple: Botany, Cultivation, and Utilization* (1960). (R. L. CG.)

PINEAU, NICOLAS (1684–1754), one of a family of wood-carvers and leading figure in the development of the French rococo style in interior decoration (*see* BAROQUE AND POST-BAROQUE ARCHITECTURE: *Rococo Architecture*). He was born in Paris on Oct. 8, 1684, the son of Jean Baptiste Pineau, a sculptor in wood. With other French artisans Nicolas Pineau visited St. Petersburg in 1716 at the invitation of Peter the Great and there first established his reputation with his carving of the tsar's cabinet in the Peterhof Palace (completed 1721). Returning to Paris about 1728, Pineau launched the vogue for rococo rooms in private dwellings. Characteristic of his style, of which the Hôtel de Roquelaure (1733) is the best surviving example, are shallow recesses with rounded corners, sometimes used to frame chimneypieces, doors, or mirrors. His ornamental vocabulary included shell and batwing motifs augmented by leafy scrolls and classical busts in medallions. His engraved works considerably influenced subsequent interior designers and architects. Many of Pineau's drawings are preserved in the Musée des Arts Décoratifs, Paris, and in the Cooper Union Museum, New York. He died in Paris on April 24, 1754. His son Dominique (1718–86) was also a wood sculptor.

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PINE BLUFF, a city of Arkansas, U.S., and seat of Jefferson County, is located SSE of Little Rock, at an altitude of 216 ft. on south bank bluffs overlooking the Arkansas River. Originally settled in the 1820s as Mount Marie, it was renamed Pine Bluff for its forest of giant pines in 1832. It was chartered in 1835. During the American Civil War, the city was the scene of an engagement on Oct. 25, 1863, when a Confederate force under Gen. John S. Marmaduke was repulsed by a Union brigade under Col.

Powell Clayton. The city is the seat of Agricultural, Mechanical, and Normal College (1873) and the state industrial school for boys.

Industrial products include electric transformers, mechanical cotton pickers, planters, kraft board and paper, newsprint, castings, brake shoes, lumber and wood products, cotton cloth, fabricated steel buildings, food products, cottonseed oil, chemicals, and archery supplies. The cotton exchange handles 250,000 bales in a normal year. There is natural gas, hydroelectric power, and water in the vicinity for industrial use. Pop. (1960) city, 44,037; standard metropolitan statistical area (Jefferson County) 81,373. For comparative population figures *see* table in ARKANSAS: *Population.* (Jo. A. T.)

PINEL, PHILIPPE (1745–1826), French physician, ranks as the great pioneer in the humane treatment of the insane and as one of the founders of modern psychiatry. He was born at St. André, Tarn, France, on April 20, 1745, and took his doctor's degree at Toulouse in 1773. He went to Paris in 1778 and for some time supported himself by translating scientific and medical works and by teaching mathematics. In 1798 he published *Nosographie philosophique,* a learned work on the classification of diseases, which gave him much reputation. He decided to devote himself to psychiatry after having been profoundly moved by the case of a friend who went mad, ran into the woods and was devoured by wolves.

He held in succession the posts of chief physician to the famous mental hospitals, the Bicêtre and the Salpêtrière, and it was at the former institution that he took the bold and unprecedented step of removing the chains from the patients, some of whom had been restrained in this way for 30 or 40 years. He did away with the old violent methods of treatment, such as bleeding, purging and blistering, and advocated simple psychological management.

Pinel's *Traité médico-philosophique sur l'aliénation mentale ou la manie* (1801) is one of the great classics of psychiatry. He died in Paris on Oct. 25, 1826.

See R. McKown, *Pioneers in Mental Health* (1961). (W. J. BR.)

PINERO, SIR ARTHUR WING (1855–1934), English playwright who made English farce literate and contributed much to the "society drama" of late Victorian and Edwardian times, was born in London, on May 24, 1855. He abandoned a legal apprenticeship for the stage in 1874, and subsequently joined Henry Irving's company. Although a young man, he specialized in older roles, *e.g.,* Claudius to Irving's Hamlet and Sir Anthony Absolute in the Bancrofts' production of *The Rivals.* His first play to be produced was *£200 A Year* (Globe, Oct. 6, 1877). For the Royal Court theatre he evolved a type of farce in which the events were often wildly improbable but the people likable and the style amusingly consistent. Of these farces, *The Magistrate* (March 21, 1885), *The Schoolmistress* (March 27, 1886) and *Dandy Dick* (June 27, 1887) still repay revival. While cultivating a profitable vein of sentiment, *e.g.,* in *The Squire* (St. James's, Dec. 29, 1881) and *Sweet Lavender* (Terry's, March 21, 1888), Pinero also studied serious drama by adapting from the French *The Iron Master* (St. James's, April 17, 1884) and *Mayfair* (St. James's, Oct. 31, 1885).

From these various elements were fused *The Profligate* (Garrick, April 24, 1889) and, much more skilfully, *The Second Mrs. Tanqueray* (St. James's, May 27, 1893), which established Pinero as a leading playwright. He proceeded to depict a series of women battling with their situation in society; *e.g., The Notorious Mrs. Ebbsmith* (Garrick, March 13, 1895), *Iris* (Garrick, Sept. 21, 1901) and *Letty* (Duke of York's, Oct. 8, 1903). In a less solemn vein, *Trelawney of the Wells* (Court, Jan. 20, 1898) portrayed an actress of the 1860s and *The Gay Lord Quex* (Globe, April 8, 1899) a theatrical rake of no placeable period but great panache. His flair for storytelling became increasingly impeded by narrowing sympathies and laboured dialogue; *e.g.,* in *His House in Order* (St. James's, Feb. 1, 1906), *The Thunderbolt* (St. James's, May 9, 1908) and *Mid-Channel* (St. James's, Sept. 2, 1909). In 1909 he was knighted. Of his numerous later plays, only *The Enchanted Cottage* (Duke of York's, March 1, 1922), a curious essay in an almost Barriesque vein of fantasy, demands notice. He died in London on Nov. 2, 1934.

Pinero played an important part in the creation of a self-respecting theatre and a fashionable audience. His plays not only provided admirable parts for women but also demanded sympathy for women, who were judged by stricter standards than men in Victorian society. The serious plays, however, are too firmly embedded in the thought and style of their day to merit regular revival. The farces, imbued with permanent theatrical values, remain excellent entertainment.

See Hamilton Fyfe, *A. W. Pinero* (1902) and *Sir Arthur Pinero's Plays and Players* (1920); W. D. Dunkel, *Sir Arthur Pinero* (1941). (GE. R.)

PINEROLO, a city and episcopal see of Turin (Torino) Province, Piedmont, north Italy, stands above the valleys of the Chisone and Lemina, 23 mi. (37 km.) SW of Turin by road. Pop. (1961) 31,507 (commune). The old part is on St. Maurice's Hill (*mons Pepinus*) around the 15th–16th-century S. Donato's Cathedral and crowned by ruins of the old walls and a monument to "the Man in the Iron Mask" (*see* IRON MASK). Other old buildings include the 15th–16th-century Church of S. Maurizio and the palace of the princes of Acaia. The modern area in the plain also has some notable buildings. Pinerolo is linked to Turin by rail, and has textile, iron, chemical, and printing industries. Pinerolo was first mentioned in 996 and in 1078 was a possession of the nearby Benedictine abbey of Sta. Maria. It was in turn under Savoy and France and in the 17th century had Vauban fortifications. Its cloth industries were well known from the 14th century. It became a bishop's see in 1748. The National Cavalry Museum was opened there in 1965. (A. F. PA.)

PINES, ISLE OF (ISLA DE PINOS), a large island (1,182 sq.mi. [3,061 sq.km.]) lying south of the western part of Cuba. It occupies one-third of the total area of Havana Province. The northern two-thirds of the island is an undulating plain of pine forests and savannas, of sandy and rocky soils, and of a few mountains up to 1,000 ft. elevation. The main activities are fishing and truck and citrus farming. The National Reformatory, a prison, is located a few miles from Nueva Gerona. The section south of Lanier swamp is small, rocky and isolated, inhabited by only a few fishermen and charcoal makers.

The island was neglected by Spain during the colonial period, and its status was not clearly defined at the time of the formation of the Cuban republic. Hoping that the U.S. would annex the island, many Americans settled there. Most of them left, however, after the United States ratified the Hay-Quesada Treaty in 1925, recognizing Cuban sovereignty. Pop. (1962 est.) 11,504. (D. R. D.)

PING-PONG: *see* TABLE TENNIS.

P'ING-TUNG (Japanese HEITO), a town in Taiwan (Formosa), lies 14 mi. N.E. of Kaohsiung in an intensively cultivated alluvial basin of which rice and fruits are the chief products. Its major function is as the market centre for this agricultural area. Sugar milling is a major industry.

P'ing-tung was settled nearly 200 years ago and thus did not benefit from city planning under the Japanese administration (1895–1945). It is a typical market town with numerous light industries including rattan weaving, small machine shops and woodworking shops. A military airbase is located nearby. It serves as the seat of the P'ing-tung *hsien* (country) government. Pop. (1956) 103,433. (N. S. G.)

PINK, the common name for plants of the genus *Dianthus* of the pink family (Caryophyllaceae; *q.v.*). There are about 300 or more species, natives of the old world but found chiefly in the Mediterranean region. They are mostly short herbaceous perennials, many of which are tufted or mat-forming hardy evergreens, often with very showy flowers; some annual forms exist. Four species grow wild in Great Britain: the Deptford pink (*D. armeria*), the maiden pink (*D. deltoides*), the Cheddar pink (*D. cæsius*) and the proliferous pink (*D. prolifer*). Two others, the grass or garden pink (*D. plumarius*) and the clove pink or carnation (*D. caryophyllus*), are more or less naturalized in Great Britain, and a few species are sparingly naturalized in the United States. The carnation (*q.v.*) and picotee of the florist are modifications of the clove pink. The sweet-william is derived from the Eurasian *D.*

barbatus. All of these are widely grown in American and British gardens, being of relatively easy culture. Fine modern varieties of both the greenhouse and hardy types of carnation are largely grown commercially.

Both annual and perennial *Dianthus* species (best treated as biennials, however) may be grown from seed sown in the spring in ordinary moist garden soil in a sunny location. The perennials will bloom the following summer and may be increased by cuttings or division of clumps.

ROCHE

GARDEN PINKS (DIANTHUS PLUMARIUS)

The term pink is also applied to a number of other plants: related plants in the genera *Silene* and *Lychnis;* sea-pink or thrift (*Statice armeria*) and the related genus *Limonium*, both of the leadwort family (Plumbaginaceae); moss pink, *Phlox subulata* (*see* PHLOX); and swamp pink, *Helonias bullata*. (N. TR.)

PINKERTON, ALLAN (1819–1884), U.S. detective and founder of a highly successful private detective agency, was born in Glasgow, Scot., Aug. 25, 1819, the son of a police sergeant. After completing his apprenticeship to a cooper, he emigrated to the United States in 1842 and settled in Chicago, Ill. Moving the next year to the nearby town of Dundee in Kane county, he set up a cooper's shop there. While cutting wood on a deserted island one day he discovered and later captured a gang of counterfeiters. Following this and other similar achievements he was appointed deputy sheriff of Kane county in 1846 and soon afterward deputy sheriff of Cook county, with headquarters in Chicago. In 1850 he resigned from Chicago's new police force to organize a private detective agency that specialized in railway theft cases. The Pinkerton National Detective agency became one of the most famous organizations of its kind. Its successes included capture of the principals in a $700,000 Adams Express company theft in 1866 and the thwarting of an assassination plot against President-elect Lincoln in Feb. 1861 in Baltimore. Later in 1861 Pinkerton, under the name E. J. Allen, headed an organization for obtaining military information in the southern states.

After the Civil War Pinkerton resumed the management of his detective agency. From 1873 to 1876 one of his detectives, James McParlan, lived among the Molly Maguires (*q.v.*) in Pennsylvania and secured evidence that led to the breaking up of this terrorist organization. During the strikes of 1877 the Pinkerton agency's harsh policy toward labour unions caused it to be severely criticized in labour circles, although Pinkerton believed he was helping workingmen by opposing labour unions. Pinkerton died in Chicago on July 1, 1884. He published *The Molly Maguires and the Detectives* (1877); *The Spy of the Rebellion* (1883), his account of Lincoln's journey to Washington in 1861; and *Thirty Years a Detective* (1884).

See J. D. Horan and H. Swiggett, *Pinkerton Story* (1951).

(B. MI.)

PINNACLE, in architecture, is a vertical ornament, usually tapering, crowning an architectural member. A pinnacle is distinguished from a finial (*q.v.*), which is only a single ornament, by its greater size and complexity, and from a tower (*q.v.*) or spire (*q.v.*) by its subordinate architectural role. Thus a tower may be decorated with pinnacles, each one capped by a finial.

Simple pinnacles were used on Romanesque churches, especially to mask the abrupt transition from square tower to polygonal spire, but they were far more prominent in developed Gothic architecture and decoration where they were used to give vertical emphasis and to break up hard outlines. They not only appeared at every major corner, flanking gables and atop parapets and buttresses, but also increased in size and were elaborated with finials, crockets, tracery, colonnettes, small gables and even subsidiary pinnacles. Some of the most striking pinnacles crown the piers of flying buttresses where, although primarily decorative, they enhance the stability of the buttresses by their additional weight. Representative buttress pinnacles are those of the early 14th century around the choir of Notre Dame at Paris and the magnificent 80-ft. pinnacles at Reims cathedral (13th century) with the spirelet and subsidiary pinnacles supported on the slender columns of a niche containing the statue of an angel with outstretched wings.

In England, pinnacles were especially developed during the Decorated period (*q.v.*) and played an important part in tower design, as at Salisbury cathedral (mid-14th century). Notable pinnacled buildings from different periods of the Gothic Revival are Horace Walpole's Strawberry Hill (1748), the Houses of Parliament (begun 1840) and the Woolworth building in New York (1911–13). (JS. S. P.)

PINNEBERG, a town in the *Land* (state) of Schleswig-Holstein, Federal Republic of Germany. Pop. (1961) 27,094. Situated on the Pinnau River, 12 mi. (20 km.) NW of Hamburg, the town is interspersed with woodlands and gardens and is a centre of rose growing, with some of the world's largest nurseries nearby. There are also various light industries. Pinneberg is a *Kreisstadt* (district town) and the seat of an *Amtsgericht* (district court).

PINOCHLE (also spelled pinocle, penuchle, binocle), a card game widely played in the U.S. in several variants. According to one account, it was invented in the 17th century by a Swedish schoolmaster, Gustave Flaker, who called it Flakernuhle. This story is probably folk etymology. Though pinochle is popularly regarded as a European game, there is no evidence that it was played there before the late 1860s, at which time it was flourishing in the U.S. It was probably developed by Germanic immigrants out of bezique (*q.v.*), with which its earliest-known form is almost identical.

The idea of all pinochle games is to meld (Ger., announce) certain scoring combinations of cards and to win tricks containing counting cards. A pack of 48 cards is used, containing duplicates in each suit of the ace, ten, king, queen, knave, nine, which rank downward in that order. When won in a trick an ace counts 11; a ten, 10; a king, 4; a queen, 3; a knave, 2; a nine, nothing.

Melds.—The following combinations score the number of points indicated, in any pinochle variant.

Sequence or flush (A, K, Q, J, 10 in trumps)	150
Royal marriage (K, Q in trumps)	40
Marriage (K, Q in any other suit)	20
Four aces, one in each suit ("Hundred aces")	100
Four kings, one in each suit ("Eighty kings")	80
Four queens, one in each suit ("Sixty queens")	60
Four knaves, one in each suit ("Forty jacks")	40
Pinochle (♤ Q and ♢ J)	40
Dix (pronounced "deece"), lowest trump	10

The dix is the 9 of the trump suit except when (rarely) a 64-card pack is used, including two 8s and two 7s of each suit, when the 7 of trumps becomes the dix.

Two-hand Pinochle.—Twelve cards are dealt to each player, three at a time. The next card is turned up and fixes the trump suit. The undealt cards are placed over the trump card so as to partly cover it and become the "stock." If the trump card is a dix, dealer scores 10.

Nondealer leads first. A card led by one player and the card played to it by the other constitute a trick and is won by the card led unless the opponent plays a higher card of the same suit or a trump on a plain-suit lead. Any card may be led and any card played; until the stock is exhausted it is not necessary to follow suit.

After winning a trick, a player may place face up on the table any meld and score the points therefor, subject to the following rules: Only one meld may be made in a turn. For each meld, at least one card must be taken from the hand and placed on the table. The same meld may be repeated only with entirely different cards from those used previously. A king or queen melded in a sequence may not thereafter be used in a marriage.

The winner of a trick may also exchange a dix for the trump card, or may merely show the dix, and score 10.

Cards once melded remain on the table but are available for play as though they were in the player's hand.

After the winner of a trick has had a chance to meld, each player draws a card from the top of the stock, the winner drawing first and then leading to the next trick.

When only one card of the stock plus the trump card remains, there can be no more melding. The winner of the next trick turns up the last card of the stock and then takes it into his hand; his opponent takes the trump card. Melds remaining on the table are picked up. The last 12 tricks are played, and each player must, if able, follow suit to the card led; if a trump is led he must win the trick if he can; and if he cannot follow to a plain-suit lead he must play a trump if he has one. The winner of the last trick scores 10. The cards in the tricks are counted and added to the player's score in even 10s, a remainder of less than 7 points not counting.

The game is won by the first player to reach 1,000. A player may call himself out in the middle of the play, and if his score, including his melds and tricks in the current deal, equals 1,000, he wins the game even though his opponent has a higher score; but if he has less than 1,000 he loses the game. If both sides pass 1,000 without calling out, game becomes 1,500 points; and so on.

The game with the 64-card pack is the same except that 16 cards are dealt to each player.

Auction Pinochle.—There are three active players, but it is customary for four to play, the dealer taking no cards. Each player receives 15 cards, dealt in rounds of 4, 4, 4, 3 or 3, 3, 3, 3, 3 at a time; a 3-card "widow" is dealt at the end of the first round of dealing.

The player at dealer's left has the first turn to bid. It is customary to rule that the first bid must be at least 300; in some games the minimum is 250, in others, 200. Each active player in clockwise rotation may bid as long as he overcalls the preceding bid, but if he once passes he may not thereafter enter the bidding. All bids are in units of 10 points.

The bidder (highest bidder) then exposes the three cards of the widow and adds them to his hand. He names the trump suit and places on the table, face up, whatever melds he wishes to show. He then buries (discards) any three other cards face down from his hand; these count as his first trick. He restores the cards melded to his hand and leads a card. No player other than the bidder may meld.

The bidder's two opponents combine in temporary partnership against him. Three cards, one from each hand, constitute a trick, which is won by the highest trump if it contains one, and otherwise by the highest card of the suit led. Of identical cards, the one played first outranks the other. The winner of each trick leads to the next. Each player must follow suit to the card led if he can; when a trump is led he must win the trick if he can. When he cannot follow suit but has a trump, he must play a trump.

The winner of the last trick scores 10. The values of the cards won in tricks are computed, and if the bidder's score for melds plus cards at least equals the amount of his bid, his contract is made. Each opponent (including the dealer) pays him in chips, on the following or a similar schedule:

If the bid was 250 to 290, 1 chip; 300 to 340, 3 chips; 350 to 390, 5 chips; 400 to 440, 10 chips; 450 to 490, 15 or 20 chips; 500 to 540, 20, 30 or 40 chips; the values of these bids depend on the custom of the club or group. If spades are trump, payment is double in each case.

If the bidder concedes defeat without leading to the first trick, he is "bete" (beaten; pronounced "bate") and pays each opponent in accordance with the schedule above. If the bidder led to the first trick and then failed to fulfill his contract, he is "double bete" and pays each opponent double.

In most games there is an imaginary extra player called the "kitty," who participates in payment and collection as an opponent of the bidder. In such games, when the compulsory first bid is passed by the other two active players, the bidder may concede defeat without looking at the widow, in which case he pays only a forfeit of one chip to the kitty.

The principal pinochle rules, established by custom, are: The bidder may change his meld, the trump suit or the cards he buries as often as he wishes before leading to the first trick, but not thereafter. If he buries a card he melded, and leads before correcting it, he loses. Any failure to play according to law forfeits the contract for the side in error. There is no penalty for a bid out of turn, or for an insufficient bid or for a bid by a player who has passed; it is merely void. A player who prematurely exposes a card of the widow must pay the value of the highest bid last made to each other player.

Many players simplify the count of cards by valuing aces and tens 10 each, and kings and queens 5 each; others simplify still further by calling aces, tens and kings 10 each. Other cards have no scoring value. The total of points to be taken in tricks is in every case 240 plus the 10 points for last trick.

Partnership Pinochle.—Four play, two against two as partners, the partners being seated alternately. The dealer gives 12 cards to each player, 3 at a time, but turns up his last card to fix the trump; if this card is a dix the dealer scores 10, and if it is any other card each other player in turn to the left may exchange a dix for it. Each player then shows his meld. Partnerships score jointly, but a player may not combine any card with a card from his partner's hand to form a meld. Once shown, the melds are picked up.

The player at dealer's left leads first. The rules of play are as in auction pinochle. If a side fails to win a trick, it loses its count for melds on that deal. It is usual to penalize a revoke by loss of the offending side's entire count for cards.

The first side to amass 1,000 points wins the game; a player may claim game at any time, or the game may continue to 1,500, as in two-hand pinochle (*see* above).

In many circles partnership auction pinochle is more popular. No trump card is turned, but each player in turn, beginning at dealer's left, has one bid. The high bidder names the trump. The nonbidding side always scores whatever points it makes; the bidder's side scores all it makes if it at least fulfills its contract, but if it falls short, the amount of its bid is subtracted from its score. Many forms of partnership auction pinochle have been developed, including firehouse pinochle, check pinochle and others.

See A. P. George, *Auction Pinnochle* (1913); Albert H. Morehead, R. L. Frey and G. Mott-Smith, *The New Complete Hoyle* (1956); E. Culbertson, *Card Games Complete,* ed. by A. H. Morehead and G. Mott-Smith (1952).

PINSK, a town of Brest *oblast* in the Belorussian Soviet Socialist Republic, U.S.S.R., stands on the Pina river, at its confluence with the Pripyat (Pripet). Pop. (1959) 41,548. One of the oldest towns of Russia, it was first mentioned in 1097. It was the seat of an early Russian princedom and derived much wealth and importance from river trade. From the 13th to 16th centuries Pinsk came under Lithuania and from the Union of Lublin belonged to Poland until the second partition of 1793, by which it was allotted to Russia. It was Polish again between the two World Wars. It was occupied by the Russians in 1939 and was made an *oblast* centre. The Germans held Pinsk during World War II and in 1945 it was ceded to the U.S.S.R. Pinsk *oblast* was dissolved in 1954. There are large timber-working industries making matches, veneer and furniture, and shipbuilding and repair yards. (R. A. F.)

PINTA: *see* Skin, Diseases of.

PINTO, FERNÃO MENDES (*c.* 1510–1583), Portuguese adventurer and author of an undisputed literary masterpiece, the *Peregrinaçam* (*Peregrination*), was born, probably at Montemor-o-Velho of poor parents, about 1510. He went out to India about 1537 and claimed to have traveled, fought and traded in almost every part of Asia during the next 21 years and to have experienced the most drastic vicissitudes of fortune, having been made "13 times a prisoner and 17 a slave" before returning to Portugal in Sept. 1558. He then married and settled at Almada near Lisbon, where he composed his famous *Peregrination* and where he died on July 8, 1583, having been awarded a pension by King Philip.

The first draft of the *Peregrination* was ready in 1569, but it was not published until 1614. It is hard to tell how far Pinto's editors rather than himself are responsible for some of the more

palpable exaggerations, contradictions, errors and omissions. It is known, for example, that Pinto was a Jesuit novice in 1554–56, but he gives no hint whatever of this in his book. The story of his life, which he told the Jesuits on admission to the society, is very different from that depicted in the *Peregrination*. In the latter he portrays himself as a swashbuckling adventurer and in the former as a wealthy and successful trader, which he certainly was when he joined the society. The *Peregrination* is of no geographical value, but it is of great interest as depicting the impression made on an intelligent Portuguese by the civilizations of the far east, and for its thinly veiled criticism of the behaviour of his compatriots in Asia. There is no good critical edition in any language to date, and the existing editions are listed in the following critical studies: G. Schurhammer, *Fernão Mendes Pinto und seine "Peregrinaçam"* (1926); G. Le Gentil, *Fernão Mendes Pinto. Un précurseur de l'exotisme au XVIe siècle* (1947); M. S. Collins, *The Grand Peregrination* (1949); A. J. Saraiva, *Fernão Mendes Pinto* (1958). (Cs. R. B.)

PINTURICCHIO (BERNARDINO DI BETTO DI BIAGO) (*c.* 1454–1513), Italian painter of the Umbrian school, was born in Perugia. According to G. Vasari he was 59 at his death, which took place in Siena on Dec. 11, 1513; he was thus born about 1454. He is first recorded as a painter in 1481, when he entered the guild at Perugia, but he may have been active before then since he is usually held to have been concerned in the series of panels of the "Miracles of S. Bernardino" (gallery, Perugia), one of which is dated 1473. In this case he may have been a pupil of Fiorenzo di Lorenzo, but by 1481 he was associated with Perugino, whose influence on him was to be permanent. It is generally agreed that Pinturicchio assisted Perugino on some of the frescoes in the Sistine chapel in the Vatican (1481/82), although his name does not occur in the documents. Vasari says that he worked a great deal for Perugino as a young man, receiving one-third of the fees. He was certainly in Rome in the 1480s, working in the Bufalini chapel in Sta. Maria in Aracoeli and also in Sta. Maria del Popolo, where he decorated two chapels and also painted the choir ceiling (this last in 1509). In 1492 he was in Orvieto, where he painted two Evangelists and two Fathers in the cathedral, but they were not liked.

His most important work of this period was the decoration of the suite of six rooms in the Vatican known as the Appartamento Borgia for Pope Alexander VI between 1492 and 1494. These rooms contain representations of Sibyls, Prophets and Apostles; the seven Liberal Arts; seven Saints; the seven Joys of the Virgin; and some extraordinary astrological and mythological references to the Borgia emblem, the Bull. The sixth room was redecorated early in the 16th century. In 1495 Pinturicchio was back in Perugia, where he painted an altarpiece for Sta. Maria de' Fossi (gallery, Perugia). In 1501 he was prior of Perugia for the months of March and April and then he went to Spello, where he decorated the Baglioni chapel in Sta. Maria Maggiore. These frescoes include a self-portrait dated 1501. Another fresco there, representing Christ teaching in the Temple, virtually repeats Perugino's "Christ Giving the Keys to St. Peter" in the Sistine chapel, painted 20 years earlier.

Pinturicchio's last major works, and his most famous, were the 10 scenes from the life of Pope Pius II painted in fresco in the library of Siena cathedral. They were commissioned by Cardinal Francesco Piccolomini, afterward Pius III (the nephew of Pius II), in 1502, begun in 1503 and completed in 1509. Vasari says that the "sketches and cartoons for all the scenes" were made by Raphael, but this view is no longer accepted; nevertheless, it is not now so confidently asserted that Raphael had nothing whatever to do with it as was often thought in the late 19th century. O. Fischel, an authority on Raphael, holds that some participation by him is highly likely, especially as the fresco outside the library, representing the coronation of Pius III, is believed to contain a self-portrait of Raphael. About 1509 Pinturicchio also painted a series of frescoes in the Palazzo Petrucci, Siena, and the fragment of "Penelope" in the National gallery, London, came from it. His last work was the "Way to Calvary" of 1513, now in the Palazzo Borromeo, Milan.

ALINARI—ART REFERENCE BUREAU

"THE DISPUTE OF ST. CATHERINE" BY PINTURICCHIO, 1492–94, FRESCO DECORATING THE APPARTAMENTO BORGIA, THE VATICAN

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(P. J. Mx.)

PINZÓN, a family of Spanish shipowners and navigators of Palos in Andalusia, three members of which—Martín Alonso, Francisco Martín, and Vicente Yañez, brothers—were associated with Christopher Columbus in the discovery of America.

MARTÍN ALONSO PINZÓN (*c.* 1441–1493) was part owner of the "Pinta" and "Niña," which he helped prepare and man for the expedition of 1492. He commanded the "Pinta," on which his brother Francisco was pilot. On the voyage his suggestion to change course (when already in the latitude of the Bermudas) was adopted on Oct. 7, bringing the fleet to a landfall in the Bahamas on Oct. 12, 1492. On Nov. 21, near the east end of the north coast of Cuba, Pinzón left Columbus, making eastward in search of the supposed gold land, but on Jan. 6, 1493, he rejoined the admiral. During the return journey Pinzón separated from Columbus again but arrived in Palos just after Columbus, having sent a letter about the discoveries from his first landfall at Bayona, Galicia. He died soon afterward.

VICENTE YAÑEZ PINZÓN commanded the "Niña" in 1492–93 and remained with Columbus throughout the expedition. In later years he made important discoveries on his own account. Early in 1500 he sailed with four caravels across the Atlantic to the southwest, and on Feb. 7, 1500, landed on the Brazilian coast at Cape Santo Agostinho (called by him Cape Santa Maria de la Consolación). He probably rounded Cape São Roque and then turned north, followed the coast to the northwest, discovered the Amazon estuary, and went as far as the present Costa Rica. After touching Hispaniola, and losing two of his vessels among the Bahamas, Vicente returned to Palos in September 1500. Although he was created governor of the newly discovered lands by Ferdinand II and Isabella, he did not take possession. In 1507 he sailed with Juan Díaz de Solís along the coast of Central America. In 1509, again with De Solís, he coasted the Atlantic side of South America as far as the La Plata estuary, hoping to find an opening westward leading to the Spice Islands. According to Herrera, he reached 40° S, not recognizing the La Plata and turning back about the mouth of the Río Negro; but this is probably an exaggeration. After 1523 no trace of Vicente is found.

See Samuel Eliot Morison, *Admiral of the Ocean Sea: a Life of Christopher Columbus* (1942).
(U. S. L.)

PIOMBINO, a seaport of the province of Livorno (Leghorn) region of Tuscany, central Italy, lies on the west coast, 50 mi. (81 km.) SE of Leghorn by road. Pop. (1961) 35,719. The town is situated at the tip of a promontory of the same name below Monte Massoncello (938 ft. [286 m.]) and opposite the Island of Elba. Piazza Bovio, standing on a cliff, is one of the finest squares in Italy. Nearby is Populonia with Etruscan, Roman, and medieval remains. A branch railway runs to Campiglia Marittima on the main Rome–Genoa line. Steamers connect Piombino with Elba. There are iron- and steelworks and significant shipping traffic. Declared a princedom in 1594, Piombino was variously owned or occupied before becoming part of the Kingdom of Italy in 1861.
(CI. D.)

PIOTRKOW TRYBUNALSKI, a town in central Poland and a district centre in Lodz *wojewodztwo* (province), is situated about 32 mi. (51 km.) SSE of Lodz by road. Pop. (1960) 53,000. The town lies in the Lodz Highlands at a meeting place of old trade routes. It is on the Warsaw-Katowice Railway. There are a regional museum and many old buildings. Textiles form the most important industry. Referred to in historical documents of the early 13th century, Piotrkow Trybunalski obtained town rights toward the end of that century. It was the seat of *sejms* (chamber of deputies) and of the crown court of justice (*trybunal*). Cloth manufacture began there in the 15th century, a guild was formed in the 16th century, and the industry was considerably developed in the 19th century. During the German occupation in World War II three concentration camps for Jews were situated there.
(T. K. W.)

PIOZZI, HESTER LYNCH (1741–1821), English writer, best known as Mrs. Thrale, the friend of Samuel Johnson, was born at Bodvel, Caernarvonshire, on Jan. 16, 1741 (old style). The only child of John Salusbury of Bachygraig in Flintshire, she spent most of her youth in London and visiting an uncle in Hertfordshire. In 1763 she married a rich brewer named Henry Thrale, who had a house adjoining the brewery in Southwark and a country estate at Streatham in Surrey. During the next 15 years she had 12 children, of whom four daughters grew to maturity.

In January 1765 Samuel Johnson (*q.v.*) was brought to dinner by Arthur Murphy, an old bachelor companion of her husband's, and the next year, following a severe illness, Johnson spent most of the summer in the country with the Thrales. Gradually he became part of the family circle, living about half the time in their homes. A succession of distinguished visitors came there to see him, as well as to eat Thrale's excellent dinners and to listen to Mrs. Thrale's amusing chatter. Thrale later commissioned Sir Joshua Reynolds to paint portraits (13 in all) of the best-known, to line the walls of the library at Streatham.

In 1781 Thrale died, and with the sale of the brewery his wife was left a wealthy widow. To everyone's dismay she proceeded to fall in love with her daughter's music master, Gabriel Piozzi, an Italian singer and composer, in temperament very different from the phlegmatic brewer. Although forced at first to give him up, in 1784 despite family pressures she married him and set off for Italy on a honeymoon. Johnson had openly disapproved of her choice, and the resulting estrangement saddened his last few months of life.

In Florence she became part of a literary group some of whom were later known as the Della Cruscans (*q.v.*) and contributed to a volume called *The Florence Miscellany* (1785). When news reached her of Johnson's death, she hastily compiled and sent back to England copy for *Anecdotes of the Late Samuel Johnson, LL.D., During the Last Twenty Years of His Life* (1786), which thrust her into open rivalry with James Boswell. The breach was further widened when, after her return to England in 1787, she brought out a two-volume edition of *Letters to and from the Late Samuel Johnson, LL.D.* (1788). Although less accurate in some details than Boswell's, her accounts are valuable in showing other aspects of Johnson's character, revealing especially the more human and affectionate side of his nature.

When many old friends remained aloof, Mrs. Piozzi drew around her a new artistic circle, the central figure being the actress Mrs. Siddons. Her pen continued active, and thousands of her entertaining, gossipy letters have survived. Among her later published works were *Observations and Reflections Made in the Course of a Journey Through France, Italy, and Germany*, two volumes (1789); *British Synonymy*, two volumes (1794); and *Retrospection*, two volumes (1801), a rambling history of the world for the preceding 1,800 years.

Because of her husband's increasing ill-health, the Piozzis built in 1794–95 an Italian villa, named Brynbella, on her family property in north Wales, and made this their home until his death in 1809. Turning over the property to her adopted son, Piozzi's nephew, she spent her last years at Bath, retaining to the end her unflagging vivacity and zest for life. She died at Clifton, Bristol, on May 2, 1821.

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(J. L. C.)

PIPE AND TABOR, a one-man band consisting of a three-holed whistle flute and a small snare drum (*see* DRUM). The player holds the pipe with his left hand, stopping the holes with the thumb, first and second fingers; the other two fingers support the instrument. A scale is obtained by overblowing, using the

second to the fourth harmonics; the gaps between the harmonics are filled by uncovering the fingerholes. The tabor, suspended from the player's left wrist or elbow, is beaten with the right hand and provides a rhythmic accompaniment to the tune.

Mention of the pipe and tabor first occurs in the Middle Ages, when it was one of the ensembles that provided music for court dances. By the beginning of the 17th century its use began to decline and it survived primarily as a folk instrument. In Provence, and parts of Spain, where players of great virtuosity provide music for traditional regional dances, the tradition of playing remained unbroken to modern times. In England, where pipe and tabor playing was associated with the morris dancers, the tradition was broken at the end of the 19th century; the renewal of interest in English folk music at the beginning of the 20th century brought about a revival both of playing and of manufacture.

PIPEFISH, the name given to fish of the genus *Syngnathus,* which, with the sea horses, form the family Syngnathidae. Pipefish are long and slender, with the approximate dimensions of a pencil, usually about six inches long when full grown. The body is encased in bony rings, and a small, toothless mouth is at the end of the long, tubelike snout. About 100 species are known from warm seas and a few from rivers. They frequent seaweeds and swim slowly by rapid undulations of the small dorsal fin. Females deposit their eggs in the male's brood pouch. "Pregnant" males maintain the eggs for some time after hatching.

See also FISH: *Trumpet Fishes, Sea Horses, Sticklebacks, etc.*

(C. HU.)

PIPELINE: *see* GAS INDUSTRY; PETROLEUM.

PIPER, CARL, COUNT (1647–1716), Swedish administrator and statesman who, during the first decade of the Great Northern War, ranked in the eyes of Europe as King Charles XII's "first minister," was born at Stockholm on July 29, 1647. Of low nobility, connected by marriage with a rich commercial family, he was one of the new type of bureaucratic official brought to the fore by Charles XI's assumption of personal power. His main career during Charles XI's reign was in the chancellery's department of home affairs, where he had opportunities to enrich himself by accepting the customary gifts for services. When Charles XII (*q.v.*) became king in 1697, he took Piper into the council (membership of which was theoretically reserved for members of the first rank in the house of nobility) and made him a count; and it was rumoured that Charles XI on his deathbed had named Piper as one who would uphold royal absolutism and the resumption of crown lands against attempts of the high nobility to reverse that policy.

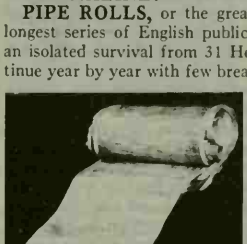
Piper was the only councillor to accompany Charles XII into the field during the Northern War (*q.v.*). The death of some officials and the illness or advanced age of others led him to concern himself with foreign relations in general. He was more cautious than the king, but the disagreement between the two over policy has been exaggerated: Piper and other chancellery-in-the-field officials were careful always to put cautious advice on paper lest they—in case of the king's death—should be held responsible at home for rash decisions; and Charles certainly considered Piper's arguments before taking action based on all information at his disposal.

During the duke of Marlborough's visit to Altranstadt in 1707, Count Piper's wife accepted, with the king's knowledge (as Piper asserted) an expensive diamond ring. The present gave rise, when misleading rumours began to circulate after 1709, to a lively discussion as to whether Piper had been bribed by England to turn his master away from Western Europe and toward Russia. Charles XII's decision to invade Russia was one with which the majority of his advisers, including Piper, concurred; but after the setbacks of the winter of 1708–09 Piper was one of those who argued in favour of returning to the base in Poland. Charles however insisted that a battle must be risked in order to draw Tatars and Turks into the Swedish coalition; and at Poltava, in July 1709, Piper was taken prisoner. Missing Piper's experience in chancellery affairs, Charles made intense efforts to have him exchanged, but Piper, who bore himself with dignity and exerted himself to alleviate the lot of the captive soldiers in Russian hands, died still a prisoner of war at Schlüsselburg (Nöteborg) on May 29, 1716. (R. M. HA.)

PIPERACEAE, the pepper family, commercially important for its members that yield the common spice pepper. It is a large group of tropical herbs, vines, and small shrubs with simple leaves having a characteristic pungent taste, and the numerous small flowers, lacking both sepals and petals, crowded in dense spikes. Most of the species belong in two genera, *Piper* with more than 600 species and *Peperomia,* also with more than 600. Pepper (*q.v.*) is the product of several species. Cubeb (*q.v.*) is the fruit of *Piper cubeba.* The leaves of *Piper betle* are widely used in the Orient for chewing with slices of betel nut and lime, while kava (*q.v.*), a stimulating drink widely used in Polynesia, is prepared from certain pepper plants. (E. D. ML.)

PIPERAZINE: *see* ANTHELMINTICS.

PIPE ROLLS, or the great rolls of the exchequer, are the longest series of English public records. Beginning, apart from an isolated survival from 31 Henry I (1130), in 1156, they continue year by year with few breaks to 2 William IV (1832). Each pipe roll consists of a varying number (ranging from 13 to 20 between 1190 and 1214) of rotulets about 14 in. wide made from two sheepskins sewn together to make one length of about four feet, the rotulets themselves being fastened together along the top. The most plausible explanation of the name is that the rolls, stored in their presses, look like a stack of pipes. Originating in the days when the sheriff was the chief financial officer in the shire, the pipe rolls were, as they remained, essentially the sheriffs' accounts. Lands temporarily in the king's hands were often entrusted to other officers who accounted for them at the exchequer, but these "foreign" accounts were generally entered on the same rotulet as the rest of the shire to which they belonged. When a sheriff was engaged on other royal business at the time he should have presented his account it was held over and he afterward accounted for two, or sometimes for three, years at once. The payments of magnates accounting at the exchequer for feudal dues were entered under the shire where their chief lands lay. Toward the year 1200 the increasing popularity of the royal courts of justice and the frequent appearance of judges in the shires brought humbler debtors to Westminster and a vast expansion to the pipe rolls. One method of reducing the work thus created was to encourage the sheriff to collect these small judicial debts locally and account for them in bulk.



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PIPE ROLL FROM THE REIGN OF HENRY II OF ENGLAND, DATED 1183–84

Calculations of the royal revenue from the pipe rolls can only be approximate, for, even in the 12th century, by no means all the king's income passed through the exchequer. Some manors always accounted directly in the household, and extraordinary taxes, such as that for Richard I's ransom and the early taxes on movables, passed through other channels. Even so, the historical value of this great series can hardly be overestimated. Between 1833 and 1844 the Record Commission printed a few of the early rolls. Since its foundation in 1883 the Pipe Roll Society has published all the rolls up to and including that for 1214, but the problem of providing access in print to the historical evidence buried in this formidable series of records is almost insoluble. Although the setting up of other accounting offices with fresh series of accounts gradually relieved the pipe rolls of much of their bulk, it was only by slow degrees that they were at last reduced again to the bare bones of the sheriffs' accounts with which they had begun. But the sheriffs' accounts of the 18th century were ghosts from a forgotten past. The continuation of the pipe rolls down to 2 William IV is a remarkable example of English administrative conservatism.

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(D. M. S.)

PIPE SMOKING. Smoking tobacco through a pipe is indigenous to the Americas and derives from the religious ceremonies of ancient priests in Mexico. Stone carvings depict priests of the Mayas using a form of pipe to blow tobacco smoke toward the sun and the four points of the compass. Such practices were also known to the ancient Aztecs, who used reeds for smoking. Farther north, in the mounds of the Mississippi Valley, archaeologists have discovered elaborate curved pipes of bone, wood, and clay that may have been smoked 1,000 years before any European set foot in North America.

American Indians had ceremonial pipes for special occasions, the chief of these pipes being the calumet (*q.v.*), or pipe of peace. Such pipes had marble or red steatite (or pipestone) bowls, ash stems about 30 to 40 in. long, and were decorated with hair and feathers. The pipes of the Algonkian tribes, who were totem worshipers, were carved with the birds and animals the tribes regarded as sacred.

The practice of cooling and cleansing the smoke of a tobacco pipe by drawing it through water was not followed in the Americas nor has it been very popular among Europeans. The Bushmen and Hottentots of southern Africa used the *dakka* pipe, which cooled and mitigated the effects of hemp smoke by drawing it through a horn of water. While Africa continued to produce more orthodox pipes of almost every possible material and size, the water pipe spread to India (where a more elegant version is called the *nargileh*) and the Far East, and the *hookah* was popular among both men and women in Persia in the 17th century.

The practice of smoking reached Europe through sailors who had encountered it in the New World. By the beginning of the 16th century both the tobacco plant and the practice of smoking had reached Spain, later spreading to France, Belgium, and other European countries. By the end of the 16th century, the tobacco-plant seeds were known in England, and clay pipes had become relatively common. Pipe smoking was carried to Holland and the Rhine area in the early 17th century.

In England the earliest Elizabethan fairy, or elfin, clay pipes had a barrel-shaped bowl that tilted forward, a flat "heel," and a 12-in. stem. Such pipes are believed to have been made at Broseley in Shropshire as early as 1575. By the beginning of the 18th century, a spur on the base of the bowl took the place of the flat heel (to prevent the hot bowls from touching the table), and makers initialed the side of the bowl instead of the heel. Broseley supplied many of the new "fancy" clays with bowl moldings in relief and longer pipe stems, as in the "churchwarden" and "London straw" pipes, made especially to suit the more leisured life of London coffeehouses and clubs. With the popularity of pipes and the perishable nature of clays, the industry thrived. The English pipe makers were incorporated in 1619.

A great variety of pipes have been used throughout the world. The Eskimo has made decorated pipes from walrus ivory; in the Far East pipes with metal bowls the size of acorns and with chased and ornamented stems have been produced for smoking opium. The clay pipe was used throughout Europe, but porcelain and pottery pipes were also popular; there are many examples of such ornately decorated French and German pipes. In Russia the pipes were of wood, with elaborate carvings; Tirol and Bavaria produced horn pipes. In the United States the corncob pipe was the most widely used; in England pipes were also being made of Staffordshire pottery and Bristol glass. The *çibuk* used in Turkey had a large, ornamented, pottery bowl and a very long, straight stem.

But the first pipe to challenge the supremacy of the clay pipe was the meerschaum ("sea foam"), a mineral material composed of magnesia, silica, and water. The pipe, usually with a mouthpiece of amber, is said to have originated in Hungary, although the mineral is found mainly in Turkey.

Wood, bone, iron, glass, porcelain, clay, and gourds had been used for pipe making long before a Corsican peasant in the 19th century is believed to have copied a broken meerschaum in the local briar wood, whereby a new industry was born, especially in France.

Briar (from Fr. *bruyère,* "white heath") is a superior pipe-

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HISTORICAL AND CONTEMPORARY PIPES

(A) Tirolean style pipe made in Bavaria, Ger.; (B) Persian pipe with clay bowl and bone stem; (C) Burmese pipe made from bamboo root; (D) china (pottery) pipe of the U.S.S.R.; (E) modern briar pipe; (F) American Indian pipe carved in slate with bowl sunk midway along the top (right-hand side, as illustrated); (G) Elizabethan clay pipe of the early 17th century; (H) traditional German pipe with china bowl, cherrywood stem, and horn mouthpiece; (I) Chinese opium pipe with glazed china bowl, decorated with enamel and ivory

making material because the roots of the heath tree (a species of heather found in Mediterranean countries) are tougher, lighter, and more resistant to heat than most other materials. Briar pipes do not readily absorb the tar residues of the burned tobacco—not to be confused with nicotine—that remain in the bowl and stem. But since the most suitable briar roots may be 60 to 100 years old and since a large number of them contain cracks and flaws that make them valueless, the supply of good briar is a difficult and costly matter for all manufacturers.

The first-class briar pipe is expensive because it must be made from top-quality briar and must undergo about 70 to 80 separate operations, the work being spread over several months. The briar has to be dug, carried in pannier baskets to collecting points, stacked, roughly shaped into blocks (called *ébauchons*), and shipped to the country of manufacture. The bowl has to be turned on three or four separate machines in sequence, and, depending

on the shape required, a considerable amount of handwork may be necessary. By the application of oils and by various drying processes the bowl is prepared for polishing operations and for fitting the mouthpiece, which is cut and shaped by hand from block vulcanite. Finally the natural appearance of the grain is brought out, not by means of stains and varnishes but by hand polishing. A defect or blemish will greatly lower the value of the pipe.

The obvious test of these processes lies in the appearance and smoking qualities of the pipe, which should improve with age. Pipes must be correctly balanced and comfortable in the mouth as well as attractive to the eye. Curved stems help to reduce the weight on the teeth and long stems to increase it. Cutaway or "saddle" mouthpieces give a more comfortable grip, making it possible to use a heavier bowl than would otherwise be comfortable. Mouthpieces with a wide aperture tend to spread the smoke and thus avoid the danger of burning the tongue.

The pattern of the grain is less important. If the bowl has clear natural markings it is likely to have been cut from an old root that contained a minimum of oil and sap; accordingly, it should produce a pipe that is strong and heat-resistant. Cracks and flaws, which are usually filled with mastic and varnished, though not necessarily impairing the smoking qualities of the pipe, indicate that the bowl has been made from indifferent briar.

Tobacco should be chosen for the individual palate, aroma and strength being a personal matter. Similarly, variety and contrast can greatly increase a smoker's pleasure. Few men, day after day, eat the same food and drink the same wine. For similar reasons it is not ideal to adhere rigidly to the same brand of tobacco. Novices who wish to experiment with a pipe often assume that they should begin with a mild tobacco. However, a mild tobacco that is finely cut and smoked rapidly—a frequent mistake among those unaccustomed to the pipe—can taste very hot and burn the tongue. It is well to begin with a tobacco of medium strength that is not cut too fine and is neither too moist nor too dry. *See* also TOBACCO: *Tobacco and Disease.*

See A. Dunhill, *The Pipe Book* (1924); Alfred H. Dunhill, *The Gentle Art of Smoking* (1954). (A. H. DU.)

PIPIL, a language closely related to that of the Aztecs (Nahuatl) and spoken today by four groups of Indians located (1) at Soconusco, on the Isthmus of Tehuantepec in the state of Veracruz, Mexico; (2) in the upper Motagua Valley and (3) Escuintla, both in Guatemala; and (4) in El Salvador.

At the time of the Spanish conquest several explanations of the presence of these Mexican Indians in Central America were given by the Indians. It was said that the Aztec emperor Ahuitzotl (1486–1502) had sent colonists to spy out the land and prepare for a never-accomplished conquest. This tale fails to account for the large and well-built cities occupied by the Pipil. More generally it is thought that they were Toltecs who either migrated from Mexico with Quetzalcoatl (*see* TOLTEC) or, more probably, fled after the downfall of the Toltec Empire in the 12th century. The Spanish historian Juan de Torquemada preserved a significant migration legend that supports the last hypothesis.

Numerous ruined cities are attributed to the Pipil by archaeologists. Of these the most important are Santa Lucía Cotzumalguapa and El Baúl, lying three miles apart, near Escuintla; and Chalchuapa, Cihuatán, and Tehuacán in El Salvador. These sites yield characteristic stone carvings and pottery types. The modern culture of the Pipil varies from village to village. In general it reflects that of their neighbours such as the Quiché (*q.v.*).

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PIPIT, any of about 35 species of songbirds chiefly of the genus *Anthus,* associated with the wagtails in the family Motacillidae. They live on the ground in grassy areas. Protectively coloured, they resemble larks, and are sometimes called titlarks. Two or three species frequent trees, walking along horizontal branches picking insects from the bark. Like some other songbirds of grasslands, pipits circle high in the air to give their songs. One of the two American species, Sprague's pipit (*Anthus spragueii*), discovered by Audubon, was called the "Missouri skylark." Pipits build a simple nest in the grass and lay three to five protectively coloured eggs.

ERIC HOSKING

MEADOW PIPIT (ANTHUS PRATENSIS)

British species are the meadow pipit (*A. pratensis*), the rare tawny pipit (*A. campestris*), and the water pipit (*A. spinoletta*); a race of the latter is also found in North America, nesting usually on mountain meadows, but migrating into inhabited areas, where it frequents plowed fields and the shores of ponds. Africa abounds in pipits and many of the species are very difficult to distinguish one from the other. (DN. A.)

PIQUET, a game of cards, probably a development of *rouſa,* a game mentioned by Francesco Berni in 1526. The Spanish name of the game was *cientos* (*centum,* a hundred). Piquet was played in England under the name of cent, probably as early as 1550.

Piquet is essentially a game for two players, although there are variants for three and four. A pack of 32 cards is used, ranking: ace (high), king, queen, jack, ten, nine, eight, seven. Twelve cards are dealt to each player, two or three at a time. The remaining eight cards, the stock, are spread face down. If either player holds carte blanche (a hand with no court card), he announces it and scores 10 points. Nondealer (also called elder, or major) discards from one to five cards and draws an equal number from the top of the stock. If he leaves any of the first five, he may look at them without showing them to dealer. Dealer (also called younger or minor) then discards if he chooses from one card up to the number remaining in the stock and draws an equal number. If he leaves any, he may turn them face up.

After the draw, nondealer announces his best holding (if any) in each of three classes of scoring combinations. The classes are point, sequence and set. Only one player is entitled to score in each class.

Point is the longest suit or, if the long suits in both hands are equal in length, the highest total count in those suits, reckoning ace as 11, court cards 10 each and other cards their pip value. Whoever has the better point scores 1 for each card in the suit. A tie scores for neither.

A sequence is three or more cards of the same suit in consecutive rank: tierce for sequence of three, quart for four, quint for five, etc. The longest sequence is "good," and the holder may also score any additional sequences he holds. Between equal length sequences, that of higher rank is good. Tierce scores 3, quart 4; quint or better scores 10 plus 1 for each card. If there is a tie for best sequence, no sequences are scored.

Sets are three of a kind (trio) or four of a kind (quatorze) of rank ten or higher. A quatorze, counting 14, is good against a trio, counting 3. Between equal length sets, that of higher rank wins. The player with the highest set may count it and any additional set he holds.

A player may sink (conceal) part or all of a combination if he thinks revealing it would aid his opponent's play. Any declared combination that scores must be proved, usually by exposing it, though etiquette varies in this matter. Carte blanche is shown, after the opponent has discarded.

Upon completion of the declarations, play begins, nondealer making the first lead. Each lead requires the other to follow suit if able. The trick is won by the higher card of the suit led. (There is no trump suit.) The winner of a trick leads to the next. For each lead he makes and each trick he wins on an adverse lead, the player counts 1 point. The last trick counts 1 extra point. The winner of a majority of the 12 tricks scores

10 points. If he wins all the tricks he scores 40 for capot.

If by declared combinations a player reaches 30 or more points before his opponent scores a point, he adds 60 to his score for repique. If he reaches 30 in declaring and play (excluding capot) before his opponent scores, he adds 30 for pique.

During declaration and play, the score is kept verbally, each player announcing his new total after each increment. At the end of play the totals are written on paper.

In the early piquet au cent, a game was continued by alternate deals until one player reached 100 points. This game was superseded by rubicon piquet, in which a game is six deals. The winner receives a bonus of 100 for game, plus the difference of the final totals. If the loser fails to reach 100 (regardless of whether the winner also is below 100), he is rubiconed, and the winner takes 100 plus the sum of the final totals. Modern players prefer the short game of four deals, the first and last counting double.

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PIRACICABA, a city in the interior of São Paulo state, Brazil, 85 mi. NW of São Paulo, with which it is connected by rail and all-weather highway. Pop. (1960) 80,670 (mun.). Piracicaba is the centre of one of São Paulo's most productive agricultural districts, where sugar cane, cotton, coffee, rice, and oranges are grown. In the town are sugar mills, brandy distilleries making *caxaça,* cotton gins, rice and coffee processing plants, tanneries, flour mills, and a paper manufacturing plant. Nearby, on an area of the purple-coloured *terra roxa* soil, is one of São Paulo state's chief agricultural colleges. (P. E. J.)

PIRACY means robbery or other violent action, for private ends and without authorization by public authority, committed on the seas or in the air above the seas, outside the normal jurisdiction of any state.

History.—Piracy has occurred in all stages of history. The extent to which it has been a menace to maritime navigation has, however, varied greatly at different periods and in different areas, depending on the number of seamen unable to find a more regular means of livelihood and on the opportunities for piratical activities and the risks involved in them.

In the ancient Mediterranean, piracy was often closely related to maritime commerce, and the Phoenicians appear to have engaged in both. In periods between the wars among the Greek states and between the Roman Republic and Carthage, piracy was common in the Mediterranean. "Sea rovers" are frequently mentioned in the *Odyssey.* Julius Caesar is said to have been captured by sea robbers when he was a young man and held prisoner until ransomed. After his release he returned with a strong force, captured the pirate ship on which he had been held captive, and crucified the whole crew. In the Middle Ages, Vikings from the north and Moors from the south also engaged in piracy.

At the conclusion of European wars during the Renaissance and after, naval vessels would be laid up and their crews disbanded. From among these men, pirates recruited their crews. Lacking other employment, sailors would often sign on a ship without asking questions; they would not be paid regular wages but would be promised an opportunity to share in the profits of the voyage. When a merchant ship was captured its crew would sometimes be invited to join the pirates. Some would do so willingly, others only under compulsion. Frequently when pirates were brought to trial they pleaded that they had joined the enterprise only to save their lives. Sometimes piracy began with a mutiny on a merchant ship. The mutineers would seize the officers, kill them, along with members of the crew who resisted, and throw their bodies overboard. This practice was resorted to in the "Tungchow" piracy near Canton, China, in 1925 during the disturbed warlord period. The mutineers killed the officers, kept the passengers in the cabin under guard until the ship approached the pirate refuge in Bias Bay; there they loaded the valuable cargo into a longboat in which they departed.

Another common source of piracy was the privateer (*q.v.*), a privately owned and armed ship commissioned by a government by a letter of marque authorizing the ship to make reprisals to gain reparation for a specified offense in time of peace, or to prey upon the enemy in time of war with the right of the officers and crew to share in "prize money" from captured vessels. The temptation was great to continue this profitable business after the war was over without submitting prizes to the proper court. During the Elizabethan wars with Spain, treasure-laden Spanish galleons proceeding from Mexico into the Caribbean were a natural target for privateers, and the line between privateering and piracy became difficult to draw. In the later period of Anglo-French hostilities a similar situation existed in interwar periods. Cotton Mather, the New England minister, in a "hanging sermon" to condemned pirates in Boston in 1704, said: "The Privateering Stroke so easily degenerates into the Piratical, and the Privateering Trade is usually carried on with an Unchristian Temper and proves an Inlet into so much Debauchery and Iniquity." Admiral Nelson also declared that, "All privateers are no better than pirates." This situation eventually led to the abolition of privateering by the Declaration of Paris of 1856 following the Crimean War. The concept of "prize money" that entitled the crew and officers of regular naval vessels to receive a share of the value of captured prizes injected an element of private gain into naval operations against commerce, and induced most governments to abolish it in the 19th and 20th centuries. The United States did so in 1904 following the claim of Admiral Dewey for prize money for having captured small vessels at Manila during the Spanish-American War. (*See* also BUCCANEERS.)

The increased size of merchant vessels, the improved naval patrolling of most ocean highways, the regular administration of most islands and land areas of the world, and the general recognition by governments of piracy as an international offense have resulted in a great decline in piracy in the 19th and 20th centuries. Piracy has, however, occurred in the 20th century in the South China Sea, and the practice of hijacking ships or airplanes has developed into a new form of piracy. During the prohibition era in the United States, for example, ships loaded with alcoholic beverages off the American coast were sometimes hijacked by men in a small vessel, perhaps with collusion of the ship's officers. The small vessel would then run the cargo into an inlet at night, escaping the U.S. Coast Guard, and the larger ship, if brought into court, would claim that it was innocent of intent to violate U.S. laws but was the victim of piracy. (*The Louise F.,* 293 *Federal Reporter* 933.)

Certain Chinese vessels under contract with the Nationalist government of China were diverted in 1957 by their officers or crew and taken to a port in Communist China. The Nationalist government initiated an action in U.S. courts against an American insurance company under an insurance contract that excluded losses caused by "seizure by another state or by pirates." The court held that if the master was responsible for these diversions he was guilty of barratry (breach of duty by the master of a ship) and the insurance company was liable. If, on the other hand, the master had been coerced by the crew, the latter had "seized" the vessel and, whatever their motives, the insurance company was not liable. Such a seizure might be termed mutiny or hijacking, but as the motive of the crew was political—they considered that they owed allegiance to the Communist government of China—it was not piracy. (*Republic of China* v. *National Union Fire Insurance Company,* 151 Federal supplement 211, 1957.)

The seizure in 1961 of the "Santa Maria," a Portuguese vessel, by Portuguese revolutionists on board who eventually brought it to Recife, Braz., was frequently described as piracy but, as the intent was political, it should be described as insurgency. This, at least, was the opinion of the Brazilian government, which returned the "Santa Maria" to Portugal but took no action against the insurgents who had seized it.

Several airplanes flying between the United States and Cuba were hijacked by persons on board in 1961. In each case the hijackers with threats of force compelled the pilot to change his course. Whether the intent was political or private, or the result of a desire for publicity by a deranged mind, was uncertain in some of the cases. The incidents presented great danger to passengers,

and induced the U.S. government to provide more effective policing on aircraft and to pass legislation for punishment of such hijacking of airplanes as an offense analogous to piracy. International agreements were also proposed to provide for the prompt return of hijacked airplanes, diverted to another country, to the country of origin.

Geography.—In areas where gold or other cargo of great value and small bulk is carried by vessels vulnerable to attack over routes that are remote from regular naval patrols and close to many unfrequented islands or safe harbours, the opportunity for lucrative piracy exists and the risks are slight. In ancient times such conditions existed in the eastern Mediterranean until Rhodes developed naval power in the Aegean, and until Rome in the period of the empire temporarily eliminated piracy from the Mediterranean by adequate naval force. The North Sea was the scene of Viking piracy in the Middle Ages, and the Hanseatic League of German cities was formed partly to protect commerce against piracy in the Baltic. After the weakening of Turkish rule had resulted in the virtual independence of the Barbary States of North Africa, piracy again became common in the Mediterranean. Morocco, Algeria, Tunis, and Tripoli so tolerated or even organized piracy that they came to be called "pirate states." Commerce in the Mediterranean became possible only for states that made tribute treaties with these states. The United States made such treaties in the 1790s, but after the U.S. Navy was developed during the hostilities with France in 1798, President Jefferson refused to make such treaties. The Tripolitan War of 1801 and the Algerian War of 1815 initiated cooperative action for the elimination of these pirate states, which was finally effected by 1830. (*See* BARBARY PIRATES.)

During the early Tudor period piracy existed around the British Isles, the pirates finding refuge in the Shetland Islands, the Hebrides, Scilly Isles, and south Ireland. Sir William Monson recorded in his *Naval Tracts* that in 1605 he discovered pirates at Broad Haven in south Ireland where an Irish gentleman named Cormat or Cormac lived in great style through sheltering pirates and disposing of their loot. The Caribbean in the late Tudor and Stuart periods was a major scene of piracy, as was the New England coast where the Isles of Shoals were for a time a harbourage. In the 19th century, piracy occurred in the Indian Ocean, the South China Sea, and the Caribbean and there were harbours for pirates in Madagascar, Borneo, Bias Bay, and Barbados.

Law.—Because piracy has been regarded as an offense against the law of nations, the public vessels of any state have been permitted to seize a pirate ship, to bring it into port, to try the crew (regardless of their nationality or domicile), and, if found guilty, to punish them and to confiscate the ship. In this sense, piracy has been defined by generally accepted custom and judicial precedent as: "Any act of violence or depredation committed with intent to rob, rape, wound, enslave, imprison, or kill a person, or with intent to steal or destroy property, for private ends without bona fide purpose of asserting a claim of right, provided that the act is connected with an attack on or from the sea or in or from the air, and does not take place in a ship or aircraft which has the nationality of a state and is within the control of its proper authorities." (Harvard Research in International Law, "Draft Convention on Piracy," *American Journal of International Law*, supplement, 1932, vol. 26, p. 743.)

Pirates have been described as enemies of the human race (*hostis humani generis*) who act with predatory intent (*animo furandi*) for personal gain (*causa lucri*) and without political purpose. It will be observed that the key points in the definition of piracy are that the act takes place outside the normal jurisdiction of a state, without state authority, and that the intent is private, not political.

Most states have laws punishing piracy, usually by death or life imprisonment. Special provisions were sometimes made for the execution of pirates so that the occasion would discourage others from following a piratical course. Pirates convicted by the London Admiralty Sessions at the Old Bailey were hanged on a gallows set up in the water between ebb and flow tides. After death they were hanged in chains farther down the river as "a horrid example to passing seamen." Laws punishing piracy sometimes go beyond the above definition and include robbery on the high seas by any person. When U.S. legislation of this character came before the Supreme Court, Chief Justice John Marshall held that a distinction must be made between piracy *jure gentium* and piracy by national law. He held that the law in question must be construed to permit the exercise of criminal jurisdiction over United States nationals committing robbery in a foreign ship at sea and over anyone committing robbery in a U.S. ship at sea, but not over aliens in foreign ships unless they were guilty of piracy *jure gentium*. Thus an alien who committed robbery in a foreign ship at sea, although literally within the terms of the act, could not be proceeded against. It was to be assumed that Congress in using the words "any person" did not intend to authorize the exercise of criminal jurisdiction beyond that permitted by international law (*U.S.* v. *Klintock*, 1820, 5 Wheaton 1144; Harvard Research *ibid.*, 811).

Acts of unlawful warfare, acts of insurgents and revolutionists, mutiny, hijacking, and slave trading have been defined as piracy by national laws of various countries or by special treaties, but they are not, in most cases, piracy by the law of nations.

An unratified convention of the Washington Conference of 1922 forbade the use of submarines as commerce destroyers and declared that such vessels destroying merchant vessels without warning were guilty "as if for piracy." By the Nyon Convention of 1937 during the Spanish Civil War, the powers declared that submarines attacking commerce in the Mediterranean should be treated as pirates and at once destroyed by the naval forces of these powers. These situations, however, would not conform with the usual conception of piracy under the law of nations because the submarines involved would be attacking under the authority of a government for political purposes. Some early treaties of the United States provided that nationals of either party accepting commissions to privateer against the other should be treated as pirates. Privateering, however, was not generally considered piracy, at least until formally abolished by the Declaration of Paris of 1856, and even then it would not conform to the usual definition of piracy because the action would be under the authority of a government.

BY COURTESY OF THE NEW YORK PUBLIC LIBRARY FROM C. JOHNSON, "A GENERAL HISTORY OF THE LIVES . . . OF THE MOST FAMOUS HIGHWAYMEN . . . ," LONDON, 1734

CAPTAIN JOHN AVERY SHOWN AS HIS CREW CAPTURES ONE OF THE GREAT MOGUL'S SHIPS; CONTEMPORARY DRAWING

Revolutionists and insurgents engaged in naval warfare against a parent state have sometimes been considered pirates, particularly if the government controlling them had not been recognized as a belligerent. Early in the American Civil War, Secretary of the Navy Gideon Welles ordered that the officers of Confederate privateers be proceeded against as pirates. This was not done because Pres. Jefferson Davis of the Confederacy threatened immediate reprisals against Union prisoners of war. Modern practice has recognized the legal status of "insurgency," which arises when unrecognized groups engage in hostilities for a political purpose, and refuses to consider naval forces acting under the authority of such groups as pirates, so long as their activity is directed only against the parent state.

BY COURTESY OF THE NEW YORK PUBLIC LIBRARY FROM C. JOHNSON, "A GENERAL HISTORY OF THE PYRATES," LONDON, 1724

CAPTAIN BARTHOLOMEW ROBERTS, SAID TO HAVE CAPTURED OVER 400 SHIPS DURING HIS CAREER; CONTEMPORARY DRAWING

Mutiny, though considered piracy under British statutes, is not regarded as piracy by the law of nations even though mutineers engage in violence and gain control of the vessel, unless their purpose is robbery. Otherwise the offense remains within the exclusive jurisdiction of the state of the vessel's flag.

Hijacking is the seizure of a ship or aircraft by passengers or other unauthorized persons on board, or by persons from another vessel, with or without collusion of persons on the vessel. The motive may be smuggling or other private end, or it may be assistance to a government especially in case of international or civil strife. It would constitute piracy according to the law of nations if committed on the high seas or in the air above, in case the hijackers gain control of the ship or aircraft or take cargo from it, and if their motives are not political.

Slave trading was declared piracy if carried on by a United States citizen by American legislation in the early 19th century. In the case of "La Jeune Eugénie," a French ship seized by a U.S. naval vessel off the west coast of Africa on suspicion of slave trading, Justice Joseph Story, in the Federal Circuit Court in Boston, held that the slave trade was prohibited by universal law and also by the law of France, but at the request of the U.S. government the vessel was turned over to France (2 Mason 409, 1822). The Supreme Court, however, ruled in the case of the "Antelope" (10 Wheaton 66, 1825), whose seizure was protested by the vice-consuls of Spain and Portugal, that, whatever might be its status under a particular system of municipal law, and however inhumane it might be, slavery and slave trading were generally recognized by the states of the world, and consequently slave trading was not piracy by the law of nations. British legislation of 1824 declared slave trading to be piracy, but the United States, under the banner of freedom of the seas, resisted British efforts to gain general acceptance of the identification of slave trading with piracy until after the Civil War when it entered into conventions to abolish the slave trade. The Brussels Convention of 1890 providing for abolition of the slave trade has been generally ratified, but France made reservations concerning the seizure by other than French warships of French vessels engaged in slave trading. In the case of the Muscat dhows before the International Court of Arbitration at The Hague in 1905, this reservation was recognized and slave-trading ships owned by the sultan of Muscat but flying the French flag were held not subject to seizure on the high seas by British warships.

National statutes frequently place the burden of determining what is piracy by the law of nations upon the courts. Thus the U.S. Criminal Code (sec. 290) declares: "Whoever, on the high seas, commits the crime of piracy as defined by the law of nations, and is afterwards brought into or found in the United States, shall be imprisoned for life."

Piracy has in the past been a scourge of peaceful maritime commerce in many places. It has now been eliminated in most parts of the world although, in addition to the special treaty situations referred to, piracy by the law of nations has occurred in certain areas such as the South China Sea in recent years.

Famous Pirates.—Capt. John Avery, alias Every, alias Bridgeman, familiarly known as "Long Ben" or "the Arch Pirate," was born in Plymouth, Eng., about 1665, took to the sea, and rose to become mate in a merchant ship. He headed a mutiny, was elected captain, proved himself a daring pirate leader, and, after much success off the Guinea coast and in the West Indies, sailed to the Red Sea. There he seized a rich ship of the Great Mogul reported to have on board 100,000 pieces of eight and the Mogul's young and lovely daughter. He took both to Madagascar where he settled down as a reigning monarch. In 1696 he was at Boston, Mass., where he bribed the governor to allow him and his crew to land and to dispose of their plunder. He died in poverty at Bideford, Eng., after being tricked out of his ill-gotten gains by certain merchants of Bristol. Charles Johnson wrote a play based on Avery's career called *The Successful Pyrate,* which was acted at Drury Lane in 1713.

Bartholomew Roberts was, perhaps, the greatest of all pirates. Born in Wales in 1682, he died fighting in 1722. He was credited with having taken more than 400 ships during his career and was remarkable for his strict discipline; he was a teetotaler and allowed no women or gambling aboard his ships. Edward Teach, alias Blackbeard, a picturesque blackguard, was killed on Nov. 17, 1718, in a hand-to-hand combat with Lieut. Robert Maynard of H.M.S. "Pearl." Captain Misson, a Frenchman of good family, was unique in combining active piracy with socialistic ideas. He reigned for many years over a Utopian republic in Madagascar. Two women pirates, Anne Bonny and Mary Read, deserve mention, as both rose high in their ancient dual professions. The

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(LEFT) ANNE BONNY AND (RIGHT) MARY READ, BOTH CONVICTED OF PIRACY IN JAMAICA IN 1720; CONTEMPORARY DRAWING

famous Capt. William Kidd (*q.v.*) was commissioned as a privateer but upon reaching Madagascar in 1697 associated with pirates and was later convicted of murder and piracy.

In U.S. history the career of Jean Laffite (*q.v.*), leader of a colony of pirates and smugglers on the Baratarian coast south of New Orleans from 1810 to 1815, is of interest. Laffite's men were pardoned by President Madison for their contribution to Gen. Andrew Jackson's victory at the Battle of New Orleans (1815).

See also references under "Piracy" in the Index.

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PIRAEUS (modern Greek PIRAIÉVS), the port of Athens, with which its story is inseparably connected, and 6 mi. (10 km.) from it by road. Pop. (1961) 183,877. About 5 mi. SW of Athens, the sandy Bay of Phaleron (Fáliron) is closed on the west by a rocky promontory which also falls abruptly landward into the plain. Its highest point, Munychia or Munichia (modern Kastéllon), is at the northeast end; the lower plateau, Acte (Akti), stretches seaward to southwest, beyond the saddle which connects two small coves, Munychia (Tourkolímano) and Zea (Passalimáni), on the southeast coast with the completely landlocked basin of Piraeus. The inner port there, Cantharus, runs northward between Munychia Hill and the detached ridge, Eëtioneia, which dominates the north side of the entrance. In early days the Athenians used only Phaleron for sea traffic. Themistocles persuaded them to fortify and utilize Piraeus for their new fleet (probably 493/492 B.C., though the fortifications were not completed until after 479). The "long walls" from the base of Munychia Hill to Athens were built soon after 460 B.C., and the town of Piraeus itself was laid out on a rectangular plan by the architect Hippodamus of Miletus. The fortress of Eëtioneia was added during the Peloponnesian War.

The ancient town plan is followed approximately by the modern streets. Traces remain of the ship houses surrounding Zea and Munychia and of a Hellenistic theatre, but the great 4th-century arsenal built by Philo can only be reconstructed from its specification, preserved in an inscription. In 1959 there was a notable find of bronze and marble statues, of the 6th to 4th centuries B.C., which had been awaiting shipment when Sulla, Roman general and dictator, burned the town in 86 B.C. Harald Hardraade, later king of Norway, captured Piraeus in A.D. 1040 for the Byzantine emperor. In World War II it was subjected to the bombing which Athens was spared. The modern port occupies ancient Cantharus and is the largest in Greece, the centre for commercial and passenger traffic. It has grown considerably since World War II, with many new factories on its outskirts (mainly for the engineering and chemical industries) as well as shipyards. It is the terminal station for all the main Greek railway lines and is linked to Athens by electric railway. (J. Bo.)

PIRANDELLO, LUIGI (1867–1936), Italian playwright, author of short stories and novels, winner of the Nobel Prize for Literature (1934), and, by his invention of the "theatre within the theatre" (with *Six Characters in Search of an Author*), one of the main revolutionary innovators in 20th-century drama. He was born at Girgenti (modern Agrigento), Sicily, on June 28, 1867, the son of a sulfur merchant who destined him for commerce. His own desire for study and for liberty, however, took him to Palermo, and, in 1887, to the University of Rome; but, after a quarrel with the professor of classics, and as a result of an introduction from the philologist Ernesto Monaci, in 1888 he went to Bonn, where in 1891 he gained his doctorate in philology for a thesis on the dialect of Girgenti. In 1894, his father arranged his marriage to the daughter of a wealthy sulfur merchant, and this gave him financial independence, allowing him to live in Rome and to write. He had already published an early volume of verse, *Mal giocondo* (1889), which paid tribute to the poetic fashions set by Carducci, and this was followed by other volumes of verse, including the translation of Goethe's *Roman Elegies* (*Elegie romane,* 1896). But his first significant works were *novelle,* at first con-

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LUIGI PIRANDELLO

tributed to periodicals without thought of recompense. In 1904, however, a landslide at the sulfur mine in which his wife's and his father's capital was involved brought poverty, and he was forced to earn his living, not only by writing but by teaching. It also brought tragedy, for his wife developed a persecution mania which manifested itself in a frenzied jealousy of her husband, and his life became a torment, only ending with her death in 1918. It was this bitter experience which finally determined the theme of his most characteristic work, already perceptible in his early *novelle*—the exploration of the impenetrability of individual worlds and the instability of human personality.

Pirandello's early narrative style stems from the Sicilian *verismo* of Luigi Capuana and Giovanni Verga (*qq.v.*), but the very titles of his early collections of *novelle—Amori senza amore* (1894; "Love Without Love"), *Beffe della morte e della vita* (1902–03; "The Jests of Life and Death")—suggest the wry nature of his realism. This is seen also in his first novels: *L'Esclusa* (written 1893, published 1901; English translation, *The Outcast,* 1925) and *Il turno* (written 1895, publ. 1902). Success came with his third novel, often acclaimed as his best, *Il fu Mattia Pascal* (1904; *The Late Mattia Pascal,* 1923). Although the theme is not typically "Pirandellian," in that the obstacles confronting its hero result from external circumstances, it already shows the acute psychological observation which was later to be directed toward the exploration of the inner consciousness. Pirandello's understanding of psychology was sharpened by reading such works as *Les Altérations de la personnalité* (1892), by the experimental psychologist Alfred Binet, and traces of its influence can be seen in the long essay *L'umorismo* (1908), in which he examines the principles of his art. Common to both is the theory of the subconscious underlying personality, so that what we know, or think we know, is the least part of what we are. Thus, before Freud's work was known to Pirandello, and before Proust had published any of his works, the themes of psychology became material for literature. They found their most complete expression in the volumes of *novelle, La Trappola* (1915) and *E domani, Lunedì . . .* (1917), and in such individual stories as *Una voce, Pena di vivere così,* and *Con altri occhi.*

Meanwhile, he had been writing other novels, notably *I vecchi e i giovani* (publ. 1913; *The Old and the Young,* 1928) and *Uno, nessuno e centomila* (1925–26; *One, None and a Hundred-Thousand,* 1933). Both are more typical than *Il fu Mattia Pascal.* The first, a historical novel, reflecting the Sicily of the *fin-de-siècle* and the bitterness of the loss of the ideals of the Risorgimento, suffers from the fact that Pirandello's genius was rather

to "discompose" than to "compose" (to use his own terms, in *L'umorismo*), and thus the individual episodes stand out more clearly than the unity of the work as a whole. *Uno, nessuno e centomila,* however, is at once the most original and the most typical of his novels, and, in its surrealistic description of the consequences of the hero's discovery that his wife (and others) see him with quite different eyes, presents an exploration of the reality of personality of a type better known from his plays, for it was as a dramatist that he became famous outside Italy.

He had first turned to the theatre in 1898 with *L'epilogo,* but the accidents which prevented its production until 1910 (retitled *La morsa*) had kept him from other than sporadic attempts at drama until the success of *Così è (se vi pare)* in 1917. This may have been fortunate for the development of his dramatic powers, for, while *L'epilogo* does not greatly differ from the bourgeois drama of its period, with *Così è (se vi pare)* began the series of plays which were to make him world-famous in the 1920s. It is a demonstration, in dramatic terms, of the relativity of truth, and a rejection of the idea of the existence of any objective reality not at the mercy of individual vision, and is to be regarded as merely a rather dry curtain-raiser to the two great plays, *Sei personaggi in cerca d'autore* (1921; *Six Characters in Search of an Author*) and *Enrico IV* (1922; *Henry IV*). In *Six Characters,* the typical Pirandellian contrast between art, which is unchanging, and life, which is an inconstant flux, found its most arresting presentation, with the materialization on the stage of the characters, rejected by their author, and yet throbbing with a more intense vitality than the real actors, who, inevitably, distort their drama as they attempt its presentation. And in *Henry IV* the theme of madness, which lies just under the skin of ordinary life, and is, perhaps, more sane than ordinary life in its construction of a satisfying reality, finds dramatic strength in its hero's choice of a fixation in preference to the uncertain world in which we all live.

The production of the first of these two plays in Paris in April 1923 by Georges Pitoëff was to a great extent responsible for making Pirandello widely known, and his work became one of the central influences on the French theatre, so that French drama from Jean Anouilh and Jean Paul Sartre to Eugène Ionesco and Samuel Beckett is tinged with "Pirandellianism." His influence can also be detected in the drama of other countries, even in, for example, the very different plays of T. S. Eliot.

In 1920 Pirandello said of his own art: "I think that life is a very sad piece of buffoonery; because we have in ourselves, without being able to know why, wherefore or whence, the need to deceive ourselves constantly by creating a reality (one for each and never the same for all), which from time to time is discovered to be vain and illusory . . . . My art is full of bitter compassion for all those who deceive themselves; but this compassion cannot fail to be followed by the ferocious derision of destiny which condemns man to deception."

This despairing outlook attained its most vigorous expression in Pirandello's plays, criticized at first for being too "cerebral," but later recognized for their underlying sensitivity and compassion. His main themes are the necessity and the vanity of illusion, the multiform appearances, all of them unreal, of what is presumed to be the truth. Man is not what he thinks he is (or what he tries to build himself to be), but he is "one, no one and a hundred thousand," according to his appearance to this person or that, always different from the image of himself in his own mind. Pirandello's plays (and this is a link with Sicilian *verismo*) deal mostly with a lower-class milieu, peopled with clerks, teachers, lodginghouse keepers, etc., but from their modest vicissitudes he draws conclusions of general human significance.

The universal acclaim which followed *Six Characters* and *Henry IV* sent Pirandello touring the world with his own company. It also emboldened him, and in some of his later plays (*e.g., Ciascuno a suo modo,* 1924; "Each in His Own Way"), he turned toward exhibitionism, just as in some of the later *novelle* it is the surrealistic and fantastic elements that are accentuated. But in *Six Characters* and *Henry IV* he shows a humanity, and a power to dramatize the metaphysical and psychological problems confronting modern man —the question marks of the 20th century—which makes them the undoubted masterpieces of his work for the theatre.

Pirandello died in Rome on Dec. 1, 1936.

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(J. H. WH.)

PIRANESI, GIAMBATTISTA (GIOVANNI BATTISTA) (1720–1778), Italian draftsman and etcher, whose large prints of the buildings of classical and postclassical Rome and its neighbourhood contributed considerably to Rome's fame and to the growth of classical archaeology and the neoclassical movement in art. He was born in 1720 near Venice and moved to Rome in 1744.

He developed the medium of etching by means of complicated repeated bitings of the copperplate, which resulted in rich textures and bold contrasts of light and shadow. A prolific etcher, he created more than 1,000 plates. The "Prisons" (*Carceri*) of *c.* 1745 are his finest early prints; they constitute a climax of late baroque fantastic, visionary architecture. Among his best mature prints are the series *Le Antichità Romane* (1756), the *Vedute di Roma* (appearing as single prints between 1748 and 1778), and the views of the Greek temples at Paestum (1777–78). His unparalleled accuracy of depiction, his personal expression of the structures' dramatic and romantic grandeur, and his technical mastery made these prints the most original and impressive representations of architecture to be found in western art.

Piranesi died in Rome in 1778.

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PIRANHA (CARIBE), the name applied to several carnivorous fishes of the family Characidae, usually of the genus *Serrasalmus.* Piranhas occur in the large rivers of eastern South America from central Venezuela to northern Argentina. They grow to about 18

HARALD SCHULTZ

(LEFT) BRAZILIAN BLACK PIRANHA (SERRASALMUS NIGER); (RIGHT) CLOSE-UP SHOWING DENTITION

in., but most do not exceed 15 in. They are all characterized by a body half as deep as it is long, an adipose fin, a large blunt head, and massive jaws with razor-sharp teeth. The sawlike teeth of the upper jaw cut against those of the lower jaw like scissors when the mouth is closed.

Piranhas are able to bite pieces out of almost any animal, including large and armoured species. They travel in groups and are able to reduce animals such as men or cattle to skeletons in a short time. Related species are sometimes called piranhas but are seldom dangerous. *See* also FISH: *Catfishes, Characins, True Minnows, etc.* (C. HU.)

PIRE, DOMINIQUE GEORGES (1910–), Belgian Dominican who won the Nobel Peace Prize in 1958 for his work in helping European displaced persons, was born at Dinant, Belg., on Feb. 10, 1910. He entered the Dominican Order in 1928 and was lecturer in moral philosophy at the Dominican College of La Sarte, Huy (1930–40), during which time he founded various charitable organizations for poor families. During World War II he was active in the resistance movement and afterward was struck by the enormous problem of refugees. To help them he founded the Aide aux Personnes Déplacées in 1949, which before long had branches in most European countries. Its goal was to guarantee every form of moral and material aid to displaced persons, regardless of their nationality or religion, and to establish what Pire called a "Europe of the heart." Pire believed that the best way toward a peace which is more than absence of war is that of "fraternal dialogue" between people separated by barriers of religion, political thought, race, etc., the beginning of an interested and understanding attitude toward others despite their differences. The first step is cooperation for a useful purpose, especially against hardship and famine. Between 1950 and 1954 Pire founded four "homes of welcome" in Belgium for aged refugees, the hard core of the problem. Between 1956 and 1962 seven "European villages" were founded in Germany, Belgium, and Austria. The principle behind them is to "re-establish men," to enable them once more to become independent members of human society. In addition, Pire initiated the system of sponsors, whereby a refugee is put in touch with a person in another country who writes to him regularly and sends him practical help.

Accepting the Nobel Peace Prize primarily as an obligation, Pire established, in 1960, at Huy, the Mahatma Gandhi International Peace Centre, later known as the University of Peace, for the instruction of young people in the principles and practice of "fraternal dialogue" and positive peace. In March 1962, at the invitation of the Pakistani government, he started the "Island of Peace" project, the development of an international community in East Pakistan on the principle of help for self-help.

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PIRELLI, an Italian family of industrialists who contributed to the development of production and commerce in rubber goods, electric wire, and electric cable.

GIOVANNI BATTISTA PIRELLI (1848–1932), born at Varenna, Como, on Dec. 27, 1848, was educated in Milan. In 1872 he started a small rubber factory there, the first in Italy and one of the first in Europe. It pioneered the manufacture of electric cable (1884) and in 1899 began producing automobile tires. In 1902 the company began its foreign expansion by starting a subsidiary factory in Spain. Pirelli died in Milan on Oct. 20, 1932.

His two sons, PIERO (1881–1956), born in Milan on Jan. 27, 1881, and ALBERTO (1882–), born also in Milan on April 28, 1882, joined the business in 1904. Factories were started, under the Société Internationale Pirelli of Basel, Switz., in Great Britain, other European countries, Turkey, and the Americas, and eventually the Italian and International Pirelli groups together employed more than 55,000 people. Piero Pirelli, chairman from 1932, greatly assisted the development of the Italian telephone service. He died in Milan on Aug. 7, 1956. His brother, Alberto, who became chairman in 1956, also has been active in economic international law. He was a member of the Supreme Economic Committee of Versailles (1919), Italian delegate to the first International Labour Office of Geneva (1920–22), served on the League of Nations economic committee (1923–27), and, as a leading negotiator on war reparations and debts, on the Dawes and Young committees (1924, 1929). He became a minister plenipotentiary in 1924 and a minister of state in 1938.

PIRITHOUS (PEIRITHOUS), in Greek mythology, chiefly known as the companion and helper of Theseus (*q.v.*) in his adventures: the war against the Amazons, the carrying off of Helen (done to please Theseus), and the descent into Hades to carry off Persephone (a service in return by Theseus). They were detained in Hades until Heracles rescued Theseus, but not Pirithous.

Pirithous was originally a Lapith (*see* LAPITHAE), and probably his earliest legend was that at his marriage to Hippodamia the centaurs, who had come as guests, in drunken fury tried to violate the bride and her attendants; this led to the battle of the Lapiths and centaurs, a favourite subject of Greek art.

(H. W. PA.)

PIRMASENS, a town in the *Land* (state) of Rhineland-Palatinate, Federal Republic of Germany. It is situated near the French frontier, 52 mi. (84 km.) WNW of Karlsruhe by road. Pop. (1961) 53,164. It was largely rebuilt after severe damage in World War II. It is the terminus of a branch railway linking Landau with Zweibrücken. The shoe industry is important, and every two years an international shoe trade fair is held in the town. A technical school of shoemaking there is internationally known. Named after St. Pirmin, who was supposed to have preached Christianity there in the 8th century, Pirmasens originally belonged to the counts of Hanau-Lichtenberg, but passed to Hesse-Darmstadt in 1736. The French took it in 1794, and it passed to Bavaria in 1816. It was a centre of a separatist movement in 1923.

PIRMEZ, OCTAVE LOUIS BENJAMIN (1832–1883), Belgian essayist, one of the intellectual elite who brought about the 19th-century literary revival, was born on April 19, 1832, at Châtelet, Hainaut. He studied at Brussels University and thereafter spent half his time in travel and half in solitary meditation. Besides a lively and interesting correspondence, he left works of considerable philosophic power and literary value—*Feuillées* (1862), *Jours de Solitude* (1869), *Heures de philosophie* (1873), and *Rémo* (limited ed. 1878; 1880)—although showing the debilitating influence of the prevalent egocentric romanticism. In these he expressed both his desire for spiritual contact with the infinite and his appreciation of the beauty of form. All his thought is conveyed in delicate nuances, pervaded with a melancholy charm. Intensely concerned with writing as an art, he developed a style of great fluidity and clarity and strongly influenced the writers of the *Jeune Belgique* group. He died at Acoz, Hainaut, on May 1, 1883.

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PIRNA, a town in the *Bezirk* (district) of Dresden, German Democratic Republic. It lies on the left bank of the Elbe about 17 mi. (27 km.) SE of Dresden by road and near the frontier of Czechoslovakia. Pop. (1962 est.) 41,030. The northern foothills of the scenically attractive Elbe Sandstone Mountains extend as far as Pirna. Founded in 1240, the town is dominated by the Sonnenstein Castle (16th century) high above the Elbe and has a church, built 1502–46 (later restored), with a sandstone altar (1611). Pirna is on the Dresden–Prague railway and has main road connections with north and south. Artificial silk, glass, paper, cellulose, machinery, furniture, steel castings, electrical articles, and grindstones are produced. There are sandstone quarries on the outskirts of the town.

PIROGUE or **PIRAGUA:** *see* BOAT.

PIRON, ALEXIS (1689–1773), French dramatist and wit, best known for his epigrams, was born at Dijon, July 19, 1689. He was secretary to a banker and then studied law, but moved to Paris in 1719, where he worked as a copyist, struggling meanwhile to enter the world of letters. After *Arlequin Deucalion* (1722) and other successful pieces written for the popular Théâtres de la Foire, Piron produced *Les Fils ingrats* at the Comédie Française in 1728. *La Métromanie* (1738), a witty, urbane comedy portraying himself as a young poet intoxicated with literary aspirations, remains his most distinguished play; it was revived at the Comédie Française until well into the 19th century. His tragedies included the moderately successful *Gustave Wasa* (1733). Having achieved a modest fame, Piron acquired noble patrons and the entree to several literary salons, but continued to live an independent, carefree life and became known for his ready wit and his epigrams.

The king vetoed Piron's election to the Académie Française in 1753 because of the licentious *Ode à Priape* which he had written as a young man. However, he was given a royal pension, and took

his revenge on the Académie in one of his most celebrated epigrams:

Ci-gît Piron, qui ne fut rien,
Pas même académicien.
("Here lies Piron, who was nothing,
Not even a member of the Academy.")

In 1741 he married his mistress, Mlle de Bar; she died in 1751. He died in Paris, Jan. 21, 1773.

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PIROT, a town in eastern Serbia, Yugos., about 41 mi. (66 km.) SE of Nis by road. Pop. (1961) 18,585. Situated amid fine scenery, it lies on the Belgrade-Istanbul railway. Pirot exports local cheese (*kačkavalj*) and carpets woven on handlooms. In Roman days it was a fortress on the military road from Old Naissus (Nis) to Philippopolis (Plovdiv, Bulg.) and always had strategic importance. (V. DE.)

PIRRIE, WILLIAM JAMES PIRRIE, 1ST VISCOUNT (1847–1924), who controlled the largest ship-building firm in the world, was born of Irish parentage at Quebec, Canada, on May 31, 1847. In 1849 he was brought back to Northern Ireland, and in 1862 became apprenticed to the Belfast ship-building firm of Harland and Wolff. By the time he was 27 he had been made a partner, and was soon left in almost exclusive control. He traveled widely to gain experience in ship design and to study practical shipping requirements, and for many years the largest passenger liners in the world came from Pirrie's yards, notable examples of which were the "Olympic" and "Titanic." Pirrie was also prominent in the development of the diesel engine for marine propulsion. Created a baron in 1906, he became a viscount in 1921. As comptroller general of merchant shipbuilding in 1918, he was mainly responsible for introducing the idea of building "standard" ships, a principle which was to have such economical results in World War II. Viscount Pirrie died at sea on June 7, 1924. (P. DF.)

PIRSSON, LOUIS VALENTINE (1860–1919), U.S. geologist and specialist in the study of igneous rocks, was born at Fordham, N.Y., on Nov. 3, 1860. Scientific inclinations, manifested in boyhood, led to advanced studies at Yale university and at Heidelberg and Paris. Field work in 1889 with a U.S. geological survey party in Yellowstone park and later in Montana confirmed him in his ultimate specialty, igneous geology. He taught at Yale from 1882 on, after 1897 as professor of physical geology, many of his students achieving distinction as geologists. His bibliography includes more than 60 titles, mostly papers on petrology published in the *American Journal of Science,* of which he was associate editor for two decades. He wrote significant treatises on the igneous rocks of Montana, *Quantitative Classification of Igneous Rocks* (with others, 1903), and two influential textbooks: *Rocks and Rock Minerals* (1908) and *Textbook of Geology* (with Charles Schuchert, 1915). He died at New Haven, Conn., on Dec. 8, 1919. (F. M. FL.)

PISA (anc. PISAE), capital of the province of Pisa, a university town and archiepiscopal see of northwest Tuscany, Italy. It stands on the north and south banks of the Arno River in the extreme northwest of the province in the broad coastal plain backed by the hills of Lucca to the north, 6 mi. (8 km.) from the Tyrrhenian Sea and 50 mi. (80 km.) W of Florence. Pop. (1961) 97,420 (commune).

Pisa stands on an ancient site; fragments of Roman baths are visible near the modern Lucca Gate. Its outstanding medieval buildings are ecclesiastical, but it retains much of its 6¼ mi. circuit of walls. In the imposing asymmetric Piazza dei Cavalieri, the centre of the medieval town, are the Palazzo dei Cavalieri (a palace reconstructed for the Tuscan Knights of St. Stephen by Giorgio Vasari, *c.* 1562) and the knights' church (S. Stefano, *c.* 1565). Until the mid-18th century Pisa was a relatively small town, but it expanded as the surrounding marshes were reclaimed, malaria was eliminated, and light industries were developed. To the north of the river, at least, something of its sober 18th-century elegance remains—fine buildings line the river—but the Arno must always have lacked at Pisa the charm it possesses at Florence. Severe destruction was caused during World War II when for 40 days in 1944 the fighting was on the Gothic Line (Pisa to Rimini). Many buildings, including churches, and notably the camposanto, were ruined or damaged, the bridges over the Arno were destroyed, and the area south of the river, especially around the railway station, suffered widespread destruction. Most of the damage was repaired, but this southern part now has a somewhat characterless aspect. Pisa remains predominantly a quiet provincial university town, distinguished above all by a remarkable group of buildings in the Piazza del Duomo (the so-called Square of Miracles) at its northwest extremity.

This piazza, partly bounded by the town walls and the camposanto (cemetery), contains the cathedral and baptistery, both built in the characteristically Pisan style of white marble with strips of black, and the campanile—the famous Leaning Tower of Pisa. The cathedral was begun in 1063; its architects, first Buschetto and later Rainaldo, were probably both Pisan. The columns of the nave and of its double-vaulted aisles are ancient. The transepts have single-vaulted aisles, and at their intersection with the nave is a dome. On the west front, the finest part of the exterior and apparently the work of Rainaldo, the range of arches running round the base of the cathedral is repeated above in four open arcades. A marvellous bronze door (*c.* 1180) by Bonanno Pisano, which depicts biblical scenes, survives on the south side. Inside are Giovanni Pisano's splendid decagonal pulpit carved in white marble (1302–10; restored 1926) and Tino di Camaino's tomb of the emperor Henry VII (1315); in the apse is a much-restored mosaic in the Sienese style.

The circular baptistery (diameter 100 ft.; height 190 ft.), begun in 1152 by the architect Diotisalvi but only completed in the 14th century, is covered by a dome surmounted by a cone; the whole making an ogival, oriental effect. The lowest range of semicircular arches consists of 20 columns and the second of 60; above this is a row of 18 windows in the same style, separated by as many pilasters. The interior, supported by four pilasters and eight columns, contains an octagonal font by Guido Bigarelli da Como, and the wonderful hexagonal pulpit completed in 1260 by Niccolò (Nicola) Pisano.

The Leaning Tower (184½ ft. high), begun in 1173, possibly by Bonanno Pisano, and completed in the 14th century, is also round and is constructed throughout of white marble, inlaid on the exterior with coloured marbles. The walls are 13 ft. thick at the base and at the top about half as much; inside is a stairway with 296 steps. The basement is surrounded by a range of semicircular arches supported by 15 columns; above this are 6 arcades, each with 30 columns. The eighth story, containing the bells, is much smaller in diameter and has only 12 columns. The campanile's foundations are not more than 10 ft. deep and their circumference is only that of the tower. Apparently they settled on one side at an early stage in the tower's construction, and the third, fifth, and top stories were straightened somewhat to compensate for the consequent lean. The tower, 15½ ft. out of the perpendicular in 1829, leaned more than 17 ft. at mid-20th century. The foundations have been injected with cement but the tower is nevertheless threatened with collapse. In 1964 the local authorities considered a plan by an English expert, J. Pryke, involving fresh cement reinforcement of the foundations, the settling of the tower thereon by means of internal supports, and finally the jacking up of the tower to lessen its lean by 45 cm. (1.4764 ft.).

The camposanto traditionally owes its origin to Archbishop Ubaldo de' Lanfranchi, who in 1203 is supposed to have brought earth for it from Calvary. The present marble buildings, erected from 1278 onward in the Italian Gothic style by Giovanni di Simone (not Giovanni Pisano as once thought), used to contain important frescoes by famous Tuscan artists, including Francesco Traini (fl. *c.* 1320–65) and Benozzo Gozzoli (1420–97). Damage to them in World War II was partly repaired; the Traini frescoes are now in Pisa's Museo Nazionale.

Notable churches, mostly north of the river, are: S. Pierino (11th–12th century); S. Frediano and S. Sepolcro (both 12th century); S. Nicola (with a four-storied tower of *c.* 1250); S.

Francesco (13th century, with frescoes by Taddeo Gaddi, 1342); Sta. Caterina (13th–14th century); S. Michele in Borgo (with fine 14th-century facade); and Sta. Maria della Spina (of white marble in the Pisan Gothic style; enlarged 1323). Three miles southwest of Pisa, toward the mouth of the Arno, is the 11th-century church of S. Piero a Grado, with the remains of a much earlier church beneath it, marking the traditional site of St. Peter's first landing place in Italy. Its campanile was destroyed in World War II. Secular buildings include fine medieval and Renaissance *palazzi* such as the 14th-century Palazzo Gambacorti and the Palazzo dei Medici (the prefecture).

The flourishing University of Pisa, founded in 1343, had nearly 10,000 students in the early 1960s, and includes engineering, veterinary, and agricultural schools, a branch of the Italian National Institute of Nuclear Physics, and the Scuola Normale Superiore (the only state university college), which occupies the Palazzo dei Cavalieri. The Museo Nazionale di San Matteo contains a good collection of Tuscan painting and sculpture, including works removed from the cathedral, baptistery, and camposanto. A modern version of the medieval *giuoco del ponte* ("joust of the bridge," a competition in which teams from each parish push a cart) takes place each year on the principal bridge across the Arno.

Pisa is on the main railway line between Rome and Genoa, and is an important junction for Florence, Lucca, and Volterra; it has an international airport and is connected by canal to the sea at Leghorn (Livorno). Since the silting up of the Arno only small vessels can sail up it to Pisa. The tourist trade and the manufacture of textiles, glass, bricks, and engineering and pharmaceutical goods bring Pisa much of its prosperity. A considerable industrial suburb has grown up.

Pisa Provincе (area, 945 sq.mi. [2,448 sq.km.]; pop. [1961] 365,822) is bounded on the northwest by the Tyrrhenian Sea, west by the province of Livorno, east by the provinces of Firenze and Siena, and south by the province of Grosseto. Most of the province is hilly; the northwestern portion, drained by the lower Arno, forms a broad coastal plain in which the town of Pisa is situated. The climate is mild throughout the year; rainfall is considerable. The province has 38 communes. Towns include Pontedera, east of Pisa, with a motor scooter works; the spa of San Giuliano Terme, northeast; and, in the southern part of the province, Volterra, with a history reaching back to Etruscan times and many ancient and interesting buildings. Linked with Pisa by a light railway is Marina di Pisa, on the Tyrrhenian shore, with pinewoods and beaches. The prosperity of the area mainly rests on the varied agriculture: vines, olives, fruit, and grain are grown, and sheep and cattle are raised.

HISTORY

From the earliest times Pisa's history was conditioned by its position on the sea; the ancient Pisae lay on the north bank of the Arno only two miles inland. It was inhabited by Ligurians and Etruscans; although the Greeks perhaps traded there they did not, as was once thought, found a colony. As early as 225 B.C. a Roman army landed at Pisae from Sardinia; the Romans were the actual creators of the city, which they used as a naval base and as a frontier post against the Ligurians to the north. After its alliance with Rome in the Ligurian and Punic wars, Roman citizenship was granted to Pisae in 89 B.C. A colony, which became renowned for shipbuilding, was founded there; it prospered as a port and as a station on the coastal road to the north, which brought additional commerce and traffic. Where water and marshes provided no defense, fortifications were erected; there were public buildings, baths, and presumably churches—since by the early 4th century Pisa had a bishop.

As the Roman Empire disintegrated and the barbarians entered Italy, the land route to the north lost much of its importance; but Pisa managed to retain its urban character, partly because it was isolated from the chief theatres of conflict, partly because it secured from the invading Lombards a considerable degree of autonomy, which meant freedom to trade. Pisa was the only Lombard port to maintain international importance. Its navy defended the adjacent coasts; ships continued to arrive from Lombard Corsica and Byzantine Sardinia; while Greek slave traders ensured contacts with the east. The impressive church of S. Piero a Grado was already in existence by the 9th century, when a second circle of city walls was constructed. Late in that century trade seems to have declined sharply, and there were Saracen attacks in 934 and 935. But local trade continued, by road and water; and 10th-century Pisa, although possibly as much agricultural as commercial, was still considered the principal city in Tuscany.

Exploiting its sea power and the products and markets of its fertile Tuscan hinterland, Pisa revived in the 11th century to become a centre of trade and administration and, with the help of Genoa, to take the offensive against the Muslim raiders. Participation in the Crusades, which secured for Pisa valuable commercial positions in Syrian ports, followed naturally and with such success that Daimbert, archbishop of Pisa, became patriarch of Jerusalem in 1099.

Thereafter Pisa grew in strength to rival Genoa and Venice. Its commercial expansion overseas was accompanied by territorial conquests in Tuscany, by growth of population and industry (wool, fur, leather) within the city, and by the rise of guilds. With this wealth and strength emerged a republican form of government, the commune, in which the great nobles, the archbishop, and the merchant guilds participated. Scholars of this period included Leonardo Fibonacci, who popularized Arabic numerals in Europe, and Burgundio Pisano, who learned Greek at Constantinople. In the 13th century Pisa, a Ghibelline city, enjoyed imperial support in the long conflict with Genoa, Lucca, and Florence which culminated in Pisa's defeat at the naval Battle of Meloria (1284) by the Genoese and the subsequent blocking of Porto Pisano by the Florentines.

Despite these defeats Pisa experienced an astonishing industrial revolution late in the 13th century. The accelerated transfer of woolen manufacturing to the town allowed the industry to increase its efficiency and to employ cheap labour, and thus reduce its costs; this in turn encouraged the movement of population from the villages to the town and the profitable enclosing of cultivated land for sheep pasturage. Pisa's merchants now abandoned the Levantine trade, but their ships brought grain to Tuscany, exported Tuscan products, and carried timber, wines, and skins all over the western Mediterranean. Pisan prosperity was reflected in the characteristic *casatorre*, a tall, inhabited tower usually built of brick and stone; and in the grandiose and spectacular group of cathedral, baptistery, campanile, and camposanto (*see* above). In the many churches built, there evolved a robust and individual Romanesque style in which Paleochristian, Lombard, Muslim, and Byzantine elements were combined into a harmoniously proportioned ensemble of white marble; the pointed Gothic arch appears predominantly as a decorative motif. Pisan sculptors were important from the 10th century onward; Guglielmo Pisano, who carved the cathedral's first pulpit (1162), and Bonanno Pisano, author of its bronze doors (1180), were outstanding. Niccolò Pisano, who completed the baptistery pulpit in 1260, probably came from Apulia, bringing to Tuscany the French Gothic. His son, Giovanni Pisano, who carved the existing cathedral pulpit (1302–10), was an even greater innovator. These and a group of artists who also took the name Pisano made Pisa a leading centre of Italian Gothic sculpture.

With economic change came political unrest and the rise of the *popolo;* in this the petty merchants, often with roots in the countryside, aligned themselves with the artisans against the privileged aristocrats and guilds to press for cheaper living. Pisa lost its trade and colonies, consequent upon its loss of sea power, and the people turned increasingly to sheep raising, which involved decay of agricultural activity and of the land. The town, surrounded by stagnant swamps, fell prey to malaria, which contributed to its further moral, economic, and military decline, still more accelerated by the Black Death (1348 onward) and by internal dissension. It was finally subjugated by the Florentine army, aided by famine and treachery, in 1406. Briefly important during the holding there of a church council intended to heal the Great Schism (1409; *see* Council), Pisa continued to decay despite the enlightened efforts of the Florentine Medici rulers, including the restoration of the

university with help from Pope Leo X and the foundation by Duke Cosimo I of an office for reclamation of marshland, and of the Order of the Knights of St. Stephen for protection against Barbary pirates (1562). Pisa settled into the condition of an elegant and prosperous, but tranquil, town. The birth there of Galileo (1564) shed lustre upon it; it was visited by Shelley (1820–22) and by Byron (1821).

See also COMMUNE (MEDIEVAL): *Italy;* CRUSADES; FLORENCE; GENOA; ITALY: *History;* TUSCANY; and references under "Pisa" in the Index.

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PISACANE, CARLO (1818–1857), Italian army officer and hero of the Risorgimento, was born in Naples on Aug. 22, 1818, the son of a nobleman. After studies at the military academy he joined the Engineer Corps of the Army of the Bourbon Kingdom of the Two Sicilies, but in 1847 he left Naples for Paris with Enrichetta di Lorenzo, the wife of a fellow officer. To avoid extradition he enlisted for service with the French Foreign Legion in Algeria, but when he learned of the anti-Austrian rebellion in Milan (March 1848) he left for Italy and, in April, fought the Austrians at Salò. After the defeat of the Piedmontese Army (*see* ITALIAN INDEPENDENCE, WARS OF) he escaped to Lugano in Switzerland, where he met Giuseppe Mazzini (*q.v.*). In December 1848 he joined the Piedmontese Army as captain, but in February 1849 he was in Rome as one of the organizers of the republican army there. When the Roman Republic collapsed (June 1849), he went as an exile to Marseilles and later to Switzerland again. In June 1857, encouraged by Mazzini, he organized a republican conspiracy against the Bourbons of the Two Sicilies. Landing at Sapri with 24 insurgents, he was killed on July 2, 1857, at Sanza (Salerno Province), in an encounter with Bourbon troops.

See A. Romano, *Per una biografia di Carlo Pisacane* (1934).

PISANELLO, ANTONIO (ANTONIO PISANO, formerly wrongly called VITTORE) (*c.* 1395–*c.* 1455), Italian medalist and painter and one of the leading artists of his age, was born shortly before 1395 in Pisa (hence his appellation Pisanello). It was first as co-worker with Gentile da Fabriano, then as the continuer of his work and finally as his heir that Pisanello painted his most considerable frescoes in the doge's palace in Venice (*c.* 1415–22) and in St. John-Lateran in Rome (after 1427). However, the only surviving frescoes of Pisanello's are an "Annunciation" at the tomb of Niccolò di Brenzono in S. Fermo in Verona (*c.* 1423–24) and the legend of St. George in the Pellegrini chapel in S. Anastasia in Verona (*c.* 1433–38). Early panels which are ascribed to him are the four panels of the legend of St. Benedict (one in the Museo Poldi Pezzoli, Milan, three in the Uffizi depot, Florence). They probably date from between 1417 and 1422.

Later, mature panels by Pisanello, which are extant, are: the "Madonna della Quaglia" (Verona museum); "St. Jerome" (National gallery, London), perhaps a contemporary replica of one of Pisanello's works; the portrait of the emperor Sigismund (Kunsthistorisches museum, Vienna; 1432–33); "St. Eustace" (National gallery); the portrait of Margherita Gonzaga (Louvre, Paris; *c.* 1438); the portrait of Lionello d'Este; and the "Madonna with Ss. Anthony and George" (National gallery).

Pisanello's fame and his importance in court circles, for which his art was admirably calculated, rested even more upon his medals than upon his painting. There he had practically no predecessors and with him the art reached its highest point. His work includes the medal of the Greek emperor John VII Palaeologus (1438); dated are: the wedding medal for Lionello d'Este (1444), Sigismondo Pandolfo Malatesta (1445), Cecilia Gonzaga (1447) and Bellotto Cumano (1447). In 1448 Pisanello was invited to Naples to the court of Alfonso of Aragon and there his most mature medals, of the king and also of Inigo d'Avalos, were produced.

Studies for many of his medals are in the Codex Vallardi in the Louvre, as are those for the craftsman's work which Pisanello was commissioned to design at the court in Naples. Drawings for his portraits in paint, frescoes, etc., have also been preserved, and in the uniqueness of their preservation as a whole these drawings are the most important thing Pisanello contributes to the history of art. They reveal the whole body of work in a studio at the dividing line between the middle ages and the Renaissance, work between the copying of traditional models and free creation from nature. This most delicate but intense early Renaissance naturalism, combined with the beauty of line of late Gothic, is the distinguishing hallmark of Pisanello's art.

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PISANO, ANDREA (*c.* 1290–*c.* 1347), Italian sculptor and goldsmith, whose chief works were executed in Florence, where he came under the influence of Giotto, and who is recorded as the author of the earliest of the three famous bronze doors of the baptistery, was born about 1290. The baptistery door, completed in 1336, has 20 quatrefoil panels with scenes from the life of St. John the Baptist and 8 with figures of the Virtues. The figures are gilded and set against a smooth bronze surface with appropriate architectural and other features.

On the death of Giotto in 1337, Andrea succeeded as architect of the campanile of the Duomo of Florence, to which he added two stories adorned with panel reliefs. Most of the reliefs on the lower part depicting the arts, sciences and occupations of man and three scenes from Genesis are generally admitted to be the work of Andrea and his studio, though tradition assigned the designs and some of the panels to Giotto. Statues in niches, originally above the reliefs now in the Duomo museum, representing David and Solomon and two Sibyls, have been assigned to Andrea but the authorship is disputed. Two statuettes of Christ and Sta. Reparata also in the museum are generally attributed to him.

In the iconography of the bronze door Andrea was indebted to the mosaics of the baptistery cupola and Giotto's frescoes in Sta. Croce. The plan of the door was influenced by Bonanno's bronze doors in Pisa cathedral, and the quatrefoil appears in French cathedrals, especially at Paris and Rouen. Andrea's style is marked by a simplicity, restraint and skillful arrangement of figures which places him in the front rank of the sculptors of the period. He is last recorded as superintending architect of the Duomo of Orvieto, in which office his son Nino succeeded him. He died about 1347.

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PISANO, GIOVANNI (*c.* 1250–after 1314), Italian architect and sculptor, who continued the revival of sculpture begun by his father Niccolò (*q.v.*) whom he assisted in the creation of the pulpit in Siena cathedral and the fountain in Perugia, was born about 1250. His principal works were the planning and sculptural decoration of the façade of Siena cathedral (1284–95), the pulpit in S. Andrea in Pistoia (completed 1301) and the pulpit in Pisa cathedral (completed 1310). This pulpit, reconstructed, was restored to the cathedral in 1926. Other works by Giovanni include statues of the Virgin and Child in Pisa, Padua and Prato, an ivory statuette of the Madonna in Pisa and the monument in Genoa to Margaret of Luxembourg.

The façade of Siena cathedral, consecrated to the Virgin, was the earliest Gothic cathedral façade in Italy. It corresponded in conception to the porches of the French cathedrals but differed entirely in execution. Giovanni placed his statues of seers and prophets proclaiming the Virgin's coming at structural points above the doorways rather than beside them, as was customary in France. Each stood alone, yet in significant relation to its neighbours. The figures have undergone much restoration and change of position; some are now in the cathedral museum.

In the architecture of his pulpits Giovanni followed the polygonal design of the earlier pulpits in the baptistery of Pisa and the cathedral of Siena, introducing however Gothic features. In his treatment of individual figures he combines antique and Gothic forms and shows a marked influence from French ivories and,

though there is no definite proof, an acquaintance with French cathedral sculpture. On this foundation Giovanni arrived at a highly developed Gothic style in his statues of the Virgin, in the figures on the Siena façade and especially in the Pistoia pulpit. Here the scenes of the life of Christ are characterized by an extreme vivacity, sense of movement and dramatic power which is reflected in the accompanying reliefs of prophets and statuettes of Sibyls. The latter rival in emotional intensity the Sibyls of Michelangelo in the Sistine chapel.

The same characteristics reappear in the reliefs of the great pulpit in Pisa cathedral but in some scenes, owing, it is thought, to the intervention of assistants, the standard achieved at Pistoia is not maintained. The defect is counterbalanced by the high quality of the supporting column statues representing the Virtues and other subjects where Giovanni returns to the restraint of the classical models which formed the basis of his father's style. It is to this combination of antique and Gothic forms, together with his extraordinary power of expressing emotion, that Giovanni owes his pre-eminent position in Italian Gothic sculpture.

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(G. H. CR.)

PISANO (DA PISA), **NICCOLÒ** (NICOLA) (*c.* 1220–*c.* 1283), Italian sculptor and architect, to whom was due the rebirth of the plastic arts in Italy, was born about 1220. Although he is usually described in terms which indicate Pisan origin or citizenship, two documents support the view that he was born in Apulia. (He has been known as Nicola de Apulia.) He probably learned the rudiments of his arts in southern Italy, and settled later in Pisa. There he spent most of his life and produced his first great work, the marble pulpit in the baptistery, completed in 1259.

The pulpit is a hexagon on semicircular arches, with trefoil cusps, supported by seven columns, of which three rest on lions and one has animal and grotesque human figures around the base. The sculpture expresses in outline the Christian scheme of salvation. In the spandrels, the reliefs of kings, prophets and evangelists bear witness to the coming of Christ. In five panels, the Nativity, the Adoration of the Magi, the Presentation in the Temple, the Crucifixion and the Last Judgment are represented, and above the columns statues are placed which personify the Virtues. Niccolò's next work, the magnificent pulpit in Siena cathedral, completed in 1268, is an enlarged version of its predecessor in Pisa, including a relief of the Massacre of the Innocents. With these pulpits, a new epoch in Italian sculpture began. To features derived from Byzantine, Romanesque and the archaizing classical art of southern Italy, Niccolò added two innovations. He used for Christian subjects the types which he found in antique sculpture; thus, the Phaedra in a relief of the legend of Hippolytus on a sarcophagus in Pisa inspired the figure of the Virgin in the Adoration of the Magi in the baptistery pulpit. His second innovation was his passage, under the influence of French Gothic sculpture, from the static, impersonal, idealized figures of his early reliefs to the presentation in his later work of his personages as individual human beings in vivid states of action and emotion.

ALINARI

"ADORATION OF THE MAGI," DETAIL FROM THE MARBLE PULPIT OF THE PISAN BAPTISTERY BY NICCOLÒ PISANO

In Siena, Niccolò had among his assistants his son Giovanni (*q.v.*), who also collaborated with him in his last great work, the fountain in the piazza in Perugia. Three basins, rising one above the other, culminate in a bronze group of female figures supporting heraldic animals. These may be the work of Giovanni, whose style may also be detected in some of the reliefs and statues which, on the lower basin, personify the Labours of the Months, the Liberal Arts and other historical and mythical subjects.

The Arca di S. Domenico in Bologna (1267) has been attributed to Niccolò. The design may be his, but the actual carving suggests the hand of a pupil, probably Fra Guglielmo. The holy water basin in S. Giovanni-fuor-civitas in Pistoia may be an early work of Giovanni but is generally accredited to Niccolò. So, too, are the reliefs of a Deposition from the Cross and a Nativity over a side portal in S. Martino in Lucca. Their date is uncertain but they show Niccolò's characteristic style in its Gothic phase, and the Deposition ranks as one of his finest compositions.

Recent research indicates that Niccolò must have been an architect of distinction, although the attribution of important works to him by Giorgio Vasari lacks confirmation. Apart from his works, little is known of Niccolò's life. He died between 1279 and 1284, having, with his son Giovanni, laid the foundations of the great art of later generations. His genius lay in his revolutionary use of classical models and his power to unite antique forms with the spirit of the new northern Gothic sculpture.

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(G. H. CR.)

PISAREV, DMITRI IVANOVICH (1840–1868), Russian critic and radical social thinker, the foremost representative of Russian Nihilism, was born on Oct. 4, 1840, at Znamenskoye, Orel province, the son of a landowner. He studied in the historico-philological faculty of St. Petersburg University (1856–61), and in 1862 was imprisoned for an article defending the emigré Russian socialist, Aleksandr Herzen (*q.v.*). During four and a half years in prison he wrote many of his critical articles. He died from drowning on July 16, 1868, at Dubbeln, near Riga.

Pisarev valued art for its utility alone; he was famous for saying that a pair of boots was more valuable than a tragedy by Shakespeare and for his denunciation of Pushkin's aesthetic theories and of Belinski's idealistic interpretation of Pushkin's work. His hard-hitting polemical style is notable for sincerity and vigour. His politico-literary articles include *Realisti* (1864; "The Realists") and *Borba za zhizn* (1867–68; "The Fight for Life").

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(R. F. HI.)

PISCES (THE FISHES), in astronomy, the 12th sign of the zodiac, represented by two fishes tied together by their tails, and denoted by the symbol ♓. In Greek legend Aphrodite and Eros, while on the banks of the Euphrates, were surprised by Typhon and sought safety by jumping into the water, where they were changed into two fishes. This fable, however, as in many other similar cases, is probably nothing more than an adaptation of an older Egyptian tale. The constellation contains only faint stars without any striking grouping.

Piscis Australis or Austrinus, the southern fish, is a constellation of the Southern Hemisphere. It contains Fomalhaut, a star of the first magnitude, which is located at a distance of about 23 light-years from the sun. It is thus one of the sun's nearer neighbours. Piscis Volans, the flying fish, is a southern constellation introduced by Johann Bayer in 1603. The name is now abbreviated to Volans.

PISCES, in zoology, a term formerly applied to all fishes but now generally used for the bony fishes, technically called the Osteichthyes. *See* FISH.

PISCO, a pleasant muscat brandy, which has been distilled since the 16th century from muscat wines produced in the Ica Valley of Peru, 180 mi. S of Lima. It takes its name from the port of Pisco at the mouth of the Ica River, from whence it was originally shipped in porous earthenware jars to Lima, the viceregal capital of Peru and all Spanish South America. Distillation was known to the highly developed Incan civilization, probably as early as the 9th century, but distillation of Pisco did not exist before the arrival of the Spanish, who introduced muscat grape vines brought from Spain.

Pisco is distilled from freshly fermented muscat wines. It has the pronounced fragrance and flavour of the muscat grape. The Pisco consumed in Peru is rarely two years old, but that which is exported will be three years old or more. It is usually bottled at 80 U.S. proof. Muscat brandies produced in Argentina and Chile and labelled Pisco for home consumption are not as fine as the Peruvian original. Pisco is consumed neat as a brandy but the national cocktail of Peru is the Pisco sour, made with lime juice, sugar, and Pisco. (H. J. GN.)

PISEMSKI, ALEKSEI FEOFILAKTOVICH (1820–1881), Russian writer whose realistic stories, novels, and plays of contemporary Russian life enjoyed a great success during the "Great Age" of the Russian novel. He was born into an impoverished gentry family in Kostroma Province on March 22 (new style; 10, old style), 1820. Upon graduating from Moscow University he became a civil servant. His best achievements are the novel *Tysiacha dush* ("One Thousand Souls," 1858), a Balzacian story of a young man out to make a success of his life; and the drama *Gor'kaia sud'bina* (1859; English translation, *A Bitter Fate*, 1933), a starkly realistic peasant tragedy anticipating Tolstoi's *The Power of Darkness*. His peasant stories are an interesting counterpart to Turgenev's *A Sportsman's Sketches*. Pisemski's realism sometimes bordered on naturalism and anticipated Zola. After the 1860s Pisemski's creative powers declined, while the sympathies of his public were estranged by the satirical portrayal of the younger generation in the novel *Vzbalamuchennoe more* ("A Troubled Sea," 1863). He died on Feb. 2 (N.S.; Jan. 21, O.S.), 1881. (G. ST.)

PISIDIA, an ancient region of southern Asia Minor, to the north of Pamphylia and to the west of Isauria and Cilicia. To its west the district of Milyas was generally taken as Pisidian but was on occasion included in Lycia, while to its north the populous and strongly hellenized area around Pisidian Antioch (*see* ANTIOCH IN PISIDIA) was sometimes counted as Phrygian and given the name Phrygia Pisidica or Phrygia Paroreius.

Pisidia included some fertile plateaus and high valleys, such as those of the Catarrhactes and Cestrus (Aksu) rivers, which were rich in olives, vines, pastures, timber, resins and iron. But most of the district was composed of the abrupt north-south trending limestone ranges of Mt. Taurus, providing refuge for a lawless population, much given to pillage, which stubbornly resisted its successive conquerors: Alexander the Great, Amyntas of Galatia, and the Roman general Publius Sulpicius Quirinius. At the end of the Republic, the population was organized in small tribes, or in groups of villages known as communes, the chief centres of which were Termessus, Sagalassus (Aglasun), Selge, and Cremna.

According to Strabo (xiii, iv, 17) the Pisidian language was distinct from those of the nearby Solymi and Lydians. The theocratic rule characteristic of ancient Phrygia seems to have obtained also in Pisidia, where there is evidence of temples with large estates and slave labour, the most famous being that of Men Ascaënus near Antioch.

On the death of King Amyntas in 25 B.C., the greater part of Pisidia was incorporated in the newly constituted Roman province of Galatia, though it was partly regrouped with Lycia and Pamphylia by Vespasian in A.D. 74. Augustus began its romanization by founding military colonies, first at Antioch and later (*c.* 6 B.C.) at Cremna, Comama, Olbasa, Parlais and Lystra. In addition, the Via Sebaste was built forward in two directions from Antioch: one branch joining the highway from Laodiceia to Pamphylia at Comama, and the other running to Iconium and Lystra. The advance of Roman civilization was at first slow, and very little coinage was struck in Pisidia in early imperial times, but in the 2nd century A.D. urbanization proceeded apace, and baths, markets, gymnasiums, temples and porticoes were built even in the little towns of the Milyades. In the following century, however, the Pisidian cities, like those of many other parts of Asia Minor, suffered a serious decline.

On the reorganization of the empire by Diocletian about A.D. 297, Pisidia was included in the Dioecesis Asiana, and in later Byzantine times it fell partly in the Thracesian and partly in the Anatolic theme (province).

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PISISTRATUS (PEISISTRATUS) (605?–528/527 B.C.), Athenian statesman, whose achievement as a tyrant was the effective unification of Attica and the consolidation and rapid increase of Athens' prosperity, was the son of Hippocrates, whose family claimed descent from Nestor. By about 570 Pisistratus was important enough to command in a war with Megara, in which he captured Nisaea, which increased his popularity. He appears in politics as leader of the third party called Diacrii, from Diacria, a district of northeast Attica (Pisistratus' family estates at Brauron were in this district), or Hyperacrii ("the men beyond the hills," as opposed to the men near the city). The other two parties were the Shore (Parali), led by the Alcmaeonid Megacles, and the Plain (Pedieis) under Lycurgus. Pisistratus' eloquence and personal charm soon made him a popular favourite; Solon warned the Athenians of the danger of his establishing a tyranny but was unheeded.

The chronology of Pisistratus' rise to power is disputed, though the sequence of events is known. By feigning an attack on his life, Pisistratus got a guard assigned to him, armed with staves. With their assistance he seized the Acropolis and established a tyranny in 561/560. Almost at once a coalition between the Plain and the Shore drove him out, but Megacles soon fell out with his allies and recalled Pisistratus. Pisistratus married Coesyra, daughter of Megacles, but apparently refused to have children by her, the Alcmaeonidae being under a curse. The coalition was renewed and Pisistratus was again driven out. He went to Eretria and with Eretrian help gained a footing at Rhaecelus in Chalcidice, established friendly relations with Macedonia and obtained command of some of the silver mines of Mt. Pangaeus. This enabled him to raise a mercenary army and he strengthened his position by intriguing with Thebes and Argos. Then he returned to Eretria as a base for operations against Athens, and about 546 landed near Marathon, defeated the government forces, and established himself as tyrant. Many of his opponents fled; he made Lygdamis, his assistant, tyrant of Naxos. He ruled Athens peaceably until his death in 528/527.

There is no doubt that the rule of Pisistratus was generally beneficial to Athens. His foreign policy was remarkably adroit. His own interest demanded that the neighbouring states be placated lest they harbour the plots of his exiled opponents. So he contrived to keep peace with Sparta, Argos, Thessaly, Aegina, and Thebes all at the same time. Farther afield he was more ambitious. His most important exploits were in the northeast. The silver of Pangaeus was an important addition to Athens' resources. By recapturing Sigeum and encouraging Miltiades' venture in the Thracian Chersonese (Gallipoli Peninsula) he gained a foothold in the vital grain route to the Black Sea. His domestic policy was just and beneficent, and preserved the form of the Solonian constitution while keeping the magistracies in the hands of himself and his family. It may be that he completed Solon's work by giving land confiscated from his enemies to those to whom Solon had given only freedom. He put a tax of one-twentieth on the produce of the land and used it partly to advance money to poor proprietors. Athens was free of wars and internecine strug-

gle, and for the first time in years knew settled financial prosperity.

The money he accumulated was put to good use in the construction of roads and public buildings. He built the Temple of Pythian Apollo and began, though he did not finish, the Temple of Olympian Zeus. To him is ascribed also the Parthenon on the Acropolis, afterward burned by the Persians and replaced by the Parthenon of Pericles (for a discussion *see* ATHENS: *Archaic Athens*). Like Cleisthenes of Sicyon and Periander of Corinth, he realized that one great source of strength to the nobles had been their presidency over the local cults. He diminished this by increasing the splendour of the Panathenaic festival every fourth year and the Dionysiac rites, so creating a national rather than a local religion. It is said that he gave a great impetus to the dramatic representations which belonged to the cult of Dionysus and that under his encouragement Thespis (*q.v.*) of Icaria, by impersonating characters, laid the foundation of the great Greek drama of the 5th and 4th centuries B.C. Lastly, Pisistratus carried out the purification of Delos, the sacred island of Apollo of the Ionians; all the tombs were removed from the neighbourhood of the shrine. He gave equal encouragement to poetry. The tradition that he first collected the Homeric poems, or subjected them to an important recension, may not be literally true, but Athenian interest in the poems certainly goes back to Pisistratus' time.

His competence and mildness caused his reign to be remembered as a "golden age," in spite of the later Athenian prejudice against tyranny (*see* TYRANT). He was succeeded, perhaps after a brief crisis, by his son Hippias.

See also GREECE: *History*.

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PISO, the name of a distinguished Roman plebeian family of the *gens Calpurnia*, which continued in existence till the end of the 2nd century A.D. Nearly 50 of its members were prominent in Roman history, of whom the following may be mentioned.

LUCIUS CALPURNIUS PISO, surnamed FRUGI ("worthy"), Roman statesman and historian, was tribune in 149 B.C. He is known for his *lex Calpurnia repetundarum*, which established a permanent court in Rome for cases of extortion. As consul (133) Piso fought against the slaves in Sicily (*see* EUNUS). He was censor in 120. His *Annales* covered the period from Rome's origins until his own time in at least seven books. His attitude was sober and his style plain, and the value of his work was acknowledged by later writers such as Livy and Pliny. (*See* also ANNALISTS.)

LUCIUS CALPURNIUS PISO CAESONINUS, father of Julius Caesar's last wife, Calpurnia. In 58 B.C., when consul, he and his colleague Aulus Gabinius supported P. Clodius in procuring the exile of Cicero (*q.v.*). Piso was rewarded with the province of Macedonia (with extraordinary powers), which he administered from 57 to early 55, when he was recalled, perhaps in consequence of the violent attack made upon him by Cicero in the Senate in his speech *De provinciis consularibus*. On his return Piso addressed the Senate in his defense, and Cicero in his speech *In Pisonem* attacked him for his misgovernment. Piso issued a pamphlet by way of rejoinder, and there the matter was dropped. Cicero hesitating to bring the father-in-law of Caesar to trial. Piso was censor in 50, and tried to mediate at the outbreak of the civil war, but when Caesar marched on Rome he left the city in protest and then remained neutral. After Caesar's murder he opposed Mark Antony; subsequently he became one of Antony's supporters, and took part in an embassy to his camp at Mutina in 43.

GNAEUS CALPURNIUS PISO (d. A.D. 20) was consul in 7 B.C. and subsequently governor of Spain and proconsul of Africa. In A.D. 17 Tiberius appointed him governor of Syria, to watch Germanicus (*see* GERMANICUS CAESAR), to whom the eastern provinces had been assigned. The indignation of the people at the death of Germanicus (19) and the suspicion that Piso had poisoned him forced Tiberius to order an investigation. During the course of this, Piso committed suicide because he was guilty, not of Germanicus' death, but of grave insubordination in having reentered his province against Germanicus' orders. Rumours that Tiberius was responsible for his death may be discounted.

GAIUS CALPURNIUS PISO (d. A.D. 65), figurehead of, rather than prime mover in, the conspiracy against the emperor Nero (*q.v.*) in A.D. 65, had been exiled by Caligula, who married Piso's wife Livia Orestilla. He was a patron of literature, probably inspiring the anonymous poem known as *Laus Pisonis*. His charm and generosity, as well as family connections, recommended him to the military, senatorial, and equestrian elements among the conspirators as an alternative to Nero; but he lacked initiative and committed suicide when the plot was discovered.

LUCIUS CALPURNIUS PISO FRUGI LICINIANUS (A.D. 38–69), adopted by the emperor Galba as his heir (Jan. 10, 69), came from a branch of the Pisones which because of its noble descent and connections was viewed with suspicion by successive emperors from Caligula to Hadrian. He himself was descended from Crassus through his father and from Pompey through his mother, and he had spent years in exile. His adoption prompted the revolt of Otho (*q.v.*), in which Piso was murdered, on Jan. 15, 69.

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Piso Licinianus: For his father (consul A.D. 27) and his ancestry *see* R. Syme, "Piso Frugi and Crassus Frugi," *Journal of Roman Studies*, 50:12 ff. (1960). (H. H. SD.)

PISSARRO, CAMILLE (1830–1903), French painter, the dean of the Impressionist group, was born at St. Thomas in the then Danish West Indies (now the U.S. Virgin Islands) on July 10, 1830; though he lived in France from 1855 till his death, he maintained his Danish citizenship. The son of Jewish parents of Spanish-French extraction, he was sent to Paris at the age of 12 but, having finished school, was called back to help in his father's general store. He devoted all his spare time to drawing and, after some years of struggle between his daily chores and his vocation, ran away in 1852 with a Danish painter, Fritz Melbye, to Caracas, Venez., where he discovered subjects even more tropical and colourful than on his native island. Many of the drawings and watercolours he made there are signed with the Spanish spelling of his name: Pizzarro. Finally his parents let him go back to Paris in 1855 and study painting.

In Paris Pissarro was particularly attracted by the work of Camille Corot whom he visited and who agreed to guide him. When he first exhibited at the Paris Salon, Pissarro's name was accompanied by the legend: "Pupil of Corot." But soon the young man found greater inspiration in the more robust style of Gustave Courbet and began to work exclusively out of doors. A little later Édouard Manet's exciting appearance left its mark on the beginner. Through chance meetings with Paul Cézanne, Claude Monet, Auguste Renoir and their friends, Pissarro became a member of the small Impressionist circle. He was to be the only one who participated in all the exhibitions of the group, from the historic first one in 1874 to the eighth and last one in 1886. In that year he broke with Impressionism and for a while adopted Georges Seurat's divisionist theories and his pointillist technique. Eventually he returned to a broader execution, more akin to his former style.

Mainly interested in landscapes and rural life, Pissarro also painted a few portraits of deep insight and some exquisite still lifes. He drew incessantly and made numerous lithographs, etchings, and monotypes. After having spent most of his life outside Paris, in Louveciennes, Pontoise and Eragny, a recurrent eye infection forced him during his last years to work from behind closed windows. He moved to Paris and also traveled each year so as to vary his subjects. The work he did then is as fresh, spontaneous and masterly as ever, depicting with admirable truth the peculiar atmosphere, colour, and teeming life of the boule-

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"LE CAFÉ AU LAIT" BY CAMILLE PISSARRO. IN THE POTTER PALMER COLLECTION, THE ART INSTITUTE OF CHICAGO

vards, streets and bridges of Paris and the churches and harbours of Dieppe and Rouen.

Pissarro was widely respected for his rare talent, his genuine understanding of nature, his sylvan lyricism and his great humility, as well as for his wisdom and kindness, his profound interest in others (he was the first to encourage Cézanne, Paul Gauguin and Seurat), his humane philosophy tinted with anarchism and his unselfishness. These qualities also appear in the beautiful letters to his eldest son, Lucien, published for the first time in 1943. He died in Paris on Nov. 13, 1903.

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PISTACHIO, the common name for the fruit of *Pistacia vera*, a deciduous tree of the cashew family (Anacardiaceae), that produces much-prized nuts extensively used as food and for yellowish-green colouring in confections. Grown in dry lands in warm or temperate climates, the tree is believed to be indigenous to Iran; it is widely cultivated from Afghanistan to the Mediterranean region and to a limited extent in California. The tree has broad-spreading branches but rarely exceeds 30 ft. in height. Each leaf has one to five pairs of thick, wide, leathery, pinnate leaflets; its small fruits are borne in clusters. The trees are usually dioecious (bearing either male or female blossoms), but rarely perfect flowered (as in a few trees found in Turkey), and is largely wind pollinated. The fruits are from one-half to three-fourths of an inch long, white, and tending to split open at one side without discharging the nut, a greenish kernel enclosed within a thin, tightly adhering, reddish skin. The kernels are single, solid pieces, with pleasing mild resinous flavour. To insure pollination and good yield, male trees are interplanted with female trees in the ratio of one to five or six. A close relative, *P. chinensis*, the Chinese pistachio, is prized for the bright autumnal colours of its foliage.

See also NUT.

PISTIS SOPHIA is the inadequate title ("Faith-Wisdom") given to the two Gnostic works of an ancient manuscript called Codex Askewianus, after Anthony Askew, who bought it before 1772; it was acquired in 1785 by the British Museum. The well-preserved manuscript has 172 leaves (originally 178); it is written in Coptic but must have been translated from Greek.

The first work was probably composed in the second half of the 3rd century A.D. in Egypt. According to it Jesus, in the 12th year after his resurrection, taught his disciples extensively on two Gnostic themes: (1) The fall, the prayers and the restoration of Pistis Sophia, the lowest being in God's spiritual realm; (2) the nature of the human soul, its fate after man's death, and the Gnostic mysteries necessary for mastering its way to the heavenly home. In the second book, written perhaps several decades earlier, Jesus describes especially the punishment of the sinful souls.

Remarkable is the Gnostic interpretation of some Old Testament Psalms, many synoptic sayings of Jesus, and five Odes of Solomon. The highly speculative and already decadent cosmology and anthropology are reminiscent of an earlier and more disciplined work, the *Secret Book of John*, which is contained in the Papyrus Berolinensis 8502 and in the finds at Nag Hammadi. *See* also GNOSTICISM.

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PISTOIA, an ancient city of the Italian region of Tuscany, capital of the province of Pistoia and seat of a bishopric, lies in the valley of the Ombrone River with a semicircle of pleasant hills (part of the Apennines) to the north. It is about 200 ft. above sea level and 18 mi. NW of Florence. Pop. (1961) 85,114 (commune). The city centre still looks medieval, with its 12th–13th-century cathedral in the Piazza del Duomo; the freestanding bell tower (once a Longobard watchtower); and the baptistery (1359) opposite. The cathedral contains the silver altar of St. James, mentioned by Dante and worked upon by generations of silversmiths. Noteworthy also are the Palazzo Comunale (1294) on the east of the piazza and the Palazzo Pretorio on the west. Churches include S. Giovanni Fuoricivitas (12th century, containing a Visitation in glazed terra-cotta by Andrea della Robbia); S. Andrea (12th century); S. Pietro Maggiore (12th century, disused); and S. Francesco al Prato (13th century). North of the Duomo is the Ospedale del Ceppo (1277), with its 16th-century "della Robbia" frieze of the purest Giovanni della Robbia school. The *dolce stil nuovo* poet Cino Sighibuldi (1270–1336), a friend of Dante, was a native of Pistoia. There are two civic libraries and several training schools and institutes.

Pistoia is a railway junction on the Bologna-Florence line, with branches southwest to Lucca and Pisa; and a junction for the arterial roads running north to Modena and Bologna and south toward the Tyrrhenian Sea. Flowers are grown for sale, including export. There is tanning, shoemaking, cement, and glassmaking.

Gauls, Ligurians, Etruscans, and (from 561 B.C.) Romans first dwelt on the site of Pistoia. The Roman demagogue Catiline was slain in battle at Pistoriae in 62 B.C. Rebellion against the Holy Roman Empire made Pistoia one of the first free Italian communes (1085); later (14th century) it came under Florence. In 1786 a famous Jansenist episcopal synod was convened there (*see* SACRED HEART).

PISTOIA PROVINCE (area, 373 sq.mi. [965 sq.km.]; pop. [1961] 232,135) is bounded north by the provinces of Modena and Bologna, west by that of Lucca and east and south by that of Florence. Its northernmost limit is defined by the ridge of the Etruscan Apennines, which slope gradually south to the fertile plain and the valley of the Ombrone. The climate is mild, with regular rainfall. The province has 21 communes. Towns include Montecatini Terme and Monsummano, both with medicinal baths; Abetone, with winter sports; and Pescia, with tanning, paper mills, fertilizer production, and plant growing. There are numerous small holiday resorts. Provincial industries include the manufacture of railway rolling stock, precision instruments, textiles, and musical instruments and the preserving of foodstuffs. Vines and olives are intensively cultivated on the sunny hillsides. The upper slopes are thickly wooded with chestnut and birch. The province is served

by a dense network of roads and railways. (VA. M.)

PISTOIA, SYNOD OF, a diocesan synod held in 1786 under the presidency of Scipione de' Ricci (1741–1810), bishop of Pistoia and Prato, and the patronage of Leopold, grand duke of Tuscany (later the Holy Roman emperor Leopold II), brother of the reforming emperor Joseph II, whose views he shared. Leopold's and Ricci's object was to prepare the ground for a national council and a reform of the Tuscan Church. The synod, attended by 233 beneficed secular and 13 regular priests, decided with practical unanimity on a series of decrees which, had it been possible to carry them into effect, would have involved a drastic reform of the church on the lines advocated by "Febronius" (*see* HONTHEIM, JOHANN NIKOLAUS VON).

The decrees were issued with a pastoral letter of Ricci and were warmly approved by the Grand Duke, at whose instance a national synod of the Tuscan bishops met at Florence on April 23, 1787. The temper of this assembly, however, was wholly different. The bishops refused to allow a voice to any not of their own order, and in the end the decrees of Pistoia were supported by a minority of only three. By the bull *Auctorem fidei* (Aug. 28, 1794), Pius VI condemned 85 propositions of Pistoia. Ricci, who had resigned his see in 1790, subsequently recanted. *See* also GALLICANISM.

See J. Carreyre in *Dictionnaire de théologie catholique,* vol. xii (part 2), col. 2134–2230 (1935), with bibliography.

PISTOL AND REVOLVER. A pistol is a small firearm designed for one-hand use, dating from the early 15th century. Tradition ascribes the derivation of the word to two distinct sources, viz., (1) Pistoia, a city in Italy where some claim the weapon originated; and (2) Pistole, an ancient coin to the diameter of which it is said the earliest handguns were bored. (Yet another explanation of its origin is that it derives from "pistallo"—meaning pommel—the common location of the weapon for mounted troops over centuries of use.)

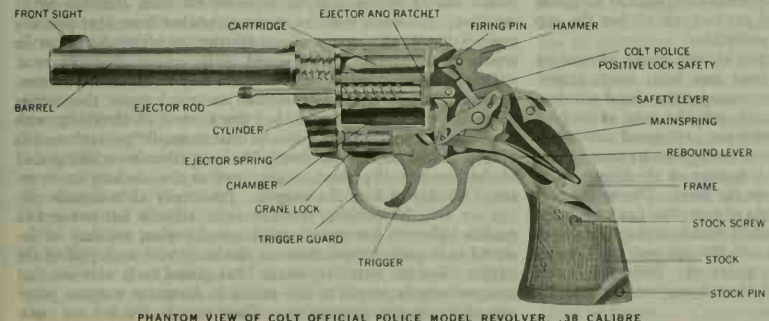
The advantages of a firearm that could be operated by one hand, leaving the other free for the use of an additional weapon, or for defence, must have been apparent from the earliest days of gunpowder, whence it becomes reasonably certain that the pistol evolved simultaneously with its heavier counterpart—the shoulder weapon. Indeed, the most primitive form of small firearm, the "hand cannon," was more a pistol than a musket, but cannot correctly be placed in the former classification since it required one hand to hold it and another to ignite its powder charge. But with the development of the matchlock (*c.* 1425) it became possible to produce a light and serviceable one-hand piece, and thenceforward the history of the pistol parallels closely that of the corresponding shoulder-arm of the period. (*See* SMALL ARMS, MILITARY.)

Through the centuries, the pistol has received the attention of untold thousands of inventors. To render it capable of firing more than once without reloading, it has been produced in every conceivable form—as with two, three, four and more barrels—the number limited only by the weight involved, and with countless other devices incorporated. Revolving types are as old as firearms, though the earlier varieties did not embody, as does the revolver of today, a short, many-chambered cylinder positioned behind a single barrel in such manner that the charge in each chamber is brought successively in alignment with the barrel. Instead they were mere sheaves or bundles of tubes of equal length, and were revolved by hand, rather than mechanically as in later specimens. (The latter, in the mid-19th century, acquired the popular designation "pepperbox"—because of the resemblance of the multichambered muzzle to a pepper shaker.) Nevertheless, the true revolver principle (in which cocking the hammer causes simultaneous rotation of the cylinder) is far older than is generally realized. Samuel Colt (*q.v.*), no matter how much the credit due him for improvements he contributed to this type of mechanism, lacks the honour of being its inventor by close to 200 years, perhaps many more. In addition to developing multishot varieties, small-arms designers have managed to produce numberless combinations of the pistol with other weapons. Thus it is incorporated with battle-axes, daggers, knives, sabres, whip handles, canes, bludgeons, pocketbooks, cigar cases, bicycle handle grips, flashlights, fountain pens and in every other conceivable (and inconceivable) association. Some of the first-named date from the 15th century; the last carries right into the 20th century. The majority of these have been more curiosities than serviceable weapons, but some few have received the stamp of actual (if limited) adoption by the military.

The date of earliest employment of the pistol as a military sidearm is obscure. Pollard tells us that it was adopted by the French cavalry in 1550, and that prior to this period it was "common in Germany." George states that the matchlock pistol was unsuited for military service, and expresses the doubt that pistols were in general use by the military prior to the wheel-lock era, or in England sooner than the opening of the reign of Charles I (1625). He bases this assumption on the absence of any reference to pistols in army records of the reign of Queen Elizabeth (1558–1603).

Thenceforward, however, the pistol held, and holds, a definite if not overly important place among military small arms throughout the civilized world. English-speaking nations, however, were slow to appreciate the advantages of metallic-cartridge types. Whereas France had adopted, as early as 1853 (for her naval service), a thoroughly satisfactory 12 mm. pin-fire revolver, the United States fought its Civil War (1861–65) almost exclusively with percussion hand-arms. The first delivery of American-made metallic cartridge revolvers to the military took place in 1871. (Some few had been purchased and carried by individuals in the war then terminated, and exactly 200 [Perrin make] secured in France by the federal government.) England also deferred until the late '60s the adoption of a metallic-cartridge weapon, although certain German states (*e.g.*, Bavaria) had preceded England by some years.

Contrary to popular belief, facility in the use of the pistol is not readily acquired, and indeed is infinitely more difficult to gain than in the case of the rifle. Further, the shortness of a pistol barrel, as a result of which a slight twist of the wrist swings the muzzle through a large arc, plus the difficulty of ascertaining at a glance whether certain modern types of pistols are or are not loaded, have resulted in many accidents due to carelessness, and gained for the weapon, among those unfamiliar with it, a reputation for dangerousness far greater than it deserves. In addition, the discovery by the novice that he cannot hit even large targets at close range quickly convinces him that it is a hopelessly inaccurate weapon. Even among the military, its possibilities for wide usefulness as a short-range arm, both of offense and defense, are usually studiously neglected. There remains, nevertheless, an informed



PHANTOM VIEW OF COLT OFFICIAL POLICE MODEL REVOLVER, .38 CALIBRE

PHANTOM VIEW OF COLT AUTOMATIC PISTOL, .45 CALIBRE (U.S. ARMY M1911)

and insistent element of military opinion which continues to fight for its more adequate recognition—to the extent, indeed, of the complete replacement of the foot soldier's bayonet with a hand firearm.

Classification.—So many types of pistols and revolvers exist that it is next to impossible to set up suitable classifications for them. Ignoring for the moment all early specimens (*i.e.*, not handling modern metallic cartridges), there are: (1) revolvers; (2) automatic pistols; and (3) other pistols. Of these the first and third are made in a variety of forms for pin-fire, rim-fire and central-fire ammunition. Automatic pistols, however, are chambered for the last two types only, having been perfected after the pin-fire cartridge was already in its decadence. Considering in turn the three basic classes above named, it is found that a revolver is a weapon embodying an element (cylinder) which revolves, whence comes its name. (By the same token, an arm containing no such component is *not* a revolver, despite the generally loose application of the term.) Within the cylinder are bored a number of chambers, disposed equidistant from each other and from the axis about which it revolves. Each chamber is designed to contain a cartridge, and each may be brought in line with the barrel, mechanically locked in position and discharged at the will of the operator by pressure on the trigger. Revolving-cylinder rifles (*i.e.*, revolvers in shoulder-weapon form) long enjoyed considerable popularity (especially during the percussion era), even receiving some military recognition, especially in the U.S. Apparently no new model of this type has been offered for sale since 1880–81, as they are not suitable save for low-power ammunition for which other, simpler and less expensive mechanisms are available.

One widely advertised disadvantage of the revolver is the inevitable escape of some portion of the propellent gases at the junction between cylinder and barrel, and various devices to make this joint more or less gastight (as in the Russian "Nagant" service revolver) have been attempted. The added power thus gained is never worth the complexity of the mechanism required to attain it, however, since the percentage of gas lost, save when the gap becomes truly enormous, is almost negligible.

Revolvers may be classified according to their modes of rotating the cylinder or of extracting the fired case into: single-action, double-action, semiautomatic, automatic-ejecting, hand-ejecting, rod-ejecting, etc. In the single-action arm the acts of cocking the hammer and rotating the cylinder are performed simultaneously by the manual retraction of the hammer, which comes to rest in a rearward position. Thereafter a squeeze on the trigger is required to cause it to fall and discharge the piece. During the percussion era this was the accepted mode of operation (as introduced by Colt, 1836), though certain excellent double-action types such as the Tranter, Webley and Adams (all British) and the Cooper, Remington and Starr (U.S.A.) also appeared. This type is still produced by Colt in its "Single-Action Army" model and by Sturm, Ruger and others.

The double-action mechanism is so designed that the hammer is cocked, and the cylinder rotated, by mere rearward pressure on the trigger, the hammer then falling and discharging the piece when such pressure is continued. To the layman this appears a most suitable design, involving as it does only a single motion, but the spring resistance within the mechanism that must be overcome by finger pressure on the trigger is so considerable, and so variable at different stages in the rearward progress of that member, that none but an expert can do good shooting when firing "double-action" save at the very closest ranges. In the hands of such persons, however, its greater speed of operation (as against the single-action) makes it the weapon of choice. (Most double-action revolvers may be operated either single- or double-action, though some of the cheaper modern types and some of the better earlier ones will function only on the latter system.)

In the semiautomatic revolver the mechanism is actuated, cocking the hammer and rotating the cylinder, by the energy of recoil, which drives the whole superstructure of the piece (barrel-cylinder assembly) rearward on a horizontal platform built into the lower frame. A "recoil spring," compressed during this movement, then uncoils to force these parts back to their forward (firing) position. The outstanding example of this type is the British Webley-Fosbery arm made in .455 (less often in .38) calibre. Another with practically identical mechanism but far less well known is the .32 calibre pocket model formerly produced by the Union Fire Arms Co. of Toledo, Ohio.

In an automatic-ejecting revolver (first popularized by Smith & Wesson, U.S.A.), the weapon commonly "breaks open" (for loading and ejecting) at a hinge located below and forward of the cylinder and a "spider" operating in the axis of that member automatically lifts out and expels the empty cases after the joint has opened sufficiently to permit this. In hand-ejecting models the cylinder ordinarily swings to one side when released by a latch, its axis remaining parallel to that of the barrel, whereupon a rod running through it and terminating in an ejector spider is manually pushed rearward, so withdrawing the fired cases.

In the rod-ejecting type, an excellent example of which is the Colt "Single-Action Army" model, the cylinder must be rotated, one chamber at a time, to bring the mouths of these successively opposite the tip of a long, slender rod in a housing attached to the side of the barrel, and held in its normal (forward) position by spring pressure. This rod must then be manually pressed down into the chamber, aligned with it to disengage and eject the empty fired case within, the spring then returning it to its forward position. The operation must be repeated for each chamber to be emptied. European practice varies somewhat from that just described, but in all systems of rod-ejection each chamber must be separately and individually cleared of its contained empty case.

Other categories into which revolvers may be differentiated are: hammer and hammerless (concealed hammer) types, the former being far the more common, but the latter (all obviously with double-action mechanisms) widely used in small "pocket" models of .25, .32 and .38 calibre wherein the spur (thumb cocking-piece) of the hammer, if present, might catch in the clothing in an attempt quickly to draw the weapon. Practically all automatic pistols are, strictly speaking, semiautomatic, since in but one or two models (Mauser, Germany), and licensed copies, are they so designed as to permit more than one discharge with each pull of the trigger. But the term "automatic" has gained such wide use that it is perforce employed in this article to designate weapons properly of the semiautomatic class. These may be divided into: gas-

operated, straight blowback, blow forward, retarded blowback and short-recoil types. Of the first named, but one short-lived example (the "Clair," France) was ever produced. This employed the usual gas port and expansion chamber beneath the barrel, the cartridges (French service revolver type of 8 mm. calibre) being fed into the mechanism through a tubular magazine in the butt of the piece. The straight blowback, numerous models of which are produced in many countries, is, as in shoulder weapons, confined to ammunition of low power and pressure (*e.g.*, .22 rim-fire). Walther (Germany), however, did produce, in small numbers, their Model MP, a straight blowback type chambered for the 9 mm. Parabellum, a powerful cartridge used in the Luger and numerous other military automatics.

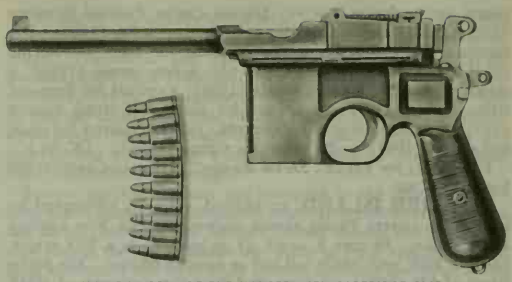
More powerful ammunition is handled in arms of the retarded blowback type, such as the Luger (Germany), or built on the short-recoil system (Webley, England; Colt, U.S.A.). Examples of the much less used blow-forward action are certain early Mannlicher (Austrian) models and the Schwarzlose (Germany). (For descriptions of the modes of operation of these several mechanisms, which duplicate exactly those embodied in machine guns and semiautomatic rifles, *see* MACHINE GUN.) Magazine capacity of automatic pistols varies from about six cartridges (6.35 mm. calibre) to as high as twelve (some .22 rim-fire models), the average military type holding seven to ten. Most modern military automatics are clip-loaded, but some (*e.g.*, Mauser, Germany; Steyr, Austria) are charger-loaded.

Calibres.—These vary for revolvers all the way from 5 to 15 mm. bore in obsolete pin-fire types, *i.e.*, about .20 to .60 calibre; from 2 mm. ($\frac{1}{10}$ in.) to .46 calibre or more in rim-fire, and from about 5 mm. to .577 calibre in central fire. The smallest sizes (2 mm.) are, of course, mere curiosities, yet capable of firing tiny ball cartridges which will destroy eyesight, if no worse. Among automatic pistols, freak arms, save as produced in tiny calibres, *e.g.*, the 2 mm. Kolibri, Germany, are unusual. The smallest really effective automatic, the German "Lilliput," is of 4.25 mm. (about .21 in.) calibre; the largest, the .45 Colt (U.S.A.) and the .455 Webley (England).

The accuracy of the automatic, save in specimens designed for target work (rare in calibres over .22 rim-fire), is, in average hands, commonly below that of revolvers of comparable weight and size and its construction is such that, except in certain makes which possess "loading indicators" (as the Luger), it is impossible, without opening the mechanism or pressing the trigger, to determine whether or not it contains unfired cartridges. Further, unless it possesses a "magazine safety," now incorporated in all the better makes, but formerly rare or absent, it remains dangerous even after the removal of the loaded magazine. This is due to the fact that, preparatory to firing, a cartridge must be transferred from magazine to chamber. If now left unfired, the subsequent removal of the magazine leaves the charge in the chamber undisturbed, but all too many persons are forgetful of this and forthwith consider the arm unloaded and treat it as such. The "magazine safety" renders an accident impossible by locking the firing mechanism automatically immediately the magazine is withdrawn.

Revolver *v.* Automatic.—Though devotees of the automatic pistol have, ever since the invention of that type of weapon, predicted the early decline and disappearance of the revolver, there is as yet little evidence to indicate that their forecastings are soon to be fulfilled. The automatic has gained acceptance by the military in many countries, but in others of equal importance the revolver remains in favour. Among civil servants, European police employ the automatic almost exclusively, whereas in the U.S.A. the revolver is practically without competition. Military revolvers now range in calibre from 7.62 mm. (Russia) to .380 and (formerly) .455 (England); automatics from 7.63 and 7.65 mm. (Germany) to .45 (U.S.A.).

The revolver bullet is commonly an unjacketed missile of lead, hardened perhaps with tin and/or antimony, whereas that of the automatic is usually full metal cased (jacketed), uncased bullets being subject to deformation, because of their relative softness, when passing through the mechanism of such an arm. However,



MILITARY MODEL OF THE MAUSER WITH CARTRIDGE CLIP

.22 calibre automatics use standard 22 rim-fire lead bullet cartridges, not jacketed. Full-jacketed revolver bullets are not unknown, but have never gained much popularity save with law-enforcement agents whose duties may require their firing through heavy doors, automobile bodies, etc. Muzzle velocities in standard revolvers average 600–850 foot seconds, but there has been developed (by Smith & Wesson, U.S.A.) a "Magnum" type in .357 calibre (actual groove diameter of all modern so-called .38 calibre revolvers) with a muzzle velocity exceeding 1,500 ft. per second and a muzzle energy of 800 ft. lb., thus exceeding that of the .44 calibre Winchester (U.S.A.) repeating rifle, model of 1873, to which has probably fallen more medium and large game than to any other firearm ever produced.

In 1956 the same firm (Smith & Wesson) introduced a .44 Magnum revolver, designed around the most powerful handgun cartridge in existence: a 240-grain bullet at 1,570 ft. per second muzzle velocity, with muzzle energy of 1,310 ft. lb. From the standpoint of "stopping power," the .38 or .45 calibre leaden revolver bullet of moderate velocity is more efficient than the high-velocity, automatic pistol missile of small (7.63 and 7.65 mm.) bore as fired by the Mauser and Luger military automatics. Although the latter may exhibit considerably more "calculated" energy on paper, its metal case causes it to penetrate cleanly and its limited diameter results in an almost tiny perforation through the tissues, with little bleeding. By reason of its high velocity it usually passes on through the target to expend most of its energy upon the scenery beyond. The soft-lead revolver projectile tends to "mushroom" (expand) on striking bone or other resistant body structure, tearing ragged holes.

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(C. GD.; J. T. AM.)

PISTON, WALTER HAMOR (1894–), U.S. composer noted for his symphonic and chamber music, was born at Rockland, Me., on Jan. 20, 1894. His paternal grandfather, Antonio Pistone, was an immigrant from Italy. Piston studied music at Harvard University (1919–24) and in Paris with Nadia Boulanger and Paul Dukas (1924–26). On his return to the U.S. he taught at Harvard and was appointed professor of music there in 1944, retiring in 1960. He published three textbooks: *Harmony* (1941), *Counterpoint* (1947), and *Orchestration* (1955). His style of composition is neoclassical, though not without romantic overtones, and is remarkable for its structural strength and rhythmic vivacity. His only piece of program music is the orchestral suite *Three New England Sketches* (1959); his only composition for the theatre is the ballet *The Incredible Flutist* (1938). Otherwise his works are purely instrumental. He wrote seven symphonies (1937, 1943, 1947, 1950, 1954, 1955, 1960), the third and the seventh of which were awarded Pulitzer Prizes. He also wrote two violin concertos (1939 and 1960); a viola concerto (1957); a concerto for two

pianos and orchestra (1959); *Lincoln Center Festival Overture* (1962), and a *Capriccio* for harp and string orchestra (1963). His chamber music includes a *Divertimento* for nine instruments (1946); five string quartets (1933–62); a flute sonata (1930); a piano trio (1935); a violin sonata (1939); a quintet for flute and string quartet (1942); a quintet for piano and string quartet (1949); a quintet for wind instruments (1956); a quartet for piano and strings (1964); and a sextet for strings (1964). (N. Sy.)

PISTON: *see* Steam: *Steam Engine;* Internal-Combustion Engine; Pump.

PITCAIRN ISLAND, an isolated, volcanic, subtropical island in the eastern Pacific almost midway between New Zealand and Panama. In area 2 sq.mi. (5 sq.km.), it is a half crater, 1,000 ft. high, with fertile soil and an equable climate. The population of 128 (1963) are descended from the mutineers of HMS "Bounty" (*see* Bligh, William) and their Polynesian consorts. It had been first sighted in 1767 and was settled in 1790 by Fletcher Christian and some of the mutineers whom he led.

Pitcairn Island is a British colony under the governor of Fiji. Local administration is by an island council elected annually. The islanders subsist on garden produce, fishing, and the sale of postage stamps and curios. Expenditure is mainly on education, health services, and the maintenance of radio communication.

(H. E. Ma.)

PITCH (Setback), a game of cards, the hardiest member of a family of card games that was known in England in the 17th century or before, and was the national game of U.S. card players, especially in the West, until it was replaced by poker. The family is called all fours, from the fact that there are four scoring points: high, low, jack, and game. *High* is the ace of trumps, or the highest trump dealt. *Jack* is the knave of trumps. *Low* is the two of trumps, or the lowest trump dealt. *Game* is a plurality of high cards won in tricks, counting: each ten 10, ace 4, king 3, queen 2, knave 1. In some variants, *game* is the ten of trumps.

The precursor of pitch was seven-up (or old sledge), mentioned in the writings of Bret Harte, Mark Twain, O. Henry, and others. The complicated method of deciding trumps by bargaining between eldest hand and dealer was abandoned in favour of letting eldest hand name the suit, or sell the privilege, and the game was then called sell-out or commercial pitch. The change to free bidding produced auction pitch, the variant now played.

From four to seven may play auction pitch, but the best game is with four, each playing for himself. Each player in rotation clockwise is dealt six cards in rounds of three at a time. Then, beginning with eldest hand, each in turn has one chance to bid, the highest bid being four. The high bidder "pitches" (leads first), and the suit of the card he pitches is trump. If able to follow suit, each player in turn may either follow suit or trump; if unable to follow suit, he may play any card. The highest trump, or if no trump is played the highest card of the suit led, takes the trick, the winner leading to the next trick. If the pitcher at least fulfills his contract, he scores as many points as he has made; if he falls short of his contract, he is "set back" the amount of his bid (has those points deducted from his score). Each other player scores what he makes. The object is to be first to reach seven points. If two or more players reach seven on the same deal, the pitcher's points are counted first; among other players the points are counted in order of high, low, jack, and game.

A special rule called smudge is often allowed—if a player fulfills a bid of four, he wins the game at once, unless he is "in the hole" (has a minus score) at the time. A different form of this rule is met with in some localities. An ordinary bid of four can be overcalled by a bid of smudge, and the smudge bidder wins or loses the game forthwith depending on whether he makes or loses his contract.

See A. H. Morehead, R. L. Frey, and G. Mott-Smith, *The New Complete Hoyle* (1964). (G. Mh.)

PITCH, MUSICAL, is a measure of the position of a single sound in the complete range of sound. The term is more particularly applied in relation to a musical performance or a musical instrument. A precise designation of pitch is needed if singers, and instrumentalists, are to perform together. This is effected by reference to the pitch of a convenient note, almost invariably A above middle C.

Pitch is expressed with greatest convenience as the frequency of oscillation of the sounding instrument (or of the air through which the sound waves are propagated) in cycles per second (c.p.s.). Thus "A = 440" means that "standard-pitch" A is the sound of a tuning fork (*q.v.*) vibrating at 440 c.p.s. For a discussion of the acoustic principles involved, *see* Sound: *Harmonic Sound Waves; Pitch, Frequency and Wave Length.*

History.—Before 1500 the main evidence concerning pitch is found in the written compass of vocal music, especially plainsong, which was sung by average voices with no special vocal training. From such evidence it would appear that pitch throughout the Middle Ages was not very different from that of today.

From the period 1500 to about 1670 large numbers of woodwind instruments survive; the pitch of most of these is remarkably constant at about A = 466, or one semitone above A = 440. This is due to the fact that most were made in Venice in the workshop of one excellent manufacturer and his pupils and successors, all of whom used identical measurements. The pitch of church music during this period was governed by the pitch of the organ. It was usual to specify that the lowest pipe (which might be F or C) should be either five, six, eight, or ten feet long. In England and much of Europe five or ten feet was the standard. However, organists of the time were required to transpose at sight in order to bring the more extreme plainsong tones into the middle of the vocal range, and they sometimes regarded this lowest note as F and sometimes as C. In the former case the pitch was about a third higher and in the latter about a third lower than A = 440. This is why the church music of William Byrd, Orlando Gibbons, and Thomas Tomkins is written either a third lower or a third higher than the pitch at which it should sound.

About the middle of the 17th century the Hotteterres, instrument makers in Paris, were remodeling the entire woodwind family. They used the Paris organ pitch of about A = 415, or a semitone below A = 440. Within 20 to 30 years they and their pupils and followers effectively set European pitch for the next 100 years. This new or Baroque pitch (known in Germany as *Kammerton*) was thus one tone below the old Renaissance pitch (*Chorton*). An old trumpet in C was now in effect in D at the new pitch; this is why nearly all Baroque music with trumpets is in D.

After about 1760 the pitch rose, reaching A = 440 around 1820. It then rose more rapidly and by the latter half of the 19th century reached the "Old Philharmonic Pitch" of A = 452. However, the inconvenience of the "high pitch," which strained singers' voices and made wind instruments quickly out of date, was eventually realized. An international commission, meeting in Paris in 1858–59, fixed a compromise pitch called *diapason normal* (known in the U.S. as "French Pitch" or "International Pitch") at A = 435. England in 1896 adopted the "New Philharmonic Pitch" at A = 439 and in 1939 adopted the U.S. "Standard Pitch" of A = 440, which is practically identical. After the middle of the 20th century pitch again tended to creep up: some Continental makers started making woodwind instruments at A = 444, unless otherwise specified, thus repeating the tendencies of the 19th century.

Absolute Pitch.—The ability to identify any note, at some standard pitch, by ear, or to sing a specified note at will, without recourse to an instrument, is popularly called "absolute pitch." Fully developed absolute pitch is uncommon. It appears in early childhood and is evidently an acute form of memory or recollection of sounds of a particular instrument such as the home piano. Some musicians slowly acquire some degree of absolute pitch, if only for the familiar "concert A."

See also references under "Pitch, Musical" in the Index.

(G. F. Ol.; X.)

PITCHBLENDE, an amorphous, black, pitchy form of the crystalline uranium oxide mineral uraninite, is one of the primary mineral ores of uranium, containing 50% to 80% of that element. Uranium was discovered in pitchblende by M. H. Klaproth in 1789, and radium by Pierre and Marie Curie and G. Bémont in 1898. Deposits, frequently in association with uraninite or with such secondary uranium minerals, as carnotite, autunite and tor-

bernite, are known in the Republic of the Congo, Czechoslovakia, southwestern England, the Northwest Territories and Saskatchewan in Canada, and Arizona, Colorado, Montana, New Mexico and Utah in the U.S. *See* URANINITE. *See* also RADIUM; URANIUM.

PITCHER PLANTS are certain carnivorous (or insectivorous) plants, the leaves of which bear pitcherlike structures or are, as a whole, pitcherlike in form. These plants have the usual nutritive mechanism of other green plants; *i.e.*, they are green, they manufacture carbohydrates, and they are capable of absorbing necessary elements from the substrate in which their roots are growing. In addition they have, in common with other insectivorous plants, evolved a mechanism for supplementing their supply of certain elements, particularly nitrogen and to a certain extent potassium and others, which are frequently deficient in the marsh or bog habitat in which they grow. In these plants the mechanism is the "pitcher," described in the following paragraphs.

Nepenthes.—This genus of pitcher plants constitutes the family Nepenthaceae. There are about 60 species, native to tropical Asia, the Philippines, north Australia and Madagascar. The Asiatic islands are especially rich in species, particularly Borneo. They are lax shrubby plants, creeping in the soil or climbing on the surrounding vegetation. While many are jungle plants, some root in relatively drier hillsides. The climbing is done by means of strong tendrils, elongations of the leaf midrib. These under suitable conditions produce at the apexes the pitchers, which stand upright at the hanging ends of the tendrils.

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PITCHER PLANT (NEPENTHES) SHOWING UPRIGHT PITCHERS HANGING FROM LEAF TENDRILS

The pitcher is a development of the end of the tendril and is in form either tapering tubular or variously expanded either at the base or upper part; or it may be goblet-shaped. The pitcher usually shows a pair of wings, running longitudinally on the ventral aspect of the outer surface, which are extensions of the margins of the leaf base.

The mouth of the pitcher has a corrugated rim of various dimensions in different species. This rim consists of the outturned pitcher margin flanked by an outgrowth on its inner surface. These two, in maturity, are indistinguishable and form one organ, the peristome. Its surface is very firm, shining and broken into transverse ridges, both primary and secondary in size, parallel to each other and prolonged at the inner edge of the peristome as teeth, beneath each of which is a large nectar gland.

Above the mouth is the lid, or operculum, which is immobile. It varies in size according to the species, from a narrow process to a huge heart-shaped expansion, overshadowing the mouth. A study of the development of the pitcher, especially in the seedling or in forced small shoots, shows that the inflated portion is a development of the midrib of the leaf, while the wings, which are especially well developed under some circumstances, represent the upwardly extended leaf base. In the mature type of pitcher there is an apparent separation of the wings from the proximal part of the leaf base by the tendril, along which the wings, readily seen in seedling leaves, are vestigial. The lid has been thought to consist of two fused leaflets, but a more recent view is that it is a transverse growth.

The short and straight or curved process on the back of the pitcher just below the lid represents the organic apex of the leaf.

The size of the pitcher varies widely in different species, from the size of a thimble to that of a pint pot or sometimes even larger. The colour also varies considerably, even in different pitchers on the same plant, according to age, light exposure or soil conditions. It may be yellowish to dark green, variously marked by red, and on the peristome the red colouring forms sharp transverse bands. Some pitchers are merely pale green. They are more or less invested by a rough pubescence of stiff branching hairs, especially when young.

Insects, particularly ants, are attracted to the plant by many deep nectar glands, which occur in scattered positions on the stems and leaves, including the tendrils. These insects can hardly escape finding the nectar glands that occur in great numbers on the inner surface of the lid in most species, and thus are lured to the mouth of the pitcher, around which the peristome forms a perilous foothold, especially for insects trying to reach the nectar secreted by the larger glands found on the inner edge. Even if the surface of the peristome offers no impediment to some insects, as in the case of small ants, there is in most pitchers a curious waxy (glaucous) surface clothing the upper half of the interior of the pitcher. This area has peculiar stomata, which appear under low magnification as crescentic cells—guard cells distorted out of position and hiding their companion guard cells beneath them. There is, moreover, no opening. Since the visible guard cells stand a little above the level of the surface in general, they have been interpreted as stumbling blocks to render the hold of insects' feet insecure. In any event the waxy surface crumbles under their feet, and they fall to their doom. This area has been called the "conducting surface," as distinguished from that below it, the "detentive" region, which could be called the digestive region, since the surface there is crowded with digestive glands, each partly covered with a sheltering overhang of epidermis. Of these there may be as many as 6,000 per square centimetre.

In some pitchers there is no waxy surface, though the two kinds of pitchers may occur on the same plant in some species. Insects that have been lured to the mouth of the trap and attempt to obtain nectar from the marginal glands of the peristome or from the underside of the lid, can, on losing foothold, fall into the trap or pitfall. If they can walk in safety on the peristome, they find it impossible, on entering the trap, to walk on the waxy surface. They fall into the fluid, which, as first secreted, is bland; however, when insects are present the glands are stimulated to secrete a weak acid and a digestive (proteolytic) enzyme. The nitrogenous parts of the insect bodies are then digested, leaving the chitinous exoskeletons to accumulate. The products of digestion are absorbed by the walls of this region of the pitcher.

The process is essentially similar to that in the sundews (*Drosera*), *Pinguicula*, and other carnivorous plants.

The presence of a digestive enzyme does not preclude the use of the fluid, enriched by insect bodies, by commensal organisms as a sheltered spot for their growth and nourishment. A rich flora and fauna consisting of desmids, diatoms, protozoa and various kinds of insect larvae have been discovered and described. It is held by some that these organisms are protected from the attacks of the digestive ferments by the presence in their bodies of antienzymes, as has been claimed for endoparasites in the animal body.

The small, primitive, monkeylike, insectivorous tarsier (*Tarsius spectrum*) is believed to rob the pitchers of their contents. One species of *Nepenthes*, *N. bicalcarata*, has sharp, clawlike hooks, developed from the inner ends of the peristome just beneath the lid. These have been regarded by some as an adaptation for catching the tarsier if he tries this game on the species. Another species, *N. intermedia*, has projections of similar dimensions in the same situation, but in this case they are too weak to act in such manner.

Sarracenia.—This genus of pitcher plants (family Sarraceniaceae) is represented by eight or nine species native in eastern United States and Canada. They naturally fall into two groups, distinguished by the posture of the leaves. Two species have recumbent leaves, *S. purpurea* (sidesaddle plant) and *S. psittacina*. The leaf of the former suggests the horn of plenty. In the latter the leaf lies in a nearly prostrate position, and the entrance

lies horizontally and is hidden beneath a hood. In other species the leaf is trumpet shaped (slightly curved in *S. minor*), with the lid either upright or more or less inclined over the mouth. The colour varies considerably from yellow-green (*S. flava*) to deep green variously infused with red, the intensity of which depends in part upon the situation, whether in bright sunlight or shade. The plant consists of a cluster of leaves springing from strong stolons and is herbaceous. The leaf has a broad sheathing base surmounted by a short stalk widening into the pitcher, which develops from the back (abaxial) part of the leaf base, the edge of which is continuous. On the ventral aspect of the pitcher arises a wing, while from the back of the mouth a laminalike expansion, the lid, arises. The outer surfaces, especially that of the wing

ROCHE

SIDESADDLE FLOWER (SARRACENIA PURPUREA): (LEFT) WHOLE PLANT; (RIGHT) PITCHER SHOWING DOWNWARD-DIRECTED HAIRS ON INSIDE OF LID

leading to the entrance, are supplied with nectar glands, which, during vigorous growth and for some time during maturity, exude a nectar that attracts insects to the entrance. The inner surface of the lid and the upper portion of the interior of the pitcher have many glands also; those on the lid and forward edge of the pitcher mouth exude nectar, whereas those within the pitcher are in all probability digestive in function. The lid is armed with strong, downward-pointing hairs, and it is a matter of observation that flies attempting to garner the nectar there almost invariably fall into the pitcher. Below its mouth the surface is smooth and glistening. The upper zone immediately surrounding the pitcher mouth is beset with nectar glands and is usually coloured red in *S. purpurea*. The wide zone below has numerous digestive glands, according to J. S. Hepburn and his associates. Below this occurs a detentive zone where the surface bears numerous stiff, straight, retrorse hairs which effectively prevent the escape of insects. The fluid of the pitcher has a ready wetting power so that insects become quickly submersed and drown.

The digestion of the prey is partly by the action of digestive ferments and partly by bacterial action—in one or two species perhaps wholly by bacterial action.

The chitinous coverings of insect bodies are indigestible, and they accumulate till the leaf dies. Doubtless when this occurs some material is released to the soil and helps to manure it. The accumulated mass of insect bodies offers nutriment to commensal insects, which take advantage of the situation to lay their eggs within the pitcher where the larvae live on the putrid mass. Birds often slit open the pitchers and feed on the living larvae. In the fluid a mosquito (*Wyeomyia smithii*) passes its immature stages in this habitat. The occurrence of clear fenestrations on the lid (*S. drummondi*), on the lid and back of the upper dorsal part of the pitcher wall (*S. minor*) or on the hood and ventral part of the pitcher wall (*S. psittacina*) is an interesting feature and is seen also in *Darlingtonia* (*q.v.*). These windowlike areas serve to attract insects.

Cephalotus.—*Cephalotus follicularis* (family Cephalotaceae) is a native of southwest Australia. It has the same habit as *Sarracenia* but is a smaller plant. Its leaves are of two kinds, growing in a rhythmic alternation: the foliage leaves, ovate and acute in form, and pitcher leaves, the latter having very much the form of a loose slipper, as stated by A. G. Hamilton, an Australian student of this plant. The simile is apt if the heel is thought of as being turned up; this is the lid that overhangs the entrance.

The pitcher is about the size and shape of a large thumb. The mouth is transversely oval and is guarded by strong, hook-shaped claws pointing inward and downward, graduated in size, the largest being in front. Overshadowing the entrance is the lid, which has several white strips (fenestrations) radiating from its base, with green-red strips between. These, it may be imagined, give the insect visiting the rim the impression of a way of escape but serve only to deflect him into the inside of the pitfall trap. The inner surface of the lid is lined with striated hairs pointing toward its base and hence toward the pitcher's interior. Within the pitcher is a thickened zone (collar) of the wall, which ends abruptly a short distance below in an overhanging shoulder, an impediment to escape. Many nectar glands are found on both the lid and the collar. The expanded lower portion of the pitcher is strikingly marked by the presence of two large kidney-shaped patches, where the wall is thickened, one on each side and placed obliquely. These are glandular in nature. The epidermis consists of cells with strongly wavy walls, interspersed with curious stomata, the guard cells of which are widely spread and immobile. These stomata are plugged by a soft cellulose wall of a cell below and are probably water-excretory, as experiment has indicated. Here also occur large glands, of a structure similar to others of smaller, graduated sizes, scattered throughout most of the rest of this portion of the pitcher. It seems likely that these glands secrete a digestive agent.

The external surface of the pitcher bears wings. One runs along the middle line and is doubled along the outer edge. Another two, one on each side, run obliquely along the sides. Two others, quite low and not readily seen, run from the edges of the lid to the stalk, which is attached to the pitcher near the lid; in this feature *Cephalotus* differs from the pitchers of all other species. The development of the pitcher shows that it is morphologically upside down.

Genlisea.—This aquatic genus with several species in tropical Africa and Brazil is a relative of *Utricularia* (*q.v.*) (family Lentibulariaceae), and, like it, grows only in wet places, partly or wholly submerged. It has traps of the pitcher-type, which are not, however, pitfall traps, but "lobster pots." The plants are small and herbaceous, consisting of a cluster of leaves arising from a short stolon, buried in mud. The leaves are of two kinds: foliage leaves, usually near spatulate in shape, and trap leaves of peculiar design. The latter leaf consists of a stalk on which arises a bulbous, hollow enlargement. From its top extends a tube, the extremity of which produces two arms twisted like corkscrews. They are ribbon-shaped extensions of the tube folded longitudinally and with the edges of the ribbon fixed and held a certain distance apart by large cells, placed like buttons. The interrupted slit thus left permits the entrance of minute animal forms (small crustaceans, worms, larvae, as in *Utricularia*). The escape of the prey after entrance is prevented by numerous sharp, stiff hairs, intermixed with many glands, which may be merely mucilaginous. Both these appendages occur in curved rows, rendering the interior of the arms curiously complicated. Passing down the arms, the prey at length passes into the tube, also lined with long, slender downward-pointing hairs, so arranged that they form what would be, if large enough, a lobster pot. In this region are digestive, as well as mucilage, glands, in transverse rows. The prey finally reaches the bulbous expansion, which has two internal ridges carrying numerous digestive glands, and there the process of disintegration is completed.

See F. E. Lloyd, *The Carnivorous Plants* (1942), in which a full bibliography may be found. (F. E. L.)

PITCHSTONE, a natural glass, generally of composition equivalent to granite, with conchoidal fracture, like glass, and pitchy or resinous lustre, formed by rapid cooling of viscous lava or magma. It may be mottled, streaked, or uniformly coloured in brown, red, green, gray or black. A rhyolite (*q.v.*), the chemical composition, index of refraction, and specific gravity of pitchstone are similar to those of obsidian (*q.v.*). Pitchstone is distinguished from obsidian by a dull, rather than vitreous, lustre. Like obsidian, however, it is translucent on thin edges but is much richer in microscopic embryonic crystal growths (*see* CRYSTALLITE). The abundance of these tiny crystallites is generally believed to account for the duller appearance of pitchstone. The crystallites assume beautiful and interesting forms such as globular, rodlike, hairlike, stellate, feathery and frondlike. Slightly larger crystal growths may also abound.

Most pitchstones occur as dikes or marginal phases of dikes and, therefore, may grade into porphyry (*q.v.*). Pitchstone porphyry (vitrophyre) consists of a glassy base enclosing abundant large crystals (phenocrysts) of such minerals as quartz (*see* QUARTZ PORPHYRY), alkali feldspar, and plagioclase and fewer crystals of pyroxene, or hornblende.

Pitchstone may reveal evidence of fluid flow by the presence of wavy streaks and trains of crystallites, microlites, phenocrysts and spherulites; and where formed in dikes, the lines and layers of flowage are most conspicuous near the margins of the intrusive body and have assumed an orientation parallel to the dike walls.

Of all the glassy rocks pitchstone is the richest in water, generally carrying 4% to 10% by weight. Most of this water may

Representative Analyses of Pitchstone and Related Glassy Rocks

	Obsidian			Pitchstone				Perlite		
	Yellowstone Park	Iceland	Mexico	Scotland	E. Germany	Madagascar	Iceland	Siberia	Sardinia	New Zealand
SiO_2	74.70	75.28	75.23	73.20	72.42	72.61	68.12	72.78	70.50	74.73
Al_2O_3	13.72	10.22	12.36	10.75	11.26	11.35	12.13	14.15	14.28	10.82
Fe_2O_3	1.01	4.24	0.96	0.95	0.75	1.19	—	0.17	0.75	2.46
FeO	0.62	—	1.24	1.02	—	0.44	1.03	—	1.22	0.58
MgO	0.14	0.25	0.01	0.15	0.28	0.20	*	*	0.49	0.20
CaO	0.78	1.81	1.00	0.76	1.35	1.03	1.63	0.82	1.00	0.80
Na_2O	3.90	5.53	4.00	3.78	2.86	1.88	5.34	4.51	3.62	2.68
K_2O	4.02	2.44	4.62	4.20	3.80	4.00	1.69	2.48	5.28	4.40
H_2O	0.62	0.23	0.73	4.70	7.64	5.13	9.70	4.35	2.86	2.94

*Trace.

have been absorbed from the sea or wet sediments into which the pitchstone was intruded. Some lavas and magmas appear to have congealed partly as glass and partly as crystalline material. Water driven out from those portions undergoing crystallization may have been trapped or taken up by the glassy portions to form pitchstone. Pitchstone is unstable, and its conversion to a very fine-grained crystalline aggregate resembles the devitrification of obsidian.

See also PERLITE. (C. A. CN.)

PITEŞTI, a town in Rumania situated on the right bank of the Argeş River, lies 113 km. (70 mi.) NW of Bucharest by road. It is the chief town of Argeş *regiune* (administrative and economic region). Pop. (1963 est.) 48,477. Piteşti originated as a trading centre, and has long been famed for its wines. It is now an important industrial town (chemicals, machinery, structural steelwork, machine tools, building materials, timber, textiles, leather, footwear, and food products).

ARGEŞ ADMINISTRATIVE AND ECONOMIC REGION extends southward from the Carpathians through a zone of foothills to the Danubian Plain. Area 6,100 sq.mi. (15,799 sq.km.). Pop. (1963 est.) 1,189,395. About one-third of the region is cultivated. Wheat and maize (corn) are the main crops, with fruit growing and viticulture in the hills. Argeş region produces nearly one-quarter of Rumania's petroleum output. Other resources include natural gas, salt, mica, and limestone.

The principal towns are Piteşti, Cîmpulung, and Rîmnicu Vîlcea. Excluding Piteşti, the main industrial activities are petroleum extraction, the production of soda and alkalis (Govora), motor vehicles (Cîmpulung, Colibaşi), timber, leather, and food products. Development projects in the 1960s include an aluminum plant with an annual capacity of 50,000 tons near Slatina and a hydroelectric plant of 220,000 kw. on the Argeş at Curtea de Argeş.

PITHECANTHROPUS, the name given to a group of fossilized remains of a primitive man, the skullcap and thighbone of which were discovered in 1891 in river deposits in Java by a Dutch geologist, Eugène Dubois. The skull gave evidence of a small-brained man with massive brow ridges, flat retreating forehead, and other apelike features. To this extinct type Dubois gave the name *Pithecanthropus erectus*, indicating that it represented a more or less intermediate phase in evolution from simian ancestors, and that it had already the upright posture characteristic of modern man (*Homo sapiens*). For some years after the discovery conflicting views were expressed by anatomists on the status of *Pithecanthropus, e.g.*, whether this extinct genus was really a giant ape rather than a primitive hominid; but the latter view came generally to be accepted. Between 1936 and 1941 other remains were found in Java, and stratigraphic evidence suggested they dated from the early Middle Pleistocene or earlier, an antiquity of 200,000 to 500,000 years. Detailed study of all the fossil material finally led to general agreement that this ancient type of man was not generically distinct from *Homo;* the term *Pithecanthropus erectus* has therefore now been replaced by the term *Homo erectus*.

In 1929 and the following years, several skulls, jaws, and limb bones of a similar hominid were discovered in cave deposits near Peking, China. These remains were assigned to a new genus, *Sinanthropus* (*q.v.*), but they are not clearly differentiated from the Javanese fossils, though they may represent a distinct subspecies. The remains in China were much more numerous and better preserved than those from Java and were found in association with crude cores and trimmed flakes of quartz and silicified rocks representing a local Paleolithic industry of archaic character. The remains of hearths and charred animal bones made it evident that these early hominids used fire for domestic purposes; their diet is indicated by collections of deer bones and hackberry seeds. In general, the Chinese variant of *Homo erectus* appears somewhat more advanced than the Javanese, with a slightly larger brain and a better-developed forehead. The geological evidence also favours a lesser antiquity in the Middle Pleistocene.

Taking into account all known remains from Java and China, the following outstanding features show how the species compares with *H. sapiens*. The mean brain volume was about 1,000 cm^3 (contrasting with 1,350 cm^3 in modern man), but it showed a remarkable degree of individual variation. The skull is markedly flattened (platycephaly) with little frontal convexity. The bony ridges are massive and prominent, and there is a very pronounced postorbital constriction of the cranium. The jaws project strongly forward (prognathism); nasal bones are broad and flat, and the mandible lacks a chin eminence. The teeth are large and in some individuals the canines projected well beyond the level of the adjacent teeth. In contrast with these primitive traits, the limb bones (as far as they were known in the 1960s) are not distinguishable from those of modern man. Thus it appears that, at least by the beginning of the Middle Pleistocene, the limbs of Paleolithic man had reached the terminal stage of evolutionary development while the skull, brain, jaws, and teeth still retained archaic characters. Jaws and teeth very similar to those of *Homo erectus* have been found (from 1954) in North Africa, associated with stone hand axes and cleavers of a lower Paleolithic industry known as the Early Acheulian. It is probable, therefore, that the species was quite widely dispersed over the Old World in Middle Pleistocene times. In the later Middle Pleistocene there appeared more advanced hominids which were probably the evolutionary descendants of *Homo erectus;* they were followed in the Upper Pleistocene by modern types of *H. sapiens*. *See* MAN, EVOLUTION OF: *Pithecanthropus; see* also references under "Pithecanthropus" in the Index. (W. E. L. G. C.)

PITHOM (Egyptian PER-ATUM or PER TUM), an ancient city in northeastern Egypt, the site of which (Tell el Maskhutah) lies in Ash Sharqiyah province about 12 mi. WSW of Ismailia. It was one of the treasure cities built for Pharaoh by the Hebrews in Goshen (Ex. 1:11). It was enlarged by the Ramesside pharaohs,

especially by Ramses II, in whose reign the Exodus may have taken place. The site has yielded statues and sphinxes of Ramses II and other monuments including the best preserved of the trilingual stelae on which Darius I the Great commemorated the completion of the Nile-Red Sea Canal on which the city lay.

(M. S. Dr.)

PITMAN, SIR ISAAC (1813–1897), English educator, inventor of the shorthand system named for him, was born at Trowbridge, Wiltshire, on Jan. 4, 1813. After grammar school, he worked as a clerk in a cloth factory, but in 1831 he was sent to a training college for teachers. After 11 years of teaching in elementary schools he opened a private school in Bath. In 1829 he took up Samuel Taylor's system of shorthand and became an enthusiast in developing the art of phonography, a system of writing shorthand according to sound. In 1837 Pitman drew up a manual of Taylor's system and offered it to the publisher Samuel Bagster. Bagster did not accept the work, but suggested that Pitman invent a new system of his own. The result was his *Stenographic Sound Hand* (1837). Bagster published the inventor's books at a low price, thus helping to bring the system within the reach of all. Pitman established at Bath a Phonetic Institute and a *Phonetic Journal* for this purpose; he printed in shorthand a number of standard works, and his book *Phonography* (1840) went through many editions. He was an enthusiastic spelling reformer, and adopted a phonetic system which he tried to bring into general use. In 1894 he was knighted. He died at Bath on Jan. 12, 1897. The Pitman system is described in the article Shorthand.

Pitman's biography was written in 1902 by his brother Benn Pitman and in 1908 by Alfred Baker.

PITT, THOMAS (1653–1726), usually called "Diamond Pitt," British East India merchant who traded in opposition to the East India Company but was later governor of Madras, was born at Blandford St. Mary, Dorset, on July 5, 1653, the second son of the rector, Thomas Pitt. He went to India in 1673 and established his headquarters at Balasore. He made several visits to England, during which he was elected member of Parliament for Old Sarum (1689) and New Sarum (1690); in 1691 he bought the manor of Old Sarum, thereby securing control of the parliamentary seat for his family. Despite legal proceedings the East India Company failed to check his activities in India, and in 1694 the company took him into its service and appointed him governor of Fort St. George, Madras (November 1697). In 1701 Pitt bought the famous diamond which he sold to the regent of France, Philippe duc d'Orléans, in 1717, and which now, known as the "Regent," is in the Louvre Museum in Paris (*see* Diamond). Dismissed from his governorship in 1709, he returned to England in 1710 and resumed his seat for Old Sarum. He died at Swallowfield, Berkshire, on April 28, 1726, and was buried at Blandford St. Mary. His grandson was William Pitt, earl of Chatham.

See Sir C. N. Dalton, *The Life of Thomas Pitt* (1915).

PITT, WILLIAM (1759–1806), English statesman, prime minister from 1783 to 1801 and from 1804 to 1806, second son of William Pitt, earl of Chatham, by Lady Hester Grenville, was born at Hayes, Kent, on May 28, 1759. Both because of his extreme delicacy and because his father disliked public schools, he was educated at home. An exceptionally precocious boy, he went to Cambridge at the age of 14, to Pembroke Hall. His college tutor was the Rev. George Pretyman (who changed his name to Tomline in 1803), afterward his friend and biographer and bishop of Lincoln. Persistent ill-health alone induced him to make use of the antiquated privilege which allowed noblemen's sons to graduate without examination (1776). Left with an income of less than £300 a year after his father's death in 1778, Pitt entered Lincoln's Inn, was called to the bar in June 1780, and joined the western circuit. In September of that year he naturally (in view of his age) failed to secure election to Parliament for his university. On Jan. 8, 1781, Sir James Lowther brought him in for Appleby in Westmorland on condition that he resign his seat if their political views diverged.

Parliament.—Joining the Chathamite section of the opposition now led by the earl of Shelburne, Pitt made a highly successful maiden speech on Feb. 26 in support of Edmund Burke's economic reform proposals. On March 8, 1782, when Lord North's ministry was already tottering, Pitt, with astonishing self-confidence for a young man of 22, publicly announced that he would never accept a subordinate position in the next ministry, and he did in fact refuse the vice-treasurership of Ireland, offered to him by the succeeding prime minister, the marquess of Rockingham.

BY COURTESY OF THE NATIONAL PORTRAIT GALLERY, LONDON

WILLIAM PITT, PAINTED BY JOHN HOPPNER. IN THE NATIONAL PORTRAIT GALLERY, LONDON

As a back-bencher he supported measures for shortening the duration of parliaments and repressing bribery at elections, and on May 7 he proposed that a select committee should inquire into the state of the representation, but was defeated by 161 votes to 141. When, after Rockingham's death (July 1, 1782) Shelburne was appointed prime minister, Charles James Fox and his friends resigned, and Pitt accepted the chancellorship of the exchequer. Though Shelburne's was a minority government, it remained in being long enough to negotiate the peace treaties with America, France, and Spain (Jan. 1783). With Shelburne's consent, Pitt, on Feb. 11, sought a compact with Fox, who, however, refused to serve under Shelburne, whereupon, according to Tomline, Pitt replied, "I did not come here to betray Lord Shelburne." This marked both the beginning of the long political duel between these two great rivals, and the end of Shelburne's ministry, for Fox and North, bitter enemies during the American Revolutionary War, combined to defeat Shelburne who resigned on Feb. 24. At his suggestion George III invited Pitt to form a government, but realizing that he would not have a majority in the Commons, Pitt declined the offer, and the king eventually had to capitulate to the hated coalition. To embarrass the new government, which, under the nominal premiership of the duke of Portland, consisted of reformers and antireformers, Pitt again brought forward the question of parliamentary reform (May 7, 1783). He suggested no extension of the franchise, but recommended measures to prevent bribery and excessive expenditure at elections, to disfranchise corrupt boroughs, and to increase the representation of London and the counties. The resolutions were rejected by 293 votes to 149. Reformers now looked to Pitt rather than to Fox as their parliamentary leader.

In Nov. 1783, Fox introduced his famous India bills, one of which was to provide the occasion of the king's quarrel with the Whigs. The king authorized Pitt's cousin, the 2nd Earl Temple, to declare that whoever in the House of Lords voted for the bill (it had already passed the Commons) would be considered by the king as an enemy. The trimming peers went over to the opposition, and on Dec. 17 the bill was rejected by 95 votes to 76. The king at once dismissed the coalition and on Dec. 19 asked Pitt to form a government. Pitt clearly did not take the premiership as the king's tool, for his first step was to try to include Fox and his friends in the new ministry. But Fox would not consent to join a government from which his ally Lord North would have been excluded.

PITT'S FIRST MINISTRY, 1783–1801

When Parliament reassembled on Jan. 12, 1784, the government was at once defeated by 39 votes on a virtual motion of censure, but Pitt refused to resign and the king was prepared to abdicate rather than again surrender to the coalition. Fox's case was that the coalition had been dismissed in a treacherous and unconstitutional way, and that the new ministry, which had been created by means of the king's influence and which did not possess the confidence of the House of Commons, must be forced to resign. Pitt admitted that his situation was without precedent, but denied that he was prime minister through backstairs influence. If Fox

had stopped supplies and persuaded the house not to pass the annual mutiny bill, he could have forced Pitt's resignation, but he felt that the adoption of such extreme measures would injure public interests and lose him the votes of many of the independent country gentlemen. He put himself in the wrong, however, by opposing a dissolution of Parliament, which the government was prepared to advise as soon as the mutiny bill had been passed and the preparations for the elections completed. "No one would say," said Fox, "that the prerogative of dissolution ought to be exercised merely to suit the convenience of an ambitious young man." The independent country gentlemen in the Commons made strenuous efforts to bring about a union of parties, and North handsomely offered to stand aside if his presence in the cabinet would prevent the formation of a nonparty government. But the Whigs insisted that Pitt must first of all resign in accordance with the wishes of a majority of the House of Commons: this he refused to do.

That majority began to crumble: many members, fearing the loss of their seats at a general election, went over to Pitt's side during February and March, doubtless in the hope that he would gain a majority in the existing house sufficient to make a dissolution unnecessary. By March 8 the majority against him had fallen to one vote, thus making him confident of victory. The mutiny bill became law on March 24, and next day Parliament was dissolved.

No 18th-century government lost a general election, and Pitt's success in 1784 was never a matter of doubt. The "influence of the crown" ensured that the new House of Commons, just as much as that of 1761 or 1780, was chosen by the treasury. The statement of Pitt's biographer, J. Holland Rose, that Pitt "never stooped to associate with jobbers" is no longer accepted. Patronage and corruption gave Pitt a majority, and secret service money was used to pay election bills. And within a few months of the election there were 17 additions to or promotions in the peerage. It is therefore misleading to say that Pitt was "the choice of the people"; he was merely the dispenser of royal patronage. John Robinson, the treasury official who advised the government about the management of the elections, calculated that Pitt's largest gains would be in the "close" boroughs, where seats were bought with money and patronage. Pitt himself was returned for the University of Cambridge; only once again (1790), at subsequent elections, did he have to stand a contest.

Financial Policy.—When Pitt became prime minister, the national credit was seriously impaired by the heavy cost of the American Revolution. The debt was about £250,000,000, a staggering amount for those days. The budget was unbalanced, and 3% Consols were down to 54. Pitt funded the unfunded debt, imposed new taxes to wipe out the deficit, checked smuggling by reducing the high duties which encouraged it—that on tea, for example, was cut down from 119% to 12½%—and reduced frauds in the revenue by establishing an improved system of auditing accounts. He also removed a number of duties, such as those on cotton textiles, which were injurious to industry, and simplified the whole range of customs and excise duties. All these, instead of being allocated to a series of distinct funds, were brought into a single consolidated fund, out of which all classes of public creditors were to be paid. In 1786 he introduced a sinking fund on a new principle: an annual surplus of £1,000,000 was to be appropriated to the purchase of stock and allowed to accumulate at compound interest for 28 years, by which time the income from it would amount to £4,000,000 a year. In 1792 another act provided that a sinking fund of 1% should be attached to every new loan, which would thereby be redeemed within 45 years. The system worked reasonably well in peacetime, because there was an annual surplus of revenue over expenditure, but after the outbreak of war in 1793 the government redeemed debt bearing a low interest by fresh borrowing at a higher rate of interest. Moreover, the wartime practice of borrowing, nominally at a low rate of interest but in reality at a high rate because of the discount at which the loan was issued, would now be regarded as a mistaken one.

Pitt's fiscal policy revealed the influence of the ideas of the political economist Adam Smith and of Shelburne, the first statesman to understand the economic theories embodied in Smith's *The Wealth of Nations*. In 1785 he tried to bring about the commercial union of the British Isles; Ireland was to purchase the advantage of complete free trade with England and the colonies by an annual contribution to the cost of defense. But the opposition of British traders and industrialists caused the plan to be modified in such a way as to compel the Irish to reject it. In 1786 an attempt was made to reestablish normal trade relations with Britain's so-called hereditary enemy, France. So a treaty (negotiated by William Eden, afterward Lord Auckland) was designed to promote freedom of navigation and commerce in all but a few articles, moderate duties being substituted for an absolute prohibition, silk goods alone excepted. The French Revolution came before either country could benefit substantially from this statesmanlike measure.

Attitude to Reforms.—On April 18, 1785, Pitt redeemed his pledge of June 1784 to bring forward the subject of parliamentary reform at an early date. Leave to introduce a bill was refused, however, by 248 votes to 174, the majority consisting of followers of Lord North, Whigs like Burke who believed only in economical reform, the proprietors of nomination boroughs (or their members), and independent country gentlemen. Pitt would have extended the franchise to the copyholders in the counties, and, proposing that 36 decayed boroughs should be disfranchised by their own voluntary application, their 72 members being added to the representation of London and the counties, he suggested the setting aside of a compensation fund of £1,000,000, each borough, on the application of two-thirds of its electors, to be entitled to one-thirty sixth of the whole sum. If the amount was not large enough to tempt the borough proprietors to sell their rights, the money was to accumulate at compound interest until the temptation became irresistible. Pitt, after this defeat, virtually abandoned the cause. When others raised the question in 1790 he declared that the time was inopportune, finding an excuse for shelving it in the apathy of public opinion. After the outbreak of war with revolutionary France in 1793 he opposed all constitutional change.

At the 1784 elections the dissenters as well as the parliamentary reformers had supported Pitt, but when, in 1787, he was urged to repeal the Test and Corporation acts he refused to do so, alleging that they did not impose any stigma or penalty on Nonconformists, and that the existence of an established church implied disabilities on nonchurchmen.

India, Canada, and Australia.—Pitt's own India bill, which had been rejected on Jan. 23, 1784, during the struggle with the opposition, was passed in the summer of that year, after the general election. His bill, unlike Fox's, left the ordinary India patronage with the East India Company's directors, while a new government department, the Board of Control, supervised the directorate. All political orders and dispatches had to be submitted to the new authority for its approval. Declaring that all schemes of conquest were repugnant to the honour and policy of the British nation, the act enjoined a policy of nonintervention in the affairs of the Indian princes. It put an end to an inappropriate division of authority in India by making the governor-general supreme over the subordinate governments of Bombay and Madras. In 1786 a supplementary act increased the authority of the governor-general over his own council. Warren Hastings, governor-general of Bengal since 1773, returned home in 1785, having greatly strengthened British power in India, only to undergo the ordeal of a seven-year impeachment (1788–95) especially for his conduct regarding the Rohilla War, the raja of Benares and the begums of Oudh. Pitt, honestly believing that there was a case to be answered, and determined that the British name should be freed from the suspicion of injustice or oppression in the government of Oriental peoples, supported the demand for inquiry. Burke and the other managers of the impeachment disgraced their cause by the rancour and virulence with which they assailed one of the greatest of empire builders. Though Hastings was acquitted of all charges, the expense of the defense almost ruined him.

Another imperial problem with which Pitt had to deal was that

of the future of Canada. By the Constitutional Act of 1791 the then province of Quebec was divided into a predominantly French province of Lower Canada, and a predominantly English province of Upper Canada, which was inhabited chiefly by the loyalists who had emigrated from the United States during and after the American Revolution. Both provinces were given representative institutions which ensured to the "United Empire loyalists" the kind of government to which they had always been attached, and to the French Canadians the opportunity of preserving their own distinct way of life. Pitt, who was in office when men were first transported to Australia, never regarded that country as anything more than a convict settlement.

Foreign Policy.—Pitt's foreign policy was only moderately successful. In 1788 he made alliances with Prussia and with Holland, both with the object of strengthening the power of the worthless hereditary stadtholder of the United Provinces, William V of Orange, which a year earlier had been and was still threatened by the republican or "patriotic" party relying on French support. The state of France's finances, however, had made her intervention out of the question, and a Prussian army had quickly restored the stadtholder's authority. The Triple Alliance served one other useful purpose: Prussia's diplomatic support enabled Pitt in 1790 to triumph over the Spanish without having to go to war, in the Nootka Sound dispute, when they attacked English ships at what is now Vancouver Island. Thus was finally destroyed the Spanish claim to a monopoly of trade and settlement on the western seaboard of North America, making possible the eventual expansion of the Canadian provinces to the Pacific. Pitt's intervention in eastern Europe, however, bore no such marks of triumph. Catherine II of Russia, at war with Turkey, was bent on establishing her supremacy in the Black Sea. In March 1791 Pitt sent her an ultimatum demanding the restoration to the Sultan of all her conquests except the Crimea. But his policy of bolstering up the effete Turkish Empire was supported neither by the entire cabinet nor by public opinion, which was not yet convinced that the Russian threat to Turkey endangered British interests in the Near East. The warlike foreign secretary, the duke of Leeds, was replaced by Pitt's cousin, William Wyndham Grenville, 1st Lord Grenville, an uncompromising pacifist, and the government, badly shaken, reversed its policy. Its failure to preserve the *status quo* in Europe through the Triple Alliance resulted in the second dismemberment of Poland in 1793, which was fatal to the prospects of the first coalition against France.

War with France.—But even Grenville was unable to keep England out of the continental war which started in 1792, precipitated by the Girondins as a means of consolidating the French Revolution. In Feb. 1792 Pitt was prophesying that "unquestionably there never was a time in the history of this country when, from the situation of Europe, we might more reasonably expect 15 years of peace than we may at the present moment." There is no truth in the Whig charge that he plunged England into an avoidable war. In face of great provocation the government clung to nonintervention as long as it was possible to do so. By remaining neutral while the French were overrunning the Austrian Netherlands, the government threw overboard one of the traditional objects of British foreign policy—the safeguarding of the Low Countries from a hostile power. It was not the execution of Louis XVI in Jan. 1793 which made a continuation of peace impossible, but the provocative French decrees of Nov. and Dec. 1792 which authorized their armies to violate neutral territory and which promised military assistance to any European people wishing to depose its rulers. The French, confident of victory after their successes against the Austro-Prussian forces, and believing that England was ripe for revolution, declared war on England and Holland on Feb. 1, 1793. For the history of these wars *see* FRENCH REVOLUTIONARY WARS; NAPOLEONIC WARS; NAPOLEON I; FRANCE: *History;* the part played by Pitt himself can here only be glanced at. Military historians have often severely criticized him for the unprepared condition of the British armed forces at the outbreak of war, for his failure to mobilize the country's manpower during its progress, and for allowing such military resources as the country did possess to be wasted in ruinous enterprises. Forty thousand troops, sent to capture the French West Indies, under the mistaken impression that the French economy would receive a mortal blow from the loss of the sugar islands, died of yellow fever there. Wellington later declared that it was Pitt's great misfortune that he had no one at hand to give him good advice about the conduct of the war. Yet, when all has been said, Pitt was, as was recognized at the time, his country's "guardian angel" in its day of need.

The French Revolution had revived the agitation for parliamentary reform, and the political societies, old and new, were inspired to some extent by the democratic doctrines embodied in Thomas Paine's *Rights of Man* (1791–92). But the cause of reform was soon discredited because its advocates were thought to approve of the violence in France where the progress of events alienated and horrified most English people. The unwise demonstrations of the radicals convinced the government that they would be satisfied with nothing less than a republic, and, to meet what was considered to be a threatening situation (the precise extent of the danger will always be a matter of controversy) the government had recourse to repressive legislation. In May 1792 a proclamation against seditious publications was issued; some of the English and Scottish reformers, including Thomas Muir, Thomas Palmer and John Frost, were transported or imprisoned on charges of sedition (1793); the Habeas Corpus Act was suspended in 1794 and remained so until 1801; and the Treasonable Practices and Seditious Meetings acts of 1795 practically put an end to the activities of the radical societies.

Ireland.—The French Revolution had disastrous repercussions in Ireland, too, creating new hatreds to exacerbate the old religious feuds. The United Irishmen prepared for a rising to be supported by a French invasion, but it was delayed when Lazare Hoche's expedition in Dec. 1796 was scattered by a storm. The rebellion (1798) was finally provoked by the excesses of the troops and the yeomanry in disarming the countryside; French aid arrived only after the revolt had been suppressed. As early as 1792 Pitt had held the view himself that an ultimate union of the two countries was the only solution of the Irish religious problem; the events of 1798 convinced him that union was most urgently necessary for the safety of the empire. Large-scale corruption carried the measure through the Irish Parliament, but opposition from Pitt's cabinet and the king prevented him from carrying his supplementary proposals—Catholic emancipation, tithe commutation, and state provision for Catholic and Dissenting clergy. The king declared (Jan. 28, 1801) that he would reckon any man his personal enemy who proposed a Catholic relief bill, and the opposition of the chancellor, Lord Loughborough, was consequently reinforced by that of the duke of Portland, the earls of Westmorland and Liverpool, and even of Pitt's brother, the earl of Chatham.

On Feb. 3, 1801, Pitt resigned, and, two days later, his friend the speaker of the House of Commons, Henry Addington (afterward Viscount Sidmouth), agreed to form a government. The crisis again drove the king insane (his first illness was in 1788), and after his recovery in March he unkindly accused Pitt of having caused his illness. Pitt replied verbally that he would never again press the Catholic question during the king's reign. In thus pledging himself he was guided by a sense of loyalty to the sovereign, not at all by personal ambition or by the desire to remove from his path the obstacle that prevented his return to office. His retirement, which took effect on March 14, caused extraordinarily little sensation. "Nobody speaks of him; no addresses, no subscriptions, no stir of any kind anywhere," wrote one of the Wellesley brothers.

1801–1806

Addington's Ministry, 1801–04.—Patriotic motives induced Pitt to support the new ministry, and the ensuing preliminary articles of peace signed with France (Oct. 1801) were described by him as highly honourable and very advantageous. For several months during the session of 1802–03 Pitt never attended Parliament, living in retirement in Walmer Castle where, as warden of the Cinque Ports, he organized a local volunteer force (Aug. 1803).

In view of the growing threat to peace, Addington, in March 1803, invited Pitt to join the government, but Pitt, by this time dissatisfied with Addington's domestic and foreign policy, made it clear that he would return only as prime minister. In demanding that Addington must resign before the government could be reconstructed, Pitt was asking him to do that which he himself had refused to do at the request of Fox and Portland in 1784. War broke out again in mid-May 1803. In June Pitt was no longer defending Addington, though he was not yet prepared to go into open opposition—a step which no honest supporter of the king's prerogative right to choose his ministers could take without a severe mental struggle. Thus on June 3 Pitt declined to support Col. Peter Patten's motion of censure, but Pitt's own view of the situation was shared in the division lobby by only 56 members. By 1804 Pitt was becoming increasingly critical of the government's measures to meet the growing danger of invasion. Addington's majority fell from 71 on March 15 of that year to 37 on April 25, and, feeling that his parliamentary position was no longer tenable, he decided to resign. Pitt's constitutional scruples would not allow him to attack the government without informing the king of his intentions (April 21), and he had already made it clear that he would not join with Fox and Grenville in any scheme to "force the closet" as Fox and North had done in 1783. On April 30 Pitt was informed that the king wished him to plan a new ministry. Pitt replied (May 2) that a nonparty government was desirable. The king expressed his astonishment that he should even have thought of inviting Fox, "my personal and public enemy," to join him in cabinet. Unless Pitt would give way on this essential point (and also renew an earlier pledge not to introduce a bill to repeal the Test Act) the king would "call for the assistance of such men as are truly attached to our happy constitution, and not seekers of improvements which . . . tend to the destruction of that noble fabric. . . ." Pitt repeated his promise of 1801 not to press the Catholic question again, and declared himself ready to acquiesce in Fox's exclusion.

Pitt's Second Ministry, May 1804–Jan. 1806.—Pitt's second ministry was weaker than the first, for the Addington group went into opposition, and so did the parties led by Fox and Grenville—Grenville declining to take office under his former chief without Fox. In spite of this weakness the king would not hear of an overture to Fox "even at the hazard of a civil war." Though at the end of the year the Addingtons agreed to join the ministry, they seceded again in July 1805—refusing to defend Pitt's old colleague Henry Dundas, then Viscount Melville, who was charged with corrupt practices while treasurer of the navy during Pitt's first ministry. Pitt never recovered from this grievous blow, and the destruction of the newly made third coalition at the battles of Ulm and Austerlitz was another severe setback to its architect. Thus the year 1805 closed in disaster, in spite of Nelson's victory at Trafalgar (October) which ended the invasion threat and ensured Britain's naval supremacy for the rest of the war. Pitt's health, never robust, was failing. In the summer of 1798 he had had a serious illness which shattered his nerves in a most alarming way.

Pitt made his last public speech at the Guildhall in London on Nov. 9, 1805. The lord mayor proposed his health as "the saviour of Europe." He replied: "I return you many thanks for the honour you have done me. But Europe is not to be saved by any single man. England has saved herself by her exertions, and will, as I trust, save Europe by her example." By Jan. 15, 1806, some of his colleagues were determined to force him to resign as the only means of saving his life, and the king was thinking about his successor. He died eight days later (Jan. 23, 1806) at Putney, and was buried in Westminster Abbey on Feb. 22. A motion for a grant of £40,000 to pay his debts was unanimously carried in the Commons. Earlier (1801) his friends had raised £12,000 in order to relieve him from embarrassment. The famous inscription under his monument in the Guildhall, by George Canning, records that "Dispensing for near 20 years the favours of the crown, he lived without ostentation, and he died poor." Careless to a fault about money, and engrossed with public affairs, he allowed his large official income to be squandered by servants and tradesmen.

CHARACTER AND IMPORTANCE

Private Life and Character.—Pitt never married, and no wholly convincing explanation of the insuperable obstacle which, at the eleventh hour, prevented him from making Eleanor Eden, daughter of Lord Auckland, his wife, has ever been offered. In his career women played an astonishingly insignificant part. He had few friends; an increasing loneliness, characteristic even as a young man, was the self-chosen feature of his private life. Even members of the government complained of his inaccessibility. Long before his death, bodily infirmities, made more pronounced by his excessive addiction to port, curtailed his working day.

His experience was remarkably limited. He never set foot in Scotland or Ireland; the greater part even of England was unknown to him. He was once in France—for a few weeks. He never came into touch with men of letters or original thinkers; he met Adam Smith and the historian Edward Gibbon, once. In his official patronage he neglected literature, science, and the arts. Even his friend William Wilberforce was struck with his ignorance of human nature and his sanguine estimate of men and of political prospects. He was confident that he could carry his reform bill in 1785; that, on the eve of the French Revolutionary War, Europe was entering upon a long period of peace; that he could compel Catherine II to give way in 1791; that the French war would be a short one; that the Roman Catholics could be emancipated; that the Treaty of Amiens (March 1802) would probably usher in a long period of peace; that Napoleon would soon be overthrown after military defeat. It was his misfortune to attain the premiership when he was little more than a boy. If he had had time to broaden his mind with varied experience, and to know his fellow men, he might have governed the country with more matured views and with a mind better stored with practical wisdom. Nevertheless, by reason of his superb debating and oratorical powers he dominated the House of Commons. His conduct there had a mixture of prudence, of firmness, and of transcendent ability never before seen and hardly ever again surpassed. "In personal purity, disinterestedness, integrity, and love of his country," wrote Wilberforce, "I have never known his equal."

Constitutional Significance.—The significance of Pitt's career has often been misunderstood. He was not a prime minister of the modern type. At no time was he the leader of a well-organized, coherent party commanding a majority of the House of Commons which itself owed its existence to the will of the electorate. He was not at all the choice of the nation; he was the nominee of the king, and he retained office only as long as he retained the king's confidence. He had to resign in 1801 because his Irish policy was not acceptable to George III. Even though Addington's inadequacy as a wartime prime minister made Pitt's return to office almost inevitable three years later, Pitt did not return on his own terms but on the king's. He was not given a free hand in the formation of the government, and his failure to overcome the royal hostility to Fox was fatal to his hopes of uniting all parties for the more vigorous prosecution of the war. And he was never free to pursue his policy of liberating the Irish Catholics from the burden of their remaining civil disabilities, a policy necessary to promote the well-being and contentment of the Irish people. He was more dependent on the king's favour than on the support of the House of Commons. A most formidable opposition assailed his position at the beginning of 1784, but fears of a dissolution caused that adverse majority to crumble, and the general election completed the work of disintegration. The real crisis came, not during the opening months of 1784 but in the winter of 1788–89 when, during George III's madness, Pitt lost the all-important support of the crown. Had the dissolute prince of Wales, the nominal leader of the opposition, become regent, Pitt would have been dismissed. Without the support of the crown neither he nor anyone else could remain long in office. All those who were later called Tories (the supporters of the royal prerogative against the Whig claim to dictate to the crown the choice of its servants) certainly were inspired by Pittite ideas during his lifetime and long after his death, but in no other sense was Pitt the re-creator of the Tory Party. Far from being a great party leader commanding the votes of over

half the House of Commons, Pitt had a personal following of little more than 50. This point is again effectively illustrated when one examines the reasons for the paucity of his legislative achievements. In spite of persistent efforts, great speeches, and the support of powerful and eloquent members, he failed to pass a slave trade abolition bill, a parliamentary reform bill, a bill to repeal the Test and Corporation acts, and a Catholic relief bill. Had he led a homogeneous party of the modern type, this legislation would have been carried, but his supporters always deserted him when he was advocating reforms which either their prejudices or their vested interests opposed. It is therefore idle to maintain that Pitt was not really sincere in advocating these great reforms; that if he had been, he could simply have put on the party whips and carried them with a high hand. Moreover, there were very obvious limitations to his absolute authority in the cabinet. For years, Lord Thurlow, lord chancellor during Pitt's ministry from 1783 to 1792, the king's personal representative there, insolently and treacherously obstructed him until he could bear it no longer, and told the king that he must part either with him or with his chancellor. Other colleagues opposed Pitt on all the great questions of the day—parliamentary reform, the Test Act, the slave trade, Catholic emancipation—and, precisely because no government could have been formed united on even one of these great questions, all had to be treated as "open," on which everyone was free to speak and vote as he pleased. And finally, Pitt had to deal with a sovereign of narrow intellect and with intense and irrational prejudices—though, indeed, these were shared by very many of George III's subjects.

Although Pitt's supremacy in the cabinet has often been exaggerated, the necessity for a prime minister who would supervise and coordinate the work of the various departments, and possess the chief confidence of the king, was never again questioned. Melville, in communication with Addington in 1803 about the possibility of Pitt's return to office, told him that it was absolutely necessary "that there should be an avowed and real minister, possessing the chief weight in the council and the principal place in the confidence of the king. . . . Power must rest in the person generally called the first minister, and that minister ought . . . to be the person at the head of the finances."

Though unable to reform the House of Commons Pitt succeeded in transforming the character of the House of Lords by his lavish creation of peerages, increasing the membership by nearly 50%. "He created a plebeian aristocracy," wrote Disraeli, "and blended it with the patrician oligarchy. He made peers of second-rate squires and fat graziers. He caught them in the alleys of Lombard street, and clutched them from the counting-houses of Cornhill." Many of these new peerages were indeed created for the purpose of supporting Pitt's political influence in both houses, but the practice of granting hereditary honours to borough proprietors in return for seats for the government's nominees, did not originate with him. Moreover, he brought much new blood into the upper house, including some of the ablest soldiers, sailors, statesmen, and diplomatists of the period. And, in accordance with the classical doctrine of the 18th century, that the peerage must always represent property, it was time that forms of capital other than land were adequately represented.

The rapid progress of industrialism at the end of the 18th century was giving rise to grave social problems. Pitt's record in this connection is frankly disappointing. There is no evidence that he was aware of the necessity of comprehensive social reform which, during the upheaval of the years after 1789, might have made England completely invulnerable to revolutionary peril. He made no attempt to grapple with such problems as those resulting from the breakdown of the old poor law. Nothing was done to reform the barbarous criminal law, the harsh game laws, prison administration, local government, the courts of justice; or to educate the children of the poor at the expense of the state. *See* also references under "Pitt, William," in the Index.

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(A. AL.)

PITTA, a genus of songbirds remarkable for their great beauty of coloration. Often called jewel thrushes, the pittas were thought for a while to be allied to the thrush family (Turdidae), but they form a separate family (Pittidae). There are about 50 species, divided into a number of genera, confined to the Old World, and ranging from India and northern China to Australia, New Guinea, and New Britain, with one species in West Africa, the greatest number being found in Borneo and Sumatra. Pittas vary in size from that of a jay to that of a lark. They are characterized by a strong bill, a thickset form mounted on rather long legs, and a very short tail. In many of the forms there is little external difference between the sexes.

PITTACUS (7th–6th century B.C.), Mytilenean statesman known as one of the Seven Wise Men of ancient Greece, was born of Thracian extraction in Lesbos *c.* 650 B.C. He collaborated with the brothers of the poet Alcaeus (*q.v.*) in the overthrow of the tyrant Melanchrus (612/611?) and distinguished himself in the war about Sigeum by entangling the Athenian commander Phrynon in a net in single combat and killing him. Subsequently Pittacus turned against the party to which Alcaeus belonged. Given dictatorial powers by the Mytileneans with the title of *aisymnetes* (598/597 or 590/589), he abdicated after ten years' rule and died ten years later. Diogenes Laërtius quotes a number of sayings ascribed to him (mostly moral or political maxims) and five lines of lyric verse, as well as a spurious letter to Croesus.

See F. Schachermeyr, "Pittakos," in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, Halbband 40 (1950).

PITT-RIVERS, AUGUSTUS HENRY LANE-FOX (1827–1900), English archaeologist and soldier who made archaeology in England a scientific discipline, was born in Yorkshire on April 14, 1827. He took the name Pitt-Rivers in 1880 on inheriting his great-uncle's estates of Rushmore in Cranborne Chase, Wiltshire. Educated at Sandhurst, he became deputy-assistant quartermaster general in the Crimean War. His interest in firearms led him to assemble a remarkable ethnographic collection illustrating the typology and development of tools and weapons; it was presented (1883) to Oxford University.

Retiring from the Army (1882) as lieutenant general, he turned to the excavation of prehistoric, Roman, and Saxon antiquities on his estates; in the same year he was appointed the first inspector of ancient monuments. He set a new standard in archaeological technique, conducting large-scale excavations in a manner which was revolutionary at the time but which formed the foundation of subsequent development. His *Excavations in Cranborne Chase* (published privately, 1887–98) remains among the classics of archaeology; other researches included excavations at Thebes in Egypt. Pitt-Rivers was elected Fellow of the Royal Society in 1876; he died at Rushmore on May 4, 1900.

See C. M. Daugherty, *Great Archaeologists* (1962). (S. PT.)

PITTSBURG, a city of Crawford County, Kansas, U.S., was established in 1876 and was named for Pittsburgh, Pa., because of its location in the Kansas coalfields. The city came into being as a direct result of mining and subsequent railroad construction. It is the centre of some of the world's largest strip-mining operations; modern equipment now does work once performed by thousands of European immigrants, who made Pittsburg one of the most cosmopolitan of Kansas cities. Plants producing coal-preparation equipment and clay pipe are among the principal industries. Kansas State College is located in the city. Pittsburg has a council-manager form of government, in effect since 1949. For comparative population figures *see* table in KANSAS: *Population.*

(R. W. RI.)

PITTSBURGH, the second largest city in Pennsylvania, U.S., and the seat of Allegheny county, is strategically located at the confluence of two major rivers, the Allegheny and Monongahela, which drain a watershed of 19,117 sq.mi. (49,513 sq.km.) west of the Allegheny mountains and unite to form the westward-flowing

Ohio. The rivers are normally 710 ft. above sea level and the highest point in the city is 1,365 ft. The climate is relatively free of extremes in temperature and destructive storms. The annual average mean temperature is about 52° F (about 11° C). Annual average precipitation is 36.28 in.

The three rivers and minor streams, flowing through narrow valleys, from which rise high hills or precipitous bluffs to rolling plateaus, give the city a spectacular setting. Nearly 300 named bridges and hundreds of lesser ones span the valleys within the county's limits. Two sets of twin tunnels carry high-speed traffic to southern residential districts and to the west, while tubes make possible the limited-access Penn-Lincoln route to the east.

Population of the city in 1960 was 604,332. Highly urbanized Allegheny county had a population of 1,628,587 and the standard metropolitan statistical area (Allegheny, Beaver, Washington and Westmoreland counties) had 2,405,435. Within the metropolitan area are the cities of Aliquippa, McKeesport, New Kensington, Washington and Wilkinsburg (*qq.v.*). (For comparative population figures *see* table in PENNSYLVANIA: *Population.*)

Many new outlying residential communities were built after 1945 and existing suburban areas experienced rapid growth. In the city a marked trend to apartment dwelling was evident in the latter part of the 20th century.

History.—William Penn was granted the province of Pennsylvania in 1681. The following year the French laid claim, through LaSalle's discovery of the Mississippi, to all the territory drained by its tributaries. In the resulting dispute, the "Forks of the Ohio" were of first importance. The argument was settled, after years of contest and conflict, when Gen. John Forbes and his British and colonial army, after hewing their way across the Allegheny mountains, moved on Ft. Duquesne, built by the French in 1754, to find it in flames and the French in flight. On Nov. 27, 1758, Forbes wrote to William Pitt the Elder that he had named the site "Pittsbourgh" in his honour. After the defeat of Pontiac's Indian forces in 1763, a later settlement with Indian tribes by the Penns and the end of a boundary dispute between Pennsylvania and Virginia, settlers arrived in ever-increasing numbers; they built cabins and stayed, built boats to carry those who pressed on to the west, discovered coal and iron ore in nearby hills and launched the town on its way to industrial greatness. After the Civil War great migrations from Europe swelled the population and by 1900 the city could boast of 321,616 inhabitants. In 1907 the independent city of Allegheny, largely German in origin, was annexed by legislative enactment.

Immediately after World War II the city entered upon a new, dramatic phase in its history. With strong civic, business and political leadership and mobilized citizen support, and based upon long and patient planning, Pittsburgh set about to build new highways and public works, to raze its blighted areas, to redesign the cleared lands and to rebuild according to a new pattern designed to meet modern needs. Every phase of the city's life—industry, transportation, education, culture, recreation—felt the impact of this new and continuing force which was quickly to become known as the Pittsburgh "renaissance."

By Nov. 1958, when the city celebrated its bicentennial, Pittsburgh was no longer a static city; it was a great metropolis in purposeful and directed motion. A $2,000,000,000 regional program of public works and rebuilding—public and private—entered its most spectacular phase in the central city in that year and several neighbouring industrial communities were concurrently moving ahead on ambitious renewal programs. Spearheading the advance was the Allegheny Conference on Community Development, a citizens' coordinating group.

Three notable advances—smoke control, flood prevention and sewage disposal—made possible the city's revival. The ban on smoke, first legislated for the city in 1947 and subsequently extended to all Allegheny county, drastically reduced air pollution. A federal program of dam building for impoundment in the upper reaches of the rivers and their tributaries reduced the stage of maximum flood in the city by ten feet. A $100,000,000 sewage-disposal program, joined in by 71 municipalities in Allegheny county, began operation in 1959, heralding major recreational possibilities in the three rivers.

By 1961 the city planning commission had certified 15 areas, comprising 1,442 ac., for redevelopment, and had under study 1,221 ac. in seven additional areas. Rebuilding in nine of these areas was completed or in progress by the urban redevelopment authority. The most spectacular of these projects cleared 36 ac. for a state park and major traffic interchange at the "point" of the "golden triangle." For development by private enterprise, 23 adjoining acres were cleared, and by 1960 six new multistory office buildings and a major hotel—all in a parklike setting—and an underground garage topped by a park had been completed in this once-blighted district.

East of the triangle, in the populous "lower hill," 95 ac. were cleared; the reconstructed section was dominated by a $20,300,000 public auditorium featuring a retractable roof. With a maximum seating capacity of 14,000, the building, completed in 1961, was designed to accommodate conventions and athletic and cultural programs. Nearby redevelopment was projected on the historic "bluff," permitting expansion of the campus of Duquesne university.

Highlighting a major road program was the 20-mi., $140,000,000 Penn-Lincoln parkway, a limited-access thoroughfare carrying traffic through the city, along the Monongahela river and from the triangle to the west

A. CHURCH—PUBLIX

PITTSBURGH BUSINESS DISTRICT, THE "GOLDEN TRIANGLE"

The "triangle" is formed by (left) the Allegheny river and (right) the Monongahela as they converge to form the Ohio

across the new double-decked eight-lane Fort Pitt bridge to and through twin 3,600-ft. tunnels under Mt. Washington. By 1959 the Pittsburgh parking authority had built seven garages with a capacity of 4,487 cars. One, in the heart of the business district, for subsurface storage under a handsome park, was made possible by gifts to the city totaling $4,000,000 by three Mellon family foundations.

Among major buildings erected after World War II are the 40-story structure shared by the Mellon National bank and the United States Steel corporation, the 30-story Alcoa building, and the Porter; and seven tall structures in Gateway centre, one built by the commonwealth of Pennsylvania. Among older governmental buildings is the Allegheny County courthouse (1884), known as one of architect H. H. Richardson's masterpieces.

DAVID CORSON FROM A. DEVANEY—PUBLIX

NIGHT VIEW OF PITTSBURGH WITH STEEL MILLS IN THE FOREGROUND

Government.—Pittsburgh was incorporated as a borough in 1794 and as a city in 1816. By act of legislature (1911) government was put in the hands of a mayor and council. David L. Lawrence, who resigned as mayor in 1959 after 13 years in office to become governor of Pennsylvania, had served longer than any other in the city's history. The mayor appoints department heads, members of various commissions and three authorities. He names the city treasurer and the city solicitor. The council is the legislative body. Within permissive state legislation, it determines the objects of taxation and fixes the rates, authorizes expenditures and contracts and fixes salaries of city employees. The chief source of revenue is a tax on real estate, the rate on land being twice that on buildings. Other taxes are levied on personal property and personal income, on mercantile activities, on admissions to amusements and on deed transfers.

The school district of Pittsburgh is a distinct governmental entity. Its members, nonsalaried and appointed by the judges of the court of common pleas for six-year terms, comprise the board of public education. Administration is through two departments: education, headed by a superintendent appointed by the board for a four-year term; and business, headed by a manager appointed annually. The chief source of school revenue is the tax on real estate, supplemented by mercantile, per capita and personal property taxes; about one-fifth of the cost is provided by state subsidy.

Commerce, Industry and Transportation.—Pittsburgh is a port of entry and a leading transportation centre. The Monongahela and the Allegheny rivers provide a minimum pool depth of 9 ft. (with minor exceptions) to Fairmont, W.Va., 128 mi. to the south, and to East Brady, Pa., 72 mi. to the north. The Ohio river connects this system with the Mississippi and the Gulf of Mexico. The total river tonnage in the Pittsburgh engineering district in the 1960s was greater than that carried by the Panama canal. The city is a major inland exporter of manufactured products to world markets. Greater Pittsburgh airport, accessible by a limited-access highway, was built at a cost of $44,000,000 on 2,450 ac.; its runway facilities accommodate jet transport planes. As the hub of major highways, the city is an important centre for motor freight and of tourist travel. It is served by the Pennsylvania turnpike and other multi-lane highways.

Pittsburgh's industrial importance, especially in steel, is based upon strategic location and natural resources which originally included abundant timber, clay for bricks and sand for glass. There were also great deposits of coal, petroleum and natural gas and there continues to be a plentiful supply of water for industrial uses. The district's coal and favourable location with respect to the great iron ore deposits on the Great Lakes gave it early dominance in the steel industry. Despite the development of large steel centres elsewhere, assembly costs of raw materials in Pittsburgh still compare favourably with those of competitors. The district is important in steel fabricating and in machinery manufacture, particularly of mill machinery and heavy electrical equipment.

In Pittsburgh are located some of the largest plants of the U.S. Steel corporation and of Jones and Laughlin, as well as of important independent producers. It is the home of three widely known companies established by the inventive genius of George Westinghouse—Westinghouse Electric corporation and Westinghouse Air Brake and Union Switch and Signal companies. The city is the seat of Aluminum Company of America and of Gulf Oil corporation. Its shipbuilding tradition is carried forward by the Dravo corporation. Its pioneering in food processing is recalled by a major plant of the H. J. Heinz company.

Public Health and Housing.—Support for programs of health received impetus from grants of $16,200,000 to the University of Pittsburgh, in the years 1948 to 1958, from the A. W. Mellon Educational and Charitable trust, to establish and support the graduate school of public health. This foundation also made other major grants to the university's health centre, the largest of which was $5,000,000, matched by equal amounts from the R. K. Mellon and Sarah Mellon Scaife foundations. Another notable advance was establishment of a county-wide health department. Within a decade, these two developments resulted in a virtual revolution in public-health programs. With cooperation of public officials and voluntary agencies a transition to professional status was effected and forward-looking programs were established. The county has over 40 hospitals, the largest of which is the John J. Kane Memorial hospital for the indigent sick, completed in 1958.

Pittsburgh is traditionally a city of single-family residences and ranks high in percentage of home ownership. After World War II, however, there was a marked increase in the building of three-story walk-up and elevator apartments and of high, so-called "luxury" buildings. Pittsburgh's best-known residential district is Chatham Village, a pioneer large-scale, planned garden-homes community, built as a demonstration by the Buhl foundation in 1932–36. The housing authority of the city has built and operates several developments with more than 9,000 dwelling units.

Educational and Cultural Institutions.—Pittsburgh's mid-century surge carried the three universities and two women's colleges to new peaks in endowment, in plant and in enrollment. Largest of the five institutions is the University of Pittsburgh, a private institution chartered in 1787, which receives state aid. It is widely known for its 42-story "cathedral of learning" opposite

Schenley park. It embraces 22 schools and divisions, operating since 1959 on the trimester plan. Carnegie Institute of Technology, a private school established in 1900, includes an affiliated women's college, a college of fine arts, a college of engineering and science, a graduate school of industrial administration, a school of printing management and a division of humanistic and social studies. Its campus also adjoins Schenley park. Duquesne, a Roman Catholic coeducational university established in 1878, has, in addition to the college, schools of business administration, education, music, nursing, pharmacy and law. The two separate women's colleges are Chatham, a private college chartered in 1869, and Mount Mercy, a Roman Catholic college established in 1929. The Western Pennsylvania School for Blind Children is in Pittsburgh.

A CHURCH—PUBLIX

THE "CATHEDRAL OF LEARNING" AT THE UNIVERSITY OF PITTSBURGH

Notable research programs in the natural sciences are conducted at the University of Pittsburgh and at Carnegie Institute of Technology. The university's experimental work in physics, biochemistry and biophysics has attracted wide support, as have its health studies, an outstanding achievement being the polio vaccine developed there by Jonas Salk. Carnegie maintains large research laboratories, especially for metals, petroleum studies and nuclear research. The latter centres about a $2,000,000 synchro-cyclotron with a capacity of 450,000,000 ev. Mellon institute, centre for industrial research, and the laboratories of the United States bureau of mines are located in Pittsburgh. Important industrial laboratories include those of Gulf Oil, Westinghouse Electric, United States Steel, Jones and Laughlin, Pittsburgh Plate Glass, Koppers and Union Switch and Signal company.

Carnegie institute is the outstanding cultural centre, with a library of 1,500,000 volumes, a department of fine arts (known for its international exhibitions of contemporary painting), a museum and a music hall. Phipps conservatory was presented to the city by Henry Phipps in 1893. The Buhl planetarium was dedicated in 1939 in honor of Henry Buhl, Jr., who established the foundation that bears his name. The Pittsburgh Symphony orchestra has been widely acclaimed and the Pittsburgh playhouse, with its school of the theatre, the Civic Light Opera and the Pittsburgh Opera company are more than local in their appeal.

The city has one morning newspaper, the *Post-Gazette* (established as the *Pittsburgh Gazette* in 1786), and one evening paper, the *Press*, established in 1884. Pittsburgh pioneered in the development of radio and KDKA was the world's first broadcasting station. Its television stations include WQED, a pioneering community-sponsored educational outlet.

Parks and Recreation.—City parks include a total area of about 2,000 ac. Most are located on high, rolling land and several afford dramatic views of the industrial valleys below. Overlooking the Monongahela river is Schenley park. Highland park overlooks the Allegheny; in its 425 ac. are found the principal city reservoirs, the municipal zoo and a children's zoo. Also in the eastern portion of the city are Frick and Mellon parks. On high ground on the north side is Riverview park, which contains the Allegheny observatory, once directed by Samuel Pierpont Langley. Supplementing these facilities are North and South parks (each 1,200 ac.), developed by Allegheny county, and six new park sites acquired in 1958. (C. F. Ls.)

PITTSFIELD, a city of western Massachusetts, 7 mi. from the New York state line, in the central valley between the Taconic and Berkshire mountain ranges; the seat of Berkshire county. Pop. (1960) city 57,879; standard metropolitan statistical area (the city and Dalton, Lanesborough, Lee and Lenox towns) 76,772. (For comparative population figures *see* table in MASSACHUSETTS: *Population.*) Pittsfield was incorporated as a town of about 1,000 people in 1761 and was named for William Pitt, prime minister of England during the French and Indian War. The first land grant in the area was made in 1763 to Col. Jacob Wendell, the great-grandfather of Oliver Wendell Holmes. In 1890 Pittsfield received its charter as a city and changed from the town-meeting to a mayor-council system of local government.

The town was completely dependent on agriculture during its early years. Between 1820 and 1890, however, more than 20 industrial and retail concerns were established. There is a large paper mill which manufactures the paper used for U.S. bank notes and government bonds. Electrical transformers, chemicals, textiles, leather goods, boxes and machine tools are other leading products manufactured in the city.

Pittsfield has an excellent public-school system, a local library and a museum. The widely known Berkshire Symphony festival at Tanglewood (10 mi. distant) is held each year. Summer stock theatres at nearby Stockbridge and Williamstown play a prominent part in the cultural activities of Pittsfield's residents.

Social and recreational facilities are abundant and among the best in New England. Parks, bathing beaches, golf courses and numerous ski trails, the best of which is located on nearby Mt. Greylock, provide yearlong entertainment for the area's many tourists and outdoor sportsmen. (P. K. HA.)

PITTSTON, a city of Luzerne County in northeastern Pennsylvania, U.S., on the left bank of the Susquehanna River just below the mouth of its tributary, the Lackawanna River; midway between Scranton and Wilkes-Barre at the entrance to the Wyoming Valley. Connecticut Yankees settled there in 1762 and named it for the elder William Pitt, British prime minister and friend of the colonists. They erected frontier Ft. Pittston (1772). Pennsylvanians protested Connecticut's charter claims to this land in three local Pennamite–Yankee Wars (1769–75; 1775–82; 1784–87). During the American Revolution the colonists met the British and Indians in bloody fighting.

The opening of anthracite mines in the 1830s brought people and prosperity to Pittston. It was incorporated first as a borough (1853) and then as a city (1894). With the decline of coal mining, the people turned to manufacturing textiles, clothing, furniture, cigars, paper products, and automobile parts. For comparative population figures *see* table in PENNSYLVANIA: *Population.* (J. C. A.)

PITUITARY GLAND (HYPOPHYSIS CEREBRI; PITUITARY BODY), one of the endocrine, or ductless, glands which secrete their products, the hormones, directly into the blood stream. The term hypophysis is derived from the Greek for "lying under," which describes the gland's anatomical position under the brain. The pituitary plays an extremely important part in the normal functioning of the human body. Among the important hormones secreted by it are those that exert growth (somatotrophic) and gonad-stimulating (gonadotrophic) effects. Since its effects are largely mediated through its control over other endocrine glands, the pituitary is sometimes described as the "master gland" or "the conductor of the endocrine orchestra."

History.—The name pituitary was given to the gland by Andreas Vesalius (1514–64), who shared the belief advanced by Galen (*c.* A.D. 130–200) that it derived from the brain a mucous substance, pituita or phlegm, which it secreted into the nose and upper pharynx. Other early workers, including Franciscus Sylvius (1614–72) and Raymond Vieussens (1641–1716), considered that the structure played a part in the elaboration of cerebrospinal fluid, a viewpoint also expressed by Thomas Willis in 1664. Richard Lower in 1672 was probably the first to ascribe an endocrine role to the gland, for he considered that it removed fluid from the cerebrospinal fluid and secreted it into the blood stream, and not into the nasopharynx.

Modern investigations concerning the structure and function of the pituitary can be said to date from 1886 when the French neurologist Pierre Marie described an association between pitui-

tary tumours and a form of gigantism. Then in 1894 the English investigators G. Oliver and E. A. Schafer demonstrated that pituitary extracts when injected intravenously caused an elevation of blood pressure. In 1896, the U.S. physiologist W. H. Howell showed the substance responsible for the pressor effect was present only in extracts of the posterior lobe of the gland, and in 1906 Sir Henry Dale observed that these extracts also caused contraction of the uterus. The U.S. neurosurgeon Harvey Cushing, in the early part of the 20th century, successfully removed the pituitary from dogs and removed pituitary tumours in man. In 1921, H. M. Evans proved that the anterior lobe of the pituitary contained a growth-promoting hormone and some 20 years later he and his associates at the University of California succeeded in isolating this hormone in pure form. Later researches were directed toward isolation and identification of the various hormones, the determination of the cells of origin of these various hormones, and the elucidation of the reciprocal relation of the pituitary and other endocrine glands.

Structure.—*Gross Anatomy and Embryology.*—The pituitary gland in the human adult weighs about 0.5 g. and measures about 1 cm. in length, 1.5 cm. in breadth and 0.6 cm. in depth. The pituitary of the whale weighs from 10 g. to 60 g.; that of cattle, 2.5 g.; of the dog, 0.065 g.; and of the cat 0.009 g. The gland is situated in a depression on the surface of the sphenoid bone. This depression, known as the *sella turcica* ("Turkish saddle"), is deep in some species, including man, and quite shallow in others. As is shown in the figure, the gland itself consists of two divisions: (1) a neural division, the neurohypophysis, derived embryologically from the floor of the diencephalon; and (2) a glandular division, the adenohypophysis, derived from an outpouching of the roof of the mouth (Rathke's pouch). The neurohypophysis consists of three parts: the median eminence of the tuber cinereum, the infundibular stem, and the infundibular process or neural lobe. An extension of the third ventricle penetrates the median eminence and in some species extends into the neural lobe. The adenohypophysis normally loses all connection with the roof of the mouth. In most species, the posterior portion of the developing adenohypophysis becomes so closely applied to the neural lobe that the two cannot be separated, and together they form the posterior lobe. The portion of the posterior lobe derived from the adenohypophysis is known as the pars intermedia, or intermediate lobe. It is frequently separated from the anterior lobe by a colloid-filled cleft. In certain animals such as the cetaceans, armadillo, and beaver and in birds, a discrete intermediate lobe is missing and anterior and neural lobes are separated by a thin layer of connective tissue. A small portion of the adenohypophysis, known as the pars tuberalis, extends up the infundibular stem and often encircles it.

Microscopic Structure.—The anterior lobe consists of branching cords of cells supported by a reticulum of connective tissue and separated by wide vascular channels known as sinusoids. Based on staining properties, the cells are classified into chromophobes and chromophils. These two cell types are present in almost equal numbers. The finely granular cytoplasm of the chromophobes has a poor affinity for the conventional stains. In about 75% of the chromophils, the cytoplasm contains granules that are stainable with acidophilic dyes and the cells are known as acidophils, eosinophils, or alpha cells. The remaining chromophils contain granules that stain with basophilic dyes and the cells are known as basophils, cyanophils, or beta cells. Chromophils are situated close to the blood sinusoids and are thought to represent the actively secreting cells of the anterior lobe. Chromophobes tend to be present in the central portion of the cell cords and it is felt that they represent inactive stages. The intermediate lobe is less vascular than the anterior lobe and consists of cells whose cytoplasm stains faintly with basic dyes, as well as cells similar to the chromophobes of the anterior lobe. The pars tuberalis is more vascular than the intermediate lobe and consists of small cells with chromophobic or slightly basophilic nongranular cytoplasm. These cells are frequently arranged in the form of small follicles with a colloid-filled lumen.

The neural lobe resembles the gray matter of the brain rather than a typical endocrine gland in structure. The cells present in greatest numbers are the pituicytes. The neural lobe also contains numerous unmyelinated nerve fibres and a fairly rich blood supply. The nerve fibres originate from nerve cells situated in the hypothalamus (the supraoptic and paraventricular nuclei). The fibres sweep down the infundibular stalk and spread out to form a rich network in the lobe. A characteristic of the neurohypophysis is the large amount of intercellular substance, which in the course of fixation precipitates into granules known as Herring bodies.

Blood Supply.—The pituitary receives arterial blood from the internal carotid and from the circle of Willis. There is also a venous portal system between the hypothalamus and the anterior pituitary. Venous drainage from the pituitary is into the cavernous sinus.

Nerve Supply.—The neurohypophysis is richly supplied with unmyelinated nerve fibres from the hypothalamic nuclei. It is questionable whether any of these enter the anterior lobe, which receives some sympathetic fibres from the carotid plexus and parasympathetic fibres from the greater superficial petrosal nerves, themselves branches of the facial nerve.

Hormones of the Pituitary Gland.—*Anterior Lobe.*—A number of hormones have been isolated from the adenohypophysis and the existence of a number of others has been postulated. The identified hormones all appear to be protein or polypeptide in nature and some have been isolated in pure form. A hormone from one species may be chemically different from that derived from another species. This may explain the occasional failure of a hormone to elicit an effect in a different species. Thus the fact that human and cattle growth hormones differ chemically may account for the apparent ineffectiveness of growth hormone prepared from cattle when administered to man. Furthermore, species differences can lead to antibody formation (antihormones), which may account for the refractoriness that often develops after extended use of these preparations. (*See* also ANIMAL EXTRACTS: *Pituitary Extracts.*)

The growth hormone is necessary for normal growth; a type of dwarfism is caused by the absence of this hormone, while an excess results in gigantism in children and acromegaly in adults. (*See* DWARFISM AND GIGANTISM.) The hormone appears to act directly on the tissues of the body. Prolonged administration to certain species results in the development of diabetes, an effect formerly thought to be due to a separate diabetogenic principle. The thyrotrophic hormone (thyrotropin; TSH) stimulates the growth of the thyroid gland and the secretion of the thyroid hormone. In its absence, myxedema may develop, indistinguishable clinically from the true myxedema due to a primary underactivity of the thyroid gland. It is possible that exophthalmos (pathological prominence of the eyes) may be the result of excessive pituitary stimulation and that thyrotropin or a closely related substance is responsible for the condition. (*See* also THYROID GLAND, DISEASES OF.)

The adrenocorticotrophic hormone (corticotropin; ACTH) stimulates the growth of the adrenal cortex and the release of its hormones. In its absence, signs of adrenal insufficiency (Addison's disease) develop. The follicle-stimulating hormone (FSH),

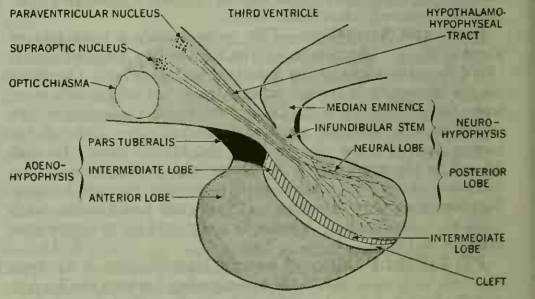

DIAGRAM OF A SAGITTAL SECTION THROUGH THE PITUITARY GLAND

the luteinizing hormone (LH), and the lactogenic hormone (prolactin) are sometimes classed together as the gonadotrophic hormones. The follicle-stimulating hormone promotes growth of ovarian follicles in the female and stimulates spermatogenesis in the male. The luteinizing hormone stimulates the formation of the corpus luteum from follicles that have ripened under the influence of the follicle-stimulating hormone. The lactogenic hormone causes secretion of milk by mammary glands adequately developed under the influence of the ovarian hormones.

Intermediate Lobe.—The intermediate lobe produces the melanophore-expanding hormone (intermedin) that causes darkening in frogs and certain other lower vertebrates due to a dispersal of pigment in the pigment-bearing cells (chromatophores). In animals in which there is no anatomically distinct intermediate lobe, intermedin is found in the anterior lobe. In the lower vertebrates, the alterations in colour scheme effected by intermedin serve as a protective mechanism, permitting the animal to blend with its surroundings and thus to escape detection. It is not known whether intermedin plays a role in higher vertebrates. Intermedin and the adrenocorticotrophic hormone are remarkably similar in chemical structure, and some investigators believe that they may be identical.

Neural Lobe.—In 1928 O. Kamm and his associates separated posterior pituitary extracts into two partially purified fractions: oxytocin (Pitocin), which elicited largely oxytocic activity, and vasopressin (Pitressin), which contained largely blood-pressure raising and antidiuretic activities. In 1953 these substances were isolated, identified, and subsequently synthetized by Vincent du Vigneaud, who was awarded the Nobel Prize for Chemistry in 1955 in recognition of this work. Both vasopressin and oxytocin are polypeptides consisting of eight amino acids each. Vasopressin, whether natural or synthetic, causes an elevation of blood pressure through a direct action upon the smooth muscles of the blood vessels and has an antidiuretic action effected by increased absorption of water by the kidney. Vasopressin also has a stimulating action on the gastrointestinal tract and a slight oxytocic activity. Oxytocin on the other hand causes contraction of the uterus, a fall of blood pressure in birds, and an outpouring of milk from the breasts of lactating animals. It also has very slight pressor and antidiuretic activities. The synthesis of vasopressin and oxytocin led to virtual abandonment of the theory at one time fairly widely held that the pressor and antidiuretic activities of neural lobe extracts were elicited by separate hormones.

It is a matter of some dispute as to which of the various pharmacodynamic actions of neural lobe extracts are of a hormonal nature. It is generally held that the antidiuretic effect, elicited by minute traces of vasopressin, plays an important role in maintenance of water balance, and it appears probable that oxytocin is responsible for the "letdown" of milk; *i.e.*, the release of milk from the lactating gland initiated by the act of suckling. It has not been established, however, that oxytocin is of physiologic importance in parturition, or that vasopressin plays a role in the regulation of blood pressure.

Considerable controversy surrounds the question of whether vasopressin and oxytocin exist in the gland as separate entities or whether they are split off from some larger protein molecule in the process of chemical isolation. The latter hypothesis was first advanced by J. J. Abel in 1920 and was supported by the isolation by H. B. van Dyke in 1942 of a protein mixture that exhibited pressor, oxytocic, and antidiuretic activities in the same proportions in which they are exhibited by the gland. On the other hand the pressor-oxytocic ratio is not constant in all species; furthermore, certain stimuli seem able to release one activity only. These findings, however, would still be consistent with the view that the active principle is elaborated as one large protein from which the active polypeptides may be split off and either stored or released according to the body's needs.

Cellular Origin of Pituitary Hormones.—*Adenohypophysis.*—The number of hormones isolated from the anterior hypophysis exceeds the number of distinct cell types; hence it is presumed that a single cell type may give rise to more than one hormone. Growth hormone is thought to be secreted by the alpha cells. Tumours composed largely of alpha cells have been demonstrated in acromegaly and pituitary gigantism. Furthermore, in a hereditary strain of dwarf mice alpha cells are lacking. Gonadotrophic hormones are thought to arise from beta cells; cited as indirect proof is the fact that castration results in typical changes in these cells, the cells becoming more numerous, enlarged, and vacuolated (castration cells). The beta cells also seem to be responsible for the secretion of the thyrotrophic and adrenocorticotrophic hormones, though the evidence is not clear with respect to the adrenocorticotrophic hormone.

Intermedin is undoubtedly secreted by the cells of the intermediate lobe. The distribution of intermedin-secreting cells has not been established in those species in which a discrete intermediate lobe is lacking.

Neurohypophysis.—The site of secretion of the active principles of the neural lobe remained a matter of some controversy early in the second half of the 20th century. The early view was that the hormones were elaborated by the intermediate lobe and diffused into the neural lobe to form the Herring bodies. This viewpoint was rendered untenable when it was shown by E. M. K. Geiling that an intermediate lobe is missing in certain species and that in these species, pressor and oxytocic activities are present only in neural lobe extracts and melanophore-expanding activity only in anterior lobe extracts.

Later, the pituicytes were considered to be secretory cells. However, considerable evidence exists to support the view advanced by E. Scharrer and B. Scharrer that the active principles are elaborated by the cells of the hypothalamic nuclei, stream down the stalk, and are stored in the neural lobe.

Regulation of Hormone Secretion by the Pituitary Gland.—Three mechanisms are implicated in the release of pituitary hormones: neural, hormonal, and neurohormonal.

Adenohypophysis.—As of the mid-1960s it appeared doubtful that the innervation of the anterior lobe plays a role in regulating the secretion of its hormones. Considerable controversy existed as to whether any fibres from the hypothalamico-hypophyseal tracts enter the anterior lobe. Certainly, if such an innervation exists at all, it is too inconstant and slight to assume any major role in the regulation of the activity of the lobe. Furthermore, the parasympathetic and sympathetic nerves to the adenohypophysis appear to be vasomotor rather than secretomotor in nature.

There was considerable evidence of a neurohormonal control of anterior lobe secretion with some unidentified substance being liberated from the hypothalamus by appropriate stimuli and reaching the anterior lobe cells by way of the hypophyseal portal blood system. It was also evident that the level of circulating hormones from target endocrine glands has a profound effect on the secretory activity of the pituitary. Thus, injection of thyroid hormone (thyroxin) leads to depression of pituitary thyrotrophic hormone, while removal of the thyroid or interference with its ability to secrete thyroxin leads to increased secretion of thyrotropin by the pituitary. This action by other hormones on the pituitary may be a direct one on the secretory cells of the pituitary or may be mediated through the hypothalamus and the hypophyseal portal system.

Neurohypophysis.—S. W. Ranson and his associates showed that severance of the hypothalamico-hypophyseal tracts by suitably placed hypothalamic lesions led to degenerative changes in the neurons and to atrophy of the neural lobe with depletion of its hormone content and the development of diabetes insipidus. These findings were interpreted as indicating that the hormones were elaborated in the neural lobe but that their secretion and liberation were controlled by the hypothalamic nuclei. However, the findings were also consistent with the Scharrers' view that the hormones are actually formed in the neurons of the hypothalamic nuclei and merely stored in the neural lobe.

Release of vasopressin from the neural lobe is apparently regulated by osmotic pressure changes in the blood, decrease in osmotic pressure leading to inhibition of the secretion of the hormone and increase in osmotic pressure leading to increased secretion. Release of oxytocin appears to be in the nature of a reflex initiated by external stimuli such as tactile stimuli of the mammary glands.

These stimuli apparently pass by afferent neural pathways to the supraoptic nuclei and result in the liberation of oxytocin.

Biological Assay of Pituitary Hormones.—Chemical assay procedures for pituitary hormones were impractical as of the mid-1960s since not all the active principles were isolated and identified and, furthermore, they are usually present in small amounts. Recourse must be had, therefore, to biological assay (bioassay) procedures in which the preparation to be assayed is compared quantitatively to a standard preparation of the hormone in question with regard to some specific biological activity. Thus, growth hormone is frequently assayed by its ability to promote growth in the hypophysectomized rat, thyrotrophic hormone by its ability to increase the weight of the thyroid or the uptake of radioactive iodine by the thyroid, and follicle-stimulating hormone by its ability to increase the weight of the ovaries of hypophysectomized rats. Methods for assaying posterior lobe preparations include study of the rise in blood pressure in the anesthetized cat, dog, or rat in the case of vasopressin, and the fall in blood pressure in the fowl or stimulation of the isolated rat uterus in the case of oxytocin. In most instances an international standard was developed so that results between workers in various parts of the world could be compared.

Therapeutic Uses of Pituitary Preparations.—Anterior lobe hormones, with the exception of the adrenocorticotrophic hormone (ACTH), were not widely used in medicine as of the 1960s. In pituitary insufficiency it is easier and more satisfactory to replace the hormones of the target glands, namely, those of the thyroid, gonads, and adrenal cortex, than to administer the appropriate trophic hormone. Adrenocorticotrophic hormone can be used in the various conditions that respond to cortisone, provided the adrenal gland is responsive. Such conditions include acute rheumatic fever, rheumatoid arthritis, and various allergic states such as asthma and drug reactions. Because of the rapidity of its action, corticotropin is particularly useful in acute illnesses. In treatment of chronic conditions, cortisone and preparations with cortisonelike action are usually preferred since they are less expensive and tend to give rise to fewer undesirable side effects.

The most widespread use of commercial posterior pituitary extracts is during childbirth, either for the stimulation of contractions before birth or for the control of uterine bleeding after birth. Posterior pituitary extracts are also used for the treatment of diabetes insipidus, a disease usually associated with injury to the neurohypophysis and characterized by a greatly increased daily output of urine accompanied by an abnormal thirst.

Extirpation of the Pituitary (Hypophysectomy).—For many years, certain tumours of the pituitary gland were treated by partial or complete destruction of the gland by surgery or irradiation. Beginning in 1952, this procedure also was used for the palliative treatment of certain types of cancer, particularly cancer of the breast, and of advanced diabetes mellitus. The depression of certain trophic hormones may be temporarily beneficial in these conditions after more conservative methods have failed.

See also BRAIN: *Development of the Pituitary Body;* ENDOCRINOLOGY: *Pituitary Gland;* HORMONES, VERTEBRATE. *See* also references under "Pituitary Gland" in the Index.

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PIURA, a department in northern Peru, bounded on the north by Tumbes and by Ecuador, on the east by Cajamarca, on the south by Lambayeque and on the west by the Pacific ocean. Area 12,767 sq.mi. (33,067 sq.km.). Pop. (1961) 716,954. The western half of the department is in the arid coastal desert but the eastern half is in the much dissected, forest-covered Andes, where slopes are very steep but altitude is not great. Emerging from the mountains are two rivers, the Río Chira in the north, the Río Piura in the south. The former carries enough water to persist in its flow throughout the year but the Río Piura only occasionally reaches the sea. Most of the time its water is lost among the sand dunes moving northward from the Sechura desert in the southern part of the department.

The valleys of these two rivers are used chiefly for the production of cotton. The water of the Chira is led into irrigation canals and ditches which keep the plantations of long-staple cotton growing luxuriantly. The cotton along the lower Piura is planted wherever the ground water is close enough to the surface. Cotton fields occupy temporary hollows among the sand dunes and the area is expanded greatly during years of plentiful moisture. The cotton is mostly of the Pima variety, a long, soft staple that brings premium prices. Some rough cotton is produced from bushes that can exist in dry areas where the long-staple varieties would perish. Upstream on the Piura irrigated fields are used to grow sugarcane, rice, tobacco, grapes and maize. Cattle are pastured in the mountains and fattened on lowland irrigated pastures. Piura is also important as a producer of petroleum. Oil was discovered in northern Peru in 1864 and has been produced from this region ever since. The chief production comes from the Lobitos and Negritos fields which form a belt about 80 mi. long on either side of Talara, where there is an oil refinery. The smaller Zorritos field is farther north.

The capital of the department is Piura (pop. [1961] 39,765) located on the Río Piura 164 ft. above sea level and 58 mi. from its port Paita. Piura, the oldest Spanish city in Peru, was founded on a slightly different site by Pizarro in 1532. It is an important cotton market and has numerous cotton gins and cottonseed-oil mills. It is accessible by the Inter-American highway and by air as well as by sea through Paita. (P. E. J.)

PIUS, the name of 12 popes.

ST. PIUS I, pope from about 140 to 155. Both the very ancient Liberian catalogue and the Muratorian canon say that he was the brother of Hermas, author of the *Shepherd.* His feast day is July 11.

PIUS II (Enea Silvio Piccolomini, known in literature as Aeneas Silvius) (1405–1464), pope from 1458 to 1464, was born on Oct. 18, 1405, at Corsignano (later called Pienza after him) near Siena, Italy. He was attracted to Florence by the teaching of Filelfo. He became secretary to Domenico Capranica, bishop of Fermo, and went with him to the council of Basel, where he stayed several years (1432–35), changing masters whenever he could improve his position. He was engaged on various errands, including a long journey to England and Scotland on secret diplomatic business. In 1436 he was back at Basel and obtained a seat in the council and exercised considerable influence. Aeneas took an active part in the council after it was transferred to Florence; and though he still declined to take orders, he was given a position on the conciliar conclave which elected Amadeus of Savoy pope under the title of Felix V. In return for his services Felix made Aeneas papal secretary.

A new period of his career opened in 1442, when he was sent by the council to take part in the diet of Frankfurt am Main. There he met the German king Frederick III, who made him poet laureate and his private secretary. He ingratiated himself with the chancellor, Kaspar Schlick, at Vienna, one of whose adventures he celebrated in a novel, *De duobus amantibus Eurialo et Lucresia,* in the style of Boccaccio. During this period he also wrote a witty immoral play, *Chrysis.* In 1446 he took orders as subdeacon and wrote that he meant to reform, "forsaking Venus for Bacchus." Aeneas was useful to Frederick as a diplomatist and managed to give all parties the impression that he was the devoted advocate of each. He took an important part in the diet of Nuremberg (1444) and made his peace with Eugenius in 1445. At the diet of Frankfurt (Sept. 1446) Aeneas modified the hostility of the electors to pope and emperor; and he was present at the conference of Aschaffenburg (1447). The new pope, Nicholas V, made him

bishop first of Trieste (1447), then of Siena (1449); and Frederick III made him a prince of the Holy Roman empire. He was made cardinal priest of Sta. Sabina in 1456.

The death of Calixtus III (who succeeded Nicholas V) occurred on Aug. 6, 1458. After a hot fight in the conclave, Aeneas was elected (Aug. 19) and took the title Pius II, with a reminiscence of Virgil's "pius Aeneas." The humanists hailed his election with joy and flocked around to secure a share of the good things, but were bitterly disappointed, as Pius did not prove himself so liberal and undiscriminating a patron as they had hoped. The fall of Constantinople in 1453 made a deep impression upon Pius, and he never ceased to preach the crusade against the Turk. In June 1459 he opened a congress at Mantua to promote the crusade, but both the French and the Germans were annoyed with him for different reasons, and he received little support, no real session taking place till September. Believing that the decline in papal influence was due to the usurpation of power by the councils, he issued (Jan. 1460) the bull *Execrabilis et in pristinis temporibus inauditus*, in which he condemned as heretical the doctrine that the councils were superior to the popes and proclaimed the anathema against any one who should dare to appeal to one.

While Pius was at Mantua war broke out between the French and Spanish in southern Italy, and a rising of the barons devastated the Campagna. Hurrying back to Rome, Pius succeeded in quelling the disorders. This measure still further alienated the pope from the French, with whom he was at that time negotiating for the abrogation of the Pragmatic Sanction of Bourges. The new king Louis XI informed Pius that he had abolished the Pragmatic Sanction (Nov. 1461), hoping in return to get the kingdom of Naples for his countryman René of Anjou. As Pius continued to support Don Ferrante (Ferdinand I), Louis reasserted the ancient liberties of the Gallican Church. At the same time a serious quarrel with the Germans prevented anything from being done toward a crusade. George of Podebrady, king of Bohemia, was plotting to depose the emperor Frederick III, who was supported by Pius. Diether, archbishop of Mainz, took George's side and replied to Pius' measures by appealing to a general council; whereupon he was declared deposed by the pope (1462). The quarrel with King George, who was accused of supporting the Utraquist heresy, continued with increasing bitterness, but without any decisive result, until the death of Pius. (*See* BOHEMIA: *History: George of Podebrady.*) In the meantime the pope did what he could to further the cause of the crusade. The discovery of alum mines at Tolfa gave him an unexpected pecuniary resource; and to stimulate the zeal of Christendom, Pius took the cross on June 18, 1464. He set out for Venice, whence he intended to sail for the east; but he was attacked with a fever and died at Ancona on Aug. 15, 1464.

PIUS III (Francesco Todeschini) (1439–1503), pope during 1503, was born at Siena, Italy. He was made archbishop of Siena and cardinal deacon of S. Eustachio in 1460 by his uncle Pius II, who permitted him to assume the name and arms of the Piccolomini. He was employed by subsequent popes in several important legations, as by Paul II at the diet of Regensburg (1471) and by Sixtus IV to secure the restoration of the ecclesiastical authority in Umbria. He opposed the policy of Alexander VI and was elected pope on Sept. 22, 1503, amid the disturbances consequent upon the death of the latter, through the influence of Cardinal della Rovere (who succeeded him as Julius II). He died on Oct. 18. Pius was a man of blameless life and would doubtless have accomplished much had he lived. (X.)

PIUS IV (Giovanni Angelo Medici) (1499–1565), pope from 1559 to 1565, was born at Milan on March 31, 1499. After studying law at Pavia and Bologna, he entered the service of Paul III and was eventually made cardinal priest of Sta. Pudenziana by him in 1549. The death of Paul IV and the conclusion of the treaty of Câteau-Cambrésis (1559) provided an opportunity for a reconciliation between France and Spain preparatory to a final settlement of the problems caused by the Reformation. Pius IV was elected after a protracted conclave (Dec. 25, 1559) as the man to accomplish these aims. He had long agreed with those who saw a need for definite reforms, but was at the same time shrewd, tactful and experienced in affairs. He took prompt action in bringing the Carafa, his predecessor's nephews, to trial, which resulted in their execution in March 1561; and after this he gave Charles Cardinal Borromeo a free hand in reforming the administration of the curia. But his greatest achievement was the successful conclusion of the Council of Trent.

Despite the peace between France and Spain, many obstacles stood in the way of this. The emperor Ferdinand still hoped for the eventual return of the Lutherans to the church and so remained in favour of some doctrinal concessions in their favour; Philip II of Spain on the other hand was opposed to any change and barely in favour of the council's resuming its sessions at all; and the Roman curia was absolutely against doctrinal change, however small, though willing to discuss the reform of abuses (partly in the hope that any changes in this direction, or toward a restoration of ecclesiastical discipline, would result in an increase in its powers). To reconcile these different interests was not easy; moreover, Pius had his own views, being prepared to concede communion in both kinds and perhaps also clerical marriage where conditions were such as those obtaining in parts of Germany, provided that his own prerogatives were maintained or even enhanced.

A year was spent in overcoming these differences and the outcome was an almost unmitigated triumph for the papacy. Thanks to the pope's own conciliatory attitude, imperial opposition ceased, while no more than a discretionary power given to the papacy to allow communion in both kinds in certain circumstances marred the appearance of unrelenting opposition to the challenge of the new doctrines. The council was dissolved on Dec. 4, 1563, and its decrees and definitions were confirmed by the pope in the bull *Benedictus Deus* dated Jan. 26, 1564. (*See* also COUNCIL: *Councils of the Western Church: Council of Trent [1545–63].*) Most significant was the exclusive power granted to the pope for interpreting and enforcing these decisions, which task, constituting the third and final period of the Counter-Reformation, was to occupy the next 25 years. Yet this apparently complete triumph of the papacy is deceptive. Pius did not long outlive the conclusion of the legal enactment of the Counter-Reformation, and his desire for a continued endeavour to reconvert the German Protestants died with him. Increasingly, the papacy found itself committed to an unwelcome degree of support for the policies of Philip II; and although, as a result, Protestant heresy was not only checked but made to retreat, in the next century Rome found itself the enemy of France, so that the diplomatic triumphs of that country involved a defeat for Rome. This process was not continuous, and Pius IV cannot be blamed exclusively for the eventual outcome of his policy; but, in taking the narrow view that to secure the best interests of the church it was only necessary to defend and to enlarge the papal power, he clearly miscalculated. The easy triumph at Trent was not repeated. Only Portugal, Poland and Austria accepted the decrees without reservation; in France, on the other hand, they were absolutely rejected. Pius died on Dec. 9, 1565.

ST. PIUS V (Antonio, otherwise Michele, Ghislieri) (1504–1572), pope from 1566 to 1572, was born on Jan. 17, 1504, in the Milanese. At the age of 14 he became a Dominican monk, taking the name of Michele. He was appointed inquisitor in Como, where his zeal provoked such opposition as to compel his recall (1550). The chief inquisitor, Giovanni Pietro Carafa, convinced of his value, straightway sent him upon a mission to Lombardy and, in 1551, appointed him commissary general of the Holy Office. When Carafa became pope (as Paul IV), Ghislieri was made bishop of Nepi and Sutri (1556), cardinal (1557) and finally grand inquisitor (1558). In this office he was continued by Pius IV, whom, however, he antagonized by his censoriousness and obstinacy. But after the death of Pius IV the rigorists, led by Cardinal Borromeo, had no difficulty in making him pope (Jan. 7, 1566). Retaining his ascetic mode of life, Pius immediately began the work of reform. Decrees and ordinances were rapidly issued; the papal court became a model of sobriety; prostitutes were driven from the city or confined to a certain quarter; penalties were attached to Sunday desecration, profanity and animal baiting; clerical resi-

dence was enforced; conventuals were compelled to live in strict seclusion according to their vows; catechetical instruction was enjoined. A new catechism appeared in 1566, followed by an improved breviary (1568) and an improved missal (1570). The use of indulgences and dispensations was restricted and the penitential system reformed.

Pius was the avowed enemy of nepotism. One nephew, it is true, he made cardinal, but he allowed him no influence; the rest of his relatives he kept at a distance. By the constitution *Admonet nos* (March 29, 1567) he forbade the reinvestiture of fiefs that should revert to the Holy See and bound the cardinals by oath to observe it. In March 1569 Pius ordered the expulsion of the Jews from the States of the Church. For commercial reasons they were allowed to remain in Rome and Ancona, but only under humiliating conditions. In Feb. 1571 the Humiliati, a degenerate monastic order of Milan, was suppressed on account of an attempt upon the life of the archbishop, Cardinal Borromeo.

The rules governing the Holy Office were sharpened; old charges, long suspended, were revived; rank offered no protection, but rather exposed its possessor to fiercer attack. None were pursued more relentlessly than the cultured, among whom many of the Protestant doctrines had found acceptance. Princes and states withdrew their protection and courted the favour of the Holy See by surrendering distinguished offenders. Venice delivered Guido Zanetti in 1566; Philip II of Spain, Bartolomé de Carranza in the same year; and Cosimo de' Medici, Pietro Carnesecchi in 1567 (receiving as a reward the title of grand duke of Tuscany in 1569). In March 1571 the special Congregation of the Index, as distinct from the Inquisition, was established, and hundreds of printers took flight to Switzerland and Germany. The regret of Pius was that he had sometimes been too lenient. He spurred Philip II on in the Netherlands and commanded the utter extermination (*ad internecionem usque*) of the Huguenots; he protested against the tolerance shown by the emperor.

In all this work, Pius confirmed Borromeo's belief that a spiritually minded pope was above all else necessary if the decrees of the Council of Trent were to be put into practical effect. The moral standing of the papacy was raised beyond belief and its effectiveness was immensely increased by the obliteration of heresy in Italy; and the morale of the church was much improved by the universal insistence on the Tridentine interpretation of its doctrines. Yet it is open to doubt how much of this improvement was due to Pius' continuous use of the Inquisition. Some of the credit belongs to the new generation of higher and lower clergy in the several provinces whose attitude was so different from that of their predecessors.

Moreover, Pius' policy had practical disadvantages. It took too little account of the wishes of secular rulers at a time when their support was essential for the defense of the church against heresy. His attitude toward Elizabeth I of England, whom he declared excommunicate and usurper (Feb. 25, 1570) without possessing the means to give force to his judgment, was especially undiplomatic, antagonizing not only England but Spain, France and the Holy Roman empire as well. Much more successful was his organization of a crusade against the Turks, which resulted in the decisive naval victory of Lepanto (Oct. 7, 1571). Pius died on May 1, 1572, and was canonized by Clement XI in 1712. His feast day is May 5.

Pius VI (Giannangelo Braschi) (1717–1799), pope from 1775 to 1799, was born at Cesena, Italy, on Dec. 25, 1717. After taking the degree of doctor of laws he went to Ferrara and became the private secretary of Antonio Cardinal Ruffo, in whose bishopric of Ostia and Velletri he held the post of *uditore* until 1753. His skill in the conduct of a mission to the court of Naples won him the esteem of Benedict XIV, who appointed him one of his secretaries and canon of St. Peter's. Raised to the prelature in 1758, he was appointed treasurer of the apostolic chamber by Clement XIII in 1766. On April 26, 1773, he was made cardinal priest of San Onofrio. In the four-month conclave which followed the death of Clement XIV, Spain, France and Portugal at length dropped their objection to Braschi and he was elected to the vacant see on Feb. 15, 1775.

Pius had received the support of the representatives of the three crowns and of the anti-Jesuit party upon a tacit understanding that he would continue the action of Clement, by whose brief *Dominus ac redemptor* (1773) the dissolution of the Society of Jesus had been pronounced. On the other hand the *zelanti*, who believed him secretly inclined toward Jesuitism, expected from him some reparation for the alleged wrongs of the previous reign. In the event, Pius proved unequal to the problems of his age. Not only was the church generally considered to be in urgent need of spiritual and institutional reform, but in addition the papacy was almost completely bereft of either power or influence. The religious orders, the essential medium of its influence in the church, were under attack by the protagonists of the Enlightenment, while its traditional allies, the kings and princes of Catholic Europe, were now indifferent to its interests, being concerned only with the possibilities for using the national churches in their schemes for administrative reform. (*See* GALLICANISM.) The emperor Joseph II inaugurated, in the *Toleranzedikt* of Oct. 1781, a policy whereby non-Catholic minorities received a large measure of religious toleration and an opportunity to enter the public service. This was followed in the next year by the dissolution of a number of religious houses, which was designed to provide the money for converting the secular priesthood into salaried officials of the state and for abolishing private patronage. Further detailed reforms were intended to abolish certain practices, such as an excessive number of festivals and a superstitious reverence for mystical phenomena, not considered in keeping with enlightened belief. Pius intervened in 1782 by a personal visit to Vienna, but even this tactful approach secured no concessions whatsoever. Without wishing for a break with Rome, Joseph yet saw no reason to modify his policy in the slightest. The church in the Habsburg dominions remained wealthy and influential, but subordinated to the state. The papacy was ignored there as it was in France, where the preliminaries to the French Revolution were taking place.

The church was not unpopular in France in 1789. At least a substantial minority of the clergy supported the third estate in its demands for constitutional reform. What undermined the church's position arose for reasons quite unconnected with it. The new revolutionary government, at its wits' end for money, turned to the wealth of the church, which it confiscated as a direct backing for its issues of paper currency. It was intended, under the Civil Constitution of the Clergy (1790), to provide for the support both of the secular and of what was to remain of the regular clergy after they had been given the option of renouncing their vows by paying them salaries out of public funds. Other features of the scheme bore a similar resemblance to the designs of Joseph II. Pius took no immediate action, but negotiations were begun to explore the possibilities of modifying the plan. At length, however, when an oath of fidelity to the new constitution was demanded, he denounced the Civil Constitution together with the Revolution itself (brief of March 10, 1791). The French church was completely split, half accepting, half defying the new regime. (*See* also FRANCE: *History: The Revolution and the Fall of the Monarchy* [*1789–92*].) Pius was on good terms with the allies against France in 1793 and felt that he could rely on them; but in 1796 he saw his territory invaded by Bonaparte. He sued for peace, which was granted on Feb. 19, 1797, at Tolentino. (*See* FRENCH REVOLUTIONARY WARS: *Directory and the Campaigns of 1796–97.*) In the following December a riot in Rome, in which the French general L. Duphot was killed, led to the occupation of Rome itself (Feb. 15, 1798) and the proclamation of a republic. Pius was taken into captivity and died, still a prisoner, at Valence, on Aug. 29, 1799.

The fortunes of the papacy had reached perhaps their lowest point since the Middle Ages. It was not the only institution to be overwhelmed by the forces unleashed by the French Revolution; but for at least some of its misfortunes Pius himself must be held responsible. He seemed unable to adopt a policy suited to the exigencies of his time. The revolutionary leaders in France, no less than their predecessors the reforming monarchs, were not primarily anticlerical; but the papacy failed to appreciate that the church could not alone expect to be left untouched by the

changes that had been set on foot (in France the patriotism of some churchmen was understandably suspect and the wealth of this church offered an obvious answer to the problem of national bankruptcy). Pius VI succeeded in confusing political reaction and religion to such an extent that it may even be asked whether the identification of liberalism with anticlericalism is not the consequence of, rather than an excuse for, his policy.

PIUS VII (Barnabà Gregorio Chiaramonti) (1740–1823), pope from 1800 to 1823, was born at Cesena, Italy, on Aug. 14, 1740. He entered the Benedictine monastery of Sta. Maria at Cesena in 1758, when he took the name Gregorio, and held various teaching appointments in the colleges of his order in Parma and in Rome. He became bishop of Tivoli in 1782 and bishop of Imola and cardinal in 1785. Not surprisingly, a seven-month interregnum followed the death of Pius VI in captivity. The central administration of the church had collapsed, and it was at Venice, under Austrian protection, that the conclave took place which resulted in the election of Cardinal Chiaramonti to the papacy on March 14, 1800.

The situation that confronted the new pope did not call for heroic measures. Europe was making its peace with the future emperor Napoleon at Amiens; it behooved the pope to do likewise. Nor was Pius himself completely antagonistic to the ideas which had evolved during the French Revolution. He was anti-Austrian in his sympathies and had already (1797) publicly expressed the view that between true democracy and the church there need be no conflict. In the circumstances perhaps any agreement was better than none. Pius then responded to Napoleon's advances and finally entrusted the detailed negotiations to his very able secretary of state, Ercole Cardinal Consalvi (*see* CONSALVI, ERCOLE). The concordat of 1801 solved the problem of the conflicting claims to recognition of the constitutional and of the *émigré* bishops, settled the fate of the confiscated church property and laid down the future relations between church and state. Catholicism was declared to be the religion of the great majority of the French people (so admitting the possibility of official sanction for the exercise of other faiths); the hierarchy was to be salaried by the state (so allowing the old church possessions to remain with their new owners); and the dioceses were completely reorganized (so permitting a fresh start to be made with the appointment of bishops). Thus there was re-established in France a church with at least some of the characteristics and privileges of its pre-Revolutionary predecessor. It was not in fact the articles of the concordat itself which were to prove so distasteful to the papacy but the "organic articles" appended to them by the unilateral action of the French government in 1802. These forbade the exercise of any papal jurisdiction in France except with the permission of the government. Pius protested and tried to use the occasion of his formal consecration of Napoleon as emperor in 1804 to have them modified. He was not successful, and from that time onward relations between him and Napoleon rapidly deteriorated. Rome was occupied by French troops in 1808, and Napoleon declared the papal states to be annexed to France in 1809; Pius excommunicated the invaders and was thereupon taken prisoner. Such he remained until the allies invaded France in 1814. During his imprisonment he was brought to assent to a most humiliating concordat at Fontainebleau on Jan. 25, 1813, but he renounced it two months later, and it disappeared with Napoleon in 1814. (*See* also NAPOLEONIC WARS.)

The papacy then faced a brighter prospect. Emerging from captivity, Pius appeared in the role of martyr and was received with tumultuous acclamations on his journey back to Rome in May 1814. At the congress of Vienna, Consalvi secured the restoration of the papal states, while the return of the legitimate monarchs promised a welcome relief from the torment of dealing with revolutionaries. Experience had taught Pius to disavow his earlier liberal leanings, and his policy after 1815 sought to re-establish the church on its old foundations. The territorial changes effected by the congress of Vienna required corresponding changes in diocesan boundaries, and so the opportunity was taken to conclude a series of concordats with the states affected. Consalvi worked to reform the administration, the Jesuits were restored (1814) and recognition was given, after some hesitation, to the new Latin-American republics in revolt against Spain. But at bottom the restored papacy remained in a critical position. It was in no doubt that it should condemn the Revolution and all its works; but the restoration of the *status quo ante*, even where it was possible, had often meant no more than a renewal of the old conflicts which had been all but fatal even before 1789. Thus Francis I of Austria maintained the ecclesiastical institutions erected in the Habsburg lands by Joseph II, while Metternich thought of the pope as just one of a number of Italian princes whose actions required careful watching lest Austrian interests be endangered. Louis XVIII of France affected a support for the church which was shallow, for his actions followed those of his predecessors, jealous of papal interference within their dominions. An attempt to replace the concordat of 1801 with one more favourable to the papacy (1817) was dropped when the French government met with opposition to it in France. From the other flank danger arose out of the discontent felt in Italy against the abolition of the social reforms brought about under Napoleon and, in particular, out of the activities of the Carbonari, a liberal secret society condemned by Pius in 1821.

It was indeed becoming plain that the cure for the ills of the church lay not in concordats of the traditional type with monarchs whose motives were not unmixed and whose own positions were insecure, but in freeing the church from the restraints of the state. To do this it was necessary to bring the national churches closer to the pope and to reassert the absolute supremacy of the pope in spiritual matters. This was the teaching of Joseph de Maistre, and while Pius VII and Consalvi still put their first trust in princes, they gave sufficient encouragement to Ultramontanism (*q.v.*) for it to become established as a real alternative to Josephinism and Gallicanism on the one side and to revolution on the other. Perhaps the foremost need of the church at this time was for a breathing space in which it could think out its future salvation. Pius VII provided this by his consistent refusal to resort to extreme or precipitate action. If his policies frequently proved unfruitful, at least it may be said that, when he died, on Aug. 20, 1823, he left the papacy in a better position than he had found it.

PIUS VIII (Francesco Saverio Castiglioni) (1761–1830), pope from 1829 to 1830, was born at Cingoli, Italy, on Nov. 20, 1761. He studied canon law at Rome and became vicar-general at Anagni and later at Fano. He was made bishop of Montalto in 1800 and bishop of Cesena and cardinal priest of Sta. Maria in Traspontina in 1816. Appointed grand penitentiary, he was made bishop of Frascati in 1821; and next year he became prefect of the Congregation of the Index. In the conclave following the death of Leo XII, Castiglioni, the candidate of France, was elected pope, on March 31, 1829. He accepted the July revolution in France and was considered to have liberal leanings but was prevented from leaving any impression upon events by his death on Nov. 30, 1830.

PIUS IX (Giovanni Maria Mastai-Ferretti) (1792–1878) was pope from 1846 to 1878, the longest pontificate in history. He was born on May 13, 1792, at Senigallia, Italy, the fourth son of Girolamo Mastai-Ferretti, gonfalonier of Senigallia, and the countess Caterina Solazzi. He first came into prominence as archbishop of Spoleto from 1827 to 1832 at a time of revolutionary disturbance. He was made bishop of the important diocese of Imola in 1832, but it was not until 1840 that he received the hat, as cardinal priest of SS. Piero e Marcellino, the delay being generally ascribed to the disquiet caused by his liberal views. He was not, in 1846, the most prominent liberal candidate likely to succeed Gregory XVI; but it took the conclave only two days to determine his election (on June 16, 1846) and so prevent that of the conservative Luigi Lambruschini. He took the name of Pius in deference to the memory of Pius VII, who had been his friend and who had, like him, been bishop of Imola. The choice was in some sense prophetic, for "Pio Nono," as his predecessor had done, began his career sympathetic to liberal ideas only to learn by bitter experience that they too often incorporated the principles of anticlericalism. In 1846, however, all this lay in the future and Europe was agog to view the unusual spectacle of a liberal pope.

The Revolution of 1848.—The new pope was confronted by a

difficult situation. All Europe, save perhaps Metternich, considered that the papal states stood in urgent need of reform. A memorandum drawn up in 1831 by the French, Austrian, Russian and Prussian ambassadors in Rome (with the British representative in Florence subscribing) had suggested that councils should be elected to assist in local government, that a central body, composed partly of elected representatives, should control finance, and that the dominant position held by the clergy in the administration and in the judicial system should be terminated. Liberal opinion clung to these measures as absolutely essential throughout the pontificate of Gregory XVI. In addition, the papacy was constantly under attack by Italian nationalists as one of the instruments through which Austria maintained its domination over the peninsula. Pius recognized that the papal administration, if not so corrupt and despotic as its opponents asserted, was inefficient and intolerant; and he was sufficiently Italian to resent Austrian interference. Above all he saw the need for the papacy to possess a greater measure of popular support. Yet he was never a revolutionary. He believed that the interests of the church must always come first, and he appreciated that the conservative Catholic powers such as Austria were entitled to consideration for the practical support that they had given the church in the past. That he should eventually disappoint his revolutionary supporters is not surprising, and Pius himself was early aware of this possibility. A criticism more substantial than that of tergiversation is that he chose to depart from the traditional policies of his predecessors without possessing any definite plans for avoiding the pitfalls that must surround the paths of a pope endeavouring to ally himself with liberalism and nationalism.

Pius wasted no time. He declared a general political amnesty on July 16, 1846, and followed it by a number of practical reforms, including a reorganization of the criminal procedure. Some financial reforms of an administrative character came next, and the censorship was mitigated. Finally came Pius' most daring innovations, the political reforms announced in 1847. The council of ministers became a cabinet of departmental heads of which only the secretary of state was of necessity to be a cleric; it was to be advised by a council of 24 elected members; and a municipal government was established for Rome which included an elected representative body. At the same time, the papacy brought support to the cause of Italian nationalism when Pius ordered the Austrian government to withdraw from Ferrara the reinforcements sent to its garrison there and opened negotiations with Piedmont for a national customs union.

The year of revolutions, 1848, began with revolution in Sicily; soon all Europe was ablaze and Pius was faced with demands, both liberal and nationalist, much beyond what he had been prepared to grant. On March 14 he was compelled to grant a constitution establishing a two-chamber parliament with full legislative and fiscal powers subject only to the pope's personal veto. On March 23 Charles Albert of Sardinia (Piedmont) declared war on Austria. For a time Pius continued to endeavour to steer a middle course, claiming in his allocution to the cardinals of April 29 that he was a disinterested spectator of the revolutionary activities sweeping Italy and that his program of reform was merely the fulfillment of the program long pressed upon the papacy by the powers. In the atmosphere of the time such sentiments were judged as displaying absolute hostility to the national cause, and the papacy was never again able to appear in Italy as anything other than a bulwark of reaction. To prevent revolution from breaking out in Rome itself, Pius consented to the appointment of popular ministries, but neither Terenzio Mamiani nor his successors Edoardo Fabbri and Pellegrino Rossi were able to control the situation. A steadily deteriorating situation culminated in the assassination of Rossi on Nov. 15. A radical ministry was appointed under Emanuele Muzzarelli and Giuseppe Galletti, and when the Swiss guards were disbanded the pope was a virtual prisoner. On Nov. 24–25, with the aid of the French and Bavarian ambassadors, he fled to Gaeta in the kingdom of Naples. In his absence, elections were held for a constituent assembly; and this, on Feb. 9, 1849, declared the temporal power at an end and a democratic republic to be established. The papacy thereupon issued a formal appeal to the rulers of France, Austria, Spain and Naples, but not Piedmont, for assistance. Although it was generally considered that the pope's restoration could take place only with some sort of undertaking to maintain constitutional government in the papal states and although Louis Napoleon, the newly elected president of France, was in favour of such a policy, Pius held out against any concessions and asserted his determination to exercise his temporal power without any restrictions whatsoever. The upshot of a period of military and diplomatic maneuver on the part of France and Austria was the unconditional restoration of papal rule by the French general N. C. V. Oudinot on July 15. The revolution was over, and Pius himself returned to his capital on April 12, 1850.

The Roman Question.—It has often been asserted that Pius returned to Rome a changed man, that the former liberal had become a narrow reactionary. That his policy had changed there is no doubt, but his fundamental attitude remained the same. The interests of the church had always been his first concern and he could never be an unconditional ally of nationalism or liberalism. He had been prepared to countenance both while they left the church intact, but experience had taught him that both led to revolution, which he had never been prepared to countenance. Furthermore, political concessions on his part had led to attacks on his spiritual power, and he considered that it could be protected only by his continued exercise of a temporal authority. Once these two aspects of his dominion had become indissolubly linked, it is easy to see why Pius considered himself obliged to oppose any alteration of his position as a temporal ruler. This is, of course, only to say that the pope can never be a successful temporal sovereign, being unable to make those compromises which statesmanship demands, and that the contradiction inherent in his position does exist. In 1846 Pius had considered that a new departure was necessary to meet the legitimate demands for reform within the papal states and perhaps also those for a change in the Italian system of states; he had experimented and failed and he now considered that he could do no more. But the problems that he had tried to solve remained, and to substitute no policy at all for one that had failed was no answer. The new secretary of state, Giacomo Cardinal Antonelli (*q.v.*), into whose hands diplomacy was now entrusted since Pius recognized his own inadequacies in that field, considered throughout that, in endeavouring to retain the temporal sovereignty untouched, he was fighting a losing battle but had no practical alternative to a policy of inaction. So, not for the first time in history, the papacy was a spectator while events changed the map of Europe.

Most of the administrative reforms carried out immediately after Pius' accession remained, and the papal territories benefited from the general increase in European prosperity after 1850. But constitutional government was never restored; the amnesty granted on the pope's return was so riddled with exceptions as to be worthless; and to all expressions of national sentiment the papacy was utterly hostile. It was not that papal government was tyrannical but that it formed an absolute barrier in the way of Italian unification upon which politically minded Italians were set. So relations with Piedmont, where Count Camillo Cavour became chief minister in 1852, grew steadily worse. What began as a dispute over the terms of a new concordat took on a much more serious aspect when Cavour found it politically expedient to encourage anticlerical feelings during the passage of a law in 1855 dissolving a large number of religious houses. Certain of papal opposition, Cavour began in the same year his plans to achieve Italian unification under the leadership of Sardinia-Piedmont alone. At Plombières in 1858 he agreed with Napoleon III to combine to eliminate Austria from the Italian peninsula and so to settle the fate of Italy between them. Pius declared his neutrality in the war which broke out in April 1859, fearing that the victory of either of his protectors would leave him at its mercy. The Austrian defeat and the armistice of Villafranca resulted in the pope's losing control over the Romagna but nowhere else. Sporadic negotiations for the establishment of an Italian confederacy under the presidency of the pope went on during the winter of 1859–60, but the pope's refusal to contemplate the loss of any part of his dominions

brought them to an end. In Jan. 1860 Cavour (who had resigned in protest against the armistice) returned to power, possibly as a direct consequence of the pope's intransigence, and agreed with France to cede Savoy and Nice in return for a free hand everywhere in Italy except at Rome itself. The newly raised papal army was defeated at Castelfidardo on Sept. 18, and the papal states were quickly overrun. French troops protected the Patrimony of St. Peter, which alone of his dominions still remained in the pope's hands.

For ten more years the remnant of the temporal possessions were retained by virtue of the presence of a French garrison at Rome. Cavour himself was favourable toward an agreed settlement of the Roman question on the basis of a continuing papal sovereignty over all the states of the church but with its exercise entrusted to the king of Italy. A start was made to begin negotiations, but then the pope suddenly withdrew. In less than a year, Cavour had died (June 1861), and it was clear that the pope would be able to hold his remaining territories just so long as Napoleon III was willing and able to maintain the French garrison in Rome. When the Franco-German War broke out that was no longer possible. On Sept. 20, 1870, Italian troops occupied the city; and in October a plebiscite was held in which an overwhelming majority of the votes cast were for the incorporation of Rome in the kingdom of Italy. Pius remained for the rest of his days a prisoner, as he regarded himself, in the Vatican. He refused any intercourse with the Italian government, so that their relations rested upon a law passed by the Italian parliament in November. The sovereignty of the pope was declared to be untouched by the loss of his dominions, in compensation for which he was to receive an annual sum of money. He was to be entitled to conduct his own diplomatic relations with other powers and to have exclusive authority within the Vatican itself and a small district around it. In the rest of Italy, church and state were to be separated. So, though the papacy did not formally recognize the fact till the concordat of 1929, the Roman question had been settled. (*See* also ITALY: *History*.)

Ultramontanism.—Important as the events just described were for the papacy, the doctrinal developments of Pius' pontificate, which spring directly out of these political disasters, constitute its most significant contribution to papal history. Ultramontanism (*q.v.*) began with Joseph de Maistre, as a reaction against Gallicanism and against Josephinism, seeking to free the church from the chains of secular control by binding it more closely with the papacy. H. F. R. de Lamennais developed it by suggesting that the church would benefit from a general increase in political freedom. Gregory XVI condemned Lamennais's teaching because he saw that freedom might mean freedom to deny religion altogether. Pius IX decided in 1846 to experiment with liberalism, but later became convinced that Gregory XVI had rightly suspected it. Nevertheless, if Italy taught Pius one lesson, developments in France, where the church prospered more under the liberal regime of Louis Philippe than it had under the clerical Charles X, suggested quite the opposite conclusions to the liberal Catholics there, whose spokesman was now Charles de Montalembert (*q.v.*). On the other hand, the coming of the Second Empire stimulated the party led by Louis Veuillot, whose Ultramontanism was of the older sort, completely divorced from liberalism and seeking freedom for the church in an authoritarian state that would guard it against revolution.

For a period after 1850, Pius' policy took little heed of either brand of Ultramontanism. Antonelli followed the paths of Consalvi (*see* above, *Pius VII*) in seeking to procure more favourable concordats with Catholic rulers. Most important was that with Austria (1855), the home of Josephinism; and others were concluded with Spain (1851, 1859), with Portugal (1857), with Württemberg (1857), with Baden (1859), with Nassau (1861) and with a number of Latin-American states (1852–62). Such agreements might be politically valuable but were no defense against intellectual anticlericalism; and Pius became increasingly convinced that the real danger to the church lay in the modern secular ideas which the liberal Catholics were endeavouring to incorporate into its doctrines. The events of 1860 finally convinced him that the notion of a "free church in a free state," as dear to Montalembert as it was to Cavour, was a snare. The encyclical *Jamdudum cernimus* (March 18, 1861) denounced not only Piedmontese aggression but all modern political doctrines, which, it said, encouraged non-Catholic religions, allowed all freedom to attack the church in print and sought always to undermine the authority of the church. The Risorgimento not only convinced Pius that liberalism in the church must be destroyed, but also placed the liberal Catholics in the difficult position of appearing to support those who had caused him so much distress. In every way the ground was being cleared for a new departure. The alternative to Montalembert's doctrine was no longer an unconditional attachment to the principles of the *ancien régime* but a new kind of Ultramontanism which asserted the necessity of concentrating authority within the church in the hands of the pope. The ground was being prepared for the first Vatican council and for the doctrine of papal infallibility.

But first the strong liberal party in the Catholic church had to be defeated. In 1863 Montalembert was invited to address a large Catholic congress at Malines, and he took the opportunity to defend the concept of a free church in a free state and to condemn intolerance in principle, citing as an example the revocation of the Edict of Nantes. Pius was content in reply to point out that on these two points he was running counter to authoritative pronouncements of Pius VI and Gregory XVI. This was sufficient to deter Montalembert from accepting a second invitation to Malines in 1864; but his supporter F. A. P. Dupanloup proved an able substitute. Meanwhile at a congress at Munich, in 1863, J. J. I. von Döllinger (*q.v.*) had pleaded for the right of a scholar to pursue independent inquiry. It was clear to everyone that the church stood in need of authoritative pronouncements about its relations with the state and with modern society, and discussion began about the possibility of calling an ecumenical council for this purpose. But once again the Roman question intervened decisively in the struggle.

On Sept. 15, 1864, the French and Italian governments came to an agreement whereby the French garrison was to be withdrawn from Rome within two years. In fact, it was not finally withdrawn until the outbreak of the Franco-German War, but the conclusion of the September convention was sufficient to decide Pius to take immediate action against liberalism now that the final disaster was threatened. On Dec. 8, 1864, he issued the encyclical *Quanta cura* with, attached to it, the famous *Syllabus* listing 80 of the "principal errors of our times." As the errors listed had already been condemned in allocutions, encyclicals and other apostolic letters, the *Syllabus* said nothing new and so could not be contested. Its importance lay in the fact that it published to the world what had previously been preached in the main only to the bishops and that it made general what had been previously specific denunciations concerned with particular events. Thus perhaps the most famous article, the 80th, stigmatizing as an error the view that "the Roman Pontiff can and should reconcile himself to and agree with progress, liberalism, and modern civilisation," sought its authority in the pope's refusal, in *Jamdudum cernimus*, to have any dealings with the new Italian kingdom. On both scores, the *Syllabus* undermined the liberal Catholics' position, for it destroyed their following among intellectuals and placed their program irrevocably out of court.

Though Dupanloup tried to explain away the *Syllabus* by insisting upon its context and by stressing its purely negative aspect (thus, though the concept of toleration as the final and universal answer was condemned, it did not follow that intolerance was universally valid), the *Syllabus* nevertheless dealt a mortal blow at liberal Catholicism, which ceased after 1864 to be the main issue taxing Catholic controversialists. While some of Louis Veuillot's followers hoped that at the forthcoming council a positive statement of the orthodox doctrine of the position of the church in society would replace the negative denunciations of the *Syllabus*, the majority looked upon that battle as won and so turned to the question of defining the pope's infallibility, the keystone of the neoultramontane program of centralizing the authority of the church in Rome so as to escape from the control of the

secular state. Conversely, the former liberal Catholics were ranged in opposition to this project. When the council at last met, on Dec. 8, 1869, everything was ready for a decisive engagement.

The Vatican Council.—In the doctrine of papal infallibility itself there was nothing new. It had been employed to define, on Dec. 8, 1854, the dogma of the Immaculate Conception, which asserted that the freeing of the Virgin Mary from all taint of original sin had occurred at the moment of her conception. The pope had previously made extensive inquiries among the bishops and other divines and there was little opposition to such an exercise of his undoubted prerogative. When, however, at a gathering of bishops and other dignitaries of the church in Rome in 1862 and again at another in 1867 it had been suggested that the doctrine of infallibility should be authoritatively defined, Dupanloup had led a successful opposition to the project. It was objected that such a definition was inopportune, tending to widen the breach between the church and modern society, and that it would present a one-sided view of the source of authority in the church; for while the pope possessed powers issuing directly from God, so too did the bishops, for instance, whose ordinary jurisdiction arose, not out of their nomination or institution (whether by the state or by the church), but equally from divine origin; so that the pope's powers ought not to be defined without reference to other aspects of the nature of the church. The criticism that must attach to Pius is that he allowed, even encouraged, the council to put aside discussion on the wider issue, which was its original program, in favour of the narrower definition. This was, of course, precisely what the Ultramontane party desired. The Ultramontanes, indeed, undoubtedly possessed the backing of by far the greater part of the church, partly because of the reaction engendered by the political misfortunes of the last decade, partly because of the immense prestige enjoyed by Pius as a result of his long and tragic pontificate, but to a larger extent because of the contemporary movement away from intellectualism and in favour of devotional religion. Pius himself was at the front of this movement and received strong support from the Jesuits, whose influence was now most emphatically increasing.

The first Vatican council opened on Dec. 8, 1869, the day of the feast of the Immaculate Conception, which Pius chose for the majority of the important acts of his pontificate. The opposition, consisting of the German, French and U.S. bishops, was strong enough to prevent a definition of the doctrines and nature of the church on the lines suggested by the *Syllabus;* but the Ultramontane party, led by Archbishops H. E. Manning (of Westminster) and V. A. Dechamps (of Malines) brought forward the question of infallibility, upon which their position was much stronger. Pius intervened decisively to alter the procedure of the council on Feb. 20, 1870, and on April 29, and to make known his personal support for Manning and Dechamps. The outcome was to postpone all deliberation except that upon infallibility. The decisive vote came on July 13 when 451 voted for it, 88 against it and 62 in favour of some amendment. Thereupon the minority left Rome and the final definition was carried on July 18 by 533 votes to 2. Infallibility (*q.v.*) was confined to those occasions upon which the pope made pronouncements *ex cathedra;* but these pronouncements were to take their authority from God and not from the consent of the church, and no mention was made of any other divine authority existing in the church except that of the pope. There is no doubt that this act secured the triumph of the Ultramontane party or that the decisive element in it was provided by Pius himself. (*See* also Vatican Councils; Council: *Councils of the Western Church: First Vatican Council [1869–70].*)

The Prisoner in the Vatican.—Pius reigned for another eight years during which he became further estranged from the Italian government and witnessed a general outbreak of anticlericalism in western Europe. In Germany this culminated in Bismarck's *Kulturkampf,* which Pius condemned in the encyclical *Quod nunquam* of Feb. 5, 1875, leaving the solution of the problem to his successor. Pius died on Feb. 7, 1878, having seen in his long pontificate the creation of the modern papacy. The exact responsibility of Pius for the events of his pontificate is still a matter for controversy. The result is clearer. Church and state were finally separated, authority in the church was centralized in Rome and the church was ranged in opposition to the dominant political forces. On that score Pius was condemned by many contemporaries; the 20th century, however, was to see nationalism develop into fascism and revolutionary principles into communism. Whether the separation of church and state reinforced anticlericalism or inoculated the church against its effects is less certain.

But perhaps the most damaging criticism of Pius is that he assumed almost the sole direction of events while never appreciating their significance. The great events of his pontificate occurred despite him rather than because of him. Thus he condemned in the *Syllabus* that very separation of church and state which it was the work of the first Vatican council, to which for the first time the secular Catholic rulers were not invited, to secure. At one time or another Pius was served by the leaders of all the important movements of his century, by liberal cardinals like Pasquale Gizzi, by ecclesiastical statesmen like Antonelli and by the saintly Manning, a convert from Protestantism. Yet it is unfair to say that he changed his principles; rather he never possessed any, save in his personal religious life, that were not rather naïve, and so he was always open to be guided by experience. In view, however, of the benefit that has accrued to the church from the loss of the temporal power, it should at least be asked whether it was not Pius' determination to maintain it at all costs that contributed most to the temporal power's being lost.

St. Pius X (Giuseppe Melchiorre Sarto) (1835–1914), pope from 1903 to 1914, was born of humble parents on June 2, 1835, at Riese in the province of Treviso, Italy. He studied theology at Padua and was ordained priest in 1858. For 17 years he acted as parish priest at various places in Venetia until his appointment in 1875 as canon of the cathedral and superior of the episcopal seminary at Treviso. He refused the bishopric of Treviso in 1880, but accepted that of Mantua in 1884, at the command of Leo XIII. He was created a cardinal on June 12, 1893, and nominated patriarch of Venice three days later. In Venice his piety, simplicity and readiness to act in harmony with the Italian government made him very popular. Elected in succession to Leo XIII, on Aug. 4, 1903 (after Austria had vetoed Cardinal Rampolla; *see* Rampolla [del Tindaro], Mariano), he took the name Pius in commemoration of Pius IX.

Pius brought the church back from the diplomatic ways of Leo XIII to the paths mapped out by Pius IX's intransigence. Yet it continued to make its presence felt in European politics through the activities of the parish priests and the opportunities afforded to them of influencing opinion in elections. The new pope was the very man to lead this movement, as he came to the papal chair with a long experience as a parish priest and without having held important office in the *curia.* The real changes introduced by him lay elsewhere. He had little interest in the social reforms supported by Leo XIII, laying his emphasis rather upon the spiritual work of the church in advocating early and frequent communion. He ceased to pursue actively the quarrel with the Italian government, and something like a *modus vivendi* was reached without either side's formally giving way. It is significant that individual Catholics were allowed to enter Italian politics with a view to combating the parties of the left.

Pius made his most important contribution to the history of the church, however, by his attitude to intellectuals. His own scholarship was entirely theological, and he was utterly opposed to the employment of secular disciplines in subjects affecting the faith. When a body of Catholic intellectuals devoted themselves to a scientific study of the Scriptures and of the history of dogmas and reached conclusions which he considered to be at variance with orthodox belief, Pius took action. In the encyclical *Pascendi* (Sept. 1907) he formally condemned 65 propositions of modernism and denounced all tendencies which aimed at the reform of dogma. (*See* Modernism, Roman Catholic.) It has been claimed that by this action Pius cut the church off from modern scholarship. It is fairer to say that he endeavoured rather to compel the church to conduct its own works of scholarship instead of leaving them to institutions outside its control.

A striking example of the new moral attitude of the papacy,

as well as the termination of its old concern with diplomacy, is to be seen in Pius' denunciation, at the end of his life, of the powers' recourse to war in 1914 and in his refusal to bless the Austrian cause. Though much of his work was later overshadowed by the changes brought about through World War I, there is little doubt that he confirmed the church in the policies which it had at first adopted of necessity during Pius IX's pontificate. Pius X died on Aug. 20, 1914. Already venerated during his lifetime, he was beatified by Pius XII in 1951 and proclaimed a saint on May 29, 1954.

Pius XI (Ambrogio Damiano Achille Ratti) (1857–1939), pope from 1922 to 1939, was born on May 31, 1857, at Desio, near Milan. He was ordained priest in 1879. His exceptional success in his studies pointed to a career of scholarship, and up to the age of 60 he was concerned almost exclusively in directing a number of great libraries. He became an expert in paleography and in the problems associated with library classification. Benedict XV recognized his great qualities and selected him for the diplomatic service. In 1918 he was sent as apostolic visitor to the new republic of Poland, where he was made nuncio the next year. Ratti became a cardinal and archbishop of Milan in 1921 and was elected pope in succession to Benedict XV on Feb. 6, 1922.

In the first year of his pontificate, Pius was confronted by the crisis that brought Mussolini to power in Italy. He lent qualified support to the Fascist movement, and when Mussolini's position had become more assured a reconciliation between the papacy and the Italian government was effected by the Lateran treaty, signed on Feb. 11, 1929. This was more than a recognition of the *status quo*, as the agreement was specifically declared to constitute a final and irrevocable settlement of the Roman question. The papacy recognized the establishment of the kingdom of Italy and received in return recognition of its full sovereignty over the Vatican City State. Further, the permanent neutrality of the Vatican and of the papacy in the military and diplomatic conflicts of the world was announced. In future, the pope would intervene in such affairs not as the head of a sovereign state but as head of the church, interested only insofar as he might work for the preservation of peace. He would attend international conferences only when invited to do so. These provisions were to prove of great value to the papacy in World War II. The pope received financial compensation for his surrender of any claim to the old papal states; significantly, it was less than that proposed by Cavour in 1861.

At the same time as the Lateran treaty, a concordat was concluded regulating the position of the church in Italy itself. It established the validity of church marriage, which was to precede, for Catholics, the civil ceremony; provided for compulsory religious instruction in school for the children of Catholic parents; and declared Catholicism to be the exclusive religion of the state.

The part played by Pius in these negotiations was considerable, and their successful conclusion owed much to his appreciation both of the real interests of the church and of the political realities of his age.

He was similarly successful in reaching an agreement with the Mexican government, which allowed the church to resume religious services in that country. Another agreement was concluded with the new Nazi government in Germany in 1933, but this was short-lived. The pope's encyclical *Mit brennender Sorge* ("With burning anxiety"; March 1937) vigorously denounced Naziism as unchristian, claimed that the German state had violated the concordat and attacked the "German-Christian" movement espoused by the Nazi party.

Holding communism to be the chief enemy of the church, Pius was favourable to the cause of Franco in the Spanish Civil War; but developments in 1938 brought a change of emphasis. Pius denounced the new anti-Semitism of Mussolini and, with it, all racial theories, so attacking the element common to all branches of fascism (to which Catholic parties had inclined out of their opposition to communism). The fulfillment of this new departure, under Pius' successor, was to bring the political views of the church back to the middle policy advocated by Leo XIII.

Pius' encyclical *Quadragesimo Anno*, dated May 15, 1931, the 40th anniversary of the *Rerum Novarum* of Leo XIII, confirmed and elaborated the theses of its predecessor on social and economic matters. Pius died on Feb. 10, 1939. (I. F. B.; X.)

Pius XII (Eugenio Maria Giuseppe Giovanni Pacelli) (1876–1958), pope from 1939 to 1958, was born in Rome on March 2, 1876, into a family of lawyers in the service of the Holy See. He studied for the priesthood at home, being thought too delicate for a seminary, and was ordained in 1899. He entered the Secretariate of State (1901), serving under Cardinals M. Rampolla, R. Merry del Val and P. Gasparri. In 1917 he became titular archbishop of Sardis and went as nuncio to Munich, to further Benedict XV's peace efforts. After the disappearance of the Bavarian monarchy in 1918, he became nuncio in Berlin to the new Weimar republic. Recalled to Rome in 1929 to become cardinal, he succeeded Cardinal Gasparri as secretary of state in 1930. On his advice Pius XI concluded the concordat with Hitler in the summer of 1933, in the vain hope that Hitler would discourage the extreme antichristian racialism of National Socialism, and he was closely associated with the anti-Nazi encyclical *Mit brennender Sorge*.

Pacelli was elected pope on March 2, 1939, after fewer ballots than had been required for three centuries. The church's opposition, under his leadership, was one of the factors which caused Mussolini to put off until June 1940 his declaration of war on the side of Germany.

Pius XII preserved, from the memories of his peace mission in 1917, the thought that the Holy See might have a great peace-making role to play, provided it kept up formal relations with all the belligerents. He refused the constant pressure of the Germans and the Italians to treat the invasion of the Soviet Union as a holy crusade against atheistic Bolshevism. He also refused to say as much as the Allies wanted, and did not denounce Hitler in terms so outright that he would have shaken the civic allegiance of the German Catholics. From 1942 onward came the Jewish extermination camps in Germany, and though Pius XII reprobated cruelty in general, he was afterward much criticized by both Catholics and others—for instance by François Mauriac and later by Rolf Hochhuth in his play *Der Stellvertreter (The Deputy)*—for not having spoken out much more categorically. In his support it has been argued that he had to be careful not to expose German Catholics to charges of treason for following the pope and turning against their government when their country could truly be said to be fighting for its existence; further, it has been said, any statement on the pope's part might easily have served to intensify the German measures against the Jews as well as against Catholics.

Pius XII continued his humanitarian work and his private representations, and when attempts were made to round up the Jews in Italy, so that they should share the fate of the Jews in other European countries, he gave orders that they were to be received into Catholic religious houses, where great numbers of them were effectively concealed. At the end of the war, Jewish bodies made public expression of their gratitude.

The fall of Mussolini was followed by the German occupation of Rome (1943–44) during which the Romans relied on their bishop to protect their city from Allied bombardment; there were only two or three minor raids on Rome. But as the Axis neared defeat, and the German threat receded with the capture of Rome by the Allies in 1944, a new danger appeared for the church in Italy. The Communists, who had been suppressed by Mussolini, reappeared in force among the partisans in the north, and Pius XII sent repeated warnings of the Communist danger in Italy to Pres. Franklin D. Roosevelt. After 1945, the Vatican organized Catholic Action, which in its turn played a great part in bringing about the decisive victory of the Christian Democrats in 1948, so that they remained in power for the rest of the life of Pius XII. The Communists, however, were allowed to maintain their antichurch propaganda and continued to be a great source of anxiety to the church in Italy, while Communist governments were instituted over many Catholic peoples in central Europe. In 1949 Pius XII issued a formal excommunication of Italian Catholics who became members of the Communist party.

Pius XII's pontificate was fruitful in the internal life of the church. He reintroduced evening Mass, relaxed the laws of fasting, revised the breviary, and in many ways prepared the ground for the

second Vatican Council summoned by his successor, John XXIII. In 1950 he promulgated as a dogma the belief in the assumption of the Virgin Mary. He encouraged the appointment of a native hierarchy in African and other overseas dioceses. He was particularly insistent on teaching the doctrine that the government of the church resides in the whole episcopate, and is not to be thought of as a monarchy. But he was himself an autocrat, who expected not advisers but executors of his will. Given the title *pastor angelicus*, he loved his pastoral work as pope, holding enormous numbers of public and private audiences for all nationalities and addressing many of them in their own tongues; latterly he seemed to derive physical strength from these mass audiences. He was a tireless writer and speaker, credited with the ambition of addressing the followers of every main human calling during his pontificate. His encyclical *Mystici corporis* (1943) was a majestic exposition of the nature of the church. *Divino afflanti spiritu* (1943) gave a new impetus and encouragement to the scholarly approach to the Scriptures, recognizing the need to study them in their historical setting. *Mediator dei* (1947) forwarded the liturgical movement. *Humani generis* (1950) showed that the church had always sought man in the full integrity of his nature. In 1957 appeared the far-sighted encyclicals *Fidei donum*, on the future of Africa, and *Miranda prorsus*, on the radio, motion pictures, and television. Pius XII was the first pope to use radio on an extensive scale, and addressing audiences of varying faiths he continually emphasized to fellow-Christians what they and Catholics have in common. Much of the agenda of the second Vatican Council was already treated in one or other of his encyclicals. He died at Castel Gondolfo on Oct. 9, 1958. For portraits of Pius IX, XI and XII *see* article PAPACY. *See* also PAPACY. (J. D. W.)

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PIZARRO, FRANCISCO (*c.* 1474–1541), discoverer and conqueror of Peru, was born at Trujillo, Spain. Of his early years hardly anything is known, but he was poorly cared for and his education was neglected. Shortly after the news of the discovery of the New World had reached Spain he was in Seville, and from there found his way across the Atlantic. He is next heard of in 1510 as having taken part in an expedition from Hispaniola to Urabá under Alonso de Ojeda, by whom he was entrusted with the charge of the unfortunate settlement at San Sebastián. He accompanied Vasco Núñez de Balboa (whom he afterward helped to bring to execution) in the discovery of the Pacific.

In 1522 Pizarro entered into a partnership with a priest named Hernando de Luque and a soldier named Diego de Almagro for purposes of exploration and conquest toward the south. They explored down the west coast of South America, during which time Pizarro was left for months with but 13 followers on Gallo Island, without ship or stores. There he displayed the courage that has made famous the story of himself and his companions. (Some authorities, among them Xeres, Pizarro's secretary, give the number of his companions as 16. Antonio de Herrera y Tordesillas states the names of 13; Garcilaso de la Vega supplies the remaining 3.) In spite of the hardships Pizarro persisted until he had coasted as far as about 9° S and obtained distinct accounts of the Peruvian Empire. Finding his now promising enterprise opposed by the governor of Panama, he resolved to apply to the Spanish sovereign in person for help, and with this object sailed from Panama to Spain in the spring of 1528. He was in Seville at the same time as Hernan Cortés and was able to win over Charles V to his scheme of conquest. Pizarro was decorated and granted a coat of arms, and 13 of his companions were ennobled.

On July 26, 1529, there was executed at Toledo the famous *capitulación* by which Pizarro was, upon certain conditions, made governor and captain general of the province of New Castile for the distance of 200 leagues along the newly discovered coast, and invested with all the authority and prerogatives of a viceroy, his associates being left in wholly secondary positions. One of the conditions of the grant was that within six months Pizarro should raise a sufficiently equipped force of men, of whom 100 might be drawn from the colonies. Unable to bring together the required force he sailed clandestinely from Sanlúcar in January 1530. He was afterward joined by his brother Hernando with the remaining vessels, and when the expedition left Panama in January of the following year it numbered 3 ships, 180 men, and 27 horses. The subsequent movements of Pizarro belong to the history of Peru (*q.v.*). After the final effort of the Incas to recover Cuzco from 1536 to 1537 had been defeated by Diego de Almagro, a dispute occurred between him and Pizarro respecting the limits of their jurisdiction. This led to battle; Almagro was defeated (1538) and executed; but his supporters conspired and assassinated Pizarro on June 26, 1541.

See also references under "Pizarro, Francisco" in the Index.

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PIZARRO, GONZALO (1502?–1548), conqueror, explorer, and leader of antiregal forces in Peru was born in Trujillo, Spain. He was a half brother of Francisco Pizarro, with whom he fought during the conquest of Peru (1531–33). For his services he received extensive grants in the Potosí mines and in 1539 was made

governor of Quito. In 1541–42 he led an expedition into the unexplored region east of Quito, during the course of which Francisco de Orellana left him to explore the Amazon. Upon his return with the rest of his men, Pizarro learned that his brother Francisco had been assassinated, and he was himself then requested to dismiss his men. But the conquerors of Peru, who saw their privileges challenged by the "New Laws" that the King of Spain wished to promulgate, acclaimed Pizarro governor of Peru. As leader of the antiregal forces, he took the field against the viceroy Blasco Núñez Vela, winning the Battle of Anaquito in 1546, and against the viceroy, Pedro de la Gasca, in 1548. Defeated and captured by De la Gasca on April 9, 1548, Pizarro was executed the following day.

See P. A. Means, *Fall of the Inca Empire, and the Spanish Rule in Peru, 1530–1780* (1932). (U. S. L.)

PLACE, FRANCIS (1771–1854), English radical reformer, best known for his success in securing the repeal in 1824 of the Combination Acts, was born in London on Nov. 3, 1771, the son of a bailiff to the Marshalsea Court. He suffered great hardships as a leather-breeches maker and was drawn into trade club and radical activity, in 1793 organizing an unsuccessful strike of the London leather-breeches makers. From 1794 to 1797 he was a member of the London Corresponding Society. He opened a tailoring shop in Charing Cross Road in 1799 and rapidly became successful. He was already known as a radical politician when in 1814 he took up the campaign against the Combination Acts, passed in 1799 and 1800 against trade associations. In 1824, through Joseph Hume, M.P., he brought about the appointment of a parliamentary committee, which reported in favour of repealing the acts. Bills to this effect were carried but the immediate effect was to increase the number and activity of trade unions. The government tried to restore the position before 1824 but Place and his allies prevented this.

Place's skilled political organization made the Westminster elections from 1807 to 1832 events of national importance in the struggle for parliamentary reform, and in 1831 and 1832, in particular, be rallied the supporters of the Reform Bill in London.

By his first wife, Elizabeth Chadd (d. 1827), Place had 15 children, 10 of whom survived. In 1830 he married an actress, Mrs. Chatterley, from whom he was separated in 1851. He died at Foxley Terrace, Earl's Court, London, on Jan. 1, 1854, having been for many years out of politics. His only published book is *Illustrations and Proofs of the Principle of Population* (1822), but his manuscripts and press cuttings, an incomparable source of political information from 1790 to 1850, are in the British Museum.

See G. Wallas, *The Life of Francis Place, 1771–1854*, rev. ed. (1918). (A. Bri.)

PLACE NAMES: *see* Name (in Linguistics).

PLACENTA. The human placenta is a disc-shaped organ that is formed on the inner surface of the wall of the pregnant womb (uterus). Through it the unborn baby (embryo or fetus; *q.v.*) is nourished. Soon after the birth of the child a mass of tissue, called the afterbirth, is expelled from the womb. Its chief constituent is the placenta; attached to the placenta are the umbilical cord and the thin membranous structures known as the chorion and amnion. Adherent to these structures, all of which are accessory portions of the fetus, is a thin layer of the lining of the uterus known as the decidua, so-called because it is a castoff portion of the mother's body. The placental portion of the mass is about 8 in. in diameter and about 1½ in. thick, thinning rather abruptly at the edges, where it is continuous with the membranous chorion. Its weight at term usually is between 500 and 1,000 g., or about one-seventh the weight of the fetus. Its outer or uterine surface is lumpy in appearance and is covered by a thin, flaky and fibrous layer of decidua. The inner surface is relatively smooth and translucent except for the branching fetal blood vessels that ramify over this surface from the place where the umbilical cord attaches, which is usually near the centre of the disc. Between the two surfaces the placental tissue consists of a spongy mass of complexly and finely branched chorionic villi containing a rich plexus of capillaries supplied by fetal blood vessels. Filling the interstices of the spongework in the afterbirth is a considerable quantity of maternal blood, trapped there when its circulation was stopped and the placenta was separated by the final contractions of the labouring uterus after expulsion of the child.

In cases of spontaneous abortion during the first three or four months of pregnancy the entire conceptus (embryo or fetus and placenta and membranes) is often expelled in one mass without rupture of the membranes. In these cases a thin decidual layer of the mother's tissue more or less completely covers the spheroidal mass. Removal of this layer reveals the thin outer fetal membrane, or chorion, all of which in younger stages, and a large part of which in older stages, is covered by chorionic villi making up the placental area. Under the chorion is a thin liquid-filled space, the chorionic cavity (exocoelom), within which is the transparent inner membrane, the amnion. Within the amnion the embryo or fetus can be seen floating in the faintly straw-coloured amnionic liquor, which, with the embryo, completely fills the amnionic cavity. Extending from the belly of the embryo toward the placenta is the narrow, twisted umbilical cord.

The umbilical cord contains two arteries and one vein; through

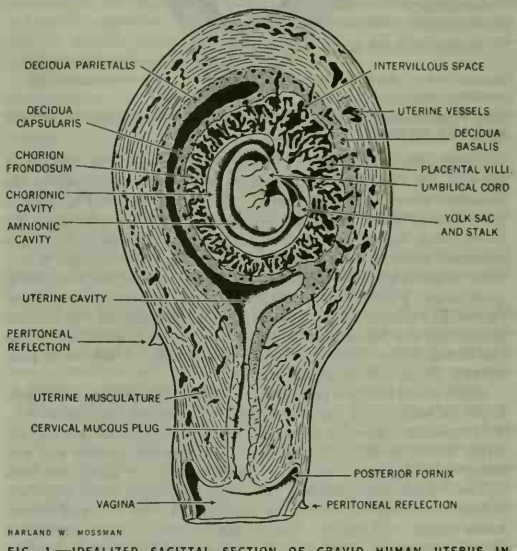

FIG. 1.—IDEALIZED SAGITTAL SECTION OF GRAVID HUMAN UTERUS IN SEVENTH WEEK OF PREGNANCY SHOWING PLACENTA AND FETAL MEMBRANES

them the fetal heart pumps blood to and from the placenta. (*See* Circulation of Blood: *The Heart: Fetal Circulation.*) Lying in the chorionic cavity between the two membranous envelopes is a small balloonlike sac attached by a delicate strand of tissue to the region where the umbilical cord leaves the amnion. This delicate structure, about ⅛ in. in diameter, is the yolk sac, or vitelline sac, and the tiny strand connecting it to the cord is the yolk stalk; the yolk stalk contains the minute artery and vein that carry blood to and from the yolk sac. The first blood corpuscles of the embryo are manufactured in the yolk sac.

Function.—Obviously, all the fetal membranes function by adapting the developing embryo to the uterine environment. The placenta is the principal physiological connection between the embryo or fetus and the mother. The two large arteries in the umbilical cord radiate out from the attachment of the cord on the inner surface of the placenta and divide into small arteries that penetrate outward into the depths of the organ through the hundreds of branching and interlacing strands of tissue known as villi. These villi are derived from the chorion and from vascular tissue (allantoic mesoderm) associated with it. From the beginning of their formation, the chorionic villi cause the mother's blood vessels in their vicinity to rupture. Consequently, the villi become bathed directly in maternal blood. Thus when the fetal arteries in these

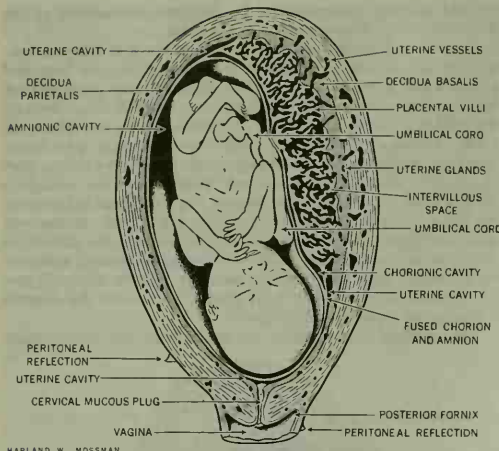

FIG. 2.—IDEALIZED SAGITTAL SECTION OF HUMAN UTERUS IN FOURTH MONTH OF PREGNANCY

villi split into capillaries that ramify just beneath the surface of the villi, the fetal blood within them is brought very close to the maternal blood bathing the villi. Since both the fetal blood and the maternal blood are being circulated constantly, and since the living tissue separating the fetal blood in the capillaries from the maternal blood bathing the villi is very thin (.02 to .002 mm.), there is provided a mechanism for efficient interchange of blood constituents between the maternal and fetal bloodstreams without (normally) allowing any opportunity for the blood of one to pour across into the blood vessels of the other. Such a mixing of the two bloods is physiologically highly undesirable. (*See* FETAL DISORDERS: *Erythroblastosis Fetalis.*)

When the placenta is regarded in terms of general function, then, it can be understood that food materials, oxygen, antibodies, etc., in the mother's blood are carried to the uterus by the uterine arteries, which break up into smaller arteries in the uterine wall and empty into the spaces (maternal blood sinuses) in which the fetal villi lie. There food, oxygen, antibodies, and other blood materials diffuse into the fetal blood in the capillaries of the villi, and nitrogenous wastes and carbon dioxide diffuse out of these capillaries into the maternal blood to be carried out of the sinuses into the uterine veins and back to the mother's lungs where she eliminates the carbon dioxide, and to her kidneys, where she eliminates the nitrogenous wastes. The purified and enriched blood in the capillaries of the villi is collected into fetal veins, which carry it back to the inner surface of the placenta and collect at the attachment of the cord to form the umbilical vein. This vein enters the cord alongside the two arteries and carries the blood back to the fetus, thus completing the circuit to and from the placenta. The placenta, because of the arrangements mentioned, can be said to function as a fetal lung, intestine, and kidney. It is also true that in last analysis the pregnant woman eats, breathes, and excretes for her unborn baby.

Widespread scientific investigations of gestation physiology since 1940 have shown: (1) that the exchange of materials between the maternal and fetal bloodstreams through the placental membrane is largely by selective, active transport, *i.e.*, it requires energy release by the living membrane and is not simply a matter of diffusion and osmosis; (2) that the placenta is capable of breaking down substances brought to it in the bloodstreams and of synthesizing compounds such as fats, fructose (levulose), and even hormones; (3) that the amnion, chorion, and yolk sac, which were once assumed to be relatively inert, are also active in physiological transport of materials to and from the fetus.

Comparative Anatomy.—Fetal membranes in the ordinary sense (amnion, chorion, yolk sac, and allantois) are characteristic of the Amniota (birds, reptiles, and mammals), but a primitive yolk sac is common in many Anamniota (cyclostomes, sharks, bony fishes, and amphibians). A true chorioallantoic placenta supplied by fetal blood vessels from the allantois is universally present in all mammals except the monotremes (platypus and echidna) and marsupials, or pouched mammals. It is, however, present in some species of marsupials and even in some viviparous reptiles. A vitelline placenta supplied by yolk sac vessels is present in one form or another, at least temporarily, in all marsupials and most placental mammals. The primitive yolk sac of viviparous sharks commonly forms a placental relationship with the wall of the uterus. In viviparous fishes gestation usually takes place within the ovary and so the vitelline (and often pericardial) net of venous capillaries becomes intimately associated with the ovarian tissue instead of the uterus. In addition to these more common types of placentation many bizarre and unique structural adaptations have been described in a few species among the "lower" vertebrates and even in some invertebrates.

The evolutionary history of the fetal membranes in general and of placentation in particular has been of great interest to biologists for many years. It is a highly complex problem because the structures themselves are highly variable and complex anatomically and physiologically; because fundamentally identical types of placentation occur in widely unrelated groups, *e.g.*, in certain lizards, marsupials, and placental mammals; and because the type of placentation in one order of mammals may run almost the whole range from a very primitive condition to a highly complex one. Obviously then there are evolutionary series from simple to complex types in several animal groups and these are often rather closely paralleled by similar series in widely unrelated forms. The

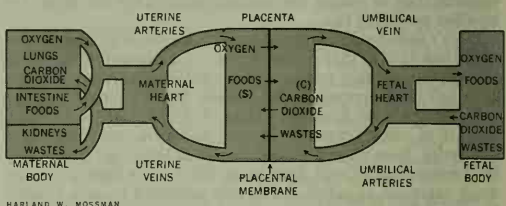

FIG. 3.—SCHEMATIC DIAGRAM SHOWING HOW PLACENTA FUNCTIONS BY ALLOWING PASSAGE OF NUTRIENTS, OXYGEN, CARBON DIOXIDE, AND WASTES THROUGH EXTREMELY THIN PLACENTAL MEMBRANE SEPARATING FETAL BLOOD IN CAPILLARIES OF VILLI (C) FROM MATERNAL BLOOD IN INTERVILLOUS SINUSES (S)

only conclusion is that placentation has arisen independently several times in different groups, but once these adaptations to viviparity have been initiated they have frequently run parallel courses because of parallel physiological conditions to be met and similar structural units inherited from oviparous ancestors.

One extremely interesting and valuable feature of the fetal membranes from the evolutionist's point of view is the fact that they are relatively "conservative" features. That is, they change less rapidly than other portions of the anatomy of the group. For instance, sea lions, dogs, and cats belong to the order Carnivora, yet they are very different anatomically. But, except for size differences and a few microscopic details, the fetal membranes of all three are almost identical. The same can be said of the Artiodactyla, including the cattle, sheep, goats, deer, etc., and of the Primates, where only an expert can distinguish between the placenta and membranes of the great apes and man. This conservatism makes it possible to see indications of phylogenetic relationships of species and groups where such extreme anatomical modifications have occurred that it has been difficult on other anatomical grounds to determine with what groups they are affiliated. One such group is the order Edentata (armadillos, anteaters, and sloths), where so much adaptive modification of skeletal features, especially of skull and teeth, has occurred that it is impossible to compare their skulls or dentition profitably with other groups. Although knowledge of the fetal membranes of this heterogeneous group is incomplete, enough is known to show that the new world

anteaters and the sloths (Myrmecophagidae and Bradypodidae) have similar membranes, and that the sloths show many affinities to the Primates; and that many features in the development of the fetal membranes in the new world armadillos (Dasypodidae) are very similar to those of the Rodentia. It seems probable therefore that these divisions of the catchall order Edentata are widely unrelated to one another and that each may be rather closely related to a different order of less highly specialized forms. *See* also references under "Placenta" in the Index.

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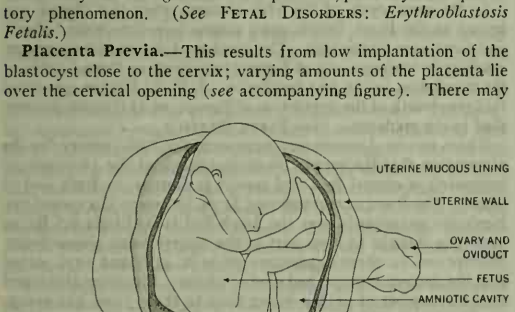
PLACENTA AND FETAL MEMBRANES, DISEASES OF, include a number of disorders that may injure the unborn fetus and endanger the health or life of the mother.

Infarction.—This condition, local death of the placenta, is a common degenerative process caused by interference with the maternal circulation to, through or from the placenta. Whether infarction of the placenta causes harm to the baby is determined by the rate and extent of infarction; usually the baby is unaffected.

Infection.—Any part of the placenta and its membranes may become infected through either the maternal bloodstream or the cervical canal. Tuberculosis, syphilis and toxoplasmosis are infections which may involve the villous structures. Malarial organisms have been found in the intervillous space and malarial pigment in the villi but without inflammatory changes. Up to the late 1960s no specific changes had been found in the placenta with virus infections other than smallpox and chickenpox. Acute bacterial infection is frequently associated with criminal abortion, and occasionally may follow infection of the amniotic sac. Much commoner is the occurrence of inflammation of the membranes following long labour or prolonged rupture of the membranes.

Erythroblastosis Fetalis.—This uncommon disease, resulting from immunization of the mother by antigenic substances on the baby's red blood cells (usually the Rh factor), may result in death of the baby and enlargement of the placenta, probably a compensatory phenomenon. (*See* FETAL DISORDERS: *Erythroblastosis Fetalis.*)

Placenta Previa.—This results from low implantation of the blastocyst close to the cervix; varying amounts of the placenta lie over the cervical opening (*see* accompanying figure). There may



PLACENTA ATTACHED OVER THE INTERNAL OPENING OF THE CERVIX (PLACENTA PREVIA)

In this uterus, about 5 months pregnant, the chorion and amnion have been opened to expose the surgically removed fetus lying in its amniotic sac

be severe hemorrhage, death of the baby and occasionally death of the mother when the uterus changes late in pregnancy.

Placenta Accreta.—In this condition the placenta adheres abnormally to the muscle of the uterus, because of local or complete absence of the decidua. Complete placenta accreta is uncommon, but partial and focal placenta accreta are relatively common. Difficulty in delivering the placenta results, occasionally necessitating removal of the uterus.

Abruptio Placenta.—This sudden separation of the placenta from its uterine attachment is one of the manifestations of toxemia of pregnancy (high blood pressure and poorly functioning kidneys), and usually results in death of the baby. The condition usually does not repeat itself in subsequent pregnancies.

Premature separation of the placenta may also occur as a result of intrinsic aging of the tissue at the placental site, in the absence of any other maternal disease.

Hydatidiform Mole.—This is an abnormality of the placenta resulting from early death or absence of the fetus accompanied by continued growth of the trophoblast (covering of the villi). It occurs about once in 2,000 pregnancies (in U.S.) and is characterized by a mass of grapelike vesicles filled with gelatinous fluid. It is usually diagnosed about the 14th to 20th week of pregnancy. More than half the patients with these tumours subsequently have a normal pregnancy. In about 16% some of the villi invade the uterine muscle, causing bleeding. In about 2.5% there is development of choriocarcinoma.

Choriocarcinoma.—This is a rare malignant epithelial tumour composed of the two trophoblastic elements, syncytiotrophoblast and cytotrophoblast. Grossly it is hemorrhagic and friable. Most commonly it follows a hydatidiform mole but may follow abortion (once in 14,000) or an apparently normal pregnancy (once in 160,000). Choriocarcinoma spreads rapidly by way of the blood stream, usually producing secondary tumours in the lung. Although rare cures of choriocarcinoma have been reported, this disease is usually fatal.

Chorioangioma.—This commonest true tumour of the placenta usually has no effect on the baby. It consists of an overgrowth of fetal blood vessels, connective tissue and trophoblast.

Others.—If the blastocyst becomes implanted deeply, all the surrounding villi may persist, resulting in placenta membranacea. The placenta may be partially divided (placenta bipartita, tripartita, or multipartita), may be completely divided (as in placenta duplex), or there may be extra lobes (placenta succenturiata).

Placenta circumvallata and its variant, placenta circummarginata, are probably caused by a small blastocyst or its shallow implantation or both. Frequent clinical complications are abortion, intrauterine fetal death, premature placental separation and premature labour. *See* also PLACENTA; EMBRYOLOGY, HUMAN; FETAL DISORDERS; ABORTION; STILLBIRTH; PREMATURE BIRTH; OBSTETRICS.

See A. T. Hertig and H. Gore in W. A. D. Anderson's *Pathology*, 5th ed. (1965). (A. T. H.)

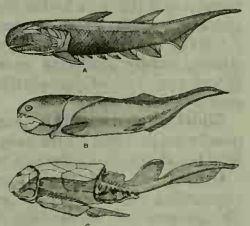
PLACIDIA, AELIA GALLA (d. A.D. 450), Roman princess, daughter of the emperor Theodosius I and sister of Honorius, was born between 388 and 393. The most noteworthy event of her life was her marriage to the Visigothic chieftain Ataulphus (*q.v.*) in January 414. She had been captured in Rome when the city fell to the Goths in 410. After Alaric's death later that year she was carried off to Gaul by her captors, and when, in 413, Ataulphus seized Narbonne, the marriage of the princess and the barbarian was celebrated there. Their only child, Theodosius, died in Barcelona, where Ataulphus was assassinated in 415. In 416 Placidia was restored to the Romans and in 417 she was married against her will to the patrician Constantius, later the emperor Constantius III (*q.v.*), who died in 421. Her son by this marriage later reigned as Valentinian III (*q.v.*). She herself died on Nov. 27, 450, in Rome. She adorned Ravenna with a number of churches which still stand. (E. A. T.)

PLACODERM, a term used for a series of plated-skinned archaic fishes abundant in certain late Paleozoic deposits but now entirely extinct. Members of the class Placodermi had progressed beyond the cyclostomes and ostracoderms in acquiring jaws and paired appendages, although these structures often differed greatly from their homologues in more advanced fishes. As in ostracoderms and bony fishes (Osteichthyes), but unlike sharks and cyclostomes, all the placoderms possessed bony armour. It is

possible that some placoderms gave rise to sharklike fishes, but there are no known links with either ostracoderms or bony fishes; most placoderm types were aberrant and destined to speedy extinction. Placoderms first appeared toward the end of the Silurian and flourished during the Devonian. They vanished at the end of that period except for one group, the acanthodians, which lingered until Permian times.

Placoderms may be arranged in two major groups, to the larger of which may be applied the term arthrodire in a broad sense. Typical arthrodires were late Devonian marine fishes, best known from shales in the Cleveland (U.S.) region. Many were of large size, *Dinichthys* being estimated to have reached 30 ft. in length. The posterior part of the body was unclad, but head and "chest" regions were covered with bony armour; the two sections of the armour were connected by movable joints (hence the term arthrodire—"jointed-neck") Small paired fins were present. The early Devonian ancestors of these arthrodires were small, with a flatter body and more extensive armour. Paired fins were absent; instead, long curved bony "horns" extended outward on either side from the shoulder region.

There were numerous variants on the arthrodire pattern. Common in fresh waters were the antiarchs (Antiarcha), such as *Bothriolepis*. In these small fishes there was an armour similar to that of typical arthrodires. As in primitive arthrodires there were long bone-covered structures extending laterally in the shoulder region, but in antiarchs these were movably articulated with the body, having somewhat the appearance of crustacean appendages. In still other forms found in marine deposits, such as *Gemündina*, paired fins, particularly pectorals, were highly developed and bony armour was reduced; possibly such types were evolving toward the shark condition.



FROM A. S. ROMER, "THE VERTEBRATE BODY," 1ST ED., 1949. REPRODUCED BY PERMISSION OF W. B. SAUNDERS COMPANY (A) DATA FROM WATSON; (B) AFTER HEINTZ; (C) AFTER PATTEN

DEVONIAN PLACODERMS: (A) CLIMATIUS, AN ACANTHODIAN; (B) DINICHTHYS, AN ARTHRODIRE; (C) BOTHRIOLEPIS, AN ANTIARCH

Classed among the placoderms, although showing little evidence of relationship, are the Acanthodii. These small fresh-water fishes, such as *Climatius*, are often termed "spiny sharks," but they resemble sharks only in their general proportions and differ markedly from these cartilaginous fishes in a body covering of typical bony scales and head plates, and in the presence of internal bone in some forms. Characteristic is the fact that all fins, paired and median (except the tail) were supported by prominent spines. In some genera additional fins, supported by spinelets, are present as well as the typical vertebrate pectoral and pelvic appendages.

(A. S. Rr.)

PLAFOND, a card game, a forerunner of contract bridge. It was played in Paris as early as 1918 and became popular in France and Belgium and to some extent in England. It differed from contract bridge only in scoring: trick values were as in auction bridge; overtricks scored 50 each in the honour score; slams, bid or unbid, scored 100 for small, 200 for grand. Undertrick penalties were 100 per trick (200 if doubled, 400 if redoubled); the vulnerable feature of contract bridge was not used. Honours scored 100 for four in one hand, 150 if partner held the fifth, and 200 for five in one hand or four aces at no trump. There was an additional bonus of 50 for making a contract, plus 100 for game, plus 400 for rubber. *See* Bridge.

PLAGIARISM, the appropriation of the literary composition of another and passing it off as one's original work. Plagiarism may be of language or of incidents or of plots. If the appropriated material has not become part of the public domain, plagiarism may be enjoined or may support an action for damages. *See* Copyright.

(J. D. Ls.)

PLAGIOCLASE, an important group of rock-forming feldspar minerals. *See* Feldspar: *The Plagioclases.*

PLAGUE (also called Pest and Oriental Plague) is a term formerly applied to any widespread disease causing a great mortality, but now confined to a specific infectious fever caused by *Pasteurella pestis* (also called *Bacillus pestis* and *Yersinia pestis*). It is primarily a disease of rodents, and epidemics in human beings originate in contact with infected rodents, most commonly rats, or their fleas. The disease in man has three clinical forms: bubonic, characterized by swelling of the lymph nodes (buboes); pneumonic, in which the lungs are extensively involved; and septicemic, in which the blood stream is so strongly invaded by *Pasteurella pestis* that death ensues before the bubonic or pneumonic forms have had time to appear. Plague as spread from rats to man in crowded urban areas is sometimes called murine (rat) or urban plague; plague in desert or rural areas where the human population is sparse but the wild rodent population large and infected may be called sylvatic (woodland) or campestral (field).

HISTORY

Many experts believe, because of the characteristics of the disease in man and the extent of the mortality in mice, that it was true plague that afflicted the Philistines in 320 B.C. (I Sam. v and vi). Another early historical notice of plague is contained in a fragment of the writings of the physician Rufus of Ephesus, who lived in the time of Trajan (1st–2nd century A.D.), preserved in the *Collections of Oribasius*. Rufus described the buboes called pestilential as specially fatal and found chiefly in Libya, Egypt and Syria. This passage shows the antiquity of plague in northern Africa, which for centuries was considered its home. Not until the 6th century A.D. was Europe afflicted by bubonic plague, as part of a great cycle that lasted 50 years. It spread over the whole Roman world, beginning in maritime towns and radiating inland. In another direction it extended from Egypt along the north coast of Africa. Whether the numerous pestilences recorded in the 7th century were caused by *P. pestis* cannot now be said, but the ones in England chronicled by St. Bede in the years A.D. 664, 672, 679 and 683 may have been this disease, especially since *pestis inguinaria* was again recorded in Rome in A.D. 690. Several infectious diseases were called plague or pest, so retrospective diagnosis must depend on clinical accounts of the buboes, the course and the contagiousness.

In the great cycle of the 14th century, when this disease was known as the Black Death, some plague infections were bubonic and some were pneumonic. The number of deaths was enormous, reaching in various parts of Europe two-thirds or three-fourths of the population in the first pestilence. J. F. K. Hecker calculated that one-fourth of the population of Europe, or 25,000,000 persons, died in the epidemic. (*See* Black Death.)

There was no documentary basis until the 20th century for the assumption that the second plague pandemic of the 14th century originated in central Asia and spread to Europe, to India and to China. The Russian archaeologist D. A. Chwolson discovered two Nestorian graveyards near the Issyk-Kul lake, Kirgiz S.S.R., an area long thought to form part of the central Asian plague focus. Inscriptions on three headstones made in 1338 and 1339 stated that the persons interred had died of plague. Chwolson also noted that the number of graves dating back to those years was exceptionally high. This, considered with other known characteristics of those outbreaks, is good evidence that plague existed in central Asia before it ravaged China, Europe and India. China, with its proximity to Mongolia, regularly suffered from plague. It was known there as *ko-ta-wen* (literally, "sore-sore") and in the Hakka dialect of south China as *ta-wun*, which, according to the philological studies of Mahdihassan, means "bubo-epidemic," a connotative descriptive name for plague. Distorted to *ta'un*, it appears in several significant early treatises on plague in Arabic.

The Great Plague of London in 1664–65 was not an isolated phenomenon. Plague had recurred frequently throughout Europe in the 15th, 16th and 17th centuries, but London had been unusually free of it in the preceding years. It was not mentioned in the bills of mortality until the autumn of 1664 (Nov. 2). A few isolated cases were observed in Westminster, and a few in the following winter, which was severe. About May 1665 the disease

again became noticeable and spread, but somewhat slowly. The total number of deaths from plague in that year, according to the bills of mortality, was 68,596 in a population estimated at 460,000. This number is probably an underestimate, since it is likely that many of the 6,432 deaths attributed to spotted fever were really caused by plague. In December the mortality fell suddenly and continued down through the winter, but in 1666 nearly 2,000 deaths were recorded. From London the disease spread widely over the country, but from 1667 on there was no epidemic of plague in any part of England, though sporadic cases appeared in bills of mortality up to 1679. This disappearance of plague from London has been attributed to the Great Fire, but it also subsided in other cities without such cause. The decline has also been ascribed to quarantine, but effective quarantine was actually not established until 1720. The cessation of plague in England must be regarded as spontaneous.

Epidemics subsided soon after in most of western Europe. In 1666 plague raged in Cologne and on the Rhine and continued there until 1670. In the Netherlands there were instances of plague from 1667 to 1669, but no definite notices of it after 1672. France saw the last of plague in 1668, until it reappeared in 1720 at Marseilles. About 40,000 persons died in the city and 10,000 in the surrounding countryside. The source of infection was a ship arriving from the Levant with plague on board; there had been eight deaths. Quarantine procedures were a farce, and bales of cloth were smuggled into the city. Apparently the infection was circulated solely by human beings and their ectoparasites; there was no mention of deaths among rats. The infection spread by leaps, often of great distances, skipping some areas immediate to Marseilles.

Between 1675 and 1684 a new epidemic appeared in north Africa, Turkey, Poland, Hungary, Austria and Germany, progressing northward. Malta lost 11,000 persons in 1675. The plague of Vienna in 1679 caused at least 76,000 deaths. Prague in 1681 lost 83,000 of its population. Dresden was affected in 1680, Magdeburg and Halle in 1682—in the latter town with a mortality of 4,397 in a population of about 10,000. Many north German cities suffered about that time, but in 1683 plague disappeared from Germany, not to reappear until 1707. In Spain it ceased about 1681; in Italy certain cities were attacked until the end of the century, but not later.

It is remarkable that in such a short time plague should totally disappear. Various explanations have been offered: the progress of civilization, in particular the control of infectious diseases by sanitation, hospitalization and cleanliness, and the supervision of the infectious sick were considered important factors. The agrarian revolution brought about a change in domestic housing that led to the exclusion of rats from human dwellings, so that the opportunity for infection was reduced. Another factor may be that, with the abandonment of the old trade routes, commercial activity centred in Amsterdam and London, and the new connections with the far east were by sea, not by land. This reduced the distribution of the disease. These explanations are not fully satisfactory, but they doubtless cover auxiliary factors.

Knowledge acquired in the 20th century leads to the conclusion that the decline at the end of the 17th century illustrates the great natural law of the rise and decline of epidemics. The seeming disappearance again in the middle of the 19th century was merely a phase of the natural history of the disease itself, no more remarkable than the similar prolonged quiescence following epidemics of the 8th century.

During the 18th and the early part of the 19th century, plague continued to prevail in Turkey, the near east, Syria, Egypt and Greece. The cases in Egypt from 1833 to 1845 played a part in the history of the disease, since they were almost the first to be studied scientifically in their home by skilled physicians, chiefly French. Because this outbreak was less severe than the previous ones, the observers were misled to believe that the disease was not particularly contagious.

An outbreak in 1878–79 on the banks of the Volga near Vetlianka, Russia, spread another panic across Europe, and most European governments sent special commissions to study and help control the epidemic. Although the foreign commissioners arrived when the epidemic was over, they learned something of the characteristics of the disease. Subsequent research in southern Russia established the region around the Volga as an old focus of campestral plague.

Once it was a maxim that plague never appears east of the Indus, but during the 19th century it afflicted more than one district of India. In 1815 Gujarat, Kathiawar and Cutch suffered epidemics after three years of severe famine. Again early the next year it struck these same localities and then extended to Sind as far as Hyderabad and southeast as far as Ahmedabad and Dholera. But it disappeared from those parts in 1820 or early in 1821 and was not heard of again until July 1836, when it broke out with violence at the town of Pali, in Rajputana. It spread from Pali to Ajmer-Merwara but died out spontaneously in the hot season of 1837.

In 1823 an epidemic broke out at Kedarnath, in Garhwal, a subdistrict of Kumaun, southwest of the Himalayas, on a high situation. In 1834 and 1836 there were others, and these at last attracted the attention of the government. In 1849 and 1850 and again in 1852 the disease raged and spread southward. In another outbreak in 1876–77 the symptoms of the disease, called *maha murree* or *mahamari* by the Indians, were precisely those of oriental plague, and concurrent deaths of rats were noted.

The third great expansive pandemic is generally thought to have gained momentum in Yünnan province in China, where the rebellion of the Muslims beginning in 1855 and possibly the movements of refugees propagated the disease. Progressing in slow stages, it reached the provincial capital of Yün-nan-fu (modern K'un-ming) in 1866, and not until 28 years later did it extend to Canton and Hong Kong (May 1894). The number of deaths in Canton has been estimated at 80,000 to 100,000. During the epidemic in Hong Kong the organism that causes plague, *Pasteurella pestis*, was identified independently by Alexandre Yersin and Shibasaburo Kitasato.

Ports in south China became plague distribution centres, and between 1894 and 1922 the disease spread throughout the whole world, more widely than during any great foregoing epidemics. Among the many points infected were Bombay in 1896, Calcutta in 1898, Japan and the Philippines in 1897, Australasia, Hawaii, Central and South America in 1899, Cape Town, U. of S. Af., and San Francisco, Calif., in 1900, Egypt and Singapore in 1901, Bangkok, Thailand, in 1904, Guayaquil, Ecuador, in 1908, Java in 1910, New Orleans, La., and Colombo, Ceylon, in 1914, Galveston and Beaumont, Tex., and Pensacola, Fla., in 1922. Being at that time a seafaring disease it struck nearly all European ports, causing local epidemics in Glasgow, Oporto, Port., Odessa, Naples and Marseilles. India suffered most. The reported number of deaths between 1896 and 1917 was 9,841,396; the maximum, reached in 1907, was 1,315,892—a rate of 5.16 per 1,000 of the population. Fortunately in the ensuing 25 years the incidence curve turned downward toward greatly diminished prevalence. In 1923 there were fewer than 250,000 deaths; in 1942, 10,577; in 1947, 41,745; in 1948, 9,757; and in 1952, 1,007. Incomplete records for 1954 listed 157 deaths in Burma and 547 in India; those for 1955 showed 720 cases, with 162 deaths. During this period Kenya in Africa had 50 deaths, and Ecuador and Peru had 159. After 1937 no cases were reported from the European part of the U.S.S.R., an old plague focus.

The usual statements that nothing definite was known about the transmission of plague during the early outbreaks is not entirely correct. Himalayan villagers long ago believed that unusual death among rats preceded outbreaks among human beings, and centuries earlier, in the Israel-Philistine controversies, mice were suspected of being in some way concerned. The discovery of the skeleton of a rat in a Neolithic site in Abu Uba cave near Mt. Carmel, Palestine, and in the Paleolithic site in the desert near Judaea attests to the antiquity of this important host of plague in the homeland of the Philistines. Some confusion about this has long prevailed because in Greek and Latin, the languages into which the Bible was first translated, the same word is used for both mice and rats, according to W. P. MacArthur. Avicenna

mentions plague in animals, and, according to Nicephorus Gregoras, mice died in 1348 during the Black Death in Constantinople. By that time a highly efficient plague reservoir, the black rat *Rattus rattus*, had become firmly established in Europe. Rat skeletons have been found in excavations at Pompeii, Italy, and votive offerings from the first century found in Roman tombs depict rats. The Justinian plague (A.D. 542 and after) spread throughout Europe, where outbreaks occurred during the next half-century; these must have arisen from some persisting source through the agency of rats.

The significance of rat mortality was again brought up in the Pali outbreak in India in 1837. From the time of the Canton epidemic, it had been noticed that plague in rats had concurred with plague in man. The relationship was so striking that in 1897 Ogata Masanori described the Formosa outbreak as "ratpest." Paul Louis Simond noted the frequency of the disease among those who had recently handled rats and the major role of the rat in its spread. It was reserved for the Plague Research commission to discover, in Bombay in 1905–06, the exact link between rats and human disease. As the result of studies of the Indian outbreak made by the advisory committee appointed in 1905 by the secretary of state for India, the Royal society and the Lister institute, the whole epidemiology of plague was elucidated.

GEOGRAPHIC DISTRIBUTION AND PREVALENCE

The distribution of plague in man depends almost solely on its distribution and course in rodents. Once this was recognized, measures were taken to stop the transportation of rats and their fleas, and these measures were remarkably successful in confining plague to areas where it prevails in domestic and wild rodents. Transportation of infected rodents and fleas, once responsible for the spread across broad geographic areas, was almost eliminated through well-planned and well-executed efforts. From 1929 to 1951 the only proved instance was on board the S.S. "Ville de Tamatave" in April 1938 at Beirut, Lebanon. Rat-proofing, fumigation of cargoes and general control measures in ports have freed the world of ship-borne plague. A change in the disease itself—away from the ports of warm countries toward the cooler hinterlands—has also contributed.

Judging from the number of deaths officially ascribed to plague by the World Health Organization, the incidence of the disease, worldwide, has been steadily decreasing. The yearly number of deaths was approximately 170,300 in the period 1919–28; 92,300 in 1929–38; 21,800 in 1939–48; 4,600 in 1949–53; and fewer than 200 a year in 1954–64.

Asia.—The principal active plague centres in Asia by the middle of the 20th century were in India, China and Burma. There are three endemic centres near the foot of the Himalayas, one in central India comprising the watersheds of the Vindhya, Bhanrer and Maikal ranges and the Mahadeo hills, and three centres in the watersheds of the Western Ghats in Bombay and Mysore, in Hyderabad state, and in the districts of Salem, Nilgiris and Madurai. These foci have been very active. Plague there early in the 1950s was both a rural and an urban problem—it moved from the commercial towns out to villages and flared up where it found a highly susceptible rat population. The epizootics on the warm tablelands were severe, mortality among rats was high and the disease ebbed in a short time. In cooler regions, such as watersheds, the disease was enzootic, persistent and less fatal to rats. Investigations have shown that the spread of infection in rural areas is caused by epizootic outbreaks among field rodents; the disease spreads from burrow to burrow and infects village rats in passing. Too, the persistence of rural plague is due to the relatively high resistance to the disease of the most plentiful field species, the Indian gerbil. The principal role played by the domestic rat is to act as "liaison rodent" between man and the field rodent. Officially reported cases in India totaled 402 with 55 deaths in 1961, 697 with 88 deaths in 1962, and 205 (in Madras) with 17 deaths in 1963.

In China, outbreaks varying in intensity were perennial in Hong Kong until 1923. Canton was free from the end of World War I until 1954, but the infection remained entrenched east of Pei-Hai, where 627 cases were recorded from Jan. to Sept. 1950. From Kwangtung it spread to other coastal provinces, of which Fukien continued to be involved. Another series of outbreaks, preponderantly bubonic, was dispersed along inland routes from Mongolia. Plague also reappeared in Yünnan province about 1938. North Manchuria, infected by human agency from the wild rodent foci in Outer Mongolia, suffered pneumonic plague epidemics in 1910–11 (more than 60,000 deaths) and a smaller outbreak (10,000 deaths) in 1920–21. Because these did not include the local rat population, they ended as soon as the climate ceased to favour spread of the infection from man to man.

Plague continued in Burma (only 157 deaths in 1954, 73 in 1962, and 7 in 1963, compared with 2,743 in 1946), Indochina and Thailand (not more than 100 cases a year) and Java (about 2,266 deaths in 1951; 829 in 1952). In Saigon, Indochina, in 1943 an epizootic among domestic mice, more heavily infested with the commonest plague-carrying fleas than were rats, was responsible for 42 cases of bubonic plague. In 1963 at least 115 cases of plague were reported in Vietnam.

Infection among wild rodents in the interior of western Asia was in part responsible for plague invasions of Turkey, Syria, Iran, Iraq and possibly Israel (a few cases in Jaffa and Haifa in 1946 and 1947). Typing of plague bacilli isolated from rats in the port of Istanbul and Antalya, Turk., and the demonstration of *Pasteurella pestis* in 376 rats in 1941, 1945 and 1947 in Palestine led to the suspicion that the infection also came in by sea or from wild rodent foci. It has been discovered that the gerbil populations, in the complete absence of rats in Persian Kurdistan, Transcaucasia and southeastern U.S.S.R., constitute the permanent reservoirs for the middle east.

Europe and Africa.—After World War II, plague appeared in Europe only in Ajaccio, on Corsica; in Taranto, Italy; on Malta; and in the Azores. Information about its real prevalence in the steppes of the southern U.S.S.R. is not available.

North and northwest Africa recorded infection in Egypt (712 cases in 1943–44), Tunisia, Algeria, Morocco (5,000 cases in 1940–45) and French West Africa (639 cases in Dakar in 1944). Central Africa—in particular Uganda, Kenya, Tanganyika and the Belgian Congo (now the Republic of the Congo)—had old campestral foci, but the incidence of cases was usually less than 400 a year. On Madagascar the outbreaks in ports and along the coast were bubonic, but on the high plateaus the infection tended markedly to secondary lung involvement and on to pneumonic plague, which accounted for 56.2% of all cases seen there in 1946 and for 4 of 17 cases in 1955.

Plague gained a foothold in the Union of South Africa in 1900, when the South African War necessitated the importation of large amounts of forage from infested South American ports. Until 1912 port areas were involved, but thereafter infected rodents and fleas spread plague to rodents in southwestern Transvaal and northwestern Orange Free State, in the Cape Midland and near Port Elizabeth, where cases began to occur after 1919. Human infections numbered 556 from 1919 to 1925, 466 from 1925 to 1931, 687 from 1931 to 1937 and 646 from 1937 to 1949. Nine cases observed in 1955 near the mission station Chitokoloki, on the Zambezi river, about 500 mi. W. of the copper belt, indicated that wild rodent plague was spreading from South Africa into Northern Rhodesia. A small outbreak (84 cases with 5 deaths) occurred in Ovamboland, South West Africa, in 1962–63.

North America and Hawaii.—In the United States, plague was first recognized in San Francisco in 1900. Up to 1904, when San Francisco was declared plague free, 121 persons had been infected, and 113 of them died. Evidence that rats were the source of this outbreak is abundant. The disease broke out again between May 1907 and Nov. 1908, when there were 159 cases and 77 deaths. Plague-ridden rats, as many as 2% of those trapped and examined, were caught in badly infected districts of the city. In New Orleans 30 persons became infected in 1914 and 25 (11 deaths) in 1920. At the same time, Florida and Texas were reporting human plague (total of 41 cases). Between 1924 and 1955 there were no outbreaks of human plague of murine or urban origin.

As the result of a case of plague in a human being in 1903, the squirrel was added to the list of animal reservoirs. A few human infections were later traced to contact with squirrels or bites by their ectoparasites: a small epidemic of pneumonic plague (13 cases) in Oakland, Calif., in 1919 and a similar one in Los Angeles, Calif., in 1924 (31 cases). A human infection was recorded in the Great Basin area in Oregon in 1934. As a result of extensive surveys, especially from 1936 to 1950, wild rodent plague has been found in 138 counties of 15 western states, from the Pacific coast east to the 100th meridian in Kansas, Oklahoma and Texas, an area comprising about 40% of the continental United States. Evidence shows that the disease in wild rodents—squirrels, chipmunks, prairie dogs, wood rats, native field mice or voles and occasionally harvest mice and rabbits—forms a vast enzootic reservoir potentially dangerous to human beings. Since 1908, 77 cases with 62 deaths have been traced to wild rodents.

Of the 533 cases reported in the U.S. between 1900 and 1964, 383 occurred in California and 65% were fatal. The only states reporting plague after 1946 were New Mexico (12 cases), California (3), Arizona (2) and Texas (1).

Infected prairie dogs and field mice have been found in Mexico.

Plague became manifest in Honolulu, Hawaii, in Nov. 1899 and spread to adjacent districts and to Kauai, Maui and some other islands of the archipelago. Between 1899 and 1949, the total of human cases reported was 416. The Hamakua district, Hawaii, has suffered several human infections.

South America.—Plague has been endemic in South America at least since early in the 20th century—in Venezuela, Brazil, Peru, Bolivia, Argentina and Ecuador. Flea-borne bubonic plague has been the commoner form, but in mountainous areas the proportion of pneumonic infections is much higher.

From 1910 to 1951 Venezuela reported 211 cases, 37 of them in Miranda and Aragua. Brazil was more afflicted—between 1899 and 1949, at least 9,248 persons were infected. In Argentina about 7,000 infections were recorded between 1899 and 1940. Bolivia was infected in 1928. Rat epizootics preceded some outbreaks there. Peru, never free of plague since 1903, reported over a period of 50 years 22,254 cases, more than any other South American country. After 1960 the provinces of Huancabamba, Ayabaca and Cajamarca and the department of Amazonas showed an increase in case incidence.

Infection among wild rodents, established in Guayaquil, Ecuador, as early as 1908, caused more than 2,700 human infections in Ecuador between 1909 and 1940, after which a limited number of cases was recorded each year in the mountainous areas. An outbreak due to a rat epizootic in 1961 involved 71 cases in the port of Manta. Extension into Manabí province and renewed, unexplained plague activity in Loga and Chimborazo provinces resulted, just as in Peru, in an increase in reported infections.

THE DISEASE

Causative Organism.—The plague bacillus, identified in 1894 by Alexandre Yersin and Shibasaburo Kitasato, is found in the local vesicle of the flea bite, in buboes in ordinary cases, in large numbers in the blood in so-called septicemic cases and in the sputum in pneumonic cases. On post-mortem examination it is found in great abundance in the lymph nodes, spleen, bone marrow and liver.

Outside the body the plague bacillus is not very resistant to heat or to chemicals, but it remains alive in dried sputum for at least three months and in dry flea feces held at room temperature, for five weeks. It is resistant to cold; cultures and organs held in the icebox retain their virulence for months, even up to ten years. In moist garden soil, virulent plague bacilli may remain alive and infective for as long as seven months.

On the whole, the capacity of the bacillus to multiply in the tissues and to cause death of its host—that is, the virulence of the organism—is remarkably stable and vigorous. Test animals (for example, mice) have been fatally infected with as few as three to ten bacilli. Most investigators agree that the virulence of the organisms does not subside in the course of a bubonic outbreak. The mildness of some infections may be explained by greater resistance of certain individuals, not by inherent differences in the causative microorganism.

Strains of *P. pestis* secured from man, rats, wild rodents and fleas from every corner of the world are biologically identical and show remarkable homogeneity of virulence and infectiousness. With special laboratory methods certain strains may be rendered avirulent, or they may spontaneously lose their virulence when kept in the laboratory. Unfortunately most of these avirulent strains are somewhat toxic. They are, however, suitable for active immunization and also are used in the manufacture of antiplague serums.

Natural History.—Plague is primarily a disease of rodents, and man enters only accidentally into the usual cycle. This cycle —rodent-flea-rodent—as a rule is enzootic, but under certain environmental conditions it reaches epizootic proportions. In some areas plague-infected rats from ships spread the infection in ports, where it became epizootic in commensal rats. Then it extended from these rodents to peridomestic and field rodents. Independently or as an extension of the infection in urban rodents, plague in wild rodents may affect guinea pigs, hamsters and rabbits; in deserts and other uninhabitable places it uses squirrels, gerbils, hamsters and rabbits as hosts.

Human beings only rarely contract the disease from wild rodents; in the midst of epizootics that have littered pastures with cadavers of plague-infected squirrels, when burrow openings were teeming with infective fleas, rarely if ever has a human being been infected. But spread of the infection among domestic rodents in the vicinity of human habitations creates conditions favourable for outbreaks of human plague. For when an epizootic reduces the rodent population, fleas from the dead animals fail to find another rodent host and thus begin to infest men. At first the cases are sporadic, but under suitable conditions large numbers of persons may be included.

As a rule, at this stage if the infection is bubonic, plague does not spread directly from one person to another. Relatively rarely are there enough bacilli in the blood of human beings to infect the fleas that ingest it. The human flea, *Pulex irritans*, is a poor transmitter of plague. Under certain circumstances when the bacilli become localized in the lung and are eliminated in large numbers in respiratory discharges, and when environmental and climatic conditions favour aerogenic droplet transmission, the infection spreads from man to man. The pulmonary plagues in Manchuria in 1910–11 and 1920–21 and later in eastern India amply attest to the importance of cool weather and crowding in badly ventilated dwellings as contributory factors in creating pneumonic epidemics. The term epidemic is used loosely to describe bubonic plague, for this relatively seldom spreads from man to man.

Infection may also be acquired at post-mortem examinations and in the course of laboratory accidents, and it was once used with homicidal intent (in Calcutta in 1933, described by Wu Lien-teh and his colleagues in 1936).

Rodents carrying plague fall into two main groups: (1) the Muridae, the rats, of which certain species living in close association with man are responsible for maintaining endemicity and for large outbreaks; and (2) the Sciuridae, Cricetidae, Jaculidae, Caviidae and Leporidae, the wild rodents, responsible for maintaining campestral and sylvatic plague.

Murine or Rat Plague.—Natural plague has been observed in a great variety of the order Rodentia, but of numerous species of the Muridae family only three of the subfamily Murinae (the typical rats and mice) are of universal importance in plague. The rats largely responsible for propagating plague are the Norway, or brown, rat (*Rattus norvegicus*), and the English black rat (*Rattus rattus rattus*), with its subspecies or varieties. In different areas different subspecies of *Rattus* and several species of *Mus* may be responsible reservoirs. The organism is ordinarily discovered through macroscopic and microscopic examination of the organs of the diseased or dead rats routinely collected in plague-infected communities.

Recurrence of plague in commensal rats in countries where the principal natural reservoirs are squirrels or gerbils without notable

repercussions in the nearby human populations cannot be explained. Commensal rats have long been thought the principal reservoir because where bubonic plague has raged or is raging, without exception domestic rats and the classical plague-bearing flea have abounded. Studies in the Kurdistan mountains of Iran, the rift valley of Kenya, and the central states of India, however, suggest that plague, in order to maintain itself in focal areas, requires resistant wild rodents capable of surviving the epizootics. They perpetuate the infection. But it cannot operate without susceptible species capable of rekindling it.

The ecological factors in the habitual niches filled with hosts, parasites and vectors are very complex, and the combinations responsible for epidemics in India, Madagascar, Senegal, Peru, Brazil and elsewhere are not fully understood. As M. Baltazard stated, although the rat has made the fortune of plague, it is not the original, probably not even the actual, proprietor of the disease, only the disseminator.

Plague in Wild Rodents (Campestral and Sylvatic Plague).—Among the wild rodents, squirrels and related species are the chief instruments for exchange of the infective agent; a group of small rodents, such as harvest mice act as complementary and auxiliary hosts. There is ample evidence that plague has spread from wild rodents to domestic rats and mice. About 250 species are subject to natural infection, not infrequently taking the form of a seasonal epizootic among the younger members of the regional wild rodent population.

The Vector.—Members of the family Pulicidae, which includes most of the common fleas, are the third indispensable factor in the propagation of plague. Simond, in his experiments with fleas, in 1898 showed them to be possible disseminators of bubonic plague, either from animal to animal, animal to man, or man to man. The ecology of wild rodent fleas has been well studied to the conclusion that comparatively few (approximately 101) of the estimated 1,500 existing species can transmit plague. The most important vectors are listed in the Table. The classical one is the Indian rat flea, *Xenopsylla cheopis*.

At one feeding on a rat whose blood contains 100,000,000 organisms per millilitre, a flea will ingest about 5,000 organisms and will ordinarily become infective because the organisms are likely to multiply in its digestive tract. The flea is not a mere passive carrier. A few days, or even longer, after it has fed on infected blood, under the microscope clusters of plague bacilli can be seen in its stomach. Later its proventriculus becomes plugged by gelatinous masses of bacilli, and the valvular action becomes inadequate. Because of this obstruction, the blood being sucked by the flea cannot enter its stomach. The esophagus containing virulent bacilli becomes distended, and the elastic recoil of the walls of both pharynx and gullet when the flea stops sucking may drive back into the bite wound highly infective blood. The infective flea may regurgitate as many as 10,000 to 24,000 organisms at one biting. Some of these usually enter the blood of the new host, and if the new host is susceptible, bubonic or septicemic plague is the result.

Vectors of Plague

Flea (known to bite man)	Distribution	Reservoir hosts	Transmits primarily to:
Xenopsylla cheopis	Widely disseminated	*Rattus rattus*	Rats and man
Xenopsylla brasiliensis	Uganda, Kenya, Nigeria	Rats	Rats and man
Xenopsylla hawaiiensis	Island of Hawaii	Field rats	Field rats
Xenopsylla astia	India, Ceylon, Burma, Mesopotamia, Mombasa	Rats	Rats
Xenopsylla nubicus	Tropical east and west Africa	Rats	Rats
Xenopsylla philoxera	South Africa	Wild rodents	Wild rodents
Pulex irritans	Nearly cosmopolitan	Man, swine, rodents, carnivores	Man, rodents
Nosopsyllus fasciatus	Temperate zone of Europe and America	*Rattus norvegicus*	Rats
Diamanus montanus	Western United States	Ground squirrels	Ground squirrels
Polycenis platensis cisandinus	South America	Cavies	Cavies, or cuys, and man
Delostichus talis	Southeast U.S.S.R.	*Cricetus*	*Cricetus*
Ceratophyllus tesquorum	Russian steppes	*Citellus pygmaeus*	Ground squirrels
Oropsylla silantiewi	Manchuria	Rodents (tarabagans)	Rodents

Fleas that have fed on severely infected rodents may spread the organisms with their mouth parts without being blocked. This mode of transmission is of particular importance during epizootics when plague is rampant. There is experimental evidence that this type of mechanical transmission by a large number of fleas is as efficient in spreading infection as is the bite of a single blocked flea. Of least importance is fecal transmission. The flea pellets are viscous, and unless the skin is broken plague bacilli could not gain entrance into the tissues of the bitten. Furthermore, not all fecal pellets contain enough organisms to overcome the inherent high resistance of many wild rodents.

Killing of vermin (lice or fleas) with the teeth may cause tonsillar infection with the plague bacillus.

The maximum life span of an infective flea with a blocked proventriculus is only 20 to 30 days, but infected unblocked fleas may live much longer. A flea infected in October can retain the infection and transmit it during the following March. Among the preservers of plague from season to season, the flea is probably important. The microclimate of subterranean burrows with a constant moderately high temperature and a constantly low saturation deficiency is particularly favourable to the longevity of the flea. Transportation of infected fleas in all kinds of cargo is frequently assured when the time of transport is not too long and climatic conditions are favourable.

The type of fleas and the extent of flea infestation of rats in an area have been stressed as factors in the severity of an outbreak. The total number of fleas per rat varies with the climate, the season and other factors. But, on the basis of epidemiologic comparisons, these factors are of less importance than the number of infected fleas that become blocked and therefore infective.

Detecting campestral or sylvatic plague among wild rodents in rural areas is greatly facilitated by the examination of their fleas, removed either from fur or burrow openings.

As an epidemic scourge, plague has been conquered, but the source of harm remains. In spite of great progress, there is no satisfactory answer to the old question of why plague assumes a short- or long-term periodicity in its local or global manifestations. Fluctuations in rodent populations may be responsible; immunity acquired by animals that survive epizootics and temporarily transmit it to their offspring enters into the balance. Fabian Hirst devotes a long chapter to this stimulating problem in his book *The Conquest of Plague* and recalls that Louis Pasteur suggested that the causative agent might persist in nature in an attenuated form, with a sudden return of virulence controlled by climate and economic factors.

Clinical Characteristics of the Human Disease.—Plague may take three clinical forms: bubonic, pneumonic or septicemic. Misleading use of the word "bubonic" (which means characterized by buboes, or inflammatory swelling of lymph nodes) has given rise to the erroneous idea that true plague is necessarily bubonic and that nonbubonic types are a different disease altogether.

The illness varies within the widest limits, exhibiting all gradations of severity from mere indisposition, which may pass almost unnoticed, to extreme violence, equaled only by fulminating cholera. The mild infections are always bubonic; the other forms are invariably severe and almost always fatal unless treated. The incubation period is usually three to six days; it may be as short as 36 hours or as long as 10 days. As a rule the onset is sudden and well marked.

Bubonic Plague.—Bubonic plague constitutes about three-fourths of the total cases. In a typical case there is usually shivering at first, occasionally a rigour, followed by a rise of temperature,

with vomiting, headache, giddiness, intolerance to light; pain in the epigastrium, back and limbs; sleeplessness, apathy or delirium. The headache is described by the patient as splitting; delirium is usually of the busy type, like delirium tremens. The temperature varies greatly; it is as a rule not high on the first day—from 101° to 103°F.—and may even be normal, but sometimes it rises rapidly to 104° or 105°, even to 107°; it frequently falls two or three degrees on the second or third day. The eyes are red and inflamed. The tongue, somewhat swollen, is at first covered with a thin, white fur, except at the tip and edges, but later it becomes dry, and the fur, yellow or brownish. Prostration is marked. Constipation is the rule at first; the occurrence of diarrhea is a grave sign. Frequently the severely ill patient appears dazed and stupid, is thick of speech and staggers, giving the impression of drunkenness.

There is nothing, however, in all these symptoms and signs that is positively distinctive of plague. The really distinctive sign is the appearance of buboes, which happens early in the illness, usually on the second day; sometimes they are present from the onset; sometimes they cannot be detected before the third day or even later. The commonest seat is the groin, and next to that the armpit; the cervical, submaxillary and femoral glands are less commonly affected. Sometimes the buboes are numerous and on both sides of the body, but more commonly they occur on only one side. The pain is described as tearing or sharply cutting. If the buboes are not treated, they usually form pus and open outward by sloughing of the skin, but they may subside spontaneously or remain hard. Petechiae (small, round red spots caused by hemorrhage in the skin) appear over the buboes or on the abdomen shortly before death. Boils and carbuncles are rare.

Pneumonic Plague.—Pneumonic plague was described in many of the old epidemics. Its precise significance was first recognized in Bombay by L. F. Childe, who found the bacilli in the sputum and showed that the inflammation in the lungs may be set up by primary plague infection. The pneumonia is usually lobular, the onset marked by shivering, with difficult and hurried breathing, cough and expectoration. The prostration is great, and the course of the illness, rapid. The breathing becomes very hurried—40 to 60 respirations in a minute—and the face dusky. The expectoration soon shows an admixture of blood, and later in the disease large amounts of blood-containing sputum teeming with plague bacilli may be coughed up. The temperature is high and irregular. The physical signs are those of bronchopneumonia; edema of the lungs soon supervenes; and death occurs in three or four days.

Septicemic Plague.—When the organisms are injected by the flea directly into the capillaries or cannot be localized in the buboes, generalized septicemic plague may develop. Prostration and cerebral symptoms are particularly marked. The temperature rises rapidly to a very high level. The patient may become comatose and die within 24 hours, but more commonly on the second or third day. Recovery is rare.

Recovery from all three forms is slow. Second attacks are rare.

Diagnosis.—In an endemic area, typical severe bubonic or pneumonic plague is relatively easy to identify. However, when the disease breaks out only sporadically, the bubonic form must be distinguished in its early stages from tularemia, lymphogranuloma venereum and pyogenic infections. In the tropics the septic and pneumonic forms may resemble various fevers—relapsing, dengue, typhus or fulminating malaria. Primary pneumonic plague has been confused with influenza, as in the Oakland, Calif., outbreak, or with lobar pneumonia, as in the Los Angeles outbreak.

There may be no clinical signs from which diagnosis can be made; bacteriologic examinations are essential. These include microscopic examination of edema fluid from a bubo or of sputum, serum hemagglutination, agglutination and complement fixation tests. Early diagnosis is of greatest necessity, not only to the patient, whose recovery may depend on immediate treatment, but also to his family and physician and to the community because of the infectivity of this disease agent.

Treatment.—A highly potent horse antiserum prepared at the Haffkine institute in India was proving quite effective in the treatment of plague shortly before the remarkable successes with sulfonamide therapy were achieved in 1940. Experimental and field trials assessed and confirmed the value of antibiotic treatment of all forms of plague, provided the drug is given early in the course. Supplementing drug therapy with inoculation of antiserum apparently offers the severely infected patient a better chance for recovery. Some of the antibiotics—streptomycin, chloramphenicol and the tetracycline compounds terramycin and aureomycin—are excellent in the treatment, even of pneumonic plague; the sulfonamide compounds, though less curative, are extremely useful and offer highly relevant advantages.

In countries where the antimicrobial drugs are scarce and expensive and where plague still causes many acute illnesses and deaths every year, the inexpensive sulfa drugs have a sound position in both the cure and the prevention of this infection. In field trials the antibiotics set a new record in lowering the mortality rate in pneumonic plague, in which the prognosis was formerly so poor. In general the consistently satisfactory experimental and field trials with streptomycin, marred only a little by the development of streptomycin-resistant strains of the plague bacillus, make it the first choice among the available antiplague drugs. Chloramphenicol, terramycin and aureomycin (but not penicillin) are active against the streptomycin-resistant strains.

Prevention.—The suppression of bubonic plague is attempted by (1) appropriate sanitary measures directed simultaneously against the vectors and the rodent reservoir; (2) efforts to enhance the resistance of the individual; and (3) isolation of the sick and the handling of all infectious material with the greatest caution.

Since plague-infective fleas represent the immediate hazard to man, it is imperative that insecticides be used early in the outbreaks. Rat ectoparasite control with the insecticide DDT (dichlorodiphenyl-trichloroethane), introduced and tested during World War II, achieved spectacular and consistent control of *Xenopsylla cheopis* and other fleas that carry and transmit plague. Dusting rat runs with DDT brings epidemics under control. This is the method of choice to speed up a suppressive program and to increase its effectiveness. Not only does it kill the ectoparasite on the rats, but some of the powder is carried by the rats back to their nests and harbourages, and this is distributed over the breeding places of the fleas. Under certain circumstances the chemical kills even the rats. During an epidemic, houses are effectively disinfected with DDT-aromex soap, which remains effective for weeks, if not longer. Several other chlorinated hydrocarbons, such as aldrin, dieldrin, and benzene hexachloride, later proved even more effective than DDT.

Because fleas acquire their infections by feeding on plague-infected rats, it is equally important that these reservoir hosts be effectively controlled in order to eliminate the source of the disease agent. For destroying large numbers of rodents, poisoning and fumigation are more effective than trapping. Red squill, phosphorus, barium carbonate, arsenic trioxide, zinc phosphide and thallium sulfate were some of the poisons commonly used before World War II. Research during the war produced ANTU (alpha-naphthyl thiourea) and 1080, the latter with an unprecedented oral toxicity for rats. The lethal anticoagulant Warfarin, developed in 1948, consistently reduces rat populations of *Rattus norvegicus, R. rattus* and *Mus musculus*, but not *R. hawaiiensis*. It has the advantage that it is self-baiting and can be given in cornmeal. Proper use of all rodenticides requires considerable skill and experience. Since some of the preparations (1080, ANTU and others) are highly poisonous for mammals, including man and domestic animals, adequate safety precautions must be employed.

No rat-control program is complete without supportive sanitation and until harbourages are destroyed and buildings are ratproofed. Importation of rats from endemic areas should be guarded against by ratproofing ships and applying measures to prevent the escape of rats from vessels and their boarding of ships from the wharves. This is accomplished by rat guards on the hawsers. Ratproofing and the use of rodenticides have reduced the necessity for fumigation of ships.

Suppressing wild rodent plague in rural districts is almost im-

possible. The area is usually of unmanageable size, and knowledge of the many ecologic factors that influence control operations is so inadequate that, except in a few small areas in California, and, according to the Russians, in the Caucasian steppes, curtailment of the rodent population cannot yet liquidate plague among the species involved. For this reason it is essential that domestic premises be surrounded by rodent-free belts.

In an outbreak persons engaged in rat control should be immunized and should wear fleaproof clothing. While flea repellents do not prevent fleas from alighting, the insects do leave impregnated surfaces without biting.

Vaccination or the injection of antigens made from killed virulent organisms is used to immunize inhabitants of epidemic regions. These do not invariably prevent infection, but they do reduce the morbidity and mortality rate of bubonic plague. The steady decrease of plague in Indonesia was attributed to the use of vaccines consisting of living avirulent plague organisms. Equally favourable results were reported from Madagascar with this type of preparation. Workers in India, using the so-called Haffkine, heat-killed broth culture of a highly virulent strain, showed repeatedly that the total number of cases and the death rates were lower in the vaccinated than in the unvaccinated groups. Whatever means is used, repetition of vaccination strengthens the immunity produced.

Unless the necessary precautions are taken, pneumonic plague spreads from one person to another, and some additional measures must be taken against the other forms. Strict isolation of the patients in insectproof rooms is essential. The patient's clothing must be disinfected and disinfested of fleas in a steam sterilizer. All those who come in contact with patients must wear gloves and gowns. If the infection is pneumonic or suspected of being pneumonic, physicians, nurses and any others in contact with the patient must be protected by complete overalls, gloves, hoods equipped with goggles, and face masks of eight layers of gauze covered by a deflection mask.

The air of the room in which patients with pneumonic plague are housed, preferably under an oxygen tent, should be kept dry; possibly other auxiliary protective measures against aerogenic infection deserve consideration. The chance of infection through droplets or droplet nuclei is quite high, and infection of medical personnel, not uncommon. Persons other than medical attendants who are exposed to plague pneumonia must be quarantined for seven days, and chemoprophylaxis with sulfadiazine may be instituted.

See also BACTERIAL AND INFECTIOUS DISEASES; EPIDEMIOLOGY; FLEA; RAT; and references under "Plague" in the Index.

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(K. F. MR.)

PLAICE (*Pleuronectes platessa*), a flatfish of the family of right-eyed flounders (Pleuronectidae). It ranges from Iceland and northwestern Europe to the Gulf of Cádiz, and is one of the most important commercial food fishes of the North Sea. Both eyes occur on the right side, and the left side is virtually colourless. The plaice is easily distinguished from other common flatfish by the red spots scattered over the body. Strong bones in the throat bear large blunt teeth used for crushing the shells of bivalves, the principal food of this species. A length of more than 30 in. and a weight of 8 lb. may be attained, but nearly all the fish marketed are less than half that length. *See* also FLATFISH.

(C. HU.)

PLAIN. The term plain is commonly applied to any part of the earth's surface that is relatively level and at relatively low elevation. The surface of plains is, in general, more level than that of hill regions; and, of course, plains are much flatter than mountains. Plains are usually distinguished from plateaus by their lower elevations. There are, however, numerous exceptions to these generalizations. The roughest parts of the world's plains are considerably more rugged than many areas named hills and even some areas locally named as mountains.

Some plains (for example the western part of the Great Plains of the United States) stand at elevations of more than a mile above sea level and are thus higher than some areas designated as plateaus. But despite numerous exceptions most plains are comparatively low and flat. Various attempts have been made to standardize the definitions of plains and other land forms, but none of the proposed schemes of classification has been widely accepted.

Size and Distribution.—Plains vary widely in size. The largest plains cover hundreds of thousands of square miles; at the opposite extreme, in some rougher areas of the world, small flat areas of only a few acres are called plains.

Plains are found on all continents except Antarctica. There are plains north of the Arctic circle, in the tropics and in middle latitudes. Extensive plains are located in the deserts and also in humid areas. Plains are located in the centres of continents and also at the continental margins. Some plains are tree covered, some support scrub brush and bunch grass, others are grassy; some support only the most sparse and scanty vegetation. Some plains are nearly waterless deserts; others exhibit widespread swamps. An unusual distributional characteristic is that most of the world's major plains—those in Africa, Europe, North America and South America—are all drained by rivers that empty into the Atlantic.

Economic Importance.—Plains are the great centres of population, industry, commerce and transportation, for a number of reasons. The flat surfaces of plains are most easily cultivated and generally contain the most productive soil. They became some of the principal areas of population growth relatively early in human history. Their level surfaces offer fewer obstacles to land transportation than do hills, mountains or plateaus, and the rivers of plains are generally much easier to navigate than those of rougher terrain.

Most of history's great civilizations have developed on plains. Babylonia and Assyria and the other early civilizations of the near east arose and flourished on the great plains adjacent to the Tigris and Euphrates rivers. Egyptian civilization developed on the Nile plain. Most of the Greek cities were on small plains scattered in and adjacent to the hill lands of the Greek peninsula. Most of the civilizations that have endured for such long periods in the far east were based on the extensive plains along the eastern margin of Asia. West European civilization developed on the so-called North European plain. The significance of plains in human history is further demonstrated in the following discussion of major plains of the world.

North America.—Some physical geographers and geologists regard all of North America east of the Rocky mountains as a plain interrupted only by the Ozarks, the Appalachian mountains and plateaus, and the Laurentide mountains lying north of the St. Lawrence river valley. Under this view more than half of North America consists of plains.

Atlantic-Gulf Coastal Plain.—One of the simplest types of plains is represented by the Atlantic-Gulf coastal plain, which in the east

lies between the Appalachian highlands and the Atlantic, and which stretches from Virginia around through all the southern states to the Rio Grande river, and thence south for nearly 500 mi. along the Gulf coast of Mexico. This plain was uplifted from the sea in recent geological times. The net effect of waves and currents is to level off the undersea surface by filling in the depressions. When such a surface is uplifted from the sea without being seriously bent or broken it forms a low flat plain bordering the ocean, and is called a coastal plain.

The coastal plain of eastern North America, like most coastal plains, is a low, flat, almost featureless plain. Because it is so flat drainage is poor. Swamps cover broad areas; the Okefenokee swamp of southern Georgia is the best known. Rivers are broad and sluggish. The plain is underlain in many places by unconsolidated sands, gravels and clays that were originally deposited beneath the sea. Although in places the coastal plain extends inland more than 150 mi., it generally lies only 100–200 ft. above sea level.

Great Plains.—The Great Plains stretch more than 2,000 mi. north and south along the eastern base of the Rocky mountains and average approximately 300 mi. in width, sloping gently to the east from the base of the mountains. The surface of the Great Plains varies from extreme flatness (as, for example, in north Texas) to areas so rough that most persons would not regard them as plains. Over vast areas the plains are built of material eroded from the Rocky mountains and spread out in a great alluvial apron at their base. These alluvial materials (some in the form of rocks, others consisting of loose sand and gravel or clay) underlie the plains. The Great Plains are an enormous expanse of grassland (*see* PRAIRIE).

Laurentian Plateau.—The whole northeastern quarter of North America is one of the areas that physiographers and physical geographers have classified in various ways. It has been designated as the Laurentian plateau, as hill country and as a plain. It is a vast area of low relief; a country of rolling hills, swamps and tens of thousands of lakes. The plain has been formed by the erosion of extremely ancient mountains to low relief. In the immediate geologic past the whole area was severely glaciated. Glaciation removed the loose surface materials, leaving the present surface largely bare rock. It smoothed and evened the surface, and thereby so disarranged the drainage pattern that it created the myriad lakes and swamps now found there. Nearly all the area is now covered by coniferous forest except on the northern margins where it grades into tundra.

Interior Plains.—Lying west of the Appalachian highlands and between the three plains areas previously described is a plain known by various names such as the Interior plains and Interior lowlands. These plains are less extensive than those mentioned previously but are extremely important agricultural areas. They contain the corn belt, the dairy areas of the lake states, the blue grass region of Kentucky and the Nashville basin of Tennessee. In general these plains are underlain by relatively flat-lying sedimentary rocks such as shales, sandstones and limestones; but in some places the rocks are warped upward into low arches or downward into shallow depressions.

The northern part of the region—north of the Missouri and Ohio rivers—is an area of glacial deposition, where the material eroded from the Laurentian rock plains was deposited. Originally the areas had three major types of vegetation—mixed conifers and hardwoods in the north, magnificent hardwood forests in the Ohio basin and farther south, and long grass prairies in the centre.

Europe and Asia.—The greatest uninterrupted expanse of plain on the globe sweeps from the Pyrenees mountains on the French-Spanish border across northern Europe and Asia nearly halfway around the world almost to the Bering sea. In western Europe the plain is comparatively narrow, rarely exceeding 200 mi. in width; but as it stretches eastward it broadens steadily until it reaches its greatest width in eastern Siberia, where it extends more than 2,000 mi. from the mountains of central Asia north to the Arctic ocean.

A plain of such vast extent exhibits a wide diversity of conditions. It embraces wide differences in human geography, rock structure and composition, climate and vegetation.

North European Plain.—The European section covers all of western and northern France, Belgium, the Netherlands, Denmark, northern Germany, southern Scandinavia, and nearly all of Poland and Finland. From northern France and Belgium eastward it is commonly called the North European plain.

Conditions in the North European plain are complex in detail. The terrain is flat or gently undulating. Most of the area has been glaciated and large sections are underlain by relatively unproductive sands and gravels. Sandy dune lands border the North sea and the Baltic. In the Netherlands an extensive delta plain is formed by the deposits of the Rhine river. Delta plains generally are among the most productive and populous. The soils are usually rich and fertile because the materials have only recently been deposited by the delta-forming stream. The terrain is flat, a favourable condition for agriculture if the land can be properly drained, and the stream that forms the delta is useful for transportation. The section of the North European plain bordering the North sea is one of the most densely populated areas in the world.

Finland and the U.S.S.R.—In Finland and adjacent parts of the U.S.S.R. are plains very similar in several characteristics to the Laurentian plains of northeastern North America. Finland is underlain by ancient, resistant, crystalline rocks that have been worn down to a surface of low relief and then severely glaciated in recent geological times. With its extensive areas of lakes and swamps caused by the disarranged drainage pattern, thin soils and coniferous forests, the Finnish plain is very similar to northern and eastern Canada in character and appearance.

The continental glaciers that planed, eroded and polished the rock surfaces in Finland deposited part of the material over the plain to the south. Heaps of glacial material called moraines are strewn in great arcs across northern Germany, Poland and the European sections of the U.S.S.R. Interspersed with the moraines are long parallel spillways where glacial meltwaters flowed to the sea parallel to the ice front. These spillways were covered with sand and gravel by the rushing glacial streams; consequently they are flat, poorly drained and relatively unproductive.

The European section of the U.S.S.R. is deeply underlain by a relatively rigid platform of ancient rocks. However, at various times in its history this area has slipped beneath the sea and been covered with sedimentary rocks. These have been mildly bent and warped but nowhere have they been sharply deformed. Consequently the whole area from the Black sea to the Arctic is one uninterrupted plain, everywhere below 1,500 ft. elevation.

Despite its great uniformity in terrain the Russian plain is not featureless. Climatic differences produce great belts extending approximately east-west across the country. The southern part of the plain is an area of semiarid grasslands which grade toward the north into more humid lands with taller grasses and rich, fertile soils. North of the grasslands lies a belt of hardwood forests; in the severely cold north lies a belt of coniferous forests, and bordering the Arctic ocean a belt of tundra.

West Siberian Plain.—The West Siberian plain of northern Asia is an extension of the Soviet European plain. In the north the sweep of the plains is interrupted by the narrow belt of the Ural mountains but in the southern half there is no break whatever. It is one of the largest and flattest areas in the world. It is underlain by flat-lying sedimentary rocks, which in the northern part are quite recently deposited. The northern part is also covered with glacial deposits. Vast sections of the northern Siberian plain are underlain by permanently frozen ground, although the surface layer thaws in summer. It contains enormous areas of swamp. The same belts of vegetation and soils are encountered in Siberia as were noted in the European section of the plain. In the south almost 1,500 mi. of semiarid steppe grades into desert. The huge steppe and desert plains east of the Caspian sea range from flat to quite rough in some areas. They are very sparsely inhabited except in the irrigated oases.

Other Plains in Asia.—Eastern Asia is predominantly a land of hills and mountains. Flat land makes up a relatively restricted

part of the whole vast area; but partly because plains are so restricted in area they are of critical importance. The two large plains are the Manchurian plain and the North China plain.

The Manchurian plain is surrounded on three sides by mountains but opens out to the sea to the south. It is underlain by sedimentary rocks that have been only slightly warped. It is an erosional plain and consequently parts of it are quite rough. It is mostly semiarid and so had a grass cover under natural conditions. This grassland produced excellent fertile soils, highly productive under agriculture.

The Manchurian plain connects by a very narrow strip of coastal plain with a great plain to the south—the North China plain or Yellow plain. The Yellow plain since earliest history has been one of the major centres of Chinese culture. It is a great alluvial deltaic plain, built into the sea by deposits of the Yellow river and a few other minor rivers. The North China plain is very flat and one of the most densely populated areas on earth. A population at least half that of the United States occupies a plain covering only about 125,000 sq.mi.

To the south the Yellow plain merges into the Yangtze plain, a somewhat smaller plain built by the Yangtze river in essentially the same manner as the North China plain. It too is densely populated.

Extending from the Yangtze plain south along the eastern coast of Asia is a relatively narrow coastal plain, which widens out in a few places where large rivers debouch into the sea and have built wide delta plains. Examples are the plain on which Canton is located in southern China, and the deltas at the mouths of the principal rivers of southeast Asia—the Irrawaddy, Salween and Mekong.

One of the larger plains of Asia occupies all of the northern part of the Indian peninsula south of the Himalayas—the Indo-Gangetic plain or lowland. Most of it is a great alluvial plain deposited by the Ganges and Brahmaputra rivers in the east and the Indus river in the west. Near its western margin it is an erosional plain. The eastern part of the plain has light rains or drought in the winter but in summer rainfall is so heavy that vast areas become swamps or shallow lakes. The plain becomes progressively dry toward the northwest and in western Pakistan is a true desert.

A narrow coastal plain borders nearly all of the Indian peninsula.

The last major plain of Asia is the great alluvial plain formed by the Tigris and Euphrates rivers in Iraq, mentioned previously as the scene of some of the earliest civilizations.

Africa.—Plains make up a far smaller proportion of Africa than of any other continent, if plains are defined as occurring only at low elevations. A strip extending along the Mediterranean sea in northwest Africa and occupying most of Egypt is a desert plain. Much of west Africa is also a vast desert plain. Elsewhere in Africa flat lands at low elevations occur only as an extremely narrow coastal plain along the west coast south of the equator and as a somewhat wider coastal plain stretching along the entire east coast south of the Red sea. These coastal plains vary from dense, tropical jungle with heavy rain and extensive swamps to some of the hottest and most rigorous deserts in the world, along the east coast north of the equator.

Vast sections of the interior of Africa are very flat and lie at elevations less than those of the western High Plains of the United States. They could be described as plains but ordinarily interior Africa is classified as a vast plateau.

South America.—Similar disagreements concerning classification are possible for the plains of South America. The Andes mountains run in an unbroken chain along the western margin of South America from the northern to the southern tip. All along the eastern base of the Andes is a great flat alluvial apron spread out by the streams flowing east from the Andes. These areas are universally regarded as plains. The vast areas of the middle and lower Amazon basin and the eastern Parana basin are rolling, slightly hilly lands. Some authorities regard these as rough plains and others consider them hill lands. Under a broad definition of the term more than half of South America consists of plains.

Australia.—Most of the interior of Australia stretching from the mountains along the eastern margin to the plateaus in the far west is one vast desert plain. Parts of the western part of the plain are moderately rough.

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PLAINFIELD, city in Union county, N.J., U.S., 24 mi. S.W. of New York city. It is served by a well-knit transportation system of express highways, major railroads, motor freight carriers, bus lines and a local airport which connect it with the surrounding metropolitan areas. Although the city is primarily residential in character and is culturally active, it possesses a number of major industries that make it the business centre of central New Jersey. Its chief manufactures include automotive equipment, printing equipment, electronic products, machinery, chemicals, garments and appliances.

Plainfield was settled in the 18th century as Milltown because it possessed a large gristmill. During the American Revolution it was part of Washington's system of defense for northern New Jersey. In 1847 it became a township; in 1869, an incorporated city. For comparative population figures *see* table in NEW JERSEY: *Population.* (W. L. Ca.)

PLAINS INDIANS are the tribes of North America popularly regarded as being the most typical American Indians. Occupying the Great Plains (High Plains) and prairie margins extending from what are now Alberta and Saskatchewan in Canada to Texas in the south, and from the Rocky Mountains to the vicinity of the Missouri and Mississippi rivers, they ranged over the primary habitat of the American bison (*q.v.*). The most typical Plains tribes depended on the bison for food, clothing, and shelter, the annual round of life being closely adapted to the habits of the herds. Eastern tribes in the prairie plains combined maize agriculture with bison hunting and in general were more sedentary. Intermontane peoples in the west periodically traveled to the plains for hunting, and a few moved there permanently after the introduction of horses.

F. V. de Coronado (*q.v.*) traversed the plains (1540–42) and reported nomadic Indians, whose tents were dragged on travois frames by dogs, and who lived off the bison. Two centuries later a more elaborate life centred on the use of horses was discovered in the northern plains; this intensified phase lasted until the virtual extinction of the herds in the 1870s.

Clark Wissler (*q.v.*) listed among the most typical tribes the Assiniboin, Blackfoot, Crow, Gros Ventres (*qq.v.*), Teton Dakota (*see* DAKOTA), Arapaho, Cheyenne, Kiowa, and Comanche (*qq.v.*), who occupied the central High Plains from north to south. On the northern margins of the plains were the Plains Cree, Plains Ojibwa, and Sarsi, who had moved out of the forest areas in recent times under pressures from the east (*see* CREE; OJIBWA). On the eastern margins were the village tribes: the Arikara, Hidatsa, and Mandan (*qq.v.*) on the upper Missouri River, and the Omaha, Pawnee, Osage (*qq.v.*), Iowa, Oto, Kansa, Ponca, Missouri, Wichita, and Eastern Dakota in the prairie plains. On the western margins were the Northern Shoshone, Bannock, Wind River Shoshone, Ute (*q.v.*), and Mescalero Apache (*see* APACHE; SHOSHONE). In the south were the Lipan Apache and the Kiowa Apache, the latter in symbiotic relation to the Kiowa and to be considered a typical tribe.

The tribes belonged to linguistic stocks as follows:

Algonkian.—Blackfoot (Piegan, Blood, Northern Blackfoot), Cheyenne, Arapaho, Gros Ventres, Plains Cree, Plains Ojibwa (*see* ALGONKIAN TRIBES).

Siouan.—Mandan, Hidatsa, Crow, Teton Dakota, Assiniboin, Omaha, Ponca, Osage, Kansa, Iowa, Oto, Missouri (*see* SIOUAN INDIANS).

Caddoan.—Pawnee, Arikara, Wichita (*see* CADDO).

Kiowan.—Kiowa.

Uto-Aztecan.—Comanche, Ute, Wind River Shoshone, Bannock.

Athapaskan (*q.v.*).—Kiowa Apache, Lipan Apache, Mescalero Apache, Sarsi.

None of these linguistic stocks (with the exception of Kiowan) was restricted to the High Plains; Kiowan is related to Tanoan, the major language group of the Eastern Pueblos (*see* CENTRAL AND NORTH AMERICAN LANGUAGES). Obstacles to communication

represented by so many languages and dialects were partially overcome by a sign language (*q.v.*) comparable to that used by deaf-mutes. Complex ideas could be expressed with hand gestures, still used in the 1960s by older Indians at Sun Dance (*q.v.*) encampments.

The population of the Plains tribes was never very large. Estimates for the period (1780) before profound European influences give a total of about 50,000 for the typical tribes and roughly the same for the eastern village tribes. Small tribes generally joined larger groups; thus the Sarsi joined the Blackfoot confederation and the Kiowa Apache formed one band in the Kiowa camp circle. The introduction of diseases new to them had devastating consequences particularly for the village dwellers; *e.g.*, Mandan numbers were cut from about 1,600 to 150 by smallpox (1837).

The High Plains, with scanty vegetation, nomadic fauna, and few trees, offered considerable difficulties to settlement. But once hunting techniques were adapted to the bison, nomadic life became practicable; with the introduction of horses by Spaniards, Plains culture reached a high degree of development and attracted marginal groups from all sides.

Collective hunting efforts were essential for the survival of large groups on the plains. Driving game into a pound is ancient practice in the northern forest regions. In the plains, converging lines of bison were driven into corrals or over cliffs; in the prairies the game was hemmed in with fire. With hunters on horseback the surround (in which the animals are encircled and forced to mill around) became highly effective; the kill was high, even with bows and arrows. Bison was the staple meat, eaten fresh or as pemmican (*q.v.*). The typical tribes cooked by roasting or by boiling with hot stones in rawhide containers.

The basic dwelling in the plains was the skin-covered tepee, erected over a conical framework of poles. Some groups used a three-pole foundation, others a four-pole base, on which other poles were added; the whole was covered by bison skins cut and sewn by women. A fireplace was in the centre and a smoke vent was controlled by extra poles. Tepees might be decorated to picture war exploits or visions of the owner. Furnishings were simple: household property and food were stored in parfleches (rawhide bags) and buffalo robes were used for sleeping. The village tribes to the east characteristically lived in large earth lodges but used tepees on summer hunts. The Wichita built modified earth lodges (with grass thatching) that were well adapted to the southern prairie plains. They were set up in semipermanent villages in contrast to those of the high plains (*see* DWELLINGS, PRIMITIVE).

Plains clothing was of dressed skins and included leggings, moccasins, shirt, and robe for men; and long dress, leggings, and moccasins for women. Women tanned hides, stitched bison sinew with awls, and decorated the skins with porcupine quills and elk teeth (later beads). Dressing and tanning were highly developed but weaving, pottery-making, and woodworking were uncommon or unknown.

Major weapons were bows and arrows, though clubs and spears were also used. Wooden bows were of osage orange (*q.v.*) or ash, or cut from horn with sinew backing for strength and resilience. Arrows were feathered and pointed with chipped stone points before iron became available; bows were retained long after the introduction of firearms since they were more effective from horseback than single-shot muskets. Circular shields of buffalo hide were used for defense.

High Plains Organization.—The basic social unit of High Plains tribes was the band, a local group who jointly camped and hunted during much of the year under one leader. Bands differed in size and composition, depending on their fortunes in war and hunting. The Cheyenne, for example, had ten bands with an average of about 360 persons each; Kiowa bands were much smaller, and those of the Teton Dakota considerably larger. Close relatives of the leader frequently composed the nucleus of a band; leaders attempted to attract followers through successful raids.

Tribal affairs developed during the summer when the bands assembled in a great circle at some prearranged camp. Each band was assigned its position in the circle which, like the lodges, was open to the east. For the Cheyenne and others the camp circle symbolized a great lodge that embraced the tribe; it was also an important defensive arrangement, and valuable horses were usually picketed inside.

Kinship (*q.v.*) was bilateral and widely extended (as far as could be conveniently remembered) within band and tribe. In the individual's own generation all cousins were "brothers" or "sisters," and relatives had important responsibilities for aid and support. Marriage was generally outside the group of known relatives, and had the effect of integrating the people. Normally, matches were arranged by the families, though the young men preferred to elope. Residence was with the wife's family in some groups but in others might be with parents of either or with siblings. Among the Cheyenne, for example, the pair normally took a separate lodge near the wife's parents' camp to form an extended matrilocal family. The husband was required to avoid all contact with his mother-in-law, but cooperated with his father- and brothers-in-law in such activities as hunting. He was expected to joke in public with his brothers- and sisters-in-law, and might marry one of the latter as an additional wife or after the death of his wife (*see* MARRIAGE, PRIMITIVE).

Oscillation between the isolated band and camp circle was closely related to the habits of the bison and the exigencies of winter. During fall and winter the bison dispersed in small herds, seeking shelter and forage along streams or migrating south. Tribes in the central plains did likewise, each band seeking a traditional wintering area where fuel, shelter, and hunting were adequate. In late spring and early summer the bison coalesced in larger herds for mating as grass became available; tribal bands also assembled for communal hunting as well as for social and religious purposes. Cheyenne report they tried to stay together as a tribe one winter but nearly starved and never tried it again (*see* ECOLOGY, HUMAN).

When the tribe reassembled social institutions dormant during winter came to life. A chiefs' lodge was erected in the camp circle and a political organization of chiefs decided tribal affairs. The Cheyenne had an unusually elaborate council of 44 chiefs, 4 elected every ten years from each band, plus an executive group of 4 held over from the previous year. Military (war) societies with membership that cut across band organization came into operation and put up headquarters lodges within the circle. Most such societies competed for war honours and in giving dances and feasts; but, notably among the Arapaho, Blackfoot, Gros Ventres, Mandan, and Hidatsa, they were organized on an age-graded basis, younger groups making up warrior units and older groups having political and ritual control. One or more parallel societies for women usually were concerned with making tepees or beadwork. One of the societies of men was usually chosen as camp police to enforce law for the chiefs. Their main duty was to organize the communal hunt; breaches of hunt rules (which might endanger food supply) were punished by whipping and by destruction of lodges and other property.

A lodge was also erected to house tribal symbols normally in charge of a hereditary keeper. The Cheyenne had four sacred medicine arrows to which offerings might be made or vows given, and the Arapaho had a sacred pipe kept in a special wrapping. Among the Cheyenne the arrows were symbols of tribal warfare; when murder was committed they were stained or polluted and had to be renewed in a special ceremony. In any case the arrows were periodically renewed and it was compulsory that every male should view them. Plains Indian religion centred on individual visions and on such great communal ceremonies as the Sun Dance. Most tribes had no central deity, though the sun was important for all. More significant were culture heroes believed responsible for securing the bison; or "Old Man Coyote," both creator and buffoon. (*See* also FOLKLORE [AMERICAN INDIAN].)

Village Tribe Society.—The village tribes in the prairie plains tended toward more complex social organization centred on unilineal descent and on maize agriculture coupled with hunting. The Mandan, Hidatsa, and Arikara in the north, and the Pawnee and perhaps originally the Wichita in the south were matrilineal (*see* MATRILINY) and matrilocal, though the Caddoan clans were weakly developed. (The Crow of the High Plains, an offshoot of the

Hidatsa, retain this organization in part.) The Omaha, Ponca, Osage, Kansa, Iowa, Oto, Missouri, and their neighbours were patrilineal. Some groups (*e.g.*, the Omaha) were matrilocal with respect to earth lodges, but patrilocal with respect to tepees. Men did the hunting; women cultivated gardens in bottomlands along streams.

The tribes were organized as series of clans, with parallel or age-graded societies of crosscutting membership. Often the clans were also organized into phratry groupings or into a dual division, and each clan was assigned particular symbolic or ceremonial functions.

After late spring planting the village tribe's communal hunt began; able-bodied men and women traveled, camping with tepees in a circle typical of the High Plains tribes, and with similar policing. After a successful surround the surplus meat was brought to the village to be dried and stored for fall and winter. After the harvest surplus corn, beans, and squash were traded to neighbouring Plains groups for meat and hides; villagers later continued hunting or went on raids.

Prehistory and History.—The archaeological record shows an early culture on the western and southern margins of the plains devoted to hunting large game, particularly the now-extinct mammoths, wild horses, bison, and camels. These Clovis and Folsom men (*see* INDIAN, NORTH AMERICAN) skilfully manufactured large fluted projectile points, and date from the end of the last glacial period (about 12,000 years ago). From about 5000 to 3000 B.C. extended drought apparently drove their successors from the plains and brought about the extinction of most species on which they lived. Later, with amelioration of climate, new species including a smaller variety of bison gradually repopulated the plains.

In the next period the plains seem to have been occupied only intermittently. Agriculture that developed in the Mississippi Valley gradually spread along the bottomlands into the plains. Earth lodges appeared soon after in the region between the Platte and Missouri rivers, and gradually grew in size and complexity.

With the introduction of Spanish horses a reorientation took place in the relations between high plains and prairie. Beginning about 1600 the horses spread northward from the region of New Mexico, reaching the Northern Shoshone about 1700, and most of the Plains tribes by 1750, though not always in large numbers. Wissler believed that horses intensified existing cultures by replacing dogs as transportation and making hunting much more profitable; A. L. Kroeber argued that horses so revolutionized values that marginal peoples moved into the plains to develop a new way of life.

With the exception of the Kiowa, every tribe of the High Plains can be traced (with historical, archaeological, or linguistic documentation) to other areas. The Athapaskan tribes moved from the solid block of Canadian Athapaskans, arriving in the south not long before the Spaniards. In the northeast the French had armed their Indian allies and fur trappers with guns, and the better-armed Ojibwa forced the Dakota groups and the Cheyenne out of the forest-prairie onto the plains. The other Algonkian groups, the Blackfoot, Arapaho, Gros Ventres, Plains Cree, and Plains Ojibwa, are also relative latecomers to the plains. The Comanche represent an advance group of Shoshone who made early use of horses to move south into the Staked Plains of the Texas Panhandle. On the east such tribes as the Pawnee and their neighbours attempted to maintain their old life and to participate in the new.

Despite the revolutionary effects of the introduction of horses, Plains life in the late 18th and early 19th centuries clearly had its origins in earlier High Plains patterns. The Cheyenne, who became one of the most typical of High Plains tribes, were living in earth lodges and cultivating maize in western Minnesota as late as 1800. By the early 1900s they barely remembered their former life. The essentials of the new adjustments, however, were present on the plains in Coronado's time, and probably much earlier.

The elaboration of Plains life that has impressed most observers is related to warfare and raiding. The tribal wars were usually not for territory, though groups on disputed hunting grounds often had to fight. Raids, on the other hand, were frequent and easily organized; many successful leaders were credited with supernatural sanctions, attracting many followers. Most often organized to obtain horses, such raids could also be used for killing and scalping enemies. Tribal leaders usually attempted to restrain such ventures, since they inevitably invited revenge. They had little success, since prestige depended primarily on a man's success in war, and such exploits were recounted on all public occasions.

A recognized system of war honours, usually called counting coup (French *coup*, a blow), grew up on the plains. Among the Cheyenne touching an enemy outranked the mere killing of a man. The Crow (*q.v.*) had four types of coups: leading a successful war party, touching an enemy, stealing a picketed horse, and snatching a weapon from the hands of a foe; a chief had to have at least one of each to his credit.

Horses gave great impetus to warfare; some southern Plains groups regularly raided Spanish settlements for horses, but only the Comanche bred them to any extent. Most groups were content to raid others, or to capture and break mounts from the growing numbers of wild horses.

With the discovery of gold in California in 1848 the plains were increasingly traversed by whites. Though Indians had once been able to play one European nationality against another, U.S. expansion made conflict inevitable. This struggle is portrayed with more or less accuracy in modern films, and forms an important part of U.S. history. By about 1890, after fighting against great odds, the Indians had all been settled on reservations.

An important aspect of this struggle was the development of the Ghost Dance (*q.v.*), one of the most important American nativistic movements. The religion, as practised among the Plains Indians, adhered to the belief that the whites would be exterminated and that the bison would return. With the defeat of Sitting Bull's forces (1890), the Ghost Dance gradually declined.

Another movement (*see* NATIVISTIC MOVEMENTS) was still growing in the second half of the 20th century. Peyotism (*q.v.*), in which peyote cactus is eaten, has a long history in Mexico but was not introduced to the southern plains until about 1870. Peyote contains alkaloids that produce such hallucinations as colour visions. The drug was ideally suited to a society in which old values were crumbling, but visions still had authority. Early following a native pattern the religion later included various Christian elements, and in the 1960s held charters as the Native American Church in many states.

Most Plains tribes adjusted poorly to reservation life at first; they had little interest in farming and their lands were marginal.

During the 1930s a gradual revival on many reservations included the performance of Sun Dances and the reorganization of old societies. With improved transportation after World War II a growing Pan-Indian movement centred in Oklahoma. Plains Indian dancing at secular celebrations (powwows), usually on such holidays as the Fourth of July, was an important feature.

According to A. L. Kroeber the Plains tribes were brave, proud, outspoken, and direct, with an unusual sense of individuality. Their long hair, buckskin costume, and eagle-feather war bonnets have captured modern imagination as epitomizing American Indians. But by mid-20th century only a handful survived who participated in pre-reservation life; their descendants, in the words of Gordon Macgregor, are warriors without weapons.

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(F. R. E.)

PLAINSONG (Plainchant) is a general term for a certain style of unisonal music, comprising chiefly the church music called Gregorian, which belongs to Rome, and that called Ambrosian, which comes from Milan. Other collections of Western church music, much less well known than these, and a good many groups of Eastern church music could also quite properly be put under this heading.

Origin.—Various factors in the genesis of music determine its essential characteristics. Music intended for a dance is necessarily regular in its rhythm; so also, though less tied, is music which is set to metrical verse. On the other hand, music fitted to a prose text is not so regular. Thus there arise different kinds of rhythm in music, ranging from strict time to the freest of movement. Again, some music arises from recitation and the need to declaim some words artistically and audibly; while other music aims at melody, that is to say a succession of sounds which is pleasant for its own sake and would be so independently of any words.

The Christian Church, like other worshiping bodies, requires euphonious sounds for the recitation of its psalms and for the reading of its scriptures in public. As these passages are not (for the most part) written in any strict metre, the music to be provided is essentially a "plain" chant. There are several classes of such plainsong. The term is a translation of *cantus planus*, meaning unmeasured music, not regular in rhythm, as contrasted with *cantus mensurabilis*, measured music.

Influence of the Psalter.—The chief influence in the evolution of plainsong has been the Psalter. Hebrew poetry follows a metrical system, but this disappears in translation. There survives, however, a more obvious feature of the original poetry, viz., its parallelism. This consequently becomes a prominent characteristic of certain sorts of plainsong, so that the chants directly derived from the psalms take a binary form. The recitation demands a reciting note, on which the text can be freely recited in its own rhythm and shape. If this note alone is used, the effect soon becomes, in the strict sense of the word, monotonous. Therefore the music adopts the natural tendency of the voice to rise up to its reciting note at the beginning and to drop down from it at the end of the phrase. Thus arises the commonest chant form of plainsong, consisting of (1) an intonation, (2) recitation, and (3) cadence, in each half-verse.

The psalm tones, whether Gregorian or Ambrosian, take this shape; and the form is capable of more or less elaboration for the psalms. The Gregorian tones are very simple; more elaborate forms are used for the Gospel canticles, and still more developed forms for the introits. A limit is naturally set to the amount of elaboration either (1) when whole psalms are to be sung at length, or (2) when they are to be sung by the whole congregation. When, however, select verses only are sung, by trained singers, there is far more scope for elaboration; and the developed responses used both at Mass and at the choir office exhibit this chant form in a highly ornamental shape.

The chief development occurs in the cadences. In its simplest form the musical cadence affects only the last syllable; there is the drop of a minor third. Next it concerns the last two syllables. The more elaborate cadences naturally followed the "cursus" used by Latin prose writers of the best, or at any rate the most formal, style. In the responses a five-syllable cadence is constantly in use, often in a highly decorated form.

All this music arises out of the recitation of psalms. For the purpose of declaiming the lessons of Scripture only the simpler inflexions were used; and the same is true of the prayers or collects, except a few which are of exceptional solemnity, such as the *Pater Noster* as used in the consecration prayer at Mass, and the hallowing of the baptismal font.

Antiphons.—Next to be considered is a totally different way of beautifying the recitation of psalms or other prose texts. Instead of elaborating the chant itself there was interpolated between the verses a suitable refrain. These refrains came to be known as "antiphons": and thus side by side with the older method, which came to be called "responsorial" from the responses which represented it at its fullest development, there arose the newer "antiphonal" method. The former music developed from recitation, and even in its most elaborate forms in more or less degree it hung round a reciting note. The antiphons were purely melodic and the method had its quality and meaning determined, not by reference to a "dominant" reciting-note, but to the "final," the note on which it ultimately came to rest.

Antiphonal music underwent modification and development just as the responsorial music did. Its relation to the psalm altered; the singing of the refrain after each verse survived mainly in processional use. In choir offices the refrain was dropped so that it was sung only at the beginning and end of the psalm, or else in a curtailed form at the beginning and in full only at the end. In the psalmody of the Mass the opposite form of abbreviation was adopted. For at the introit and the communion the psalm became restricted to only one or two verses, and at the communion it ultimately disappeared altogether, leaving the antiphon alone.

Some antiphons composed on a large scale arose independently of any connection with a psalm. These were used especially in processions. Others retained the idea of a psalm verse, but utilized for such verses not the normal psalm tones but independent melodies, perhaps as elaborate as the psalm itself. Such antiphons especially prevailed at the offertory in the Mass.

The greater part of the classical Gregorian plainsong falls into one or the other of these two classes. The amount of elaboration depended mainly upon two considerations: (1) the importance of the occasion; and (2) the capacity of the singers. A great festival or a specially dignified part of the service demanded richer treatment, and the trained singers undertook the more difficult music.

The Gregorian Music.—The *cantilena Romana*, Gregorian chant proper, is a body of music, purely vocal and ecclesiastical, evolved by the papal choir in the course of the 5th and 6th centuries. This was codified in the time of Pope St. Gregory I (*c.* 540–604) and stands as the basis of all the Gregorian music. The Milanese tradition was similar but less artistic. It is called "Ambrosian" (*see* Ambrosian Chant), but the term has no historical significance as the term Gregorian has. A comparison of these two families of plainchant brings out clearly the comparative crudity of the Ambrosian tradition as distinct from the artistic balance and delicate finish of the classical Gregorian chant. The same is true also of such other specimens of Western ecclesiastical chant as are known. The Gregorian reform marks the close of a golden age of classical monody. The Middle Ages subsequent to St. Gregory produced nothing so good; and the later Middle Ages, while producing only little and decadent plainsong, degraded also the form of the classical tradition.

Gregorian music covers the whole set of services of the Roman rite, but principally the Mass and the series of daily choir services. At the Mass some of the things sung are invariable, while others change according to the Sunday, or festival, or other special occasion. The unchanging elements are chiefly the *Kyrie*, *Credo*, *Sanctus*, *Agnus Dei*, and *Gloria in excelsis*. For these the old tradition provided little or no change of music; and what there was followed very simple lines suitable for congregational singing. The variable elements were principally the introit psalm, the responses of the gradual, the offertory antiphon, and the communion antiphon. The gradual was at times replaced or supplemented by an alleluia with a verse attached to it, or by a tract. The alleluia belonged specially to festive seasons and occasions, the tract to penitential. Neither of these falls exactly into either of the two chief categories, responsorial and antiphonal. The tract is a very ancient but elaborate type of the developed psalmody; the alleluia was an innovation which came in toward the end of the classical period and extended beyond it into the "silver age" when little else was being composed.

For the choir offices there was provided a large number of antiphons to go with the psalmody, and a considerable number of responses which mainly served as interludes between the lessons at matins. When hymnody began with St. Ambrose it was taken up and incorporated into the services by the monks; but Rome was for a long time too conservative to admit hymns. The plainsong hymn tunes are, in the nature of the case, more clearly metrical than the other music, but they retain a considerable free-

dom of movement, and are not "measured," like modern hymn tunes.

Underlying Musical Theory.—Plainsong is based on a series of eight scales, called "church (or ecclesiastical) modes." It uses the old diatonic scale of the Greek theorists (equivalent to the white notes of the piano with the addition of B♭), but the modes themselves are different from the old Greek modes, and the use of the old Greek names only leads to confusion. The eight-mode system is probably the same as that which underlies the Eastern church music; but the origins are obscure alike in East and West. The scheme seems to go back at least to St. John of Damascus (died *c.* 752); but it is known in the West only in theoretical treatises derived through the Byzantine teachers at the court of Charlemagne at the end of the 8th century.

The eight modes are really four pairs, each pair being founded on the same note, the one scale (called authentic mode) being an octave ranging above the foundation or final note, the companion (called plagal) being an octave ranging above and below it. Each of these pairs has a character or tonality of its own, dependent upon the position which the semitones have in the scale. None is similar to the major or minor key of modern music. It is this tonality which gives the special character to plainsong melody. Some theorists have reckoned 12 or even 14 modes; but this is unnecessary. As far as pitch goes, the range of two octaves covered by the eight modes is adequate; and as far as tonality is concerned, the new modes would be only the same as the first four or six over again with the B♭ used instead of B. (*See* also Modes, Musical.)

This modal theory does not fully account for all the procedure of the classical plainchant, but these eight modes form the foundation of this music, whether responsorial or antiphonal.

In the Middles Ages the *cantilena Romana* was handed on by tradition from St. Gregory's days; in the 9th century it was recorded in staffless neumes (*see* Musical Notation). The notation on a stave which began later, while it fixed accurately the pitch of each note, failed to indicate the rhythmical delicacies of performance. Hence the renaissance of classical plainsong was based on a return to the neumes, as interpreted by the subsequent tradition.

The revived interest in music during the Carolingian era (8th and 9th centuries) stimulated composition, which had been long in abeyance. New music for new feasts was produced and also fresh settings of the ordinary (fixed elements) of the Mass. The old music was preserved, together with interpolations known under the generic name of "trope." The tropes pervaded all church music for a century or more; but then they went out of fashion, leaving only two considerable legacies: (1) a further series of settings of the ordinary; and (2) the new form of rhythmical, or (later) metrical, poem called sequences or proses. These survived in considerable numbers down to the 16th century, but only a few are in modern use.

Modern Revival.—The rise of the art of harmony diverted attention from the monody of plainchant, and part-singing had the effect of "measuring" the music so that it fell into regular time and was no longer free or "plain." Under these influences the old plainsong was progressively debased and, with the development of the harmonic concept, plainchant declined. Not until the 19th century did this decline cease. The efforts then made in various quarters to recover alike the true rhythm and tonality of the old music culminated in the work of the Benedictines of Solesmes Abbey in France and their followers, and in the revival which produced the new Vatican gradual and antiphonal. With the recovery of the music came a new insistence upon its use and study as the official music of the Roman Church.

See also Mass: *The Music of the Mass.*

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(W. H. F.; X.)

PLAINTIFF, the party who brings a legal action or in whose name it is brought, as opposed to defendant, the party sued. The term corresponds to petitioner in equity and the civil law and to libelant in admiralty. It is generally applied also to the equity petitioner, particularly in those jurisdictions in which law and equity are merged. The party who sues out a writ of error to review a judgment or other proceeding at law is often denominated the plaintiff in error, irrespective of whether he was the plaintiff or the defendant in the lower court proceedings. *See* Practice and Procedure. (C. E. Cl.)

PLANCK, MAX KARL ERNST LUDWIG (1858–1947), German physicist who introduced the quantum theory, one of the great achievements of modern science, for which he won the Nobel Prize in Physics in 1918. Planck was born at Kiel on April 23, 1858. He studied at the universities of Munich and Berlin and received his doctorate at Munich in 1879.

Although he studied under Gustav Kirchhoff and Hermann von Helmholtz in Berlin, his early work drew its inspiration from Rudolf Clausius' writings on thermodynamics, and Planck devoted himself for some years to clarifying the concept of entropy and showing its importance in thermodynamics. During these years he was first instructor (*Privatdozent*) in Munich, from 1880 to 1885, and then associate professor of theoretical physics in Kiel until 1889. In that year he was called to the University of Berlin as Kirchhoff's successor and taught there until his retirement in 1928.

LOTTE MEITNER-GRAF

PLANCK, PHOTOGRAPHED IN LONDON IN 1946

In 1897 Planck turned his attention to the problem of blackbody radiation, and tried to derive the wavelength distribution of the energy emitted by a black body (*q.v.*) as a function of temperature. He tried first to show that thermodynamics and electromagnetic theory required this distribution law to have the form proposed earlier by W. Wien, which agreed with the experimental results then available. When it became apparent in 1900 that Wien's distribution law was not in agreement with new data at long wavelengths, Planck determined the equation for the proper distribution by empirical arguments guided by his mastery of thermodynamics. Then, on Dec. 14, 1900, he announced his derivation of this new distribution based on the revolutionary idea that the energy emitted by an oscillator (a continuous variable in all previous theories) could take on only discrete values or quanta. The quantum of energy for an oscillator of frequency ν is $h\nu$, where the universal constant h, Planck's constant, has the units of action and the magnitude $(6.6252 \pm 0.0002) \times 10^{-27}$ erg sec.

Planck did not take the lead in the development and extension of his idea initiated by Albert Einstein in 1905, but he continued to make important contributions for many years to thermodynamics and to the quantum theory. Since the fruition of Planck's ideas in Niels Bohr's theory of atomic structure (1913) and then in the quantum mechanics (1926), the concept of quanta has influenced virtually every aspect of modern physical science. Planck's work was widely acclaimed and in 1918 he won the Nobel Prize in Physics for his quantum theory. In 1926 he was elected a foreign member of the Royal Society of London and in 1928 received that society's Copley Medal. He became president of the Kaiser Wilhelm Society for Scientific Research (later the Max Planck Society) in 1930.

Planck felt it his duty to remain in Germany during the Nazi period, but he openly opposed some of Adolf Hitler's policies, especially the persecution of Jews. His second son was executed by the Gestapo for his part in the unsuccessful attempt to assassinate Hitler in 1944. Planck lost his home near Berlin in World War II bombings, suffering many hardships before his rescue by U.S. forces in 1945. He died in Göttingen on Oct. 3, 1947.

See Quantum Mechanics; Physics: General Survey; *see*

also references under "Planck, Max Karl Ernst Ludwig" in the Index.

See Planck's *Scientific Autobiography and Other Papers*, with a memorial address on Planck by Max von Laue, Eng. trans. by Frank Gaynor (1949); M. J. Klein, "Planck, Entropy and Quanta, 1901–1906," *The Natural Philosopher*, vol. 1 (1963). (M. J. K.)

PLANE, in botany the common name of a handsome tree, *Platanus orientalis* (family Platanaceae), native of Greece and western Asia. A favourite shade tree of the Greeks and Romans, it was introduced by the latter to southwest Europe. The plane is a successful tree in industrial cities: the smooth face of the leaf is easily washed by rain; and periodical peeling of the brownish bark, revealing yellowish, light green and cream-coloured underlayers, serves to discard surface deposits. It is a large tree with widely spreading branches and alternate, palmately five-lobed leaves resembling those of the sycamore maple in shape, but hairless and of a brighter green. The bud in the leaf axil is protected during its development by the hollow base of the leaf-stalk, which lifts off when the leaf falls in autumn. The minute, unisexual flowers are borne in dense pendulous heads, which contain either male or female flowers; the small one-seeded nutlets, each bearing a tuft of long silky hairs, are densely crowded in a ball, from which they gradually separate in drying, and are readily carried by the wind.

A variety of forms are known in cultivation; var. *laciniata* has very deeply much-divided leaves, and var. *variegata*, variegated foliage. The London plane, *P. acerifolia*, features three-lobed leaves. Several authorities regard this as a natural hybrid (*P. occidentalis* × *orientalis*) rather than as a distinct species. *Platanus occidentalis*, an allied species, is a native of the United States, being most abundant and growing to its largest size in the basin of the lower Ohio and the Mississippi rivers. It was introduced into England early in the 17th century, and is occasionally met with in western and central Europe; it is known in America as sycamore and buttonwood. It differs from *P. orientalis* in its less deeply lobed, more leathery pubescent leaves and in the usually solitary balls of fruit. Both the native sycamore and the London plane are extensively planted as ornamental trees in the eastern United States. The California sycamore (*P. racemosa*) and the Arizona sycamore (*P. wrightii*), of the extreme southwest, are much smaller than the eastern species.

JOHN MARKHAM

LEAVES AND SPINY FRUITS OF THE LONDON PLANE (PLATANUS ACERIFOLIA)

PLANER: *see* MACHINE TOOLS; WOODWORKING MACHINERY.

PLANETARIUM is the name given to an arrangement for producing an artificial sky. By optical methods, images of the sun, moon, planets, and stars are projected on a hemispherical dome; and by mechanical and electrical means the apparatus can be moved to show the daily and annual motions of these objects. The name planetarium is given because of the success with which the apparent motions of the planets among the stars can be shown; however, the apparatus makes possible the representation of many other astronomical phenomena.

For several centuries orreries have been used to demonstrate the motions of the planets around the sun according to the Copernican system. Perhaps the best arrangements of this kind are in the American Museum–Hayden Planetarium at New York City and the Morehead Planetarium at Chapel Hill, N.C. At these planetariums models of each planet from Mercury through Saturn revolve on tracks about a lighted model of the sun, with the entire system mounted on the ceiling of a circular room large enough to accommodate an audience of several hundred persons. The fixed zodiacal constellations on the walls illustrate how the sun and planets apparently move through the stars. The major satellites revolve about their appropriate planets, and all velocities are proportionately correct, with the earth completing a year in ten minutes. Although the scale of time is accurate, it is impossible in a model of this nature to make relative distances and sizes accurate and thus portray a realistic impression of the orientation and appearance of the planets in the heavens. Furthermore, such a model presents a perspective of the planets from outside the solar system rather than a reproduction of the skies as viewed from the earth.

In 1913 the firm of Carl Zeiss was asked by the director of the Deutsches Museum in Munich, Ger., to study the practicability of constructing a model depicting the heavens as seen from the earth, and it was suggested that the heavenly bodies might be represented by electric bulbs that would either be fixed or moving on a rotating dome. This suggestion, however, was soon discarded in favour of a method suggested by W. Bauersfeld of the Zeiss firm, in which the images of the bodies were projected optically on a fixed dome. The apparatus which evolved from this suggestion has been a great success. The reproduction closely resembles the real sky. To produce the motions of the stars it is merely necessary to have the projector mounted so that it can be rotated about an axis parallel to the earth's axis. For the sun, moon, and planets small separate projectors are constructed. The angles between the orbital planes are allowed for, and by the use of eccentric circular motion in the projecting instrument the apparent motions of the planets in the sky are quite closely represented. For example, to show the planet Venus, a small projector is attached to a gear at the points where pins represent the positions of Venus and earth with respect to the sun. A linkage between the planets always directs the light away from the earth. As a consequence, the image of the planet on the dome is in the correct position among the stars. The gearing is so arranged that the mean motions are accurately represented and only comparatively slight periodic errors affect the positions of the sun, moon, and planets. The phases of the moon are shown by an occulting device contained within the moon projector.

A planetarium can be operated at varying speeds, different for each of the phenomena to be demonstrated, so that even such a slow motion as the precession of the equinoxes is within its range. To show the rising and setting of the heavenly bodies, a day is compressed into an interval as short as 4 minutes; to show the sidereal motion of the planets, a year can be reduced to intervals varying from 7 seconds to 12 minutes. The original planetarium was made for one latitude only (that of Munich), but in later models, by introducing an additional axis of rotation, the latitude can be altered at will. The stars are shown brighter than they appear in the sky so that spectators can see them without requiring undue time to become adapted to the darkness. It is, of course, impossible to make the sun as bright as in nature but this has the advantage of enabling the viewer to see the stars and the sun at the same time; thus the planetarium can demonstrate the motion of the sun among the stars.

With a planetarium the spectator can see in about one hour motions which can be seen in the heavens only by years or even centuries of watching. When a year is compressed into one or two minutes, the planets can be seen chasing one another about the sky, describing loops, advancing and retrograding, just as they do much more slowly in nature. Great attention has been paid to details so as to make the apparatus as perfect as possible; *e.g.*, the brightness of the objects is dimmed as they approach the horizon and the light is almost entirely cut off as the star actually reaches the horizon. The date corresponding to the configuration can be projected on the dome as well as the names or pictures of the constellations, and by means of a luminous pointer a lecturer can point out objects of interest.

Prior to World War II, all planetarium projectors were constructed by Carl Zeiss of Jena, Ger. The Zeiss firm was reestablished in Oberkochen, West Germany, after the war, and several instruments were produced there after 1950, although instruments were also being produced at the original Zeiss factory in Jena by the East German firm VEB Carl Zeiss. The newer models are essentially similar to the earlier ones, though the fidelity of reproduction of the heavens has been enhanced by adding scores of

small projectors to produce star images of varying intensity, so that brighter stars are represented by brighter images rather than merely larger images as in the early instruments. Also, the colours of the brighter stars are depicted.

Several planetarium instruments have also been constructed in the United States and in these, too, the basic principle of projecting from the centre of a fixed dome has been followed. Two of the projectors were modifications of the Zeiss plan, basically optical in design, though the positions on the instruments of some of the projection equipment were varied somewhat. Another U.S.-built planetarium projector, made by Spitz Laboratories of Yorklyn, Del., produces stars by means of a high-intensity pinpoint lamp shining through holes representing the stars rather than by means of optical systems. In several of the newer Spitz projectors a third axis has been provided. When properly programmed, the combination of motions permits the selection of any axis of rotation, thus enabling the operator to simulate diurnal motions of the skies as viewed from places other than earth.

Through popular usage, the word planetarium also refers to the institution in which the projection instrument is a major attraction. Thus, according to local variations, a planetarium can be an astronomical museum or an educational facility devoted to the exposition of astronomical information. In order to be attractive to returning visitors, most planetarium operators have emphasized changing themes on a wide range of astronomical subjects and have developed auxiliary projectors for demonstrating eclipses, auroras, sunrise and sunset, comets, meteors, horizon scenes, etc. Music and sound effects are commonly used to establish a mood and to support the presentation.

Corridor exhibits outside the planetarium chamber usually include astronomical art, pictures and transparencies from astronomical observatories, orreries of various types, and charts for star identification. Some planetariums exhibit Foucault pendulums, telescopes (often fitted for actual observing), and models or devices for explaining certain concepts in physics, chemistry, meteorology, and space science and technology.

Special demonstrations for school groups are arranged on a regular schedule in most planetariums. It is common practice to plan lectures as a supplement to the science curriculum of the local schools. For younger children, the offering is usually planned to inspire and develop an appreciation for and a curiosity about the skies. The emphasis for students in the fifth through eighth school years is on the transmission of factual descriptive data, and for older secondary school and college students on the explanation of phenomena. The planetarium instrument is admirably suited to these purposes.

Courses and lecture series of varying duration on a wide range of topics are offered in some planetariums. The most popular subjects are introductory and advanced astronomy, star identification, and celestial navigation. In some instances, the courses are offered in cooperation with local universities.

Smaller, less elaborate, planetarium installations have become increasingly common in museums, schools, and even private homes, made possible by the development since World War II of modest instruments of limited capabilities. (J. M. Ch.)

PLANETS. The term "planet" was applied in the ancient Ptolemaic or geocentric astronomy to the seven heavenly bodies which were observed to change their places as projected against the background of the so-called fixed stars. These bodies were the sun, the moon, Mercury, Venus, Mars, Jupiter, and Saturn, all of which were supposed to revolve around the earth. In the modern or heliocentric astronomy (taught by Aristarchus of Samos in the 3rd century B.C. but forgotten or neglected till revived by Copernicus in the 16th century A.D.) it is applied to all dark and opaque bodies in revolution round the sun, and the number of such bodies known has been greatly increased by successive discoveries. In 1781 William Herschel discovered Uranus. In 1801 Giuseppe Piazzi discovered Ceres, a small planet revolving between the orbits of Mars and Jupiter and the first to be detected of a great host of small bodies known as minor planets or asteroids; in 1846 Neptune was added to the list of major planets as a result of mathematical work on the unexplained irregularities in the motion of Uranus by Urbain Jean Joseph Leverrier and, independently, by John Couch Adams (*see* NEPTUNE). In 1930 a yet more remote planet was found at the Flagstaff observatory near the position predicted by Percival Lowell. It was named Pluto.

Most of the major planets possess moons or satellites. Neptune is known to possess 2, Uranus 5, Saturn 9, Jupiter 12, Mars 2, and the earth 1.

Distances of the Planets.—An empirical rule expressing the planetary distances from the sun was discovered by Titius of Wittenberg in 1766 and later brought into notice by Johann Bode. If a series of 4's be written down, and 3 be added to the second, 3×2 to the third, 3×2^2 to the fourth, and so on, the sums of the numbers are 4, 7, 10, 16, 28, 52, 100, 196, 388, 772, etc. Division of these numbers by 10 shows fair agreement with the actual mean distances up to Uranus (*see* Table I), provided that the figure 2.8 is thought to represent the mean position of the asteroid ring. The success of representing approximately the first seven planetary distances by the Titius-Bode rule is not remarkable, since it was accomplished with five parameters (the three

TABLE I.—*Principal Elements of the Orbits of the Major Planets for the Epoch 1956, Jan. 1. G. M. N.*

Planet	Symbol	Mean distance from sun in		Eccentricity	Inclination	Period of sidereal revolution*
		Astronomical units	Millions of Miles			
		a		*e*	*i*	
					° ′ ″	*P* (Years)
Mercury . .	☿	0.387099	36.0	0.2056257	7 00 14.1	0.24085
Venus . .	♀	0.723332	67.2	0.0067940	3 23 39.1	0.61521
Earth . .	⊕	1.000000	92.9	0.0167276	. . .	1.00004
Mars . .	♂	1.523691	141.6	0.0933680	1 50 59.8	1.88089
Jupiter . .	♃	5.202803	483.4	0.0484288	1 18 20.1	11.86223
Saturn . .	♄	9.538843	886.3	0.0556956	2 29 24.3	29.45772
Uranus . .	♅,♁	19.181962	1,782.4	0.0471985	0 46 22.9	84.01320
Neptune . .	♆	30.057731	2,792.9	0.0085717	1 46 26.8	164.79375
Pluto . .	♇	39.51774	3,671.9	0.2486438	17 08 38.4	248.4302

*In tropical years.
Source: *American Ephemeris and Nautical Almanac* (1956).

constants 4, 3, and 2 and the two rules of putting the exponent of 2 at $-\infty$ for Mercury and of starting the regular count at Venus with the exponent 0). Furthermore, the rule fails for the major planet Neptune. The modern equivalent is to consider the planetary distances as a rough geometric progression, *i.e.*, the radius of each orbit differs by roughly a constant factor from its neighbour. Actually, the factor varies from 1.4 to 2.0 (not counting Pluto, *see* below). It appears to have been determined largely by the local density of the solar nebula from which the planets formed.

Orbits and Phases of the Planets.—From the observations of Tycho Brahe, the great Danish observer, Johannes Kepler deduced the following three great laws of planetary motion:

(1) The planets move in ellipses with the sun at one focus. Hitherto it had been believed that the celestial motions took place in circles, the circle being the perfect geometrical figure.

(2) The straight line from the sun to a planet (radius vector) passes over equal areas in equal times. The importance of this law was that it involves a continually varying rate of a motion, which was also contrary to accepted beliefs at the time. To maintain the equal description of areas in unit time a planet must travel faster in the neighbourhood of perihelion where the radius vector is at a minimum than near aphelion where it attains its maximum value.

(3) The squares of the periodic times (the times required for the orbital revolutions of the planets) are proportional to the cubes of the mean distances (the semimajor axes of their orbits). This is known as the harmonic law and defines the relationship between a planet's orbital motion and its distance from the sun.

From these laws of planetary motion Isaac Newton deduced his law of universal gravitation which has achieved such remarkable success and prepared the way for Albert Einstein's relativity theory.

The dimensions, form, and aspect of a planet's orbit as well as the position of the planet in the orbit at any time are defined by six quantities known as its elements. These are:

(1) Half the major axis, or mean distance (generally denoted by *a*). This defines the size of the orbit and also the period (*P*)

A 17th-century planetarium based on the Ptolemaic theory which had the sun, moon and five planets revolving around the earth

The Copernican orrery in the American museum—Hayden planetarium, New York city; the large centre globe represents the sun, the other globes represent the major planets. An Aztec calendar stone replica is embedded in the floor

EARLY AND MODERN PLANETARIUMS

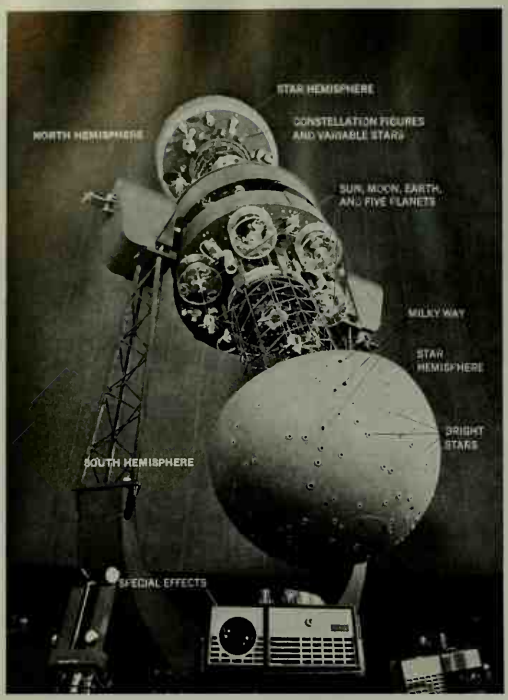
A 17th-century armillary sphere representing the important circles of the heavens, with two dials indicating the altitude of the celestial equator and pole

The earth with its encircling Van Allen radiation belts as projected on the dome of the American museum—Hayden planetarium

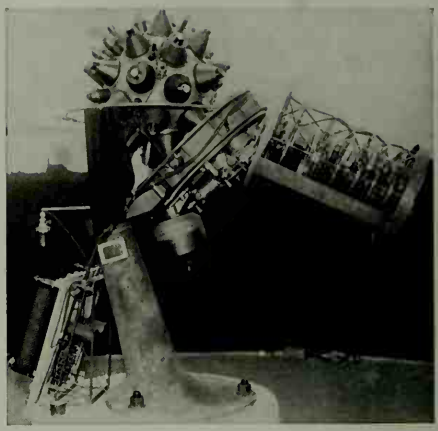
The Adler planetarium of Chicago, typifying the domed structure of planetarium buildings

PHOTOGRAPHS, (TOP RIGHT AND BOTTOM LEFT) THE AMERICAN MUSEUM-HAYDEN PLANETARIUM, (OTHERS) THE ADLER PLANETARIUM AND ASTRONOMICAL MUSEUM, STEPHEN DEUTCH—PUBLIS

PLANETARIUM

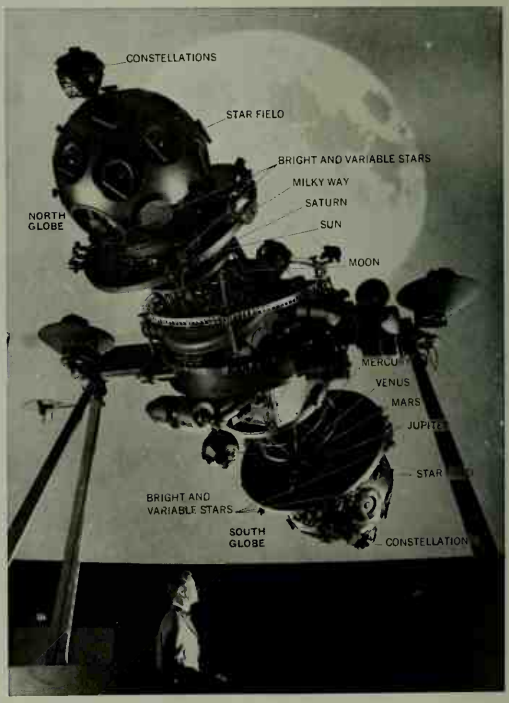


The Spitz Intermediate Space Transit planetarium. The star hemispheres project the invariant star field, Milky Way, nebulae and star clusters. Mounted under the star hemispheres are auxiliary projectors for the constellation figures and variable stars. The annual motion of the sun, moon and five planets as well as the view of the earth seen from the moon are reproduced by mechanical analogues. The meridian, pole, zenith, cardinal points and aurora are projected from the special effects turntable. The Spitz Laboratories planetarium has three axes of rotation: the first simulates the effect of the movement of the earth about its own axis; the second simulates various aspects of the sky from various latitudes of the earth; the third simulates a scanning of the skies. An interaction of these three axes through computer control permits simulation of the visual effect caused by the pitch, roll and yaw of a trip through space out as far as the moon as well as creating the accurate pole of rotation of the moon



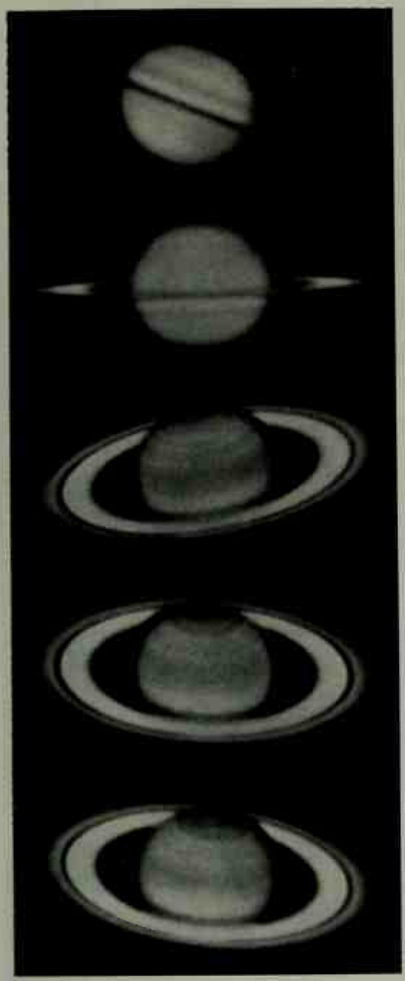
The first modern planetarium instrument, built by the Carl Zeiss firm in 1923, had a single sphere with cone-shaped lens supports for stellar projections and a cage framework for projectors of the sun, moon and five planets. It projected approximately 4,500 stars from lantern slides of exact drawings of the sky. The shortcoming of this projector was that it showed the sky from one latitude only

PLANETARIUM PROJECTORS

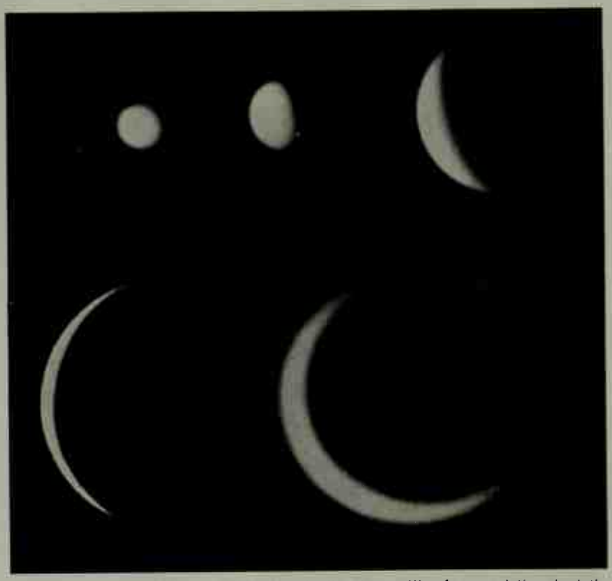


The Zeiss planetarium. A system of about 150 projectors forms part of this planetarium. The two large star globes house the projectors for the northern and southern hemisphere star fields while the smaller spheres at either end project the constellation names and figures. Separate projectors mounted on "ruffs" at the base of the star fields produce the 42 brightest stars, the 3 variable stars and the Milky Way. The moon with surface details and automatic phase changes, the sun with aureole and gegenschein, and five planets are projected from cages below the star globes. Projectors for the equator, ecliptic, hour circles and pole marker are in smaller globes mounted on the central mass while the meridian and zenith projectors are located at the base of the instrument's supporting structure. Seven motors provide the daily rotation of the heavens, the annual movements of the sun, moon and planets, the precessional movement of the heavens about the ecliptic axis, and the variation of polar altitude. Thus, the firmament may be "observed" from any global latitude

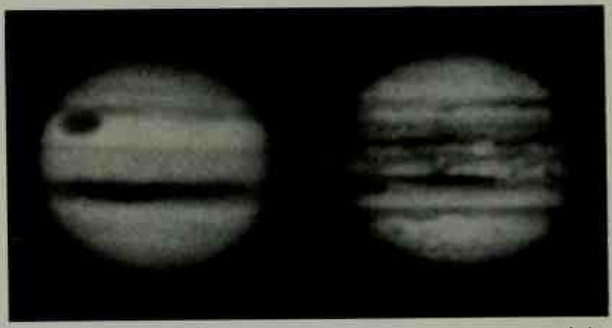
PHOTOGRAPHS: (TOP LEFT) SPITZ LABORATORIES INC., YORKLYN, DELAWARE, (TOP RIGHT) CARL ZEISS, OBERKOCHEN, WEST GERMANY, (BOTTOM RIGHT) J. J. BARTON, THE FRANKLIN INSTITUTE, PHILADELPHIA, PA.



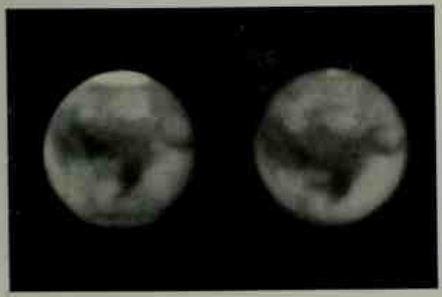
Saturn, various aspects of the planet and its ring system (1936–45)



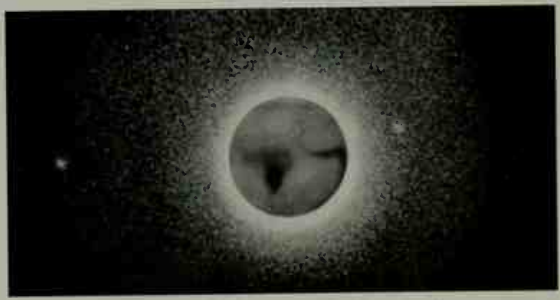
Venus, showing the phases and greatest range in diameter resulting from revolution about the sun in an orbit inside that of earth. When passing between earth and the sun, the night side of Venus is completely encircled by a ring of light (lower right) due to sunlight reflected through the planet's atmosphere



Jupiter, 1936 (left) and 1938 (right), showing the great red spot and notable changes in the belts



Mars, showing its southern hemisphere in springtime (left) and in summer (right) with notable changes in the polar snowcap and the dark markings



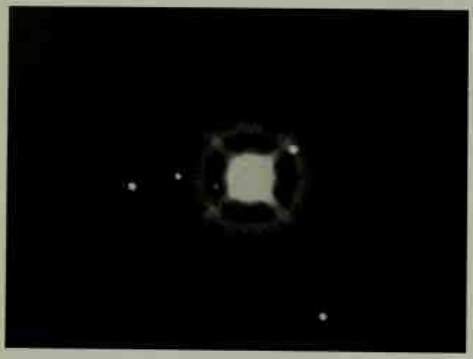
Mars and its satellites, photographed Aug. 17, 1924. Phobus is close to the planet, at the right; Deimos is fainter and farther from the planet, at the left. Composite photograph

PHOTOGRAPHS OF PLANETS

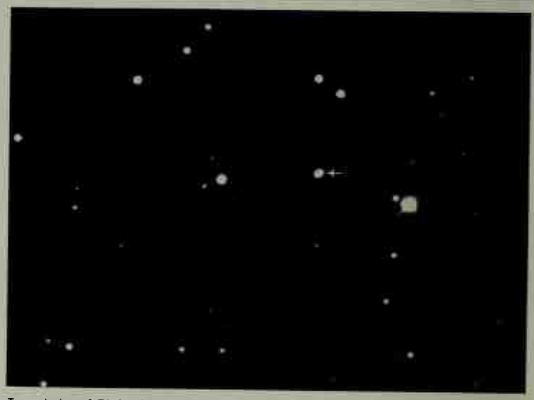
BY COURTESY OF E. C. SLIPHER, LOWELL OBSERVATORY

PLANETS

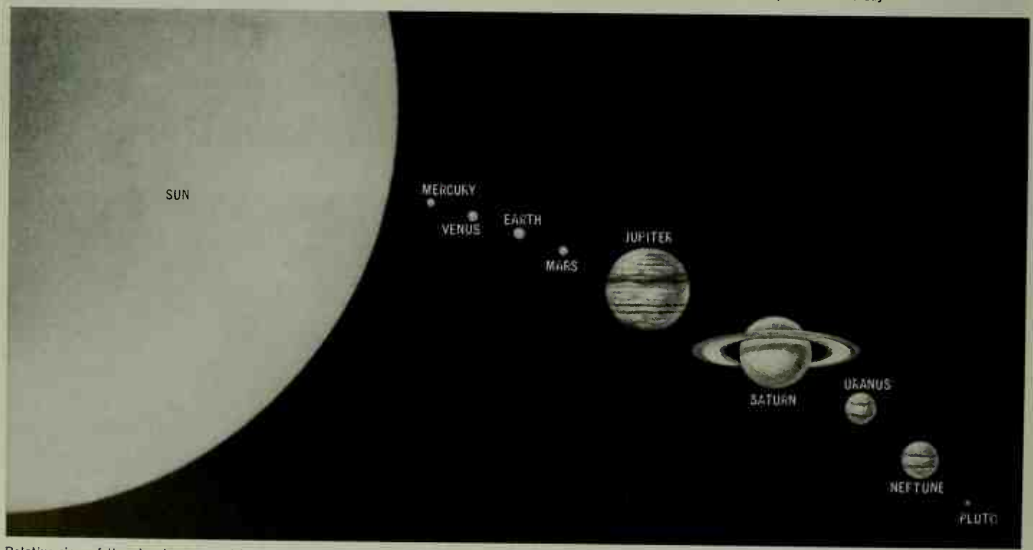
Neptune and two satellites; Nereid shown with arrow, Triton below over-exposed image of Neptune. The rays and the halo are caused by the instrument



Uranus and five satellites. Rays and halo are caused by the instrument



Two photos of Pluto showing movement of planet in one day



Relative sizes of the planets, arranged in order of their distance from the sun. (From left: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto)

MOTIONS, SATELLITES, AND RELATIVE SIZES OF PLANETS

PHOTOGRAPHS, (TOP LEFT) M. HUMASON, (CENTRE AND RIGHT) G. P. KUIPER

by means of Kepler's third law, above.

(2) The eccentricity (e) or the ratio of the distance of the sun from the centre of the orbit to the mean distance. This defines the shape of the orbit.

(3) The inclination (i) of the orbit plane to the ecliptic, *i.e.*, to the plane of the earth's orbit.

(4) The longitude of the ascending node (Ω), *i.e.*, the direction at the sun of the point on the orbit (measured from the vernal equinox or "first point of Aries") at which the planet crosses the ecliptic from its south to its north side. This defines the aspect of the orbit.

(5) The longitude of the perihelion ($\tilde{\omega}$). This defines the direction of the major axis in the plane of the orbit.

(6) The longitude (L) of the planet at the epoch or time (T) of the planet's perihelion passage. The elements a, P, e, and i are given for the several planets in Table I.

Since the orbits of Mercury and Venus lie within that of the earth these two planets when observed telescopically will show phases similar to those presented by the moon. When on the far side of the sun, *i.e.*, near the time of superior conjunction, each of them will appear like a small full moon. As the angle earth-planet-sun increases, a proportionally diminishing fraction of the illuminated surface will be presented to view; and when the angle reaches 90°, the planet will appear half illuminated like the moon at first quarter. Following this, a crescent form of steadily diminishing breadth will be assumed as the planet moves toward inferior conjunction, at which point it passes between the earth and the sun. Subsequent to this, the phases described will be repeated in the reverse order up to superior conjunction when the planet will again be "full." The phases of a planet revolving outside the earth's orbit differ from those of Mercury and Venus inasmuch as the angle earth-planet-sun can never increase to 90°. Thus Mars, although at times presenting a gibbous aspect like an 11- or 12-day-old moon, is always more than half illuminated. In the case of Jupiter the defect of illumination is so small as to be almost imperceptible. In the cases of the planets revolving outside Jupiter the phase is quite imperceptible even in powerful telescopes. The variations in apparent diameter and brightness will, of course, also be small in the cases of the remoter planets.

Planetary Atmospheres.—There are striking physical distinctions between the giant planets Jupiter, Saturn, Uranus, and Neptune on the one hand and the terrestrial (or earthlike) planets Mercury, Venus, earth, and Mars on the other hand. The planets of the first group, besides being much larger and more massive than the terrestrial planets, show no fixed permanent surface features and are of very low density. The density of Saturn is actually less than that of water. The terrestrial planets range in density from 4.07 that of water for Mars to 5.5 for Mercury. Both Mars and Mercury show fixed markings on their surfaces. Impermanent clouds, often arranged in roughly parallel belts, can be seen in the atmosphere of Venus. The masses and, consequently, densities of those planets possessing satellites are derived with great precision from the distances and periods of their satellites by an application of Kepler's third law. The masses of Mercury and Venus are deduced from their gravitational disturbances on the motions of other planets and asteroids, and, for Venus, from observations by the spacecraft Mariner 2; whereas the mass of Pluto has proved too small to be determined.

The knowledge of the mass and diameter of a planet permits the calculation of the attraction of gravity at its surface, g, and the velocity of escape, v_e, which is the limiting velocity which a particle must exceed if it is to escape from the planet. The computed vaues of g and v_e are found in Table II. Note that for planets of different density, ρ, the values of g and v_e are not proportional; the reason for this is found from the definitions ($g = Gm/r^2$; $v_e = \sqrt{2Gm/r}$; $m \sim r^3\rho$; m and r are the mass and radius of the planet and G is the constant of gravitation).

The rate of escape of molecules from the uppermost layer of a planetary atmosphere (called *exosphere*) depends not only on v_e but also on the temperature and the molecular weight of the gas: both a high temperature and a low molecular weight will increase the molecular velocities and therefore the fraction that exceeds v_e. The exosphere temperature depends on the strength of the solar radiation received (which may be computed for each planetary distance) as well as on the atmospheric composition. Thus for each planet a prediction may be made as to which gases, if any, will be retained near its surface. It is found that Jupiter and Saturn will retain even the lightest gases, hydrogen and helium, for astronomically long intervals of time (several billion years or more); while the earth and Venus will lose these light gases but will retain all heavier ones. Mars will retain carbon dioxide, argon, and probably nitrogen, but may lose oxygen (which, because of its strong ultraviolet absorption heats up exceptionally).

The observations support these conclusions in a general way. The spectra of the giant planets show strong absorption bands due to methane and ammonia, identified by Rupert Wildt in 1932 and confirmed in detail by T. E. Dunham. The only correction to this work is the discovery by T. Owen (1964) that the so-called ammonia band in Saturn at 0.79 μ is in reality due to methane; no ammonia has so far been discovered on Saturn. Further, hydrogen has been observed directly on all of the four giant planets. Gerard P. Kuiper observed an absorption in Uranus and Neptune at 8270 Å (1949), identified by Gerhard Herzberg (1952) as due to the pressure-induced dipole spectrum of hydrogen. C. C. Kiess observed four of the hydrogen quadrupole lines in Jupiter in 1960, Guido Münch and Hyram Spinrad (1963) found two in Saturn, and Spinrad found one such line in Uranus (1963). Other unidentified features, 22 in number, were found by Kuiper in Uranus and Neptune between 7400–7600 Å. These were explained satisfactorily in 1964 by Owen as being caused by methane; their laboratory production required long paths (8 km-atm.). Helium causes no visible absorptions of its own, but Herzberg, from laboratory experiments, found evidence that the planetary spectra of hydrogen show pressure effects attributable to helium. Kuiper discovered methane on Saturn's satellite Titan in 1944, but no ammonia, which would have frozen out; he concluded that Pluto and Neptune's satellite Triton may have tenuous atmospheres, which would account for the rather strong ultraviolet reflectivity of these bodies; so far no specific molecular absorptions have been found. Tenuous atmospheres may exist on two of the Galilean satellites of Jupiter, II and III, which show spectroscopic evidence of ice deposits on their surfaces.

On the earth hydrogen and helium are constantly being replenished in the atmosphere, by the photodecomposition of water vapour in the upper atmosphere and radioactive decay in the crust, respectively. The other gases in the atmosphere, though of secondary origin (*i.e.*, due to degassing of the crust), are not now being lost. In pregeologic time, however, there must have been very severe losses to the protoatmosphere as is shown by the very low relative abundances of the noble gases, neon, argon, krypton, and xenon. These gases must always have been part of the atmosphere and are therefore of great importance in tracing its early history.

On Venus a dense atmosphere of carbon dioxide was discovered by Walter S. Adams and T. E. Dunham in 1932; but water vapour and oxygen could not be detected. More recently, A. Dollfus and J. Strong found positive indications for the presence of traces of water vapour but no good value yet exists. Carbon monoxide is essentially absent on Venus (<2 cm-atm. in the observable atmosphere), as is oxygen, an interesting geochemical balance. The pressure on the surface of Venus may approximate 10 atm. (J. Kaplan, 1961; Spinrad, 1962). The surface temperature is high (*see* below) and the tremendous greenhouse effect of the atmosphere is not fully understood. The bulk of the atmosphere of Venus is presumably nitrogen; the self-pressure by carbon dioxide is not sufficient to explain the pressure broadening of the 7820 Å carbon dioxide band.

On Mars, carbon dioxide was discovered by Kuiper in 1947, and water vapour was first directly observed by Münch, Spinrad, and Kaplan in 1963. Its presence had been inferred from the identification of the polar snows as solid H_2O rather than CO_2 by Kuiper in 1948. The surface pressure of the Martian atmosphere was found to be 0.017 atm., or 17 millibars, by Owen and Kuiper from the pressure broadening in the Martian carbon dioxide bands.

The atmospheric mass is about 1–2% that of the earth's per unit surface area. About 85% of the atmosphere is probably nitrogen, 14% is carbon dioxide, and about 1% is argon. Water vapour accounts for about 1 cm-atm. in a vertical column.

The Martian atmosphere appears to have a composition similar to that of Venus (about 6 times as much nitrogen as carbon dioxide) though its mass is vastly (200 times) smaller and the surface pressure about 500 times less. The atmosphere of the earth differs from both in two main respects: its free oxygen, $\frac{1}{4}$ of the total atmosphere; and its greatly reduced carbon dioxide content, only $\frac{1}{3\cdot0\,0\,0}$ of the amount of nitrogen. The latter is due to the presence of liquid water on the earth that has bound as carbonate rock nearly the entire available carbon dioxide supply and holds most of the remainder (all but $\frac{1}{60}$) in solution in the ocean. In fact, if this bound carbon dioxide were to be liberated, there would be more carbon dioxide in relation to nitrogen on the earth than on Venus and Mars. This raises the question whether on these two planets, also, some carbon dioxide might also be bound. Mercury has no perceptible atmosphere, the upper limit being 0.3% of our atmosphere, according to Dollfus. The moon may have a trace, about 10^{-13} terrestrial atmospheres, as appears to follow from certain radio observations. Such an amount is about what would be expected from the rate of argon production in the lunar crust, coupled with the expected rate of escape to space from the lunar exosphere.

Planetary Surface Temperatures.—The heat radiated to space by a planet is nearly in balance with that fraction of the solar radiation which the planet absorbs. For the terrestrial planets the heat flow from the interior is so small that the balance is precise; for Jupiter and Saturn the heat flow from the interior is not negligible, as is shown by the "spontaneous" disturbances in their cloud covers. Nevertheless, even for these planets there will be approximate balance. Now the heat loss by radiation per unit area is proportional to T^4, while the gain by absorption per unit area is proportional to $(1 - A)/a^2$, where A is the planetary albedo and therefore $(1 - A)$ the absorbed fraction of the received solar radiation; a is found in Table I. For a surface placed at right angles to the solar rays one finds, from the known "solar constant," the equilibrium radiation temperature to be $394° \times (1 - A)^{¼}a^{-½}$, counted from the absolute zero. For a rapidly rotating planet the solar radiation is spread over an area four times that of the cross section of the beam, and therefore the temperature will be $4^{¼} = \sqrt{2}$ times lower than for a "normal" surface. The computed mean radiation temperatures for rotating planets are found in Table II. They apply to whatever atmospheric or surface layer is most effective in the radiation to space. Note that this layer on Venus is no warmer than that on the earth, owing to the high albedo. For planets with dense atmospheres and condensation products, the surface temperatures must be higher than the radiation temperatures owing to the greenhouse effect. For the earth the difference is about 30° C and the difference is not constant, as is shown from the occurrence of ice ages.

Planetary temperatures may be measured by placing a sensitive infrared detector at the focus of a large reflector. Such work has been done especially at the Mt. Wilson and Lowell observatories. The measures are hampered by the variable amounts of water vapour in the earth's atmosphere, but the region from 8 to 14μ is comparatively free and is used. This means that temperatures much below 200° absolute (−73° C) are not readily accessible. Results on the giant planets are therefore uncertain; furthermore, they are strongly affected by particular molecular absorptions and emissions in the 8–14μ region, such as are due to ammonia. Thus, the measured temperature of Jupiter is essentially the temperature at which ammonia vapour makes its appearance, about 130° absolute (−143° C). This is in good accord with the 1962 measures of Bruce Murray and R. L. Wildey (128° absolute). For Saturn the temperature is about 93° absolute (Frank Low), in accord with the spectroscopic absence of ammonia vapour.

For the terrestrial planets and the moon the results are in good general agreement with the computed temperatures. Edison Pettit established the important result that the day and night sides of Venus are virtually at the same temperature, 241° absolute (−32° C), indicating rapid atmospheric convection between the two hemispheres. The surface temperature of Venus is about 700° absolute, or 430° C, above the melting point of lead. For the moon Pettit measured, among others, the temperature drop during a lunar eclipse, which led to a determination of the coefficient of thermal conductivity; from these data the lunar surface was found to be covered with a fine powder (probably caused by meteoritic impacts). For Mars the noon temperature at the equator was found to be about 0°–10° C, somewhat less, as it should be, than the maximum attainable for a normal surface exposed indefinitely, that being 34° C.

Composition of the Planets.—The terrestrial planets are composed of silicates and metals, in varying proportions, as follows from their different densities. Mercury, though of small mass and therefore little compressed, is as dense as the earth which, if uncompressed, would have a density of about 4.2. Mercury must contain about $\frac{2}{3}$ iron, and this suggests that the liquid core of the earth is iron also and not a high-pressure phase of silicates. Detailed discussions on the composition and the equation of state of the earth's interior have been given, particularly by A. E. Ringwood. Jupiter and Saturn are composed of about 80% and 60% hydrogen, respectively, according to W. C. DeMarcus (1958). The composition of Uranus and Neptune is still uncertain. De Marcus and Reynolds (1963) find $<23\%$ hydrogen for Uranus and $<14\%$ for Neptune. All four giant planets must have earthlike cores at their centres, though more massive and more compressed than the earth, since these planets arose from protoplanets that were more massive than protoearth. This conclusion is compatible with the planetary models of DeMarcus.

Origin of the Planets.—It is reasonably certain that the planets condensed from large gaseous clouds, or protoplanets, about 5×10^9 years ago; and that these protoplanets were essentially of solar or cosmic composition. Protoearth was about 500 times more massive than the present earth; proto-Jupiter about 20 times. The protoplanets appear to have segregated from a primeval nebula that surrounded the sun; the mass of the solar nebula was about 6% of the solar mass. The process of planetary formation appears to have been incidental to the formation of the sun itself, with the solar nebula consisting of the material that, because of its large angular momentum, stayed behind in the general contraction process. The protoplanets were formed by gravitational instability within the nebula before the sun had completed its contraction and had become luminous. The temperature in the nebula at the time of breakup appears to have been exceedingly low, <100° absolute, which, because of the abundance of snows, greatly speeded accretion. During the last phases of contraction the sun was probably surrounded by a cloud of very high-energy particles, causing much induced shortlived radioactivity in the accreting solids. Also the young sun appears to have gone through a very luminous stage, causing intense radiations that drove off the gaseous envelopes or protoatmospheres of the terrestrial planets and left them virtually bare. It also greatly reduced the masses

TABLE II.—*Physical Constants Pertaining to the Major Planets*

Planet	Mass ⊕=1	Mean diameter ⊕=1	Mean density (water=1)	Inclination of equator to orbit	Rotation period	Albedo A	Mean Radiation Temp. (°absolute)	Surface gravity ⊕=1	Velocity of escape km/sec
Mercury	0.0543	0.38	5.5	7°	88 days	0.058	625*	0.38	4.3
Venus	0.8136	0.961	5.06	30°?	very long	0.71	241	0.88	10.4
Earth	1.0000	1.000	5.52	23°27′	$23^h56^m4^s.1$	0.36	250	1.00	11.3
Moon	0.0123	0.273	3.33	1°32′	$27^d7^h43^m$	0.072	274	0.16	2.4
Mars	0.108	0.523	4.07	25°	$24^h37^m22^s.6$	0.159	217	0.38	5.1
Jupiter	318.35	10.97	1.35	3° 7′	9^h50^m–56^m	0.51	102	2.65	61.0
Saturn	95.3	9.03	0.71	26°45′	10^h–11^h	0.50	76	1.17	36.7
Uranus	14.54	3.72	1.56	98°.0	$10^h.7$	0.66	49	1.05	22.4
Neptune	17.2	3.38	2.47	29°.0	$15^h.8$	0.62	40	1.23	25.5
Pluto	0.05?	0.45	3?	?	$6^d.39$	0.17	42	0.25?	4?

*For subsolar point, since Mercury does not rotate with respect to the sun.

of the giant planets. These gigantic mass losses had several indirect effects, such as great increases in the inclinations of the planetary equators (*see* Table II); the loss of satellites to interplanetary space (probable formation of Pluto from Neptune, and Hidalgo and the Trojan asteroids from Jupiter); and the formation of a dozen irregular satellites (being lost satellites that were recaptured).

The minor planets or asteroids appear to have originated as condensations in a tenuous part of the solar nebula between proto-Jupiter and proto-Mars. Gravitational instability could not occur in this tenuous ring so that not one large condensation (or planet) developed but instead innumerable smaller condensations formed by accretion, much like snowflakes in a cloud. A similar tenuous ring must originally have existed outside proto-Neptune, which appears to have given birth to the comets. The dimensions and compositions of the asteroids and of the comets are in general accordance with the predictions based on this theory. The meteorites appear to be fragments of asteroids that have collided; Edward Anders has shown in 1964 that the parent bodies are not asteroids in general but a small subclass of them that moved near the planet Mars.

Habitability of the Planets.—The giant planets appear to have solid surfaces only at great depth, as a result of excessive pressures (over 100,000 atm.); while the atmospheres are strongly reducing (large excesses of free hydrogen). No life as we know it could exist there. The moon and Mercury are unsuited for life due to lack of atmospheres. Venus must have produced some free oxygen or its atmosphere would be expected to contain carbon monoxide as well as carbon dioxide, since both are produced by terrestrial volcanism. This oxygen originated probably from photolysis of water vapour, rather than from organisms. The apparent absence of appreciable quantities of water and oxygen, the high carbon dioxide content, and the very high surface temperature make Venus an unlikely place for life to have developed.

The case of Mars is distinctly different. This planet possesses an atmosphere containing carbon dioxide in quantities similar to the earth, as well as traces of water vapour, and probably nitrogen and argon. Photosynthesis is therefore possible. The daily temperature range, while larger than in the terrestrial deserts, is not extreme. The night temperature may reach −80° C or −100° C, but would not be fatal to some organisms, as lichens, occurring on the earth. In fact, some terrestrial lichens, if transplanted to Mars, might survive.

The dark areas on the planet bear some resemblance to those on the moon and on Mercury, and are therefore likely to be extensive lava fields. The delicate green and brown colours occasionally observed on these dark areas may represent a hardy type of vegetation partially covering these lava fields. *See* also references under "Planets" in the Index.

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PLANING MACHINE: *see* MACHINE TOOLS; WOODWORKING MACHINERY.

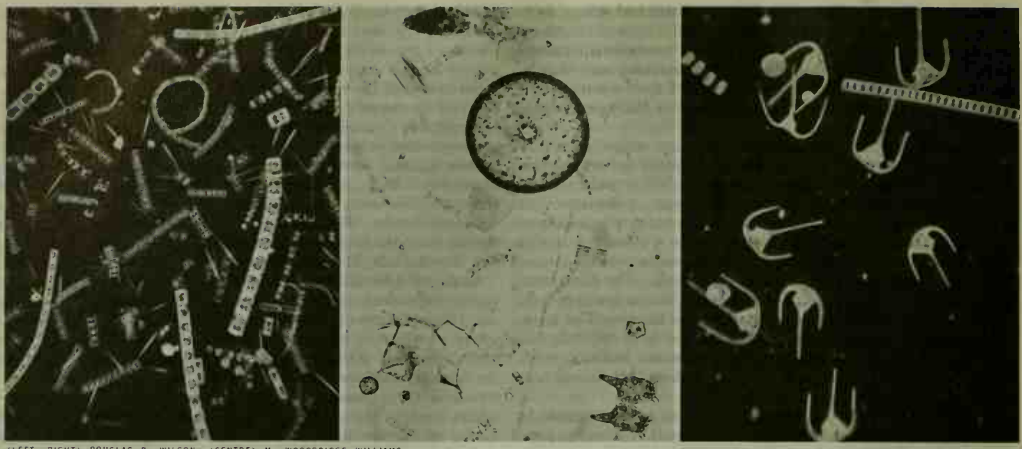
PLANKTON, the name used for that comprehensive section of marine life which drifts under the influence of sea currents, to distinguish it from those organisms (nekton) that can swim against the currents and those (benthos) that are found attached to, or crawling on, the sea floor. Planktonic life is important because almost all animal life in the sea is ultimately dependent on it for existence. The great majority of planktonic organisms are microscopic plants and animals; by definition, plankton also includes bigger organisms, even the largest jellyfish.

Little was known of any except the largest species of plankton until, in 1845, Johannes Müller towed a small conical net of fine-meshed cloth behind a boat and collected a sample of the minute plants and animals. Many forms new to science were soon collected in this way, even in coastal waters, although it was not until 1872–76, when the "Challenger" expedition explored the great oceans of the world, that a real impression was obtained of the almost infinite variety hidden in the sea. In 1889 Victor Hensen (who first used the term plankton) led his special "Plankton Expedition" in a more detailed survey in the Atlantic. In 1902–08 the International Council for the Exploration of the Sea set an example of cooperation in research by arranging for its program to include an international survey of plankton distribution in and about the North Sea. Many other surveys followed; among them was the series of "Discovery" expeditions to study the life of whales in Antarctic waters. Equally important is the work done from the marine shore stations; those at Plymouth, Eng.; Edinburgh, Scot.; and Woods Hole, Mass., are among the best-known.

Cycle of Life in the Sea.—Just as life on the land is ultimately dependent on the sun for its existence, so also it is in the sea. Simple nutrient salts (phosphates, nitrates, etc.) are everywhere dissolved in minute quantities in the water together with carbon dioxide. With the aid of light energy from the sun's rays, the large seaweeds of the shores build these into the complex materials of their tissues. For this reason the seaweeds live only within reach of the sun's rays. Since they are normally attached to the sea bottom they can form only a fringe of vegetable life around the continents and islands. Again, as on land, the marine animals need their food in a complex form, ready-made either by plants or by other animals which themselves have fed upon plants. The seaweeds are too few to feed more than a small proportion of marine animals; most of these animals depend on the planktonic plants (phytoplankton). The phytoplankton floats in countless billions in the upper layers of the water, buoyed by a variety of devices which lessen their density so that they remain in the sunlit zone. When the supplies of nutrient salts are sufficient and the light and temperature adequate, the unicellular plants double their numbers daily, until in places the sea becomes coloured with them. They provide the food of the minute planktonic animals (zooplankton), which in turn form the chief food supply of young fish. Some fish, such as herring and mackerel, feed largely on plankton all their lives, as also do the whalebone whales. Other fish, as they grow, feed more and more on larger animals, either fish or animals that live on the sea floor, such as crabs and whelks. This life of the sea floor in turn is fed by the rain of dead and dying plankton that is continually falling from the upper layers of the water. The whole system forms a network of feeding "chains," which, as the salts and carbon dioxide are returned to the sea by excretion and death, is seen to be one part of an elaborate chemical cycle. (*See* ECOLOGY, ANIMAL.)

As the sunlight strengthens and penetrates deeper during the spring, the few green plant cells that have remained in the upper layers over the winter months begin to divide and spread through the waters, usually first near the coasts and then farther out to sea. The warming of the surface waters in late spring and summer sets up a boundary between the less dense surface water and the deeper layers that are still cool, so that chemical exchange between them becomes difficult. The phytoplankton consumes most of the surface supplies of nutrient salts during its spring increase, so that phosphorus and nitrogen exist mainly in the plant tissues and in the animals that have fed upon them. These animals then increase at the expense of the green plants, which become more scarce in the summer. At the same time smaller numbers of brownish cells (dinoflagellates) are often found. Increase in the zooplankton takes place both by the reproduction of permanently planktonic animals and through the hatching of innumerable planktonic larvae of fish and bottom-living species. A little later these planktonic larvae take up their adult lives as swimmers or bottom dwellers; their survival up to this stage has also depended on the supplies of plankton food available to them.

Fish and other animals take their toll of the permanently planktonic animals, which by autumn are decreasing. The year is not over, however, for there is a second (autumnal) harvest in the sea. As the autumn winds develop and the sun's rays decline, the boundary between the warmer surface waters and the cooler deep waters breaks down. The two layers mix again, providing fresh



(LEFT, RIGHT) DOUGLAS P. WILSON, (CENTRE) M. WOODBRIDGE WILLIAMS

FIG. 1.—MARINE PHYTOPLANKTON, HIGHLY MAGNIFIED

(Left) Diatoms, mainly chains of *Chaetoceros;* (centre) diatoms and dinoflagellates; (right) dinoflagellates, mainly *Ceratium tripos*

supplies of salts to those waters still influenced by the sun. Another crop of green plants, not always the same kinds as in the spring, has a brief period of abundance before winter sets in. Usually, small amounts of plankton are found in the winter months, but during this time the supplies of nutrients are redistributed and restored (following the continual processes of decay) by strong vertical and horizontal water movements.

The cycle just described is typical of temperate waters in the northern and southern latitudes. In higher latitudes the spring and autumn plant harvests are respectively later and earlier, until in the polar regions they meet as one. In warmer waters neither is so prominent; the plant numbers at any time are far fewer, but with the possibility of reproduction over the whole year and throughout a deeper layer the quantities available for animal food may still be appreciable.

Planktonic life is usually found in recognizable communities, often taking the form of distinct patches in the sea. The communities are by no means static; their natures and constitutions are continually changing not merely because of the rapid rate of increase and decrease common to all small organisms but also because of changes in the environment and the complex interactions among the organisms themselves. The proportions of prey and predator in the different food chains are never constant. A change in one is rapidly reflected in others, since the chains are parts of a continuous network. Feeding relationships are not the only relationships whereby the organisms interact, for there are also relationships depending on the plants' varying needs for the different nutrient salts. More subtle relationships depend on the release by some organisms of metabolites (ectrocrines), which influence favourably or unfavourably the lives of other organisms.

Kinds of Plankton.—There are representatives in zooplankton of nearly every important group of animals from the fish downward, although only one major plant group (the algae) is found in the phytoplankton.

Phytoplankton.—The best-known members of phytoplankton are the diatoms, unicellular greenish-brown plants enclosed in a transparent shell of silica. They range in size from forms like the large *Coscinodiscus*, just visible to the naked eye, to the most minute species of *Nitzschia*. Many live individually, but others (*Thalassiosira*) are joined in chains. Some forms have their shells drawn out into long hairs (*Chaetoceros*). Together the diatoms form the most conspicuous plankton plants, and in places their empty shells have accumulated to give rise to large beds of "diatom ooze." (*See* also DIATOMS.)

Diatoms were long believed to be the chief food producers in the sea, but it is now thought that far greater numbers of smaller algae, mainly flagellates, may play a more important part. The flagellates are also unicellular. The most familiar are the dinoflagellates, which are typical of the summer and produce much of the phosphorescence seen then (*Ceratium, Peridinium,* etc.). By means of a pair of whiplike flagella they can move and produce minute currents bearing the smallest particles of food. Some secrete strong toxins; when dense they give rise to the phenomenon known as "red tide." The smaller green (μ) flagellates live more like plants, except for their locomotion by means of flagella. Most of the flagellates exist individually, but one form *Phaeocystis,* lives colonially in a gelatinous mass and is normally nonmotile. Like many other flagellates, it seems that in this form *Phaeocystis* is illustrating only one phase of an interesting life history, but this jelly may at times be abundant enough to clog herring fishermen's nets, causing much trouble in cleaning.

Zooplankton.—The coloured flagellates, with their animal movements and plant nutrition, have been studied by both zoologists and botanists. There are numbers of colourless flagellates which can be considered only as animals. A large and unusually coloured flagellate, *Noctiluca,* causes luminescence on summer nights.

Two other unicellular plankton groups, both related to amoebae but far more striking, are the Radiolaria and Foraminifera. Both have elaborate skeletons and have accumulated in such numbers over certain parts of the oceans as to give their names to distinctive oozes on the seabed.

Most marine animal groups are represented in plankton for a time by their eggs and larvae; few are without at least one wholly planktonic representative. Among the most beautiful are the ctenophores, siphonophores, and jellyfish, as well as the medusoid larvae of the bottom-living coelenterates. The so-called arrowworm (*Sagitta*) is particularly important in plankton research. Other adult worms and their trochophore larvae are found in plankton. Whole groups of mollusks are planktonic: there are the pteropods (*Limacina,* etc.), which by their cast shells have given a name to yet another type of ooze, and the heteropods (*Carinaria, Pterotrachaea,* etc.); in addition there are the veliger larvae of many bottom-living mollusks. The pluteus larvae of the echinoderms are also prominent forms of plankton, although the pelagothurians are the only wholly planktonic echinoderms. Another group, closely related to the sea squirts, includes the salps and doliolids, with their barrel-shaped gelatinous bodies; they are colonial, wholly planktonic, and in coastal regions may be valuable indicators of oceanic water. A related animal is *Pyrosoma,* which is luminescent but found only in warm waters.

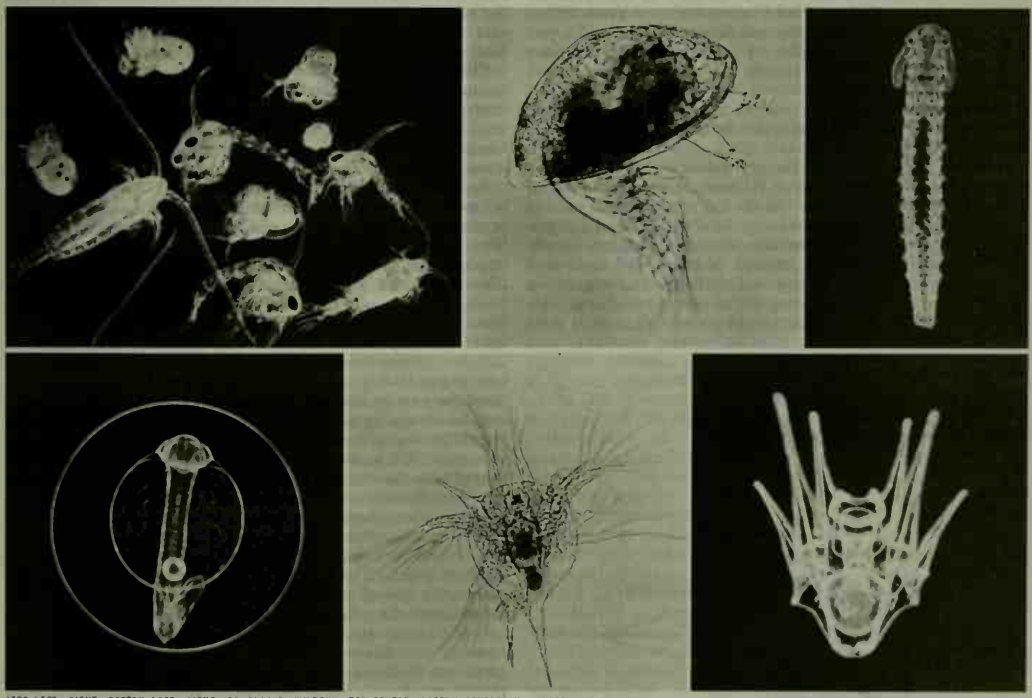
The Crustacea must be considered the most important members of the zooplankton. They have many kinds of planktonic larvae

(*e.g.*, the zoea larvae of crabs). One particular group, the planktonic copepods, plays in the sea some of the parts played by insects on land. Most of the copepods are less than one-eighth inch in length. They are among the most numerous animals in the sea, grazing on phytoplankton and providing basic food for fish. There are many species, but the best known is *Calanus finmarchicus*, abundant over much of the North Atlantic Ocean. The euphausians, with their serried luminous organs, are another important planktonic section of the Crustacea. These are the chief food (krill) of the largest animals the world has known, the blue and fin whales. So dense are their swarms in Antarctic waters that the whales, by taking gulps of water and straining the plankton through their whalebone, can feed fast enough to grow within two years to sexual maturity and attain a weight of 60 to 70 tons.

An early but most important discovery was made by G. O. Sars when he showed that most fish, including those of economic importance, give rise to planktonic eggs and larvae; herring differ in laying their eggs on the seabed, but their larvae, on hatching, immediately drift into the upper waters. This discovery answered one of the early objections to the use of heavy trawls in fishing on the sea bottom, for many fishermen had feared that by trawling they would ruin the spawning grounds of the fish.

Distribution and Movements.—There are few, if any, masses of water without plankton. Although phytoplankton is necessarily limited to the illuminated layers, zooplankton has continued to be found, in gradually decreasing numbers but often increasing size, as new methods have made deeper sampling possible. Before the cruises of Wyville Thompson in the "Lightning" and "Porcupine" (1868–70) it had been thought that life was impossible at depths greater than 300 fathoms. These and later expeditions, particularly that of the "Galatea" (1950–52), showed that while depth determined the nature of marine life it did not prevent it. Whether on the bottom or free in the water, life at great depths is necessarily scarce, since it, and all the animal life for perhaps five miles above it, is indirectly dependent on the activities of the plants close to the surface. While there are many exceptions, it is general for transparent or pale blue animals to be limited to the surface layers, in contrast to the occurrence of red and violet animals at deeper levels; vivid scarlet and black animals are mainly found only at great depths. More astonishing is the abnormal development of the eyes and often the elaborate structure of luminous organs in some deep-dwelling forms.

Light has been thought to play a major part in the regular vertical migrations that most plankton animals make each day. Usually they move upward as the light declines and downward again, sometimes through hundreds of feet, as the light strengthens in the morning. Sometimes the larger zooplankton and associated fish in the deeper waters form a "scattering layer," which may be seen on the graph of an echo sounder, moving up at night and down in the daytime with striking regularity. Many observations and detailed experiments have been made to uncover the processes resulting in this vertical migration. While light must almost certainly play a large part, some research has suggested the possibility of its interplay with other factors, such as a changing response to the effects of gravity or a daily rhythm in the need for plant food. Some plankton animals appear to vary in the range of their vertical migrations roughly in accordance with their tendency to avoid dense phytoplankton. During vertical migration the animals alternate between layers of water which often move at different speeds and directions; their horizontal positions are automatically changed, not only in relation to each other but also in relation to the phytoplankton.



(TOP LEFT, RIGHT, BOTTOM LEFT, RIGHT) DOUGLAS P. WILSON; (TOP CENTRE, BOTTOM CENTRE) M. WOODBRIDGE WILLIAMS

FIG. 2.—MARINE ZOOPLANKTON, HIGHLY MAGNIFIED

(Top left) *Calanus finmarchicus, Centropages typicus, Podon intermedius*, and three zoee larvae of crabs; (top centre) cypris larva of a barnacle; (top right) late larva of a spionid polychaete worm; (bottom left) developing fish egg, *Sardina pilchardus;* (bottom centre) nauplius larva of a barnacle, *Balanus tintinnabulum;* (bottom right) pluteus larva of purple tipped sea urchin, *Psammechinus miliaris*

Apart from the influence of light, it is probable that temperature is the chief governing factor in the distribution of plankton. Many animal forms are found in deeper waters during the summer than in the winter. Others with a wide distribution may appear at the surface in polar waters but live only in the depths of tropical waters, where a low constant temperature is maintained. Heat must be the controlling factor there, although light may have a part in the seasonal migration. Within the surface waters there are striking changes as one travels from the north, through the tropics, and so to the Antarctic. In contrast to the vast quantities of plankton found in the higher latitudes at any one time, the tropical waters are much more thinly populated. On the other hand, the tropics provide a wealth of variety which has made the plankton there a permanent source of interest to marine biologists. Also, the metabolic rate in these warmer conditions is much more rapid than in cooler waters, and recent research shows that the production in the tropics can be greater than was once thought; hence the abundant stocks of fish in some tropical waters.

While some planktonic organisms are almost worldwide in distribution, most are limited by some factor so that each of the seas has its own particular combinations of life. Collections from different places and different depths can easily be distinguished. In another type of distinction the saltiness of the water is important. Coastal waters have their distinct types of plants and animals, usually termed neritic, in contrast to the more widespread but often less abundant oceanic plankton. The mixed waters between them in temperate and polar seas are among the richest in the world, for the oceanic waters, replenished by deep ocean currents upwelling against the coastal banks, provide large supplies of nutrient salts. Phytoplankton flourishes there and animal life is abundant. It is in just such places that the largest trawl fisheries have been established, while the largest fishery in the world, the anchoveta fishery off Peru (and likewise the local guano industry), is based on the immense phytoplankton crop produced in just such a situation. The interplay of oceanic and coastal waters is intensively studied for this reason. An important advance was made when it was found that some of the larger planktonic forms (such as the species of *Sagitta*) may be used as easily recognizable indicators of the relative strengths and distributions of these waters in different years.

Methods of Collection.—The commonest means of collecting plankton have changed little since Johannes Müller first towed his conical net at the sea surface. At the tail of his net was a small glass tube into which the filtered organisms were washed and preserved from damage. The plankton nets used on modern expeditions are essentially the same, though developed and specialized for various purposes. The finest and smallest are of silk (up to 200 meshes to the inch) and elongated so that the meshes provide as great a filtering area as possible. In place of glass tubes there are small detachable metal "buckets" to collect the samples. Larger and coarser nets made of stronger material are used for collecting the larger animals. Since the nature of plankton varies greatly with the depth of water, it has become essential, whether the net is used vertically or not, to know the net's fishing depth. It is common for nets to be fitted with throttling ropes so that they may be opened and closed when desired, as also with flow- and depth-metres. Such methods can be supplemented by pumping water through a flexible pipe and filtering the plankton on deck; this has the advantage of more complete control than when using nets, although delicate planktonic forms may be destroyed by the water pressure. For some purposes samples are best taken in a "water bottle" that can be closed or opened at will to collect a known quantity of water. This is suitable for small forms which easily pass the meshes of the finest silk; they may be collected into a small volume of water by centrifuging or sedimentation after "fixation."

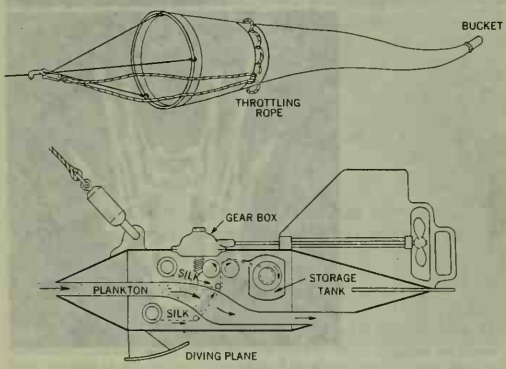


FIG. 3.—APPARATUS FOR COLLECTING PLANKTON

(Top) Plankton net with throttling rope; length about 8 ft., diameter 3 ft.; (bottom) continuous plankton recorder showing plankton being collected on bands of silk mesh

Other instruments include the plankton indicator, which collects samples on a disk of silk mesh placed at the end of a small tube and is convenient for certain types of research and for commercial purposes. Several modifications, including large "high-speed" nets, are used. Another instrument, the Hardy continuous plankton recorder, is a development of the indicator for collecting continuous samples of plankton on a moving band of silk. It is so arranged that it may be loaded in a laboratory and handed to the officers of commercial ships for automatic collection and preservation of plankton, while being towed between selected points on their routes; the machine with its record is then returned to the laboratory for analysis. Since its origin in the southern North Sea in 1931, the continuous plankton recorder survey, now operated by the Scottish Marine Biological Association from Edinburgh, has been extended to cover most of the North Atlantic Ocean at regular intervals. It is being used to provide standardized data for comparison with environmental observations and the catches of fish.

Plankton and the Food Supply.—Though the place of plankton in marine economy had been realized for many years, its practical applications did not begin to be developed till the 1930s. Not until a wide knowledge of the types of plankton and their variations in abundance had been obtained could scientists begin to ask those questions which might give answers of commercial value.

An association of herring with plankton had long been realized before detailed analysis of the stomach contents of thousands of herring showed them to be dependent on plankton throughout their lives. The herring feeds first on the smallest animals, later on larger ones. The adult herring can obtain from plankton alone those supplies of oil which make its flesh so valuable as human food and which seem to be associated with its own reproduction. From late spring to summer, varying a little with the years, herring feed intensively on the copepods (especially the large *Calanus*), and their growth rate depends on the supply of this food. It is now known that the success or failure of a fishery may be influenced not only by the abundance and distribution of the copepods but also directly by planktonic plants. Small samples of plankton were taken regularly over several years with the plankton indicator in waters fished by herring drift nets; each was analyzed and correlated with the numbers of herring caught with it. One of the resulting correlations showed the regular scarcity of adult herring in waters where planktonic plants were very abundant. The other correlation showed that more herring were caught when the copepod *Calanus* was abundant than when it was scarce. While the plankton indicator has been used by a number of fishermen with success, the animal correlation is not always reliable. Fishermen can get much more help now from the echo sounder.

In addition to studying the structure of the different types of plankton, valuable work has been done in marine stations on the conditions which are necessary for plankton life. There the nature of the annual cycle in the sea was worked out, and the first attempts were made by J. E. Allen to provide a suitable mixture of nutrient salts that would allow full and free growth of planktonic plants in the laboratory. While most plants require the phosphates and nitrates which are familiar in plant growth on land, the spe-

cific additional needs for full growth were difficult to discover. Recent research has shown that many of these plants require minute quantities of organic substances for growth, while others can benefit from them even if they are not essential. Vitamin B_{12} is the best-known substance, but others are concerned. All so far known are substances which are released by other marine organisms, including bacteria. Similar evidence showed how other substances may be harmful, while some may be harmful to some and beneficial to others in the community (plants as well as animals). The ecological web is indeed complex.

So far only a few algae have been cultured using nutrient salts, but success has laid the basis for an attempt at larger-scale work. The unicellular alga *Chlorella* has been cultured on a pilot-plant scale at densities far exceeding those found in nature. It has been suggested that this is a method for producing proteins and fats commercially, using the sunlight so freely available in many desert areas. Much has yet to be done, however, before it is known whether this could be economically feasible. Another step was the "manuring" of large tanks of natural sea water in which oysters could spawn, so that their planktonic larvae could have abundant plant food as they hatched. After this nursery period they were transferred to commercial oyster beds for later growth. In another development a small area of the sea (a small sea loch) was isolated and manured; then processes in this area were compared with those in a similar area nearby where only natural nutrients were found. The benefits of artificial manuring were seen in the increased quantities of planktonic plants and animals. More important was the effect manuring had upon the bottom animals in the experimental stretch of water; they also increased and in turn supplied enough food to young fish to enable them to grow at twice their normal rate. In selected spots (brackish tropical lagoons, for example), and with the use of herbivorous fish, such cultivation has been economic for centuries and has made big advances in the first half of the 20th century. As much as two tons of fish per acre have been obtained by skilful farming. Such instances can and doubtless will be extended, but it was still far from certain, however, whether artificial manuring had any useful economic possibilities in temperate waters already providing profitable commercial fisheries. Most of the fish that interest us are carnivorous, so that only a small fraction (1% or less) of the fertilizer could be recovered as conventional fish food. Moreover, the fish would have to compete with a wide variety of "weeds" and other animals, which would also benefit. Besides, much of the world's nutrient supplies are already in the sea; but experiments are continuing.

In his early attempts to introduce rigorous methods into plankton research, the pioneer Victor Hensen hoped to be able to estimate, from actual counts of plants and animals, the productivity of different parts of the sea. If he was not successful, it was mainly because much more knowledge was needed before even approximately useful estimates could be made. The plants must be the basis of any estimates of production, but their total numbers at any moment bear little relation to what has been or what will be produced during the year. Better estimates are made from knowledge of the decreases of nutrient salts in a body of water and the amount of phytoplankton they may produce. The radioactive isotope of carbon, C^{14}, has been widely used in such estimations. It is estimated that production over the world's oceans lies between $1\frac{1}{2} \times 10^{10}$ and $1\frac{1}{2} \times 10^{11}$ tons (in terms of carbon) per year. Whichever of these is correct, only a minute fraction of this weight is now available to man in the form of edible fish, although some forms of plankton (particularly *Calanus*) are quite edible in both the raw and the cooked state. As with commercial culture proposals, the great problem in utilizing this immense potential resource is that of filtering the microscopic plants and even the minute animals. The sea is a vast resource, but its treasures are very diffusely spread. The herring and the whale still have the most efficient "automatic" filters, but it is possible that an efficient commercial filter will be developed. *See* also ALGAE; PROTOZOA; MARINE BIOLOGY; and references under "Plankton" in the Index.

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PLANNING, NATIONAL ECONOMIC. This article deals only with central economic planning by governments. It is divided into the following sections:

I. Introduction
II. Economic Planning in Developed Non-Communist Countries
  1. Origins of Planning
  2. Objectives of Planning
  3. Stages of Planning
III. Economic Planning in Communist Countries
  1. Origins of Planning in the U.S.S.R.
  2. Structure of the Planning System
  3. Planning in Other Communist Countries
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IV. Economic Planning in Underdeveloped Non-Communist Countries
  1. Initial Stages of Planning
  2. The Resources Available
  3. Allocation of Resources
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I. INTRODUCTION

The concept of economic planning is at the other end of the spectrum, as it were, from the concept of *laissez faire* (*q.v.*). According to that economic doctrine, springing from Adam Smith and developed by the Anglo-Saxon economists of the 19th century, if all economic decisions were to be left to individual entrepreneurs, the pressure of free competition, unaided by the state, would bring about the best possible distribution of resources. Any central planning would upset such a balance. The opposite idea behind economic planning is, to the contrary, that certain key economic decisions should be made, or at least influenced, by some central authority, rather than left to the free play of market forces.

It should be emphasized that this antithesis between *laissez faire* and economic planning is not the same as the antithesis between privately owned and state owned means of production. In theory, it would be perfectly possible to have a high degree of governmentally influenced economic planning in an economy of privately owned production. It would also be possible in theory to have an economy in which, though the means of production were owned by the state, there would be practically no central economic planning in the usual sense of the word. In practice, however, there has in general been an apparent connection between planning and government ownership of the means of production —at least to the extent that it is easier for a government to plan when it owns the elements being planned for, than when it does not. The basic point—that state ownership is not the same as economic planning, and that private ownership is not the same as *laissez faire*—is an important one for understanding the history of the idea of economic planning and for understanding the attitudes toward, and status of, planning in the modern world.

Historically, the attack on capitalism was an attack on private ownership of wealth; the major 19th-century critics—notably Karl Marx—did not really concern themselves with the way in which the economy would be run after the "expropriators had been expropriated." They felt that expropriation in itself would solve all other problems in some automatic way. Thus, when in 1917 the new Soviet government found itself in fact owning the means of production, it found no ready guidance in Marxist texts about what to do next, and thus the evolution of central economic planning had to be essentially an empirical matter; methods were tried and discarded, and new ones were introduced.

At the other end of the political spectrum, a number of western industrial countries have discovered that, although their economies are predominantly privately owned, this does not preclude them from doing a good deal of economic planning. Coercion is not always needed; but, even when it is, the government finds that it has available means of control short of taking industry into public ownership.

By the mid-1960s the majority of the world's population conducted their economic affairs in the framework of a national economic plan. Before World War II, examples of national economic planning were confined to the Soviet Union and, to some extent, Nazi Germany. For the purpose of this article, distinction is made between economic planning as it is found in developed non-Communist countries, in Communist countries, and in developing non-Communist countries.

Nations undertake economic planning for a variety of reasons, a prime one of which is to improve the living standards of their peoples and to use their resources to optimum capacity; others are: concern for ideological beliefs (*e.g.*, in a Communist or Socialist state); power politics; self defense (*e.g.*, in wartime).

Between 1945 and the early 1960s most countries in western Europe experienced growth rates that were at least twice as great as those achieved before the war. Others, *e.g.*, the United Kingdom, managed only to repeat their earlier levels of performance, and were increasingly conscious of the fact that they were lagging behind their more dynamic neighbours. France, which had evolved a very sophisticated model of economic planning, was exercising a notable influence in causing other western European countries to adopt national economic plans.

In Communist countries, policies for rapid industrialization called for large-scale state intervention and only the government could undertake the task of marshaling the productive resources of the country to achieve desired results. In this context, however, the adoption by the newly created Communist states after World War II of the model of economic planning evolved during the interwar period by the Soviet Union was not inevitable.

The economic problems of the developing non-Communist countries are different from, and more serious than, those confronting the countries in the first two groups. As a general rule living standards are lower, the countries possess practically no industrial base, and there is no indigenous class of businessmen capable of ensuring the development of the economy. In such circumstances, the main impetus to economic development can come only from the state.

In western Europe, economic planning is adapted to, and can benefit from, the existence of a diversified economic structure, a dynamic class of business managers, and a long tradition of political and economic liberty. Consequently, although planning implies an extension of the economic responsibilities and activities of the state, the mainspring of economic growth remains the private sector. Only rarely does the state intervene directly in the affairs of individual firms. Economic planning remains indirect—or "indicative"—and takes the form of collaboration between the public and the private sectors. Producers and consumers are free to adapt their activities in response to changes in market conditions and relative prices.

Communist methods of planning since the mid-1950s have been in a state of flux and the highly centralized administrative type of planning inherited after the war from the U.S.S.R. by all the newly established Communist states has undergone considerable modifications. In China and Yugoslavia the national Communist parties followed policies very different from those of the Soviet model, and differences also existed in the practice of other eastern European countries. In the Soviet Union itself a debate concerning the most appropriate means for implementing plans was under way but, despite numerous efforts to reorganize the machinery of planning (*see* below), fundamental obstacles had still to be overcome.

The knowledge of these difficulties has given rise in the developing non-Communist countries to a repugnance to Soviet planning methods, while the planning methods used in the developed non-Communist countries are felt to be not directly applicable either. By the 1960s there was no settled planning doctrine in these countries and the approach of governments remained empirical. In practice, this meant that the state played a major role in setting up new industries and in modernizing agriculture. This was particularly the case in countries whose independence had been acquired only recently. The state budget was a major source of savings, supplemented frequently by the local currency counterpart of foreign aid. But the absence of a highly qualified civil service placed limits upon the extent and efficacy of state action. Thus, in urban areas, privately owned businesses continued to supply most local consumer goods. In agriculture, peasant proprietorship or large private estates—particularly for export products—remained the general rule.

II. ECONOMIC PLANNING IN DEVELOPED NON-COMMUNIST COUNTRIES

Governments of all countries, regardless of their political beliefs, are concerned with problems of economic growth and attempt to foresee future economic trends and to adjust policies to meet them. However, the distinction between countries that set up planning mechanisms and those that do not is an important one.

1. Origins of Planning.—To have an overall plan means that the government makes its attitude toward economic growth explicit; quantitative targets are fixed and subsequently provide a basis for judging performance; and measures are proposed for achieving the targets. The decision to plan thus represents a break with older conceptions of the role of government in economic life, and involves notable changes in the process by which economic policy is decided. In general, planning involves making arrangements for bringing the representatives of all sectors into a more intimate relationship with overall economic policy-making. The number of developed countries with planning of this type in the 1960s included Belgium, Finland, France, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and Japan.

Contemporary national planning experiments are, to a great extent, the result of changes in ideas about the proper role of the state in economic life that followed the depression of the 1930s. By the 1960s governments in all industrial countries considered themselves responsible for maintaining full employment; they usually spent from 20% to 30% of the gross national product; and in a number of instances the public sector of the economy—including the nationalized industries—was responsible for between 40% and 50% of total-investment expenditure. But this state of affairs does not necessarily imply that the government has an overall economic plan for the country. There is no inevitable progression from government participation in certain activities to the adoption of such a plan.

Left-wing political parties in practically all the western European countries are favourable to planning, and the political complexion of governments has on occasion been a determining factor in the decision to adopt plans. In the Scandinavian countries, Socialist parties have been active in developing planning; and the shift to the left in the political balance in Italy in 1964 probably gave an impetus to planning. But the decision to plan has most often been taken following a crisis in a country's economic affairs, as was the case in France after World War II when there was an urgent need to reconstruct and to modernize the economy. In the United Kingdom, the setting up of a medium-term plan accompanied the emergency measures taken to deal with the balance-of-payments crisis in July 1961; in Belgium and Ireland dissatisfaction with the past performance of the economy was a major reason for planning.

2. Objectives of Planning.—The plans drafted in the developed countries all postulate target rates of growth which are high by historical standards (usually 4–5%). They require that a choice be made in allocating rates of increase to the various kinds of expenditures on available goods and services (private and public consumption, social investment, directly productive investment, stocks, and exports). Further, as the plan has to be balanced, the total of these components of overall demand must fall within the total likely available supply of goods and services, after allowing for the desired level of the current balance-of-payments surplus. The rates of increase of some types of demand—directly productive investment and stocks in particular—are fixed within fairly narrow limits by technological considerations once the overall rate of growth of output has been chosen. But an important area of choice concerns the respective rates of growth of

private consumption by individuals and of so-called collective consumption (education, health, urban facilities, provision for culture).

Another planning objective which has become very prominent (and which figures in the plans of the United Kingdom, the Netherlands, France, and Italy, to mention only a few) is the correction of imbalances in regional development. The criteria which receive most attention in fixing priorities here are regional differences as to living standards and employment opportunities.

Although the adoption of a medium-term plan implies that governments give special stress to the objectives enumerated, the more traditional objectives of government policy—reasonable price stability and equilibrium in the balance of payments—are not neglected.

3. Stages of Planning.—The three distinct stages of planning, each raising quite different problems, are: choosing the objectives; detailed drafting; and implementing the plan.

Choosing the Objectives.—Planning should offer scope for extending the range of democratic consultation about the objectives of economic policy. As P. Massé, the head of the Commissariat Général du Plan (French Planning Office), has put it, "the economist is concerned with the coherence of the preferences that are expressed, not with the preferences themselves."

In France, Parliament is consulted on the broad outline of the five-year plan on the basis of a number of alternative balanced sets of objectives. Thus, more "collective consumption" can be balanced against a slower rise in individual incomes after tax, or—a rather more difficult choice to make explicit—a higher growth rate can be balanced by greater willingness on the part of producers and consumers to relinquish restrictive practices and to adapt themselves quickly to changes in markets and technology. In 1964, the French Parliament was invited to choose between sets of balanced objectives for the fifth five-year plan (1966–70). In other countries, the choice of objectives tends to be left to the government, which thus implicitly makes the plan a part of the program upon which it will be judged at the next elections. In some countries, *e.g.*, Sweden, although the annual state budget is accompanied by forecasts of developments over the next four years, these forecasts are not approved by Parliament. In the Netherlands, though very sophisticated annual plans have been drawn up every year since World War II, it was not until the early 1960s that an attempt was made to plan production on a medium-term basis. The first British plan (1961–66) was approved in 1963 by a tripartite body (*see* below), the National Economic Development Council, whose chairman was the chancellor of the exchequer, and is now the secretary of state for economic affairs.

In the field of regional policy a special problem arises because a five-year period, the usual length for national plans, is too short when development policy is being decided, for it takes many years to complete some big investment projects. In Italy, the Vanoni Plan (1955–65) concerning especially the Mezzogiorno (the south of Italy) was for a period of ten years. In France, the main lines of regional development policy are laid down for a 20-year period and, in the United Kingdom, regional plans are based upon projections for at least 10 years ahead. When there is an overall plan, ways have to be found of integrating regional policy into the national plan. In France, the whole country is divided into 21 "program regions" but the problem areas are the Paris conurbation, where there is serious congestion, and the west and south of the country where there is too little industry to provide jobs for the population. It is the task of each medium-term plan to implement part of the longer-term development programs for each region. In the United Kingdom, the establishment of a plan in 1961 gave a new impetus to regional development policies and since 1963 a cabinet minister (the secretary of state for economic affairs) has been responsible for regional policy.

Detailed Drafting.—Plans differ in their degree of detail, partly because many examples of national planning are still in an early stage. The French plans are probably the most comprehensive, but France began planning in 1946. In the United Kingdom, planning was not embarked upon until 1961, and Italy did not decide until 1964 to prepare its first five-year plan for the period 1966–70.

Since targets in the plans of the developed countries do not constitute orders to producers and consumers to do or not to do particular things, the plan has to take account of what private firms say they intend to do, or could do, during the period of the plan. Drafting a plan therefore requires arrangements for bringing the representatives of the private sector—both employers and workers—into the planning process. This is usually done by setting up a tripartite body (the National Economic Development Council in the United Kingdom, High Planning Council in France, Council for Economic Planning in Sweden) where representatives of the private sector are brought together with representatives of the government. These bodies have much greater responsibility for economic policy-making than the older consultative committees which exist in all developed countries. In exchange, the representatives of the private sector are expected to commit their organizations to helping carry out the decisions made.

Detailed discussions on planned targets and ways of achieving them are frequently entrusted to tripartite committees, one for each major sector of activity. The French have 21 such committees, called modernization commissions, some of which—the horizontal commissions—deal with specific topics such as investment and its finance, regional policy, or manpower questions, the others being specialized by sectors of industry. In the United Kingdom similar committees for major branches of industry were set up in 1964. It is a difficult problem to ensure that the targets of the branches as regards investment, employment, and output do not conflict with each other and are consistent with the targets for the economy as a whole. The French try to avoid such conflict by giving each planning commission an outline of the overall plan as a starting point for its own projections. This procedure is said to facilitate coherence since the individual commissions all work toward the same targets.

As regards the public sector, most government departments have programs several years in advance for expenditure on, for example, education, road building, urban improvement, and hospital construction. But it often happens that, by analogy with the private sector, these programs are not mutually consistent. One of the advantages of an overall plan is that the confrontation and coordination between the various programs has to be done in an explicit manner. But the task can be a difficult one; watertight administrative compartments are not always easy to break down.

Efforts to incorporate into the plan all that can be known about the intentions of the private and public sectors need to be supplemented by more general economic analysis. As has been stressed already, the plan should be, above all, coherent, and the best way of ensuring this is to build up the planned targets within the framework of the national accounts. Since World War II, such accounts have been drawn up on an annual basis in all the developed countries. From there it is only a step to projecting the national accounts for the final year of the medium-term plan. To do this, various economic techniques are used so as to provide a cross-check with the data collected from private firms. The amount of investment required to secure the overall-output targets can be estimated by the method of "capital coefficients"; or the relation between incomes received by consumers and the latter's expenditures on goods and services can be projected on the basis of "income elasticities" of demand. These results may be further supplemented by studies of financial balances (demand for funds for investment and supply of savings) and manpower balances (demand for labour, in total and by types of skill, and supply of labour). Some countries are also able to use input-output analysis techniques to describe the gross flows of goods and services between major sectors of the economy. A great deal of work remains to be done, however, to improve statistical knowledge in all European countries.

Implementing the Plan.—In their planning, all the western industrial countries leave a large margin of initiative to individual producers and consumers; *i.e.*, they rely upon market mechanisms rather than upon direct controls. There is no contradiction between this state of affairs and the existence of a plan. First, as already noted, the fact of associating the private sector with the

drafting of the plan encourages its representatives to be dynamic in their behaviour, a prerequisite for any successful growth policy. Secondly, when a plan is drafted in this way it may reasonably be expected to favour spontaneous coherence, as all sectors are encouraged in making their own plans to adopt the same general assumptions about the growth of the economy. In France this aspect of planning is called "generalized market research." Thirdly, participation in drafting the plan can help to make the representatives of the employers and workers more conscious of existing obstacles to growth and encourage them to find constructive solutions for overcoming them.

But the government is not freed from participating actively in carrying out the plan. The government's budget and its monetary policy must be used in such a way that overall demand rises as steadily as possible along the medium-term growth path. But the problem of avoiding checks to growth due to balance-of-payments difficulties is likely to call for more direct means of influencing the private sector of the economy. That is why governments in developed countries are increasingly seeking to define "incomes policies" to prevent undue increases in costs and prices. In those countries where there is a medium-term plan, planning and incomes policy tend to be linked. It is likely that participation in working out the plan makes it easier for employers and trade unionists to perceive the need for such a policy and to accept the disciplines it calls for.

If certain objectives in the medium-term plan are not likely to be achieved it may be necessary to revise some of the targets. It is necessary, in any event, to keep the plan as flexible as possible in view of the inevitable uncertainties surrounding future events. Recourse to "revolving" plans may become more frequent; in this way new targets can be set up each year for the final year of the planning period, which thus remains a fixed distance ahead.

In addition to these general measures for implementing plans, some governments attempt to influence more directly the behaviour of private firms by granting depreciation allowances for investments and tax exemptions for some activities, such as expenditure on research. In addition, in France, which has gone further than most countries in using such measures to implement planned targets, large requests for medium-term credit from the banks are granted after consultation with the Planning Office, and private firms have to receive the permission of the Ministry of Finance before issuing debentures on the capital market.

But it is in the field of regional development policy that governments intervene most actively to influence the decisions of the private sector of the economy. There is widespread use in western Europe of tax incentives and grants from public funds to encourage private firms to expand in less-developed regions. Frequently, permission to set up a new factory, or to expand an existing one, in already congested areas where labour shortages are acute is refused. Such areas are the southeast, including London in the United Kingdom and the Paris region in France. In addition, governments endeavour to stimulate growth in the less-developed areas by improving transport facilities, housing, and urban infrastructure generally. (Jn. Ht.)

III. ECONOMIC PLANNING IN COMMUNIST COUNTRIES

1. Origins of Planning in the U.S.S.R.—As noted above, when the Bolsheviks seized power in Russia in 1917 they had no clear idea as to how an economy should be run. Marx had given some rough indications that a socialist society would consciously operate the economy for the common good, which certainly involved the creation of organs of economic administration whose decisions would replace the spontaneous force of the market mechanism. In the future Communist society there would be no money, no profit motive. No wages would be necessary to stimulate effort. It would be "from each according to his ability, to each according to his needs." Economics as such, in the sense of being a science of exchange relationships, would wither away, or be replaced by a kind of higher management. "People will be able to manage things very simply, without the intervention of the famous 'value'," wrote Friedrich Engels in *Anti-Dühring* (1878). In the same tradition, N. I. Bukharin wrote, in 1920: "As soon as we deal with an organized national economy, all basic 'problems' of political economy, such as price, value, profit, etc. simply disappear . . . , for here the economy is regulated not by the blind forces of the market and competition but by the consciously implemented plan" (*Economics of the Transition Period*). Lenin, too, shared these somewhat Utopian expectations. It was not clear from his pre-1917 writings just what kind of economic organization he had in mind for Russia if he achieved power. As events turned out, the revolution of November 1917 was accompanied by economic breakdown, boycott by officials and managers, civil war, and uncontrollable inflation. Partly under the stress of these circumstances, partly because of their ideological beliefs, the Bolsheviks, during 1918, established all-round state control over industry and trade, nationalized everything, declared all private enterprise illegal, and demanded that the peasants (who retained operational control over the farms, though the land was formally nationalized) deliver all surpluses to state procurement organs. Money lost all value.

Some theoreticians greeted these developments as evidence of a leap forward into communism. On paper, this period of "war communism" was one of centralized planning. All economic units, except the peasant producers, were subjected to orders from the government's Supreme Council of National Economy (V.S.N.Kh.). However, this initial essay in planning was a failure—except insofar as it facilitated the concentration of the few available resources for the civil war fronts. Output fell drastically; there was famine; rationing functioned spasmodically; and economic life ground to a halt.

In 1921 Lenin introduced the New Economic Policy (N.E.P.). The small-scale private manufacturer, private trade, and free sale of peasant surpluses became legal once again, while the state retained the "commanding heights" (large-scale industry, foreign trade, banking, transport, etc.). The state sector continued to be operated under the aegis of V.S.N.Kh., by trusts and enterprises with state-appointed managers. In 1921 the State Planning Committee (Gosplan) came into existence to advise the government and its economic alter ego, the Council of Labour and Defense; but planning was still a shadowy process. Trusts and enterprises had considerable autonomy and were free to make agreements and grant credits to one another. The planners made forecasts and government policy decisions influenced the level and direction of state investments; but this was not a "command economy," in that there was no integrated system of production and allocation planning, even in the state sector, while the sizable private sector was not directly planned at all. In 1924, only 35% of the national income, 1.5% of agricultural production, less than half of all retail trade, and three-quarters of industrial output, were "socialized"; the rest was private.

In 1926–28 a vigorous discussion raged about the future basis of planning. Two schools of thought developed, one advocating "genetic" and the other "teleological" planning. The former, composed of the more moderate and cautious planners, believed that plans should be based on existing trends and reasonable extrapolations thereof. The latter considered that drastic measures were necessary to break through, and this "teleological" school produced extremely ambitious drafts of the first five-year plan, which was the subject of discussion at this period.

The first five-year plan (1928–32), which was to be carried out in four years, called for immense investments in heavy industry; for example, in one of the "maximum variants" of the plan, steel output was to be more than doubled by 1932. Amid great confusion, the planning mechanism was overhauled, and gradually a "command economy" was established; that is, the subordinate units of the economy (*e.g.*, industrial enterprises) operated in accordance with administrative instructions, and they did not decide their inputs or their outputs by negotiation with other enterprises, these being decided by the planners. Interenterprise contracts were henceforth, as a rule, merely part of the implementation of planners' decisions. The sole effective criterion of management decision was henceforth conformity to plan; *i.e.*, to the instructions issued by the central administrative planning

organs (*see* below). In this way, the central political authority achieved a high degree of control over resource allocation and was able to enforce its priorities. Consequently, when the first five-year plan ran into trouble, the government was able to insist on the fulfillment of most of the plans for key sectors of heavy industry, at the cost of a drastic fall in availability of consumers' goods.

2. Structure of the Planning System.—A rearrangement of the planning system was the necessary consequence of the new tasks it was called upon to perform. In 1932 three People's Commissariats (for heavy, light, and timber industries) replaced the V.S.N.Kh.; these were further split, and by 1939 the industries of the U.S.S.R. were run by 21 People's Commissariats (the numbers varied in subsequent years). Each commissariat (renamed ministry in 1946) controlled a branch of industry, either directly or through a ministry in one of the union republics. (There were also purely local small-scale industrial establishments, controlled by republican or local soviets). The ministries issued instructions to "their" enterprises, organized the supply of materials and components, and also the disposal of the output. Thus industry came to be organized and run on a sector basis, facilitating the handling of problems common to each separate industry, but necessarily throwing a heavy burden on the coordinating organ, Gosplan, acting as a commission (or committee) of the Council of People's Commissars (ministers after 1946).

At the apex of the system there stood, and still stand, the leaders of the Communist Party who decide the policy objectives, in economic as in other matters, and make choices as to means of achieving those objectives. It was the party leaders who decided, in 1957–58, to make drastic changes in fuel policy, to launch the virgin-lands campaign (1954), and greatly to expand the chemical industry (1963). The government's role is to carry out the decisions of the party. All key appointments in the economic hierarchy are made or confirmed by appropriate party committees. Local party officials play an important role in checking on the implementation of plans and in undertaking or authorizing local initiatives.

It is Gosplan's task to "translate" the politically determined objectives into a consistent set of plan targets. Over various periods of time there must be coherence between production and supply plans and between the investments needed to make a reality of long-term growth plans and the current production of capital goods. Foreign trade must also be taken into account, as a drain on available resources (exports) and as a source of needed goods (imports). The planners proceed by drawing up a series of material balances, which express anticipated supply of, and demand for, all key commodities. It is, naturally, necessary to amend the first version of the plan as and when it is found that the various parts do not match, since it is no use planning an increase in production of, for instance, steel if the necessary additional machinery, raw material, and fuel cannot be made available. The task is of especial complexity in the short term, *i.e.*, in planning within a period of a year, since the plan must, in the last analysis, take the form of millions of consistent instructions to thousands of enterprises to produce, deliver, transport, and process many more millions of commodities of a great many shapes, sizes, and types.

Needless to say, all these decisions must be made somewhere in all economic systems. However, the Soviet type of "command economy," developed under Stalin, provided no criterion for decentralized decision making, such as is provided, however imperfectly, by the market mechanism in western "capitalist" countries. Consequently, the coordination of all these decisions must be consciously achieved by the planners. True, the enterprises and other local organs can put forward their own plans and suggestions, as well as applications for material inputs, and this certainly influences what the planners do and know, but in the last analysis only the centre can be aware of the needs of the economy as a whole. This became apparent after the reforms of May 1957 scrapped the industrial ministries and sought to base planning on territorial economic councils (*sovnarkhozy*) in the republics and regions, with Gosplan as the coordinating body. The object, insofar as it was economic, was to strengthen inter-industrial coordination, regional, republican and national, at the expense of ministerial industrial "empires." It was soon found necessary to tighten central control, and the resultant proliferation of coordinating agencies and state committees has greatly complicated an already highly complex planning process. In the 1960s there have been vigorous and far-reaching discussions of reforms in the system, designed to overcome some of its known weaknesses, which spring essentially from the sheer volume of decision making. This led to a considerable *de facto* dependence on low-level decisions and also on information which it often suited the enterprise management to withhold: for example, since bonuses and promotions depend on plan fulfillment, it "paid" management to argue for a modest plan, to conceal potential, to hoard materials and equipment (in case supplies did not match production plans, which, owing to the unavoidable fragmentation of the planning mechanism, they quite often do not).

The growth of the economy, itself evidence of the success of the system as an engine of growth, has led to greatly increased complexity. The fact that various components of the plan, originating in different offices, often failed to match one another frequently gives subordinate organs a choice as to which orders to obey.

Reformers in the 1960s were concerned, first of all, with finding ways of adapting the electronic computer and programming techniques to the tasks of the planners, both in the process of allocation and in making rational choices between alternatives; they were also concerned with seeking criteria for decentralization. The latter they hoped to achieve by utilizing the profit motive and by making prices reflect in some measure supply-and-demand conditions and opportunity cost, instead of being based on average costs of some previous year. Discussions and cautious experiments were continuing, though no fundamental changes had been attempted by 1964.

Agricultural planning has had a peculiarly difficult history. With priority given to industrialization, agriculture in the Stalinist period was essentially treated as a source of cheap food and materials for the cities. The peasants were, in fact, expropriated by force in the period 1930–35, and the bulk of them were compelled to join collective farms (*kolkhozy*), which were nominally a form of voluntary cooperation. State farms, in which peasants became wage labourers, were of relatively minor importance until after 1954. Mechanization was for many years confined to a very few crops and especially to grain growing. The entire system was primarily designed to ensure deliveries of produce at low prices, and the planners and administrators concentrated on procurements, while production plans were seldom, if ever, fulfilled. Under N. S. Khrushchev there was a substantial change of policy, with much improved prices and a major investment program designed to restore agriculture to health. After initial successes, especially in the period 1955–58, reality again fell far short of planned growth. Endeavours to stimulate output on collective and state farms often took the form of centrally organized campaigns, which led to the imposition by party officials of practices and crop patterns that were unsound or harmful in particular areas. Here also, following repeated organizational changes, major reforms were under consideration.

3. Planning in Other Communist Countries.—In other European Communist-ruled countries the Soviet system was extensively copied, even in minor details, until 1956. After that date it is not possible to generalize. In Poland there was talk of drastic reforms in the direction of a looser, market type of socialism, but shortages and low productivity checked the would-be reformers. Alone among this group of countries, the Poles did not collectivize the peasants, and so Polish agriculture was dominated by the private sector. In Czechoslovakia, a decentralizing reform, launched in 1958, was followed by some disorganization, due partly to difficulties in foreign trade, on which that country is very dependent, and in the period 1960–64 the economy underwent a severe crisis, with growth virtually at a standstill. However, at the end of 1964 they adopted a sweeping reform, which went farther toward decentralization. In Hungary, by contrast,

the Kadar regime, after 1956, undertook measures of economic liberalization which were expected to go yet further in the direction of "market socialism," of which the prototype is Yugoslavia. The Yugoslav Communists sought to copy the Russian system until the Tito-Stalin split in 1948, after which they developed their own conception of socialist planning. This was based on decentralization of state-owned enterprises, which were to be managed by workers' councils, free to decide their own production programs by reference to the profit motive, with prices subject to negotiation. Investments were partly allocated by the central planners, partly financed out of bank credits and enterprise profits. While the stresses and strains of reality caused the Yugoslav leadership to modify this system in the direction of tighter central control, it still had substantially more elements of market relations, and much less administrative regulation, than that to be found in the U.S.S.R. and most of its allies. The bulk of the peasantry was not collectivized.

The Soviet type of planning ran into serious difficulties in foreign trade, not least in trade arrangements between Communist-ruled states. Since each country planned centrally, and since (apart from Yugoslavia) none had, by the mid-1960s, a price system which reflected scarcities or needs, trade planning encountered a double obstacle: on the one hand, comparative cost calculations were all but impossible, and on the other hand, the necessary coordination required a supranational authority which could enforce a "socialist international division of labour," and no such authority existed. "Comecon" (*see* MUTUAL ECONOMIC ASSISTANCE, COUNCIL OF) had no power to enforce its decisions. Efforts to create an effective international planning body encountered opposition from the less-developed countries, notably Rumania, which refused to accept any limitation on its own industrialization plans.

Chinese Communist planning at first also followed the Soviet pattern. In 1958, however, came the "great leap forward" and the communes. Due partly to disorganization engendered by grossly excessive plans, and partly to droughts and floods, this was followed by disaster. It was admitted that production statistics in industry and especially agriculture had been greatly exaggerated. Plans were drastically revised and organizational excesses corrected. The quarrel with the Soviet Union contributed to industrial difficulties (the U.S.S.R. had been by far the largest supplier of capital equipment to China) and caused the Chinese Communist leadership to devise its own planning methods, adapted to a vast country that had poor communications and was at a low stage of economic development. In the mid-1960s, a severe censorship made it impossible to obtain knowledge of Chinese economic performance and organization. Even basic statistical data were unpublished.

The Soviet type of planning had grown up under the special conditions prevailing in the U.S.S.R. and was adapted to the task of speedy industrialization of a poor country, with strong bias toward heavy industry, explicable partly by the logic of industrialization (steel and machinery are more conducive to industrial growth than textiles and jam), partly by concern for military potential. The system was well adapted to ensuring a high rate of forced saving and investment and a rapid buildup of basic industry, though at the cost of neglecting for many years the elementary needs of the citizens and at the same time enforcing the priorities of the regime through a one-party state and Stalinist terror.

4. Assessment of Soviet-Type Planning.—Planning of the Soviet type does have certain positive advantages, at least potentially. It should enable the economy to progress steadily without running into periodic economic crises; the growth of the Soviet economy in the early 1930s, for example, was in striking contrast to the situation of the "capitalist" world at that time. Through their control over the level of economic activity, financial institutions, and personal incomes the planners should be able to avoid inflation. In their investment planning they should be able to avoid the type of wasteful duplication that sometimes occurs under private enterprise through lack of knowledge of other people's investment intentions. The system should also make it possible to reconcile the conflict between short-term sectional profitability and long-term advantage. Insofar as the investment plans of most basic industries depend in the last resort on a quantitative estimate of future demand, the Soviet system is better adapted to make such estimates, since so much of the additional demand is a consequence of the planners' own decisions.

In practice, of course, Soviet-type planning is not always able to realize these potential advantages. Thus there have been repeated instances of over-investment, followed by the abandonment or freezing of partly finished projects. Inflation, with large unplanned increases in prices and incomes, affected the U.S.S.R. in the 1930s, though price stability was reasonably well maintained during 1950–65. Experience has also shown that the separate administrative units into which a nationalized economy must be divided can take as narrow and short-term a view as any capitalist entrepreneur. Thus the most easily accessible forests have been cut, the richest sources of iron ore exhausted, and fallow land reduced in order to fulfill current plans, with little consideration of the consequences. A centralized system of material balances is not an insurance against erroneous forecasting; thus in western and eastern Europe alike the demand for coal was greatly overestimated at the beginning of the 1950s. The material balances approach exercises a conservative influence, perhaps because it is simplest to plan on the assumption that the various technical coefficients will remain constant. The economy grows, but preserves its existing pattern, until the need for change has been overwhelmingly demonstrated. Thus the Soviet planners were very slow to turn from solid fuels to oil and gas, and to shift from natural materials to synthetics and plastics. When change does come, it often has to be ordered by the top party leadership, and a political campaign is launched to catch up on arrears caused by past neglect. However, it is necessary to bear in mind, in any comparison with western economies, that the latter also have many imperfections. A model of centralized planning works as smoothly and as efficiently as a model of a perfectly competitive market, but neither exists in the real world.

Following the death of Stalin in 1953 the Soviet economic system was presented with new problems. It showed itself unable to cope effectively with the finer adjustments required in a sophisticated industrial economy. It dealt very clumsily with the satisfaction of consumer demand, though this became more important in the changed political conditions, not only in the Soviet Union but in most of its European allies. The system is in urgent need of reform, to save it from being overwhelmed by the complexities inherent in an attempt to base decision making on plans; *i.e.*, on commands. Yet Soviet experience may have a marked appeal to those in developing countries (*see* below) who seek to achieve rapid and drastic changes. Insofar as rapid industrialization involves social and political coercion, the fact of such coercion in the history of Communist countries may be a source of attraction rather than revulsion. (A. No.)

IV. ECONOMIC PLANNING IN UNDERDEVELOPED NON-COMMUNIST COUNTRIES

1. Initial Stages of Planning.—The economic development program of an underdeveloped country stipulates first of all the plan period for which the program is drawn up. This is often five or seven years. The aim is to select a period long enough to include projects spanning a number of budget years but not so long as to delay periodic assessment of the development effort stretching over a series of plans. Next there are the objectives of the plan, including the target figures for increases in national income, consumption, and investment desired at the end of the plan period. These target figures may also be shown in detail in terms of the increase in outputs of different goods and services. In any well-formulated plan there will also be estimates of the quantities of various resources, such as capital, manpower, and foreign exchange, needed to implement the target figures. Parallel estimates will then be made of the quantities of various resources, including external capital funds and skilled labour, which are expected to be available during the plan period. Finally, there should be a program of action, with timetable, showing how the

resources required for the plan are to be mobilized and allocated among the different sectors of the economy in accordance with the target figures.

Given sufficient information under the above headings, the plan may be tested by asking certain fundamental questions. First, the question can be asked whether the total amount of resources expected to be available is sufficient to meet the total requirement of resources set by the target figures. Second, is the allocation of resources planned for different industries or sectors of the economy consistent with the target figures for the increased production of specific goods and services? Third, even if the plan appears to be feasible and consistent on paper, how far is it likely to be successfully carried out, with the given administrative and organizational capabilities of the developing country? In order to form a reliable judgment on this, it is necessary to have an intimate knowledge of the local conditions of the developing country, not only about its economics, but also about its politics and sociology. Unfortunately, this type of background information cannot adequately be stated in the economic development plans of any country. Though the three questions raised are closely interrelated, they are treated separately below for the purpose of convenient exposition.

2. The Resources Available.—In many underdeveloped countries the attempt to carry out economic development plans has resulted in some degree of inflation. This suggests that the total amount of investment is in excess of the total available resources that can be mobilized through domestic saving and taxation, and that the loans and grants obtainable from abroad have been insufficient to fill the gap. If this is true, the target figures set for the increase in consumption and for the increase in investment cannot be simultaneously fulfilled. Either one or the other or both will have to be reduced in order to equate the aggregate requirements of resources to the aggregate supply of resources and thus make the plan feasible. Many underdeveloped countries are unwilling or unable to do this and it is often claimed that "forced saving" through inflation is the only practicable way of reducing consumption and fulfilling the planned rate of increase in investment.

Inflation in a developing country is generally accompanied by a tendency for imports to exceed exports, because excess internal purchasing power seeks outlets in the form of increased demand for imports, while the rising domestic costs of production reduce the country's competitive position and its capacity to expand its sales abroad. Most of the developing countries attempt to deal with this balance-of-payments disequilibrium by a direct control over, and restriction of, all types of expenditure requiring foreign exchange. This is not very satisfactory for two reasons. First, so long as the excess of internal demand over the available resources is not curbed (*e.g.*, by reducing government expenditure and by increasing taxation), the effect of the foreign exchange control is merely to bottle up demand internally and to aggravate the inflationary pressure. Beyond a certain point, this makes efficient economic planning very difficult. Second, few countries are able to avoid mistakes and delays caused by foreign exchange controls, and these tend to hold up production in those industries which are dependent on imported machinery, spare parts, and raw materials.

Inept foreign-exchange control is one of the most important causes of inefficient planning in the underdeveloped countries. While it is generally true to say that a shortage of foreign exchange is a symptom of a shortage of resources in general, there are exceptional countries such as India which have a very low ratio of foreign trade to national income and which cannot hope radically to expand their exports. Thus a shortage of foreign exchange may not be due to a general shortage of resources but to the fact that an increase in domestic saving results in too small a reduction in demand for imported consumer goods.

It is important to try to determine whether a plan is held up by a shortage in the aggregate supply of resources or by a shortage in a particular type of resource, such as transport, power, or skilled labour. If the plan is held up by an insufficient aggregate supply of resources, then it should be revised radically by cutting down some of the target figures. If, on the other hand, it is held up by a particular shortage, it may still be possible to fulfill the target figures by a rearrangement of priorities and a reallocation of resources to break the bottleneck. This also illustrates the close connection between the total supply of resources required to carry out the plan and the efficiency of allocation of the available resources. The greater the efficiency and flexibility in the allocation of resources among different uses, the less will be the total volume of resources required.

3. Allocation of Resources.—Given the target figures for the increase in output of specific goods and services, and given sufficient knowledge of the technical conditions of their production, it is theoretically possible to make accurate calculations of the amounts of various inputs which have to be allocated to different industries or sectors of the economy to achieve the target figures. In practice, however, not having sufficient information, most planners resort to the simplifying approximation that the amounts of inputs required in a given sector can be calculated on some pro-rata basis from the target figures of increase in output set for that sector. This approach may cause errors in both directions. By assuming that various inputs are required in a fixed combination to produce a given unit of output, it ignores the possibilities of technical substitution between different inputs to produce the same commodity. Such substitution may significantly economize the resources required to achieve a given target figure of output.

Thus in those sectors where the possibility of substitution between different inputs is important, this method may lead to an overestimation of the resources required. On the other hand, by assuming constant returns (*i.e.*, that the extra amount of capital or labour required to produce successive extra units of a given output is constant) it may lead to a serious underestimation of the resources required in those sectors in which the assumption does not hold. The most important sector is agriculture where, with given methods of cultivation, extra units of capital and labour applied to a fixed quantity of natural resources are notoriously subject to diminishing returns.

The problem of estimating the correct allocation of resources among the different sectors of the economy is complicated further by the interdependence among sectors which require that their outputs be expanded in a "balanced growth" relationship with each other. In broad terms, the most important illustration of this relationship is to be found between the agricultural and the manufacturing sectors of a developing country. The output of the agricultural sector cannot be effectively increased unless the manufacturing sector is expanded concurrently to provide the farmers not only with capital goods, such as fertilizers and implements, but also with manufactured consumer goods which will give them incentives to increase their output. Similarly, the output of the manufacturing sector cannot expand successfully unless the expanding agricultural sector provides a market for its output and unless there is an expanding agricultural surplus to feed the expanding number of workers in the factories. In overpopulated countries the weaker side of this balanced growth relationship is generally the agricultural sector where it is more difficult to expand output. Thus the success of the first and second Indian five-year plans (1950–60) was based on a series of favourable harvests and successful expansion of agriculture. In the early 1960s, however, this expansion tapered off, creating difficulties for subsequent planning.

If sufficient information is available, the broad sectors of the economy can be divided into a number of smaller sectors, and an input-output table constructed which brings out the problems of interdependence in greater detail. It will then be seen that the inputs required to fulfill the target output in any given sector are not only primary resources such as labour and land, but also raw materials and intermediate goods which are the outputs of other sectors. Similarly, the output of any given sector is required, not only to fulfill the target figure of final use of its own output, but also to supply the inputs to other sectors so that all these in turn can fulfill the target figures of final use of their outputs and also supply the other sectors with the inputs which they

require from them. Where such intersectoral relationships are important, the (direct) inputs required by each sector can no longer be calculated separately. The planners have to take the target figures of final use required from all the sectors together and calculate the direct and indirect inputs which are required in all these sectors to fulfill the given set of target figures simultaneously.

Even where the composition of the plan does not require the construction of an elaborate input-output table, the planners in developing countries frequently underestimate the amount of resources required to be held in the form of stocks of raw materials, intermediate goods, and spare parts in order to keep the economy running smoothly. This is perhaps most clearly illustrated in the inept foreign exchange controls mentioned above. An important function of foreign exchange in planning is that it serves as the final economic reserve for financing imports in the event of unforeseen, crippling shortages in specific inputs which cannot be supplied by local production. But the planners often make the mistake of using up the available foreign-exchange supply in rigidly planned commitments, particularly in the purchase of machinery and other fixed capital goods. This does not leave them with a sufficient reserve to correct the inevitable mistakes in planning. Thus it is not uncommon to find newly built factories in developing countries working at a fraction of their full capacity because they cannot obtain the necessary imports of raw materials or spare parts.

Last, but not least, account must be taken of the complications created by the time element. Although a given plan is to be completed at the end of a certain period, this does not mean that different parts of the plan can proceed at their own independent speed to the final dateline. Given the interdependence among the different sectors, each must adhere to a timetable consistent with the timetables of the others. Thus if one of the interdependent sectors is behind the agreed time schedule it will form a bottleneck holding up the progress of the others. This means that, although a plan is drawn up for a period such as five or seven years, there should be much shorter periods (certainly not longer than a year) at the end of which a check is made to determine how far the different sectors have progressed. Such reporting enables the responsible authorities to make prompt adjustments for the various unforeseen delays and bottlenecks that emerge as the plan unfolds.

4. Organizational Problems.—It can now be seen why it is so difficult to separate the formal logical properties of an economic development plan of an underdeveloped country from that country's practical capacity to carry out the plan. A plan based on erroneous estimates of the country's practical capacity to carry it out is clearly a bad plan however good it may look on paper. This is not always appreciated by the governments of some of the underdeveloped countries that employ foreign economic experts on short-term contracts to draw up their economic development plans. These experts do not stay long enough to acquire a sufficient knowledge of local conditions and are usually under considerable pressure to draw up imposing plans. Thus it frequently happens that the plans are too complex and exacting for the administrative and organizational capacity of the countries concerned.

In this connection, it should be emphasized that the developing countries are not a homogeneous group but a mixed collection of countries at different stages of political and economic development and with very different local economic conditions. Yet the theory of economic planning for the developing countries has tended to be formulated with reference to a model country, such as India, and then extended uncritically to all other developing countries. Whatever India's chances of ultimate success in achieving economic development through planning, it is generally admitted that its administrative and planning machinery is well in advance of other countries, some of which are still finding it difficult to maintain a reasonable degree of law and order and political stability, and to provide a minimum of essential public services. Such countries may not be wise to copy India's model of an integrated development plan based on a detailed set of target figures over a wide range of industries. They might do much better with more rough-and-ready methods, making a greater use of the market mechanism combined with judicious indirect controls exercised over strategic sectors of the economy. The argument that a greater degree of direct government participation in economic activities is needed in the developing countries because of a shortage of entrepreneurs in the private sector is not convincing, for many more such "entrepreneurs" will be needed as civil servants if the public sector is to be expanded efficiently. The practical problem facing the developing countries is to find a workable mixture between market forces and state interference that is suited to their particular circumstances, instead of being bemused by the abstract virtues of either overall development planning or free enterprise. (HL. M.)

See also ECONOMIC DEVELOPMENT; PUBLIC ADMINISTRATION.

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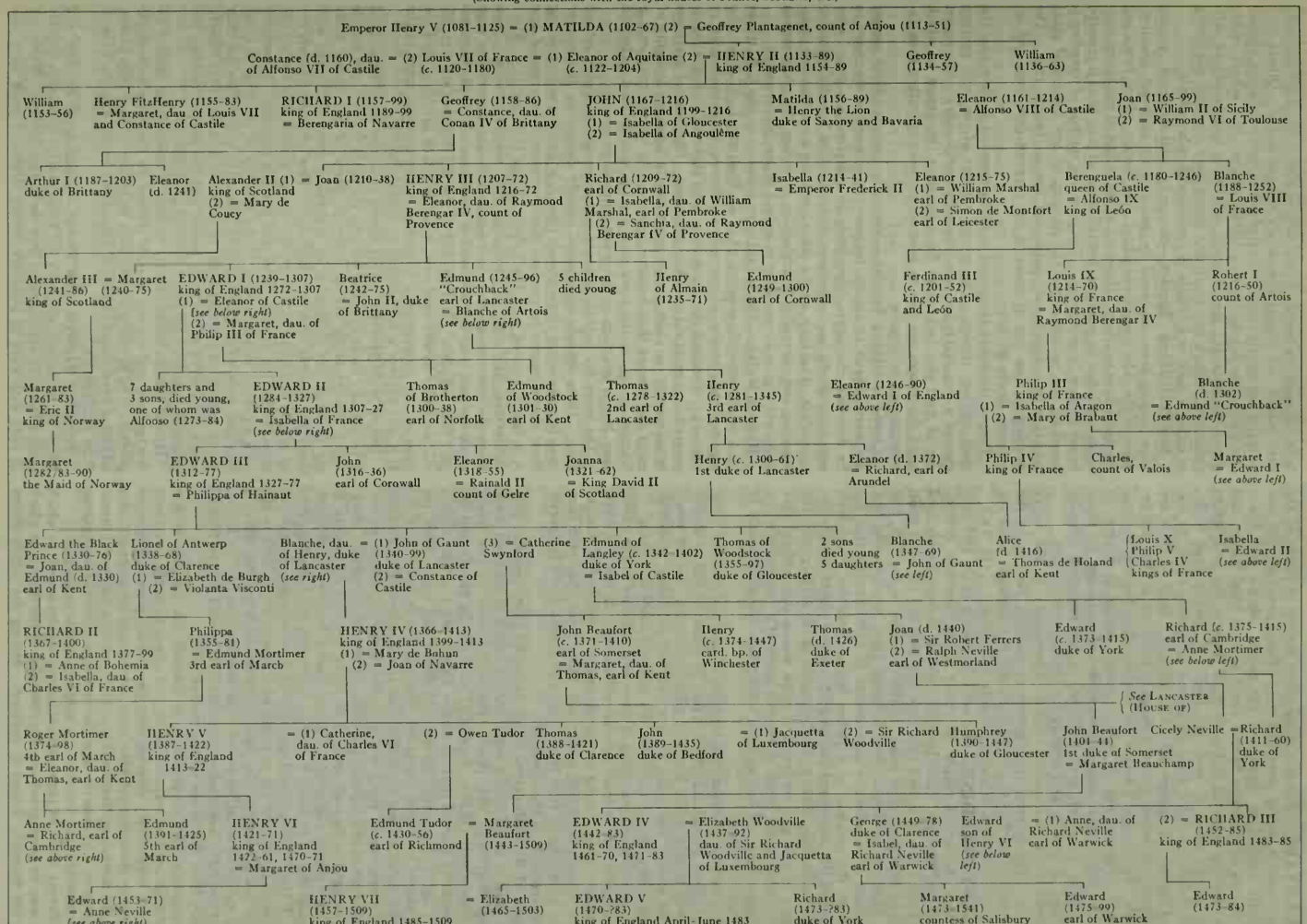
PLANTAGENET, a surname commonly applied to members of the royal house of England between 1154 and 1485, the members of which were descended from the union between Geoffrey, count of Anjou (d. 1151), and the empress Matilda (*q.v.*), daughter of the English king Henry I. Although well established, the practice has little historical justification. The name "Plantagenet" seems to have originated as a nickname for Count Geoffrey, such as was common with his predecessors, for example, Geoffrey Martel or Fulk IV le Rechin. It has been variously explained as referring to his practice of wearing a sprig of broom (Lat. *genista*) in his hat, or, more probably, to his habit of planting brooms to improve his hunting covers. It was not, however, a hereditary surname, and Geoffrey's descendants in England remained without a common family name for more than 250 years, although surnames became universal outside the royal family. Geoffrey's son, afterward Henry II of England, when not styled by his titles, was known as Henry fitz Empress, from his mother's first marriage (*see* genealogical table). Thereafter individual members of the royal family were known either by nicknames, such as John Lackland (king of England) or Edmund Crouchback (earl of Lancaster), or by their place of birth, as with John of Gaunt (Ghent; duke of Lancaster) or Thomas of Woodstock (duke of Gloucester). Henry II and his sons, Richard I and John, all of whom included Anjou among their dominions, are now generally styled by historians "the Angevin kings," but, for want of a better patronymic, their successors, notably the three Edwards, are still described as Plantagenets. After 1399, Henry IV, Henry V, and Henry VI may properly be called the "House of Lancaster," for this was already three generations old; similarly the Yorkist kings, Edward IV, Edward V, and Richard III, may be called the "House of York." The first official use of the surname Plantagenet by any descendant of Count Geoffrey occurs in 1460, when Richard, duke of York, claimed the throne, according to the Parliament roll, in the name of "Richard Plantaginet"; he may have used it as early as 1448, to show the superiority of his descent over that of the Lancastrian line. The name was later used by an illegitimate son of Edward IV, Arthur Plantagenet (d. 1542), who was created Viscount Lisle in 1523. The legitimate male issue of Count Geoffrey and the empress Matilda became extinct with the death in 1499 of Edward, earl of Warwick, grandson of Richard, duke of York.

See also LANCASTER (HOUSE OF); YORK, HOUSE OF.

(C. D. R.)

Houses of Plantagenet, Lancaster, and York

(Showing connections with the royal houses of France, Scotland, etc.)



(1) (2) Next to name indicate order of marriage

PLANTAIN, a common name given mainly to plants of the genus *Plantago*, of the plantain family (Plantaginaceae), but also popularly applied to species of the genera *Alisma* and *Musa*. The species of *Plantago* have a dense tuft of basal leaves, and scapes bearing terminal spikes of small flowers; the long spikes of *P. major*, when in seed, are used for feeding cage birds; *P. lanceolata*, so-called from its narrow lanceolate three- to six-ribbed leaves, is popularly known as ribwort. Both of these are widespread pernicious weeds, difficult to eradicate as they are perennials. Spraying of 2,4-D in hot weather offers the best control. *Plantago psyllium* and *P. indica* produce leaves in whorls on branched stems; their mucilaginous seeds are used under the name of Psyllium, of which over 1,000,000 lb. are imported annually into the U.S., mostly as a remedy for chronic constipation.

Alisma plantago-aquatica (family Alismaceae) is the water plantain. The tropical fruit known as plantain belongs to the genus *Musa* (*see* BANANA). Plantain lily is a common name for *Hosta* (*q.v.*) species of the lily family (Liliaceae). (N. TR.)

PLANT BREEDING. Not until the middle of the 18th century was the sexual nature of plants incontrovertibly demonstrated, and the term "plant breeding" did not become widely used until after 1900. Up until that time selection had been the main means of improving plant lines. Luther Burbank, in the U.S., and I. V. Michurin, in Russia, were foremost plant breeders who first performed many effective experiments in hybridization that resulted in the creation of varieties having desirable characters. Thereafter the intentional breeding of superior plants quickly became a world-wide activity; by the middle of the 20th century the breeding of field and horticultural crops was so standardized that it was largely in the hands of experts, much of it centred in a few large agronomic and horticultural institutions operated mostly at government expense.

For a variety of reasons the breeding of new and superior ornamental plants, though carried on in part by scientists and by tradesmen, was largely in the hands of gifted amateurs. As the result of their efforts, thousands of new varieties of dahlia, gladiolus, African violet, peony, narcissus, iris and rose came into being.

The breeding and purveying of these new varieties to the public spawned hundreds of small business enterprises. In the U.S. alone the business of producing and marketing new varieties of African violets brought in, during peak years, more money per year than all the marketing of fruit trees, vines and bushes (both temperate and subtropical) in the same area.

Mode of Reproduction.—Any successful plant breeding program must be based upon a sound understanding of the exact mode of reproduction of that plant. Plants reproduce in two ways: (1) vegetatively (that is, asexually), through the growth and development of a small portion (bulbs, tubers, etc.) of the original plant; and (2) sexually, through the flower and seed. Even for those plants in which vegetative reproduction is not highly developed under natural conditions, the artificial rooting of cuttings and the grafting of roots and of stems, make it possible to disseminate pieces of a superior individual by vegetative means. Asexual propagation through seeds is of fairly frequent occurrence in the higher plants, and careful research work is required to establish the exact degree to which it may be a factor in any breeding problem. Either an unfertilized egg cell may develop into a mature but very weak plant (and yet of potential economic importance to the hybrid maize industry, for example, since such a plant offers a rapid means of isolating useful, true-breeding strains), or in any one of several different ways the embryo in the seed may be formed directly from the tissues of the mother plant.

Frequently the two processes go forward side by side so that some seeds are true sexual offspring and others from the same seed head are vegetatively derived from the mother plant. The more thoroughly these matters have been investigated for any particular crop, the more completely is it possible to set up a successful breeding program. Vegetative reproduction is of practical importance in permitting rapid increase of a single desirable individual.

Different kinds of plants not only vary in the extent to which they may be propagated sexually, but also in the degree to which they are naturally inbred or outbred. Among the higher plants both extremes are found. Crops such as wheat, which are naturally very inbred, are almost completely self-pollinated. Others such as maize are mostly cross-pollinated under field conditions, though self-pollination is possible by artificial means. Still others (many plums for instance) are naturally self-sterile and cannot be self-pollinated, though any particular flower may function effectively as either a male or a female in crosses with other plants.

Self-Fertilizing Species.—Naturally self-fertilized species have largely been improved by pedigree or pure-line selection. Most of the older varieties of wheat, oats, barley, cotton, beans and tomatoes have so arisen. However, as the ceiling of remaining variation is reached by selection, hybridization of pure lines is resorted to for further improvement. The pure-line method of breeding is based on the principle that the progeny of any individual plant selection in naturally self-pollinated species breeds true. The problem is then one of isolating the superior pure lines and increasing stocks of these.

Proper statistical treatment is often essential in detecting the most efficient strains. The second quarter of the 20th century showed a remarkable increase (virtually world-wide) in the expert use of field plot techniques for estimating the extent to which yield differences are due to inherent superiority rather than favourable soil or climate.

Cross-Fertilizing Species.—Naturally cross-fertilized species are more difficult to handle, because any inbreeding necessary to fix desirable characters often leads to a decline in vigour. One may accordingly use continuous mass selection broadly, avoiding inbreeding. One may, on the other hand, use a combination of inbreeding and controlled hybridization to utilize the phenomenon of hybrid vigour as was done in hybrid maize improvement.

Hybrid Maize.—The hybrid corn industry in the U.S. traces back to the scientific research of G. H. Shull and E. M. East who reported their results of inbreeding followed by hybridization in 1907–10. Not until the 1920s were these theoretical results incorporated into practical breeding programs. Phenomenal increases in uniformity, in yield, and in resistance to lodging (dropping of ears) and disease then became possible. As late as 1933 only a fraction of 1% of the Iowa corn acreage was devoted to hybrid corn, but in less than 10 years the percentage was 99.

The bases for hybrid corn are self-pollinated or highly inbred lines. These inbreds are crossed, usually detasseling the mother rows to make either single crosses (line A × line B), or by utilizing these single crosses to produce double crosses (the cross of line A × line B crossed with the hybrid of line C × line D). Most commercial field corn is produced from double crosses. Seed from the commercial crop is not saved by the grower for seed stock the next year but new seed is purchased each year from expert corn breeders. This has led to the development of a multi-million dollar hybrid seed corn industry which produces seed for most of the commercially important maize-growing areas in the U.S. and exports a fair amount to other countries.

Use of Male Steriles.—This inbred-crossbred breeding method is technically facile in maize because the male (tassel) and female (ear) inflorescences are in different parts of the plant, making artificial self-pollination or controlled cross-pollination economically feasible even on a field scale. Few other crop plants are so readily manipulated, but by the use of male-sterile strains the mass production of cross-bred seed is made possible. It requires such a precise understanding of the genetics of the crop in question that male-sterile plants can be created at will. They are then grown in isolated plots adjacent to male-fertile lines of the variety which is to serve as the male parent and the desired matings are produced naturally by insect or wind pollination.

Hybrid tomato seeds quickly became a commercial success by this method, and the use of male steriles for the more economical production of hybrid seed was soon extended to other crop plants, including even maize (where it helped reduce the expense of artificial detasseling).

Breeding Bacteria and Fungi.—Breeding of bacteria and fungi for increased efficiency in fermentation processes quickly passed from the experimental into the industrial field. Beginning in 1935 with work in Denmark, better strains of yeast were pro-

duced by hybridizing different species and varieties. The rapid development of antibiotics led to large-scale selection and breeding programs with many strains of microorganisms.

Polyploidy.—It was a full quarter century after the improvement of small grains had been reduced almost to a rule of thumb before the significance of chromosome numbers in plant breeding was well understood. Gradually it was realized that a considerable proportion of the higher plants have their germ plasms arranged in several sets of chromosomes. The simplest condition is similar to that which prevails among the higher animals. There are two sets of chromosomes and the species (or variety) is said to be diploid. However, there are in the higher plants many species and varieties with four (tetraploid) or six (hexaploid) or even more sets. Any organisms with more than two sets is said to be polyploid. Generally speaking, polyploids with even numbers of sets of chromosomes are more or less fertile, those with odd numbers being generally sterile, sometimes completely so. For instance, if a cross is made between a fertile tetraploid and a fertile diploid, the hybrid normally inherits two full sets from its tetraploid parent and one set from its diploid parent and is in consequence a triploid, which may be quite sterile for this reason alone. Breeding programs with such organisms must, to be successful, take polyploidy into account. They may work with diploids and tetraploids to produce further triploids. They may, by expert manipulation with such external agents as colchicine (*see* COLCHICUM), at length succeed in doubling the chromosome numbers of the sterile triploids, producing fertile hexaploids from them.

As an understanding of the main facts of polyploidy gradually spread to more and more amateurs and tradesmen, the improvements of such partially polyploid ornamental crops as irises, orchids, and narcissuses lost much of their mystery. In all of these crops polyploids are often intrinsically more valuable than diploids since an increase in flower size and keeping quality frequently goes along with polyploidy. All of these crops had tended to have the smaller diploid varieties of a century ago, replaced by the larger flowering tetraploids and triploids when they accidentally arose.

Until the significance of chromosome numbers to breeding problems was generally realized, plant breeders did not know how to interpret the differences in breeding behaviour between closely related triploids and tetraploids. The development of rapid methods for determining chromosome numbers and the consequent clarification of various breeding problems related to polyploidy has catalyzed both amateur and professional plant breeding with such crops.

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PLANT COLORATION. The colours of the plant world are predominantly the green of leaves and stems, attributed to chlorophyll; the yellow and orange of many flowers, fruits and leaves, attributed to carotenoid pigments; and the scarlet, red, blue and purple of flowers and fruits, attributed to anthocyanin pigments. These three classes of pigments account for most of the colours found in plants, and only a very small fraction of plant pigments belong to other chemical classes. The anthoxanthin pigments, while universally distributed in plants, are pale yellow to yellow-orange in the pure state; consequently, they contribute little to the visible colours of petals and leaves in which they occur. White flowers—which are often actually pale ivory or cream-coloured—usually contain anthoxanthin pigments, the presence of which can be recognized by the yellowing that occurs upon exposure of the petals to the vapours of ammonia.

Most flower petals, white or coloured, contain mixtures of two or more kinds of pigments. Brownish and red-orange flower petals owe their colour to the presence of mixtures of anthocyanins and carotenoids. Yellow flowers usually contain carotenoids and flavones, but certain yellow flowers, such as the garden coreopsis or tickseed are pigmented by mixtures of carotenoids and the deep yellow-orange benzalcoumaranone (aurone) pigments. It is to a member of the latter class of substances that the yellow colour in the lips of the ivory-coloured garden snapdragon is due.

The autumnal reddening of leaves is due to the disappearance of chlorophyll and the formation of anthocyanins (in many cases especially the cyanidin-3-glucoside, chrysanthemin). Anthocyanin formation is promoted by high light intensity and low temperatures. Thus, autumnal colouring is often most striking when a succession of clear, sunny days precedes the advent of frost.

Certain mineral deficiencies in plants often contribute to and can be recognized by the formation of red anthocyanin coloration. Phosphorus deficiency in tomatoes, calcium deficiency in corn (maize) and boron, zinc or molybdenum deficiencies in other plants often manifest themselves by the appearance of reddening of the leaves and stems. However, such reddening can occur only in those plants that possess the genetic factors necessary for the synthesis of anthocyanins.

Disease and injury often cause reddening of the affected plant as a result of derangement of normal metabolic processes and consequent diversion of synthetic pathways toward anthocyanin formation. On the other hand, virus infection is also known to cause the disappearance of normal anthocyanin pigmentation. The "breaking" of red flowers to white in virus-infected stock (*Matthiola incana*) and sweet pea (*Lathyrus odoratus*) is a well-known example. *See* also CHLOROPHYLL, CHEMISTRY OF; ANTHOCYANINS AND ANTHOXANTHINS; PLANTS AND PLANT SCIENCE: *Plant Physiology*.

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PLANT DISEASES. Plants as well as animals are susceptible to injurious and often fatal diseases. Some of these disorders can be attributed to inanimate and nonparasitic factors such as adverse environmental conditions: unfavourable temperature or humidity; unsuitable soil and light conditions; excess or deficiency of minerals needed for proper plant growth; and presence of poisonous substances in the air or in the soil. Furthermore, physical and mechanical damage brought about by violent storms, improper cultivation practices, etc., besides being disastrous in themselves, may prepare the way for widespread infection by other disease agents.

Among living agents such animals as insects, besides often interfering directly with plant metabolism, frequently serve as carriers in transmitting other disease agents from plant to plant. Since the development of plant pathology (or phytopathology, the study of plant disease) and entomology into separate disciplines, the study of insect and mite pests has usually been considered the province of economic entomology (*see* ENTOMOLOGY: *Applied Entomology*). The damage done to plants by larger animals (slugs, birds, rabbits, rodents, etc.), though not strictly speaking disease, may be of local importance; the depredations of these pests are studied in economic zoology (*see* ZOOLOGY: *Economic Zoology*). These plant eaters and plant dwellers also may serve as carriers of disease agents, though they are of far less importance in this regard than are insects.

The greatest number of economically important disease-causing plants are found among bacteria and fungi; a few algae are responsible for some relatively unimportant tropical plant diseases (*see* BACTERIOLOGY; FUNGI; ALGAE). Among flowering plants only a few forms are of occasional importance (*see* PARASITOLOGY). Several slime molds (organisms bordering the animal and plant kingdoms) and numerous viruses (*q.v.*; organized particles bridging life and nonlife) also are important agents of plant disease.

This article is divided into the following sections:

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I. HISTORICAL BACKGROUND

Plant diseases are referred to in some of man's earliest writings. Among the abominable curses reported in the Bible (Deut. xxviii) for disobedience to the commandments were doubtless both rust and bunt or stinking smut of wheat. These diseases probably did not often wipe out an entire crop but, like poverty, they were ever present, sometimes mild, sometimes severe. Frequent biblical references to blasts, mildews and plagues of locusts are suggestive of the fear in which these pestilences were held.

The early Greeks—Aristotle, and particularly his pupil Theophrastus, the father of botany—described diseases of a number of cultivated crops. The Romans were so concerned about rust on their grain that each spring they tried to appease Robigus, the god of rust, with the feast of Robigalia, in which they supplicated him so that rust would do less damage to their crops.

In Shakespeare's time, discussion of the damage caused by rusts and smuts reached parliament. In 1660 a law was passed in Rouen, Fr., to the effect that barberry bushes, which had recently been shown to be associated with cereal rusts, were to be eradicated. Similar laws were passed in the New England states during the American colonial period.

The Irish famine began in 1845–46 following an epidemic of late blight on potatoes. The epidemic continued for several years, and starvation occurred in many places in western Europe after failures of the potato crop. Other famines have occurred from time to time because of failures of wheat, rice and other food crops brought about by plant diseases. The extensive plantations of larch trees in western Europe were destroyed after about 1860 by larch canker. Powdery mildew in 1851 and downy mildew in 1878 began devastating epidemics in European vineyards. The epidemic of coffee rust in Ceylon, beginning in the 1870s, is sometimes credited with helping to keep the English confirmed tea drinkers; after the rust destroyed the thriving Ceylonese coffee industry, new plantations were grown to tea, and South America became the coffee-growing centre. In the United States the American chestnut was practically wiped out following the introduction of the chestnut blight fungus in 1904. Peach yellows, curly top of sugar beets and flax wilt have been disastrous from time to time in the U.S. before being brought under control.

Plant diseases have always caused substantial reductions in yield of many economic crops. For example, in 1958, 70% of the production costs of a large fruit company in Central America were expended in controlling banana diseases. In addition to the actual losses in production caused by plant diseases, there also have been violent fluctuations in crop yields: when the crop was in short supply, prices went up; when large plantings were made to allow for losses that never occurred, there was a superabundance of crop with a corresponding fall in prices and disturbance in economic balance. One or another plant disease is a continuing threat against each of the economic crops.

Fortunately, the microorganisms causing diseases of plants are not agents of disease in animals and man. Some of the fungus structures are poisonous, however, if eaten. Ergot (*Claviceps purpurea*) of rye appears as elongated, hard, purple, beanlike masses (sclerotia) which replace certain grains on the rye head. Ergot-infected rye was often used in cheap bread until the poisonous nature of the infected grain was understood; ergot poisoning, which often induced gangrene, swept over France nine times in the 17th century and seven times in the 18th century (*see* ERGOT). Grain infected with scab fungus (*Gibberella zeae*) also is toxic.

Although the history of plant pathology is too extensive to be treated here, two occurrences are especially noteworthy. First, Bénédict Prévost, in his classic work on wheat bunt (1807), demonstrated that microorganisms cause disease; his findings went unheeded till Anton de Bary confirmed them in 1853. Second, following the epidemic of downy mildew on grape in 1878, Bordeaux mixture, discovered by P. M. A. Millardet, established the use of sprays against plant diseases. Bordeaux mixture, because of its robin's-egg blue precipitate, was originally applied along the roadside edges of the vineyards to discourage thievery of the grapes. It proved to be also a control against downy mildew.

II. DEFINITION, CLASSIFICATION AND SYMPTOMS

1. Definition.—The early plant-disease terminology was frequently borrowed from medicine. The term "disease" is used, even though plants feel neither ease nor discomfort. "Populations" are spoken of, though plants are not people, and when disease affects large numbers of individual plants it is called an epidemic (meaning "on people"), although some plant pathologists prefer the term epiphytotic ("on plants").

It is difficult to arrive at a definition of plant disease that covers all cases. One definition regards a diseased plant as an abnormal plant. Normality, then, may be defined in terms of rough averages of important plant characteristics, and disease as a serious departure from the norm. Among the various definitions the following has proved useful as a working statement: A diseased

BY COURTESY OF (LEFT) UNIVERSITY OF ILLINOIS, (CENTRE, RIGHT) J. R. SHAY, PURDUE UNIVERSITY

SYMPTOMS OF PLANT DISEASES

(Left) Hypoxylen canker, an extensive destruction of tissue seen on the trunk of a quaking aspen tree, is a symptom of bacterial infection. (Centre) Variation from normal colour, as in this example of early blight fungal infection of tomato leaf, is a symptom of disease caused by many different agents. (Right) Blister spots, shown here on an apple, are symptomatic of infection by bacteria

plant is one which is so impaired as a whole or in any of its important parts that its usefulness to itself or to mankind is seriously reduced.

2. Classification.—Classification of plant diseases commonly is based on causal agent: nonparasitic, virus, bacterial, fungus, etc. Classification also may be made according to plants affected. Host indexes (lists of diseases known to occur on certain hosts) are valuable; *e.g.*, when a new disease is found on a known host, a check into the index for the specific host may often lead to identification of the causal agent. Classifications according to symptoms have been tried, but they fail in many detailed approaches because one causal agent may induce several different symptoms which often intergrade.

BY COURTESY OF (TOP LEFT, RIGHT) MORTON ARBORETUM, (BOTTOM LEFT) UNIVERSITY OF IOWA

THREE CAUSES OF GALLS

Galls, localized swellings usually affecting a part of a plant, are symptoms of various types of diseases. (Top left) Hedgehog galls on an oak leaf are caused by insect damage to the vein of the leaf. (Right) Cedar apple gall, natural-looking and seemingly attractive, is actually the result of a fungal infection. (Bottom left) Crown galls on raspberry stems are produced by bacterial infection

3. Symptoms.—The symptoms of plant diseases, though they may be quite variable, are frequently helpful in diagnosis. Among the more important symptoms are the following:

1. Change in colour. Instead of the normal green, leaves frequently are pale green or yellow (chlorotic) or spotted. Coloured spots vary between red, green, yellow, brown and black. In some cases a separation of the epidermis of a leaf from the tissue below may cause "silvering."

2. Shot hole in leaves. Certain fungi and certain toxic agents induce in leaves many small holes, as though the leaf had been hit by shotgun pellets.

3. Wilt. Plants often droop and lean or fall over, usually from lack of water but sometimes from injury to the supporting stems or roots.

4. Death of the entire plant or of a part is called necrosis, a common symptom.

5. Stunting or failure to develop. This may involve the whole plant or only leaves and flowers.

6. Galls. An increase of size of cells is called hypertrophy. An increase in the number of cells is called hyperplasia. Often they occur together in galls.

7. Transformations occur when parts are replaced, as in ergot of grain, in corn smut or when flower petals develop as abortive green leaves.

8. Mummification involves the shriveling and drying of fruits.

9. Alterations in growth habit and in normal symmetry involve many changes in the stems, leaves and flowers.

10. Destruction of organs through changes in flowers and seeds, as in loose smuts of cereals.

11. Dropping of leaves, blossoms and fruits.

12. Production of malformations. These are of many kinds, including abnormal hairs, blisters, warts, galls, cankers, witches' brooms, hairy root, curling, fusion of plant parts (fasciation) and deformation of fruits.

13. Extrusion of liquid or oozes. Examples are the sticky exudate in fire blight, slime flux of trees, formations of masses of gum, production of resin and exudation of milky sap.

14. Rots. The soft rots usually are watery and have a bad odour. They commonly are associated with soft tissue, dry rots with woody structures. Often the rots are characterized as root rots, stem rots, bud rots, fruit rots, wood rots and so on, depending upon the part affected.

III. CAUSES

Factors inducing plant disease may be classified as physiological or nonparasitic, virus and living organisms. (The viruses, as mentioned above, hold an intermediate position while their status as nonliving or living is debated.)

A. Nonparasitic Agents

Injuries which occur because of "accidents," poisons or defects in the environment often result in diseased tissues. In addition, these injuries may enable microorganisms to enter secondarily and cause still further damage. The cause of such disease is sometimes obvious (*e.g.*, lightning or drought), but often it is obscure to untrained eyes. Only when the cause is known can an intelligent search for a remedy or a means of prevention be conducted.

1. Physical and Chemical Injury.—Fire, water, frost, higher animals, insects and machinery as well as poor agricultural techniques may cause serious damage to crops and permit invasion by disease agents. Graft knots often follow badly fitted grafts on apple trees grown from piece-root grafts. Waste products such as noxious gas, smog, dust and smoke may provoke injuries.

Many chemicals are profitably used alone or in combinations to prevent damage by insects and microorganisms or to kill weeds. However, when these materials are applied improperly, serious physiological diseases may result. Such injuries are fairly common from improperly used sprays, seed treatments, fumigation, soil treatment, fertilizers, herbicides and hormones.

2. Unsuitable Environment.—Plants in unfavourable environments may vary so far from their normal growth habits that they are considered diseased. In addition, such plants often are unusually subject to attack by microorganisms.

Too high a temperature may cause sun scald and death in the tips and margins of leaves. In some small plants, cankers develop at the soil surface where the temperature in direct sunlight may greatly exceed the air temperature. Frost injury is relatively common, but even low temperatures above freezing may cause damage, such as net necrosis in potatoes. On many exposed northern trees frequent alternations of thawing by day and freezing by night kill the bark and cause southwest canker. Drought often accompanies high temperatures and causes stunting, wilting and burning. On the other hand, if water covers the roots too long they may be damaged because of insufficient oxygen. An excess of water, if it falls on a warm day followed by a cool night, may induce flooding of the tissue. Such diseases result as water core of apples, celery heart rot and tomato blossom end rot. The last two often lead to invasion by secondary microorganisms. Abundant moisture usually favours infection by bacteria and fungi.

Both the intensity and duration of light may influence the development of plants. With insufficient light, sun-loving plants may become chlorotic. In certain greenhouses a short day may combine with a high temperature. These conditions promote rapid but relatively succulent growth. Spindly growth thus formed may be more susceptible to attack by pathogens than is normal growth.

Poor aeration may cause black heart in stored potatoes. An accumulation of certain gases from the respiration of apples in storage may cause apple scald.

Plants require various essential elements for their normal growth. The classic ones include carbon, hydrogen, oxygen, nitrogen, sulfur, magnesium, iron, calcium, potassium and phosphorus; chlorine also has been listed as essential. In addition, many other trace elements are necessary, among them boron, zinc, copper and

DISEASES CAUSED BY NONPARASITIC AGENTS

(Top) Chemical injury. A yellow mottling of soybean plant leaves was the result of improper application of a weed-killing chemical, atrazine. (Bottom centre) Discoloured and thickened leaves of rose-of-sharon caused by air pollution. (Bottom) Blossom end rot of pepper, indicated by brown discoloured areas, produced by unsuitable weather conditions that result in flooding of tissues with liquid

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manganese. Characteristic symptoms occur with an excess or deficiency of mineral salts.

Thus a considerable group of nonparasitic or physiological diseases occur when, for one reason or another, the plant's physiology departs critically from the normal. In addition to their influences on the host plants, these environmental factors often affect the activities of pathogens, as well as the interactions that result between hosts and pathogens.

B. Viruses

A number of infectious diseases result from viruses (*q.v.*), particles visible only in the electron microscope and small enough to pass through a filter that excludes ordinary bacteria. Plant viruses thus have great economic importance. To mention tobacco, potato, sugar beet, peach, orange and elm is only to begin the list of economic plants which are affected by viruses.

The plant disease symptoms caused by viruses include: (1) change in colour such as yellowing, mottling and vein clearing (becoming translucent); (2) malformations such as distortion, rosetting (close, tight whorls of leaves), proliferation and little or no leaf development between the veins; (3) necrosis such as leaf spots, rings, streak, wilt, droop and internal death, especially of phloem tissue; and (4) stunting. In some cases infected plants may carry the virus and show no disease; thus they are symptomless carriers which provide a source of inoculum for other host plants.

Transmission of viruses from one plant to another in some cases involves only touching a diseased plant and then touching a healthy one, but in others it occurs less easily. Many viruses are carried by insects, especially aphids and leafhoppers. Transmission of a virus disease is practically assured by budding or grafting with diseased material. Certain viruses have been able to persist in the soil. Seed transmission has not been common, but it has occurred, for example, with certain large-seeded legumes, with melons, squash, stone fruits (*Prunus* species), lettuce, barley and elm.

In many cases a single virus may infect a number of different kinds of plants, and a single kind of plant may be infected by a number of different viruses.

Control of viruses has been accomplished by using resistant plants, by destroying infected plants, by inspection and certification of disease-free stock, by quarantine and by other special means. Infected peach twigs and sugar cane shoots have been heat-treated for a short time so that the new plants developed from them were free from viruses. Certain rapidly growing sprouts from diseased dahlias and chrysanthemums have outgrown the slower traveling virus, so that the stem tips could be used vegetatively to propagate healthy plants. With certain potatoes, a few cells from the growing tips have been grown aseptically in tissue culture (*see* Tissue Culture), and from them the whole plant has been developed free from virus. A delay in the spread of virus infection has been accomplished by control of insect vectors and by sanitation in agricultural operations.

Among the numerous virus diseases of plants, that caused by the tobacco mosaic virus (TMV) is well known and has great economic importance. Besides affecting many members of the nightshade family (Solanaceae), which includes tobacco, tomato and potato, TMV occurs on some 30 species of plants in 14 other families. The symptoms characteristically appear as dark green spots irregularly elevated and scattered on the tobacco leaf. The remainder of the leaf becomes more and more pale green and sometimes yellow in colour. The name "mosaic" derives from these variable small blotches of different colours. The effects from TMV often are similar to those caused by the cucumber mosaic virus.

TMV, like some other viruses, is resistant to many unfavourable conditions. It has been the subject of many important fundamental researches on viruses that have led to a better understanding not only of plant viruses but also of animal and human viruses. TMV was the first virus to be crystallized; this was accomplished in 1935 by W. M. Stanley. Twenty years later its rodlike structure was shown to consist of a central core of ribonucleic acid (RNA) surrounded by a spiral of amino acids forming proteinaceous material.

C. Living Organisms

Relationships between microorganisms and higher plants are not always disadvantageous. The root nodules of leguminous plants (such as alfalfa, clover, soybean and pea) are produced by bacteria with resultant fixation of atmospheric nitrogen and benefit to the plant (*see* Symbiosis). Various fungi assist in the germination of seed and the growth of plants, such as orchids, heaths and forest trees (*see* Mycorhiza).

1. Parasitism and Pathogenicity.—Most microorganisms are beneficial in clearing away the debris of dead plants and animals and in building up the soil for more plants to grow. Those growing only on dead tissue are called saprophytes. However, some microorganisms secure their food from plants which are still living. They are called parasites, and if they cause significant injury or disease they are termed pathogens. An obligate parasite requires living tissue; a facultative parasite can grow on either living or nonliving material.

Proof of Pathogenicity.—The evidence necessary to prove that a certain pathogen is the cause of a particular disease is frequently arranged in a series of experimental steps called Koch's postulates, after the German bacteriologist Robert Koch. Only when these four steps are successfully carried out is the pathogen definitely identified as the cause of the disease:

1. The pathogen must be found in the diseased tissue of the infected plant (or animal), and must always be associated with the disease in question; conversely, the disease must never be found without the pathogen's being present or having been present.
2. The pathogen must be isolated from the diseased host and must be grown in pure culture (*i.e.*, without other pathogens present as contaminants) and characterized in the laboratory.
3. Some of the laboratory-grown pure culture is then inoculated into a healthy host, under favourable conditions, and symptoms of the disease as it appeared in the original host must appear in this experimental host.
4. From the experimental host the pathogen must again be isolated and definitely proved to be identical to the first isolated pathogen.

Many different culture media are used for the isolation and laboratory cultivation of pathogenic microorganisms; one favourable for the culture of certain bacteria and fungi pathogenic on plants is a mixture of potato extract, distilled water, agar and dextrose (PDA medium). After the medium has been properly

processed (potatoes cooked, extract decanted and mixed with other ingredients, acidity checked, filtered and placed in culture tubes or flasks plugged with cotton), it is sterilized about 20 min. at 15-lb. pressure in a steam sterilizer (autoclave). When melted the agar medium may be poured into sterilized covered dishes (Petri dishes) and allowed to solidify.

Isolation of pathogenic bacteria usually follows the common dilution poured-plate technique. In this method the bacterial culture is diluted in media, and after suitable incubation characteristic colonies are transferred to culture tubes for further study.

In isolating fungi, many small pieces of diseased tissue, each weighing usually 4 to 12 mg., are taken from the most advanced margin of the infected area. Three to ten of these pieces are placed aseptically on sterile medium in each of several Petri dishes and incubated several days at a suitable temperature (usually 20° to 28° C.). In many cases the pathogen, free from other microbes, grows from some of the pieces. The pathogens are transferred to fresh sterile medium in culture tubes. The small size of the diseased tissues, their points of origin and their considerable number improve the chances of pure cultures of fungi free from the secondary invaders that usually follow rapidly behind the pathogens. Development of many specialized techniques has been necessary to facilitate the recovery of the pathogens and their identification (*see* BACTERIOLOGY; FUNGI).

Inoculations of susceptible plants are made with temperature, moisture and other factors favourable for the pathogen. The details of the technique depend on the life history of the causal agent. Pathogens occurring commonly in the roots frequently are introduced into the soil where the plants are growing. Seed inoculations often are used by applying spores to the seed. Growing plants are commonly sprayed with a liquid containing the pathogen. A favourite method is the introduction of bacteria or spores through artificially made wounds—cuts, stabs, etc.

In identifying virus and obligate pathogens Koch's postulates must be modified by other rules of proof since these forms can reproduce only in living tissue. Man may experimentally inoculate susceptible hosts with viruses by mechanical abrasion or grafting, or by the use of insect vectors, especially aphids and leafhoppers, or virus-bearing dodder (*see* below).

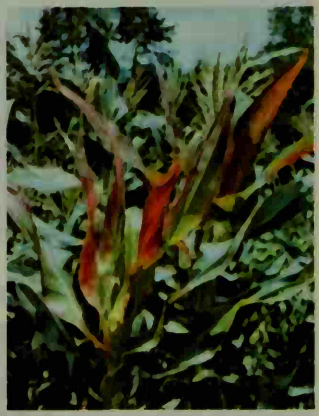
Life History in Relation to Pathogenesis.—Large populations are the primary interest of the plant pathologist because individual plants are seldom of great value. He is, therefore, especially concerned with epidemics. Epidemics develop as an endless chain of events, chief among which are transmission of the pathogen to the host plant, its entrance, its establishment and development inside, and its exit and once again its transmission to new hosts. Depending on favourable or unfavourable weather and on the intervention of harvest or of winter, the number of times this cycle is repeated influences the severity of the epidemic.

The chief events in this life history may be clarified further. Entrance of the pathogen may be by direct penetration through the outer covering or cuticle of a leaf, through wounds made by insects or other agencies or through natural openings in the plant. Such natural openings include growing tips of roots or stems, lateral root exits, lenticles on stems, stomata, open ends of leaf veins (hydathodes) and flower parts. Once inside, the pathogen may become established either between or inside the cells, sometimes both. As a pathogen develops and produces the characteristic symptoms, portions of it may grow to the surface or reach the outside after decomposition of the tissue. The pathogen then may be carried to a new host by wind, water, animals, insects or agricultural operations.

While many of these agencies operate in relatively localized areas, pathogens can be distributed widely over the world in shipments containing plants or plant materials; for example, straw used to pack around dishes has been found to carry important small grain pathogens.

Life Cycle.—In fungi, in addition to this life history, the life cycle, particularly when the fungus has an alternate host, may be important. The life cycle of black stem rust of wheat (discussed below) shows as many as five different kinds of spore-bearing structures, with as many different kinds of spores and two kinds of mycelium. It is essential to know these different stages and their bearing on the life history in relation to pathogenesis for both the primary and the alternate hosts. Such information may show the weak links in the endless chain of events in an epidemic, may indicate how such links may be broken and thus how control may be achieved. Critical points in the development of an epidemic may appear if the temperature and moisture should become unfavourable. Thus the weather often provides control, but it is notoriously unreliable.

Environmental Influence on Host and Parasite.—The important environmental factors listed under *Nonparasitic Agents*, above, also affect host plants and their pathogens. Among these factors temperature, moisture and soil reaction may be particularly important. What is good for one pathogen may be bad for another. For example, red pine seedlings growing in Plainfield sand at a forest nursery in Wisconsin have been attacked by one damping-off fungus (*Pythium*) when the soil was cool, moist and neutral to slightly acid; this fungus was almost completely replaced by another damping-off fungus (*Rhizoctonia*) when the soil was relatively warm, dry and acid. Special studies with pathogens and hosts under closely controlled conditions both in the laboratory and greenhouse are useful to describe environmental conditions.



DISEASES CAUSED BY VIRUSES

BY COURTESY OF (TOP RIGHT) J. R. SHAY, PURDUE UNIVERSITY, (BOTTOM LEFT AND RIGHT) UNIVERSITY OF WISCONSIN, (BOTTOM LEFT) JAMES E. KUNTZ, (BOTTOM RIGHT) R. W. FULTON; PHOTOGRAPH, (TOP LEFT) FRANK P. MCWHORTER

(Top left) Clara Butt tulip showing normal colour and the streaked colour produced by a virus. (Top right) Corn plants affected by a virus that causes reddening of leaves and stunting. (Bottom left) Malformed aster flower infected by aster yellows virus compared with a healthy flower. (Bottom right) Tobacco leaves showing symptoms of tobacco mosaic virus, including mottling and chlorosis

Records of what happens in nature as the season progresses also are essential.

Seasonal Development of Disease.—To understand how a disease develops in the field is critical for the successful application of control measures. Records of important factors should be taken from the beginning to the end of the growing season. Some of these factors are: (1) weather (maximum and minimum daily temperature and humidity, amount and times of rain, dew and sunshine); (2) growth of the host (increase in vegetative growth, time of flowering and development of fruit); (3) presence of the pathogen (availability of inoculum and of insect or other vectors for spreading it); (4) development of lesions from primary and secondary natural inoculations (parts infected, spread of the lesions, formation of secondary inoculum for further spread of disease); (5) incubation periods following artificial inoculations made at frequent intervals throughout the season; and (6) times of sprays or applications of other control measures. With such information the investigator may, for example, take the date when natural infection appears, subtract the days necessary for an incubation period and determine the date when natural inoculation took place. By checking the records he may determine the natural conditions that were favourable for infection. Thus when sufficient evidence is available, the critical times and conditions for control efforts are clarified.

Disease Forecasting.—Valuable forecasts are being made in certain cases from a background of long experience with seasonal development studies and from long-range weather predictions. Time and expense have been saved by avoiding unnecessary spray application; *e.g.*, against potato late blight and apple scab.

2. Bacteria.—Over 150 different bacterial species incite diseases in plants. In general these diseases fall into the following categories: galls, wilts, local spots or lesions, extensive lesions and soft rots. All these symptoms may grade into one another. Sometimes two or more bacteria, bacteria and insects or bacteria and fungi combine to produce a much more damaging disease than may be produced by one agent alone. After bacterial and fungus pathogens have entered a plant, saprophytic organisms usually follow closely and assist in the disintegration of the injured or killed tissue.

Plant bacteriologists have learned a great deal from medical bacteriologists and in return have made many contributions to the advancement of the general field (*see* BACTERIOLOGY). Two representative bacterial plant diseases are mentioned briefly.

Fire Blight.—The first plant disease proved to be of bacterial origin was fire blight on apple, pear and related plants. The bacteria (*Erwinia amylovora*) invade blossoms and rapidly growing shoots, killing the tissue. With suitable warm, moist weather a bacterial exudate appears on the surface. In susceptible species the bacteria may move down the stem, producing an extensive canker; the bacteria may even go down into the root system. This disease has driven certain high-quality pears and apples out of intensive cultivation in the eastern United States.

The life history is simple. The bacteria may enter the tree through wounds, stomata and particularly through flower parts to which they are carried by bees. The bacteria invade the tissues between the cells, but soon kill and enter the cells. The bacteria overwinter in stem cankers (slowly decaying bark and wood). They come to the surface as a bacterial exudate, and new plant parts and other trees are infected when spring rains splash the bacteria-laden exudate and bees carry contaminated nectar from blossom to blossom.

Control in warm, rainy weather is difficult to accomplish. It consists of the removal of diseased parts and the application of antibiotic sprays during the blossom period. In Oregon much success has been achieved by growing a low framework from a blight-resistant pear tree. In the branches of this stock, twigs from high-quality but susceptible trees are grafted. Then if the blight starts in one branch it kills only down to the point of grafting and a new graft may be substituted for it.

(Left) An apple twig infected by fire blight, a bacteria that travels from the limbs down the trunk to the root system of the tree. (Bottom left) A mature tomato with brownish-black scabs caused by bacterial spot infection. (Bottom right) Decayed leaves of lettuce infected with bacterial soft rot

BY COURTESY OF (LEFT, BOTTOM RIGHT) UNIVERSITY OF ILLINOIS, (BOTTOM LEFT) UNIVERSITY OF IOWA

DISEASES CAUSED BY BACTERIA

Crown Gall.—Perhaps the best known of the bacterial plant diseases is crown gall, which derives its name from the knobby growth which appears near the top of the ground or at the crown of the plant. The disease occurs widely over the world, apparently distributed with nursery stock. Its host range is wide, including among many dicotyledonous plants, such economically important ones as peach, apple, pear, rose, raspberry and sugar beet.

The bacteria (*Agrobacterium tumefaciens*) enter only through wounds. They apparently live between cells, which they stimulate to grow both in size and in number. When the galls develop, bacteria appear on the surface, from which they may be washed into the soil or picked up and carried by chewing insects. The disease has been held in control by nursery inspection, disinfection of parts used for vegetative propagation and by planting in well-drained soil that is free from root-chewing insects.

Crown gall often has been called a plant tumour. Many detailed studies have been made of the bacteria, the host plants and the galls. This has been excellent material for fundamental work on diseased growth, and an extensive literature

BY COURTESY OF (LEFT) ILLINOIS NATURAL HISTORY SURVEY, (TOP) MORTON ARBORETUM

DUTCH ELM DISEASE

(Left) An elm infected with the Dutch elm fungus showing browning and thinning of its foliage, typical symptoms of the disease. (Top) Galleries of the elm bark beetle, where the fungus spores multiply, in wood immediately beneath the bark

has developed. Crown gall tissue, free from the causal bacteria, provided the material for early work on plant tissue cultures.

3. Fungi.—Fungi are responsible for by far the greatest number and diversity of plant diseases. Descriptions appear elsewhere of the various fungus groups and of their activity (*see* FUNGI). Although many members of the numerous genera among the fungi are purely saprophytes, interest here is with the many disease inciters. All the economic plants apparently are attacked by one or another of the fungi; often a dozen or more different fungi induce disease on a single species. A few diseases are mentioned briefly as examples.

Late Blight.—The late blight fungus (*Phytophthora infestans*) commonly occurs in the cool, moist regions wherever potatoes are cultivated. A devastating epidemic of this disease on potatoes beginning in Europe in 1845 brought about the famine, particularly in Ireland, that caused starvation, death and mass migration; it influenced the economic, political and cultural development of many people. The damage late blight caused to the potato crop in Germany during World War I is credited with helping to terminate the war.

Symptoms of late blight may appear on any part of the potato; above ground, small black or purplish lesions having pale green margins often increase in size rather rapidly. A whitish mildew is usually present near the margin of the lesions. The progress of the disease over a potato field may be rapid in moist, cool weather; commonly it is checked by dry weather. Tubers may be infected in the field. A brown or rusty, sometimes purplish skin discoloration appears first and usually extends into the tuber five to ten millimeters. A damaging rot, in association with secondary organisms, may develop. Tuber rot, a slimy, evil-smelling soft rot that may completely destroy the tuber, may continue in storage.

The infection cycle begins with the planting of infected tubers in which the fungus overwinters. The infection may come also from infected cull piles or plants in a field. Spores developing from these sources may infect nearby plants and may spread rapidly in an almost endless cycle so long as cool, moist weather prevails.

Control has been achieved by various means, including suitable sanitary measures, the use of resistant varieties, forecasting of weather favourable for a blight epidemic and applications of protectant sprays.

Chestnut Blight.—The American chestnuts have been practically eliminated from their commercial range by a fungus imported from the orient. The blight occurs in Japan and China as a minor disease on the native chestnuts there. When it appeared in New York in 1904 it was a curiosity; its seriousness was not realized until several years had passed.

By 1908 this disease had produced extensive damage in areas around New York and had appeared as far away as Delaware and Virginia. Numerous costly efforts failed to bring the widespreading epidemic under control, and it continued with alarming and deadly rapidity, with the subsequent decimation of this extremely valuable native hardwood species.

Young infections on two- to six-year-old chestnut shoots appear as yellowish or brown patches contrasting with the olive green of healthy bark. The lesions spread until the shoot is encircled, at which time the shoot dies. Fruiting pustules of the fungus appear. During moist weather, spores embedded in a mucilaginous matrix are extruded from the pustules, forming long, irregularly twisted threads or spore horns, buff to yellow in colour. After one to several years, large trees assume a staghead appearance; later, the entire top of the tree dies. The roots have a surprising capacity for sending up sprouts, which often escape the disease for a number of years.

The causal fungus is *Endothia parasitica*. The spores extruded from the pustules are carried short distances by splashing rain and wind. The rapidity and pattern of spread over long distances have been correlated with the flight of migratory birds. Presumably the birds carry spores upon their feet from a diseased

DISEASES CAUSED BY FUNGI

BY COURTESY OF (TOP LEFT) UNIVERSITY OF ILLINOIS, (TOP RIGHT) UNIVERSITY OF IOWA, (BOTTOM LEFT) MORTON ARBORETUM, (BOTTOM RIGHT) UNIVERSITY OF WISCONSIN

(Top left) A cucumber showing small, circular, water-soaked lesions and brown necrotic tissue of fungal scab. (Top right) Plums decayed and mummified by brown rot fungus. (Bottom left) Grapes covered with white fungus spores of downy mildew. (Bottom right) An ear of corn deformed by a large smut gall

branch to a healthy branch, sometimes some distance away. The number of spores produced, as with many fungi, is enormous; a single, average spore horn contains over 100,000,000 spores.

Although no control measure was found to save the American chestnut, other species have shown more or less resistance. Long-range breeding experiments have been undertaken to develop blight resistant trees of good timber quality. Crosses between American and Asiatic chestnuts have produced trees with excellent nuts, but timber quality has been closely linked with susceptibility to blight.

Dutch Elm Disease.—A serious new disease on elms was described in 1921 in the Netherlands, thus acquiring the name "Dutch elm disease," though it doubtless originated much farther east. Following the description of the disease, reports of its occurrence soon came from many regions in both Europe and Asia.

BY COURTESY OF UNIVERSITY OF ILLINOIS

STEM RUST OF WHEAT

Stem, sheath, and leaves of wheat covered with the red rust, or summer, stage of black stem rust fungus (*Puccinia graminis*)

On an infected twig the leaves progressively wilt, curl or turn yellow and drop off. The progress of the disease is rapid on succulent, young, rapidly growing trees and relatively slow on older or more slowly growing trees. As large trees die slowly during several years, the dead upper branches appear stagheaded. A cut across an infected branch shows a brown arc or ring where brownish gum has accumulated in the water-conducting vessels. These symptoms are easily confused with those caused by *Verticillium* or *Dothiorella* wilts. Laboratory culture of the causal fungus, *Ceratostomella ulmi* (or *Graphium ulmi*), has been necessary for accurate diagnosis.

The fungus spreads rapidly through vascular tissue of the trees. European and American elm bark beetles bore into and colonize the larger killed branches. Subsequently, spores of the fungus develop in great abundance in the insects' tunnels or galleries. The insects then inoculate the spores into other trees.

Selected smoothleaf elm (*Ulmus carpinifolia*) seedlings have shown promising resistance in the Netherlands. Likewise, a few American elm (*U. americana*) saplings have withstood severe, successive inoculations. Some species such as Chinese elm (*U. parvifolia*) and Siberian elm (*U. pumila*) have appeared somewhat resistant. Tree breeders may hope that suitable disease-resistant trees can be developed.

Meantime, the best control measures consist of removal and destruction of beetle breeding sites, which consist of all dead and weakened elm wood. In addition to this, a dormant spray with a suitable insecticide has proved useful to prevent feeding by the beetles on the small elm twigs. Control measures, to be effective, must be carried out with great care. A few undestroyed breeding sites or poor spray coverage may vitiate the entire effort. Such control measures are expensive, but in urban areas the removal and replacement of dead elm trees as well as the resultant loss in real-estate values are also expensive. Research seems promising both on resistant trees and on chemicals that are active against either the causal fungus or the insect vector. (*See* ELM.)

Black Stem Rust of Wheat.—One of the oldest known and still one of the most important diseases of food crops is the black stem rust caused by the fungus *Puccinia graminis*. Its destructive ability on wheat crops in the U.S. may be judged by a few examples. In 1935 almost 60% of the hard red spring wheat crop was lost in Minnesota and the Dakotas. In some areas the loss was practically complete. The grain harvested was lightweight and inferior in quality. In 1953 and 1954 about 65% to 80% loss occurred over the same area in durum wheat and 10% to 35% loss in the spring wheat. The short supply caused sharp changes in prices and large economic disturbances.

This rust has a wide host range, but the discussion here is limited to wheat. It occurs practically everywhere that wheat is grown. In its complex life cycle there are several different kinds of spores, some on wheat and some on the barberry.

The uredial or red rust stage occurs on wheat leaves and stems as elongate pustules containing enormous numbers of reddish spores called uredospores. The epidermis is broken, giving a rough appearance. The spores are blown to other wheat plants where they germinate and again give infection. The cycle repeats so long as susceptible living wheat and suitable weather occur. The symptoms vary from tiny scattered yellow flecks to numerous pustules close together. Sometimes chlorosis develops. Different kinds of resistance or susceptibility have been classified by the characteristics of these pustules.

The red colour turns to black as the uredospores blow away and the blackish teliospores develop (hence the name black stem rust). These thick-walled two-celled spores are hardy; they live over winter and germinate in the spring to form special spores called sporidia or basidiospores. Sporidia cannot infect wheat. They blow onto the leaves of common barberry bush, and there the fungus develops to form spermogonia on the upper surface. These orange-yellow spots exude a sticky liquid containing spermatia. Following a suitable cross-fertilization between spermogonial spots, the fungus develops a cluster of tubular cups called aecia on the lower surface. These cups contain still another type of spore, aeciospores, which infect wheat but cannot infect barberry. When aeciospores blow onto wheat or grasses the red rust stage again develops. The wind may carry red spores hundreds of miles.

The susceptible common barberry (*Berberis vulgaris*) has been successfully eradicated in most areas of North America. The Japanese barberry (*B. thunbergi*), a common ornamental shrub, is immune to wheat rust.

Both the rust fungus and the wheat plant are highly variable. By means of distinctive rust symptoms on a dozen differential wheat varieties, over 250 physiological races of black stem rust have been described. As researches on physiological races have

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DISEASES CAUSED BY NEMATODES

(Top) Cysts, or tiny nodes, on soybean plant roots, containing eggs of nematodes. (Bottom) Tiny, gall-like swellings on carrot roots, caused by root knot nematodes that distort the tissue

shown, certain varieties of wheat may be resistant to some races and susceptible to others. Practical breeding programs for wheat have centred on the important regional races of black stem rust, on resistance to other rusts, smuts, root rots and on the various characters which add to the quality of the grain. To keep ahead of the variability of the fungi, breeding must be a continuing process. One curious evidence of resistance has been described as the necrotic fleck reaction. After the rust fungus has entered a leaf and has made contact with the wheat cells below, both wheat cells and fungus have died, thus cutting off the progress of the pathogen and leaving only a fleck spot. (*See* also SMUT AND BUNT.)

The blister rust (caused by *Cronartium ribicola*) on white pine trees has a comparable cycle with gooseberry and currant bushes as the alternate hosts (*see* BLISTER RUST).

Wood Rots.—Certain higher fungi actively decompose forest timber. The losses from dead trees and from the effect of decay on growth may approach 45% of the losses of timber from all causes combined. Furthermore, such fungi may decay lumber and wood products in use so that expensive replacements become necessary (*see* DRY ROT).

4. Other Pathogens.—Although viruses, bacteria and fungi comprise the greater number of pathogens, flowering plants and microscopic roundworms or eelworms (nematodes) are sometimes important.

Flowering Plants.—Among the numerous parasitic seed plants, mistletoe, dodder and witchweed serve as examples.

Mistletoe, really a semiparasite, is well known, especially for its ornamental and sentimental uses at Christmas time. But various species are dangerous parasites of certain deciduous and coniferous trees. The bushy green growth appears on the tree branches, becoming especially conspicuous after the deciduous leaves have fallen; the dwarf mistletoe that is common on conifers is not so obvious. After the parasite has grown for a year or more the branch may die or break off. Infection may also induce delayed growth in the spring and stunting. The sticky seeds sometimes are ejected and carried a few yards by the wind; they may also be carried longer distances by birds. Once the seeds adhere to a branch, they germinate and penetrate the water-conducting tissue where they obtain primarily water and mineral salts. (*See* MISTLETOE.)

Dodder has various uncomplimentary names such as strangle-weed, devil's hair and hellbind. The numerous species are widely distributed (*see* DODDER), and it has appeared seriously in southern Europe and the U.S.S.R., being of less importance in North America. Its chief damage is to clover, alfalfa and flax. The yellow-orange threadlike stems wind around the host plants. By extending to other plants it may draw them together and toward the ground. The area invaded seldom exceeds three metres the first year, but the spread may be much more rapid in later years. Dodder may be widely distributed as a contaminant in seed. For control in the field dodder may be cut, dried, sprinkled with fuel oil and burned.

Witchweed (*Striga asiatica*) is widely distributed in Asia and South Africa. It appeared in South Carolina in 1951 and caused increasing concern in that region. Witchweed parasitizes the roots of a wide host range, including corn (maize), sorghum, sugar cane, rice, rye and oats. Serious infestations can destroy the yield from a cornfield. The parasite grows eight to ten inches high and has red or orange flowers. It produces enormous numbers of tiny seeds that live in the soil for years until stimulated to grow, apparently by an excretion from the root of a host plant. Witchweed robs the host of water and food. Infected plants fall far behind normal plants in growth and often die. Control has been difficult. Some methods have proved helpful, such as rotation with a resistant crop and prevention of seed set by growing trap crops and then destroying them, and by covering a small area with dry refuse and burning it. Active research is seeking better control measures.

Nematodes.—Plant parasitic nematodes are slender microscopic eelworms of great economic importance. One or more species attack practically all crop plants. Usually they live in the soil and attack underground parts, but occasionally certain eelworms inhabit the buds, stems, leaves or inflorescence. More than 100 species cause decline, stunting or death (*see* ROUNDWORM).

Nematodes usually attack only small roots. Root injury develops partly from the nematodes' feeding on cells penetrated and partly from the toxic salivary excretions of the parasites. The tissues often respond by producing either an enlargement (hypertrophy) or degeneration of cells, and sometimes both. In the field nematodes may associate with fungi and bacteria to induce disease complexes such as root rots that are more conspicuous than the injury caused by nematodes alone.

Many nematodes are native and transfer to cultivated plants when their natural hosts are removed. Others have been introduced with seedling plants, bulbs, tubers, seeds and particularly in soil balled around the roots of nursery stock.

Root knot nematodes (*Meloidogyne* species) are well known because of the conspicuous tiny gall-like swellings they induce on roots. Many kinds of higher plants are subject to their attack. Losses are often heavy, especially in warm regions with long growing seasons; certain species, however, such as the northern root knot nematode (*M. hapla*), are found where the soil may freeze to a depth of two or three feet. Truck crops, potatoes, tomatoes, melons, cotton, strawberries and orchard trees are commonly attacked. Garden plants and ornamentals frequently become infested through planting stock.

Root lesion nematodes (*Pratylenchus* species) are migratory internal parasites (endoparasites) which cause severe losses in many crops by penetrating roots and making their way through the tissues, breaking down the cells as they feed. They deposit eggs from which new colonies develop. After the root begins to decline they move out into the soil in search of healthy roots. Lesions form as fungi and bacteria enter the damaged tissues, and root rot often sets in. Annual crops may succumb early in the season, but perennials and orchard trees may not show decline for several years.

The golden nematode of potatoes (*Heterodera rostochiensis*) is a leading menace of the potato industry of Europe. Great effort is being made to control it. A related species, the sugar beet nematode (*H. schachtii*), is a critical pest that has restricted the acreage of sugar beets in Europe, Asia and America.

The citrus nematode (*Tylenchulus semipenetrans*) occurs throughout the citrus-producing regions and exacts a heavy toll. Typical symptoms are the common slow decline and dieback visible in many groves over 15 years old. Infested nursery stock has given the parasite wide distribution.

The burrowing nematode (*Radopholus similis*) is a serious parasite in the tropics, where it attacks citrus, banana, pepper, abacá and other important crops, causing severe losses.

Many important surface parasites (ectoparasites) feed on the roots of plants somewhat as aphids feed on the stems. Among the most important are the American dagger nematode (*Xiphinema americanum*), stubby root nematodes (*Trichodorus* species) and spiral nematodes (*Rotylenchus* species).

Leaf (foliar) nematodes include the bulb and stem nematode (*Ditylenchus dipsaci*), which has caused severe losses in the bulb industry and in clover, alfalfa and other crops.

The wheat nematode (*Anguina tritici*) is a dangerous pest that transforms the seed into a blackened cockle. Other species of *Anguina* destroy the seeds of many grasses.

Nematode control is approached in several ways. Many nematodes have certain host preferences so that crop rotations give satisfactory control. Resistant varieties of plants have been selected against certain species of nematodes and have been grown successfully over large areas. Such work is promising for the future. Direct control by means of soil fumigants, known as nematicides, has become an established procedure for certain high-value crops such as nursery stock and seedling plants.

IV. CONTROL

Control of plant diseases covers a broad, highly technical and rapidly developing field of study. A technique effective with one disease may be ineffective for another. Also, the effective method

for a disease in one situation may be ineffective for the same disease in other circumstances. Furthermore, with continuing research, improved procedures keep developing. Discussion of control in this article is limited to general considerations and to a few representative examples. Locally useful information may be obtained from governmental agricultural research centres.

A. Vulnerability of Pathogens

Various preventive measures are possible at each of the stages in the life history of plant pathogens.

The entrance of a microorganism into the host may be opposed, for example: (1) by employing chemical preventives such as sprays, dusts, disinfectants (applied to seed, propagating stock or wounds) and wound dressings; (2) by using disease-escaping or resistant varieties; (3) by removing the host from the contaminating organism, as through the selection of disease-free seed and through rotation with other nonhost crops; and (4) by reducing the inoculum with available sanitary measures or with environmental conditions such as soil character, soil reaction, moisture and temperature that are unfavourable to the microorganism.

Establishment and multiplication of a pathogen in the host may be lessened, for example, by employing sprays which burn out initial mild infections, by pruning or excising diseased parts, by using resistant varieties and by providing environmental conditions unfavourable for the microorganism.

Exit of the pathogen from the host may be prevented by various sanitary measures, including excision of diseased plant parts or destruction of diseased plants, removal of agents of distribution, such as insect vectors, and disinfection of contaminated tools.

Transfer or distribution of the causal agent may be reduced by various means, such as prevention of exit or entrance, removal of alternate and weed hosts, control of insect vectors, disinfection of tools, shipping containers and other contaminated materials, use of disease-free or disinfected seed, use of chemical or other sanitation procedures and enforcement of inspection and quarantine measures.

Control measures have been classified in various ways; they include the use of inhibiting agents, proper cultural practices, repulsion of disseminating insects and development of disease-resistant varieties.

B. Inhibiting Agents

Applications of inhibiting or eradicant agents are effective preventive measures for certain diseases. Diseased seed may be treated in some cases by hot water and in others by various disinfecting solutions, slurries or dusts. Hot water has been effective for loose smut of barley, and various chemicals have controlled smut of oats and bunt or stinking smut of wheat. Seed treatments may be considered wherever the pathogen is carried by seed; suitable machines have been developed for treating seed. Sprays on growing plants are important in the control of such diseases as apple scab, cherry leaf spot, cucumber downy mildew and potato late blight. Direct attack on pathogens by eradicant fungicides has shown promise against apple scab. Many of the sprays are combined so that one application acts against both insects and plant pathogens. Large industries have developed to supply both the chemicals and the machinery for applying them.

Much research has been aimed at finding a chemical that will move from place to place in a plant and confer systemic resistance against infection. Some experiments have given encouraging results.

C. Cultural Practices

Control may be achieved through cultural practices including sanitation. These may involve the selection and treatment of the soil in which the crop is grown. Crop rotation has been effective against pathogens which may disappear from the soil within one to three years. Many pathogens, however, are little affected by rotation, either because they readily establish themselves as saprophytes in many soils (*e.g., Rhizoctonia* and *Fusarium* species, and the potato scab actinomycete, *Streptomyces scabies*), or because the spores apparently, in some percentage at least, remain dormant but viable for many years (*e.g.*, the fungi causing club root of cabbage and onion smut). In selecting a suitable location for a crop, certain diseases (*e.g.*, crown gall of raspberry) that develop in connection with injuries by root-chewing insects have been partially overcome by avoiding ground heavily infested with such insects (old pastures, newly cleared land and weed patches). Soil treatments, often effective, are used only where the value of a crop justifies the expense. Suitable fertilizers may stimulate a host to outgrow the injury from a pathogen.

Destruction of sources of inoculum, an important measure of control involving various cultural and sanitary measures, may take many forms. (1) Burning, fall spraying or plowing under debris containing the overwintering fungi have been used against, for example, apple scab, brown rot of plum and *Septoria* blight of tomato. (2) Removing weed hosts has been effective against cucumber mosaic. (3) Similarly, the eradication of alternate hosts has been employed, for example, with white pine blister rust and wheat rust. (4) Destruction of diseased plants has proved effective in many cases. Removal of diseased plants (roguing) and testing of crops before general release to growers (indexing) are practised, for example, on potatoes as a control against potato viruses. The destruction of citrus canker in southeastern United States provided a dramatic story of eradication. Infected trees were sprayed with oil and burned. During the campaign (1914–31) more than $2,500,000, not counting the value of 260,000 trees, was spent on eradication in Florida alone. (5) Pruning and excision of the diseased portion of the plant, followed by a wound treatment, have served to destroy the sources of inoculum for fire blight of apple and pear trees.

Other cultural practices important for prevention of plant diseases are connected with methods of propagation, as mentioned above with graft knots and fire blight. High-yielding rubber trees have been developed by two grafts. Seedling rootstock received a scion from a selected high-quality but susceptible tree. This in turn, after spray protection until it was tall enough, received a top graft from a disease-resistant tree.

A sanitary measure of value in controlling certain diseases has been the disinfection of contaminated articles. Tools require disinfection when used for excision of fire blight. Likewise, contaminated packing and shipping containers must be disinfected to prevent the development of various transit and storage diseases.

Limitations on shipments of diseased plants are common. At important ports of entry most countries have agricultural inspections and quarantines against injurious insect pests and plant diseases (*see* Plant Quarantine).

D. Repulsion of Insect Vectors

Control of insect vectors has been effective in reducing various diseases such as apple fruit rot, cucumber wilt and aster yellows. In the first two instances, attacks by the apple maggot and cucumber beetle, respectively, have been opposed by sprays or dusts. In the last case the virus-bearing leafhoppers have been excluded from plants by cloth enclosures.

E. Use of Disease-Resistant Plants

When other control measures are impractical, the main hope is control by the use of disease-resistant varieties. Extensive efforts to develop disease-resistant varieties have been made, and conspicuous success often has been attained. Some investigators have claimed that this is the ultimate solution of a disease problem. Although great flexibility and potential to change exists in most agricultural plants, flexibility also exists in the pathogens. New strains may appear among pathogens through importation, through development from already existing strains or through new associations with insect vectors. Also, a plant breeder may develop a new variety that may be susceptible to a previously unimportant pathogen.

1. Types of Resistance.—Disease resistance may be mechanical or physiological. Mechanical resistance has been attributed to certain external characters, such as hairiness, a thick waxy layer, small or sunken stomata and thick cuticle or bark layers; and

to internal characters, such as thick cell walls, composition of the middle lamella, production of gum and formation of layers of suberized cells or wound cork.

Physiological resistance has been associated with factors such as osmotic pressure, cell-sap acidity, tannin, nutrition, substances toxic to the parasite and substances which neutralize parasitic action. Various combinations of factors may enter into a given case; the concepts of resistance and of parasitism complement each other; there are overlapping grades of parasitism as well as overlapping grades of resistance.

A good example of physiological resistance is the resistance of coloured onions to fungus smudge. When an extract of coloured onions was chemically purified and tested for resistance to the fungus, it was shown that two substances, protocatechnic acid and catechol, were the source of resistance. However, in many cases resistance is more complex than this.

2. Variable Resistance.—The characters which may be associated with resistance or susceptibility are subject to several kinds of variations. Among the nongenetic variations are fluctuating variations exhibited as a result of the unequal influence of different environmental conditions; and possibly relatively temporary changes (*Dauermodifikationen*), exhibited as a result of development under particular abnormal conditions, which perhaps may persist under normal conditions for one or more generations through the female line.

Among the genetic variations (*see* GENETICS) are combinations owing to the normal operation of the Mendelian mechanism, including segregation, recombination, linkage and crossing over; and mutations. There are different kinds of mutations, including gene mutation, polyploidy and sectional chromosome mutations such as deletion, duplication, inversion and reciprocal translocation. Changes in the characters of a plant by these or other means may have a bearing on disease resistance.

3. Securing Disease-Resistant Plants.—Several means of securing disease-resistant plants commonly are employed either alone or in combination. These include introduction from an outside source, selection and induced variation. All three may form different stages in a continuous process. For example: (1) a large number of varieties which are free from injurious insects or plant diseases are introduced for comparison with local varieties; (2) the more promising strains are selected for further propagation; and (3) these are further improved, first by promoting as much variation as possible through hybridization or special treatment, and then by selecting the plants having greatest promise. This commonly is a continuing process.

Among the special treatments for inducing useful gene changes is the application of mutation-inducing chemicals such as colchicine and mustard oils. Irradiation with ultra-violet light and X-rays commonly induces deleterious genetic changes, but occasionally produces a beneficial alteration.

A prime requisite in experimental studies of disease resistance is the presence of the pathogen under conditions that allow no susceptible host plant to escape infection. Natural infection or artificial inoculation may be used in different cases. For instance, in the development of wilt-resistant asters and peas, natural infection has been adequate. The causal organism lived abundantly and persistently in the soil so that the chances for infection of susceptible plants were practically 100%. Those plants that showed no infection under these conditions were judged to be resistant.

In general, plant breeders wish to supplement natural infection with artificial inoculation under controlled favourable conditions in order to destroy any plants that have escaped natural infection and to ensure uniform trials for progenies of succeeding generations.

A knowledge of genetic behaviour of a character or characters for resistance has been valuable in developing disease-resistant varieties. Artificial crossing and the selection of desirable characters in the progeny of later generations have given promising results.

From the foregoing account it appears that the complete investigation of a plant disease clearly ramifies into various branches of biological science. The research may call for work in many disciplines: mycology, bacteriology, virology, entomology, nematology, soils, physiology, taxonomy, morphology, genetics, cytology, chemistry, physics, engineering and mathematics. Important advances have been emerging from a co-ordinated group attack on plant diseases by investigators having diverse backgrounds and abilities. For more information on particular plant diseases see the article dealing with the host plant; *e.g.*, APPLE; BANANA; COFFEE; HOP; LEMON; PEACH; POTATO; ROSE; WHEAT; etc.; and articles on pests; *e.g.*, LEAF MINER; CORN BORER; etc. *See* also references under "Plant Diseases" in the Index.

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PLANTIN, CHRISTOPHE (1514–1589), French printer, founder of an important printing house, and publisher of the Antwerp polyglot Bible, was born in a village near Tours (probably Saint-Avertin). He learned bookbinding and bookselling at Caen and settled in 1549 as a bookbinder in Antwerp, where he became preeminent in his profession. A bad arm wound seems to have led him (about 1555) to turn to typography.

Plantin's publications were distinguished equally by their great numbers and their excellent typography. His originality lay in his use of copper engravings for book illustrations. His unconventional but successful methods extended to managing his business, printing and selling his publications, and paying authors for their works.

The first known book printed in his office was *La institutione di una fanciulla nata nobilmente*, by G. M. Bruto, with a French translation, and this was soon followed by many other works in French and Latin that rivaled the best printing of his time. The masters in the art of engraving then flourishing in the Netherlands illustrated many of his editions. In 1562, while he was visiting Paris, Plantin's workmen printed a heretical pamphlet, which resulted in the seizure and sale of his property. It seems, however, that he recovered a great deal of the money, and in 1563 he associated himself with some friends to carry on his business. Among them were two grandnephews of Daniel Bomberg, who furnished him with the latter's fine Hebrew types. Plantin produced editions of the Bible in Hebrew, Latin, and Dutch; a *Corpus juris;* and Latin and Greek classics.

He also planned a much greater enterprise in those years—the publication of a *Biblia polyglotta*, which would fix the original text of Old and New Testaments on a scientific basis. In spite of clerical opposition he was supported by Philip II, king of Spain, who sent him the learned Benito Arias Montano to superintend the work. The project resulted in an eight-volume work (1569–72). Plantin earned little profit but received the privilege of printing all liturgical books for the states of King Philip and the office of "prototypographus regius." Though outwardly a faithful son of the church, until his death he was the partisan of a mystical sect of heretics.

Besides the polyglot Bible, Plantin published editions of St. Augustine and St. Jerome; the botanical works of Dodonaeus, Clusius, and Lobelius; the description of the Netherlands by Guic-

ciardini, etc. In 1575 his printing office contained more than 20 presses and 73 workmen, besides a similar number that worked for the office at home. But in November 1576 Antwerp was plundered and in part burned by the Spaniards, and Plantin had to pay an exorbitant ransom. He established a branch of his office in Paris, and, when in 1583 the states of Holland sought a typographer for the newly erected university at Leiden, he settled there, leaving his much reduced business in Antwerp to his sons-in-law John Moerentorf (Moretus) and Francis van Ravelinghen (Raphelengius).

When in 1585 Antwerp was taken by the prince of Parma and affairs there became more settled, Plantin left the office in Leiden to Raphelengius and returned to Antwerp, where he worked until his death on July 1, 1589. His son-in-law John Moretus continued to print many works of note "in officina Plantiniana," but from the second half of the 17th century the house began to decline. It continued, however, in the possession of the Moretus family, which religiously left everything in the office untouched. When in 1876 the town of Antwerp acquired the old Plantin buildings with all their contents for 1,200,000 fr., the authorities created one of the most remarkable museums of its kind, the Musée Plantin-Moretus, opened Aug. 19, 1877. (P. A. T.)

PLANTING MACHINERY. Putting seed in or on the ground is the means of starting most food and fibre crops the world over. Hand seeding by scattering the seed on the ground was the earliest planting method and is still practised where conditions are not suitable for machines. Very small fields, extremely rocky, stumpy and steep lands must be seeded by hand. Dibbling sticks used to make a hole in which to place the seed were an early, primitive improvement to secure better germination (*see* AGRICULTURE, PRIMITIVE).

This article describes broadcast seeders, grain drills, corn (maize) planters, potato planters, transplanters and airplane seeders. For preparation of the ground before planting *see* TILLAGE MACHINERY. *See* also FARM MACHINERY and separate articles on individual crops, as CORN; TOBACCO; etc.

Broadcast Seeders.—Hand seeding was followed by the development of mechanical means of scattering or broadcasting the seed. Knapsack seeders with a fanlike wheel to scatter the seed developed later into endgate seeders which are mounted on the back of a wagon. A chain drive from a sprocket on one of the rear wheels provides the motion for the distributing wheel. Wheelbarrow seeders have a long hopper with an oscillating rope or chain in the perforated bottom to regulate the seeding rate.

Grain Drills.—The forerunner of grain drills, which place the seed at a controlled depth and in accurate amounts, made its appearance as early as 2000 B.C. in China and Mesopotamia. This machine consisted of a plow of that era equipped with a seed hopper and a tube to convey the seed to the groove made by the plow point. The method of metering is not known. In the 16th and 17th centuries, metering systems to ensure accuracy of rate were invented. Almost all of these systems used wheels equipped with small spoons. These dipped into the seed carried in a hopper and transferred a measured amount to seed tubes which guided it to the furrows made by plow points or special openers. This metering and feeding method was still used in many European drills in the second half of the 20th century. In the 19th century there were numerous developments particularly in the United States where there was a trend to force-feed systems which provide a more positive metering of the seed.

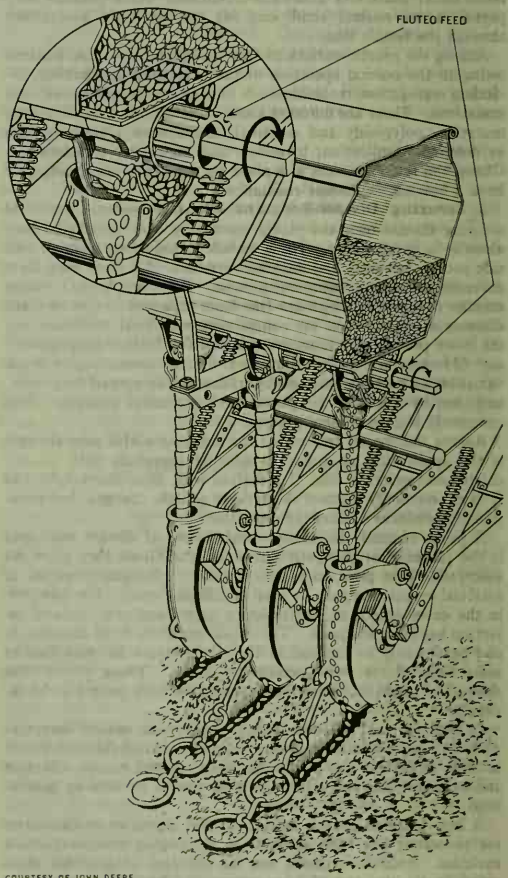
Types of Grain Drills.—In general, drills are classified by the type of metering system (spoon or cup feed, external fluted roll and internal double run) and by the type of furrow opener used (hoe, shoe, single disk and double disk).

Metering Systems.—The seed is carried in a hopper with the metering devices (one for each row to be seeded) located in the bottom and actuated by the wheels which carry the machine. The seed is carried by a tube from each metering unit to a furrow opener which is forced into the soil by means of springs or weights. Usually a short length of chain is dragged behind to cover the seed. Some drills have additional hoppers to carry fertilizer and grass seed.

The cup feed drill is used in the flat land of southeast England and on the European continent. It has a seed box divided into compartments and must be kept level to ensure a uniform supply of seed to each distributing unit. In a separate chamber behind the seed box there is a horizontal geared shaft carrying a number of flat disks with cups mounted on each side at the periphery for lifting the seed from small hoppers or feed runs into funnels connecting with the furrow openers. The seed passes from the seed box to the feed runs through apertures which may be fitted with slides for regulating the supply of grain at this point. Cups may be made with two seed faces so that by reversing the shaft different kinds of seed can be sown. The shaft is driven by a pinion from one of the drive wheels, and the rate of sowing can be altered by using pinions of different sizes. This was the earliest type of metered drill.

In the external fluted feed type a fluted roll revolves in the bottom of each small hopper. (*See* fig. 1.) The quantity of seed sown per acre is controlled by exposing more or less of the feed roll to the seed inside the feed cup, although in some machines the feed may be further controlled by adjusting the size of the opening through which the seed flows.

In the internal double-run type of drill the rate of sowing is



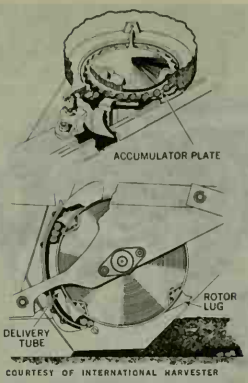
COURTESY OF JOHN DEERE

FIG. 1.—EXTERNAL FLUTED FEED TYPE DRILL SHOWING PATH OF SEED FROM SEED BOX TO FURROW

Seed is lifted from seed cup by feed roll over adjustable gate, and travels down grain spout and closed disk boot, into ground. Chains close trench over seeds

regulated by altering the speed of the shaft by gearing devised for the purpose and by a small gate inside the feed cup. The double-run feed wheel or disk (fig. 2) is flanged on both sides with corrugations around the inside of the rim—coarse on one side for large seed and fine on the other for small seed.

Furrow Openers.—The hoe furrow opener (fig. 3) consists of a single- or double-pointed shovel fastened to the lower part of the boot which is usually fitted with a replaceable break pin or compression spring for protection when encountering an obstruction such as a heavy stone or large root.



COURTESY OF INTERNATIONAL HARVESTER

FIG. 2.—HILL-DROP PLANTER MECHANISMS

(Top) Hopper bottom showing seed being pregrouped on accumulator plate; (bottom) seed delivered to ground by rotary valve mechanism

The shoe opener (fig. 4) is made from two flat pieces of steel on edge welded together in a wedge and curved upward at the front. The boot is attached on the upper side at the rear and open end of the wedge.

The single-disk furrow opener (fig. 5) is saucer-shaped, similar to a harrow disk. It is for cutting through trash and is of two types, the open boot where the disk serves as one side of the seed tube and the closed boot where a separate tube extends to the bottom of the furrow.

The double-disk opener consists of two disks, usually flat, facing each other at a slight angle to form a wedge where they penetrate the soil. By this arrangement a small ridge is left in the furrow, causing the seeds, as they are deposited, to make two distinct rows approximately one inch apart.

Features and Attachments.—In the second half of the 20th century it became recognized that under many conditions a more satisfactory stand of grass could be secured if planted just above a band of fertilizer. Hence hand seeding features for combined grain, fertilizer and grass seeding drills were developed.

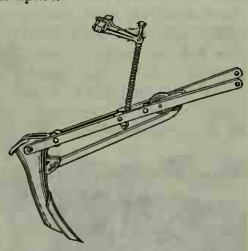

COURTESY OF JOHN DEERE

FIG. 3.—HOE-TYPE FURROW OPENER

Seeding attachments resembling a grain drill are sometimes mounted on a one-way disk plow (disk tiller) or on a corrugated roller soil pulverizer; they are mounted on the latter mainly for sowing grass seed.

For planting beets or beans, drills fitted with the same type of internal double-run feed as is used in wheat drills are available to plant in 18-, 20-, 24-, 26- or 28-in. rows. For planting sheared or "segmented" sugar beet seeds, drills with special fluted feeds or with holed plates similar to cornplanter plates are used. Segmented seed is made by grinding down seed balls to one germ as an aid to thinning the beet plants, which, because of the nature of the seed, normally come up in clumps.

Corn (Maize) Planters.—In the "corn belt" of the U.S. almost all corn is planted four rows at a time, but six-row machines are also used. In areas of smaller farms, many two-row planters are used. Most are pulled behind a tractor but mounted machines and unit-planters, which feature a self-contained unit for each row planted, are available for mounting on tractor tool-bars. Pull-type machines have two or more wheels to carry the planter and to drive the planting mechanism. Press wheels are mounted behind each planter unit to firm the soil over the seed. The trend has been to the use of pneumatic carrying wheels and zero-pressure rubber tires for press wheels.

A vertical cylindrical seed box is provided for each row. In the bottom of this box is a revolving seed plate with seed cells. Plates with holes to suit the various sizes and shapes of seed are used. If the corn is to be drilled the seeds fall at regular intervals directly into the boot of each furrow opener and thence into the ground as the plate revolves and the cells register with the opening underneath. The seeding rate or the spacing in the row depends upon the rotation rate of the seed plate and the number of cells in the plate. Corn planters are available for drilling only, but checkrow planters can be used as drills by locking open the valves in the boots.

Checkrow Planters.—If the corn is to be checkrowed (planted in checkerboard fashion), a planter with a check head is used, and this requires a check or trip wire with uniformly spaced buttons. With the trip wire laid across the field in the direction of planting, the planter in position and the wire placed in the check head, the operation is as follows: as the machine proceeds the drive wheels actuate a feed shaft, which by means of the seed plates causes the seed (2, 3 or 4 per hill, according to the nature of the soil) to be deposited in the upper valve in the boot. As the button trips this valve, the lower valve already charged with seeds discharges into the furrow opener and into the furrow, and the seeds from the upper valve drop into the lower one, ready for the next hill. The main wheels positioned directly behind the furrow openers then cover the seed and compact the soil around it. The common types of furrow openers are the stub runner, the curved runner and the single and the double disk. Row markers are provided to keep the rows equidistant.

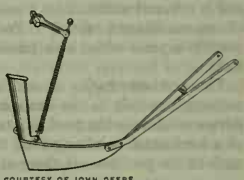

COURTESY OF JOHN DEERE

FIG. 4.—SHOE-TYPE OPENER

Fertilizer Attachments.—Corn planters may be fitted with equipment to apply dry or liquid fertilizer. It was formerly customary to use a split-boot which, under ideal conditions, placed the fertilizer in bands on both sides of the row of seeds. The fertilizer was sometimes placed too close to the seed, impairing germination, and consequently separate furrow openers were developed to place the fertilizer well to one side and below the seed.

Liquid fertilizers are metered by pump or by orifices selected to give the desired rate.

Listers.—In dry regions, corn is sown or listed with an attachment to a middlebuster (similar to a right- and left-hand plow bottom mounted back to back) designed to open a narrow furrow, in a previously prepared seedbed, into which the seeds are dropped. They are then covered by cover disks and compacted by press wheels. By altering the plates in the corn planters and listers cottonseed can be planted and also many other coarse seeds such as peanuts, beans and kafir corn. Cotton, however, is seldom checkrow planted.

Potato Planters.—In the United States machine planting of potatoes is common practice, and two types of machines are used—the automatic and the semiautomatic, or assisted-feed. With the automatic type, one man only is needed to plant. As the machine is pulled forward on its two wheels, two disk openers produce a

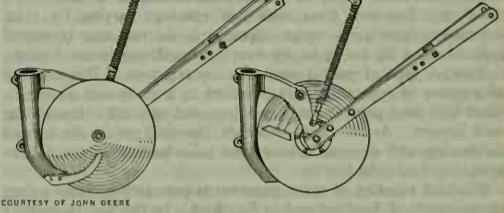

COURTESY OF JOHN DEERE

FIG. 5.—SINGLE-DISK FURROW OPENER WITH CLOSED REAR DELIVERY

(Left) Convex side of single disk, showing rear closed-delivery disk boot; (right) concave side of single disk showing adjustable T-shaped scraper

ridge, on both sides of which fertilizer may be deposited if the machine is provided with an appropriate attachment. Following this is a V-shaped opener shoe which splits the ridge, opening a furrow for the seed pieces and covering the bands of fertilizer simultaneously. The seed pieces are deposited at uniform distances in the furrow by the dropping mechanism. This consists of a spider or disk to which are attached picker arms revolving through the seed potato hopper. Each arm, fitted with a picking hand or sharp staplelike points, picks a seed piece as it rises in the trough in the hopper bottom. As the arm descends on the other side the seed is automatically dropped into the furrow and is covered with soil by a pair of saucer-shaped disks. Frequently a press-wheel attachment is used in place of the covering disks.

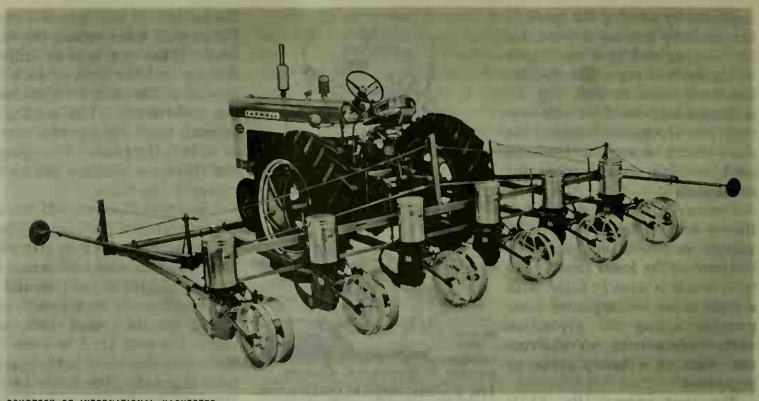


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FIG. 7.—SIX-ROW DRILL PLANTER
Interchangeable seed hopper bottoms enable this machine to plant seeds of several different sizes

The semiautomatic, or assisted-feed, planter differs from the automatic mainly in the dropping mechanism. This consists of a device to elevate the seed pieces from the hopper into the pockets of a horizontal revolving feed ring. One seed piece should be in each of the pockets—if there are two, one must be removed, and if none, one must be supplied. The feed ring carries each piece to the planting tube through which it drops into the furrow already prepared. This is a two-man outfit since it requires an extra man to attend the feed ring.

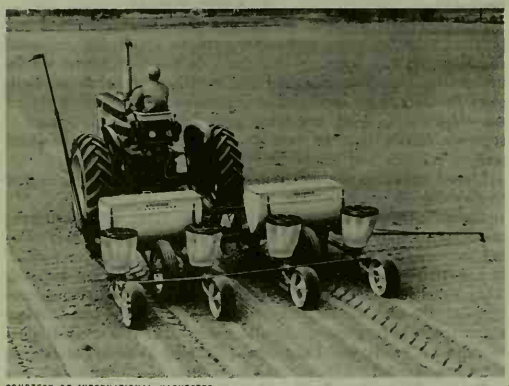

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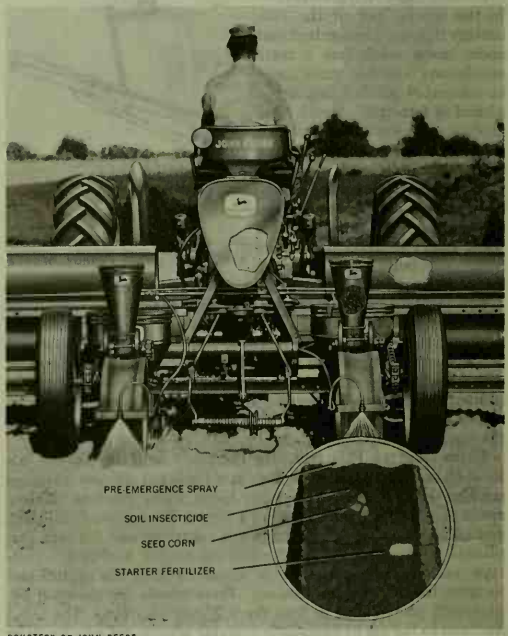
FIG. 6.—FOUR-ROW ROTARY VALVE HILL-DROP PLANTER WITH FERTILIZER BINS AND TRANSPARENT PLASTIC SEED HOPPERS

The above two types of planters are available in one-, two-, three- and four-row sizes, with row spacings varying by 2 in. increments from 32 in. to 42. Spacing in the row may be varied from about 6 in. to 24 in. by varying the dropping mechanism.

Another type of potato planter is the cup type. This consists of a series of cups which are attached to a chain and which are filled with seed potatoes as they are passed vertically through the seed hopper. As the chain proceeds, the seed pieces are carried to the top and dropped into a seed tube leading to the furrow opener and into the furrow.

Machine planting of white potatoes is practised to some extent in the north of England and in Scotland. In the potato-growing regions of the English Fens district, however, seed pieces are generally allowed to sprout before planting and mechanical planters are seldom used because of the damage these cause to the sprouts.

Transplanters.—Where large quantities of such plants as cabbages, tomatoes, strawberries, celery, tobacco and sweet potato slips are to be set out, transplanting machines are much used. Many such machines not only set the plants but water them and firm the soil over the roots. There are two principal types of machines in use, the manual-setting and the mechanical transplanters, both of which may be equipped with fertilizer attachments designed to place accurately a prescribed amount of fertilizer at the optimum position with respect to the plant. Both types have two main wheels in the rear and generally one or two steering wheels in front. Two-row machines are frequently used. The



COURTESY OF JOHN DEERE

FIG. 8.—PLANTER WITH ATTACHMENTS FOR APPLYING WEED-CONTROL CHEMICALS, SOIL INSECTICIDES, AND FERTILIZER

machine must be strong, for it must support the weight of the drive, two plant setters for each row, a 40-gal. to 55-gal. steel tank containing water, and possibly 150 lb. of fertilizer and plants.

The manual-setting type of transplanter usually has a subframe carrying the planting mechanism, which consists of a furrow opener or shoe, a water valve in the heel of the furrow opener, and press wheels or plates. As the machine proceeds down the field and the water valve opens automatically for each plant, the operators, or setters riding on the machine, alternate in manually setting the plants in the furrow, which is immediately closed and compacted by the press mechanism.

The distance between plants in the row may be varied from about 8 in. to 60 in.

In the mechanical transplanter the plant setters place the plants in transplanting pockets or grippers which firmly hold them and revolve on a chain until they are automatically released in the furrow already opened. As the plant is released the water valve supplies water and the packing device closes the furrow and compacts it.

Airplane Seeders.—Airplanes were first used for seeding rice in 1929. This method permits seeding in flooded fields. Airplanes are also used for seeding rough range land. The seed is metered from a hopper in the plane to a venturi tube (that is, a tube with flaring ends and a constricted connecting throat which reduces the pressure of the air and increases its velocity) below the fuselage. The blast of air through the venturi spreads the seed to provide a swath about 25 ft. wide when flying at a height of 20 to 30 ft.

See also AGRICULTURE (ARTICLES ON).

See Roy Bainer *et al., Principles of Farm Machinery* (1955); Archie A. Stone and Harold E. Gulvin, *Machines for Power Farming* (1957).
(R. B. G.; G. E. PD.)

PLANT PROPAGATION is the perpetuation of plants as independent units by means of seeds, bulbs, layers, cuttings or grafts. Theophrastus (370–285 B.C.) in his *Inquiry Into Plants* wrote that "the ways in which trees and plants, in general, originate are these: spontaneous growth, growth from seed, from a root, from a piece torn off, from a branch or twig, from the trunk itself; or again from small pieces into which the wood is cut up." This list of techniques has been slightly modified and refined, but only a relatively few new methods have been added. Since in most species of plants seeds result from fusion of the male and female gametes or sex cells, raising plants from seed is termed sexual propagation. Asexual or vegetative propagation encompasses all other methods for raising plants that do not depend on seeds or sexual combination.

Sexual Propagation.—The typical seed when mature consists of the young embryo, or miniature plant; variable amounts of elaborated food, or endosperm; and the seed coat or coats, the testa (*see* fig. 1). The endosperm may be lacking in seeds of a few plant species; the embryo and seed coats are found in all seed types.

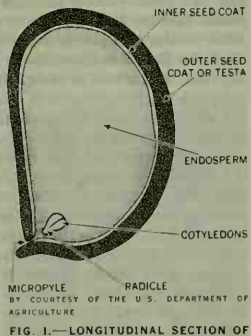


FIG. 1.—LONGITUDINAL SECTION OF SEED OF WILD SARSAPARILLA

Since the plant kingdom covers a wide range of climatic conditions, the methods utilized by the various species to maintain themselves have resulted in a wide variation in the nature and behaviour of seed. There are seeds that because of climate germinate almost immediately when placed in a favourable environment. Other types of seeds cannot germinate even under favourable growing conditions.

Many trees and shrubs of the temperate zone produce seeds that require a conditioning period before development occurs. If such were not the case, many young seedlings developing from fruits that mature during late summer and autumn would be killed by cold during the winter months; in these species a full growing season for the seedlings is ensured by the inability of the seed to germinate until it has been subjected to temperatures around 40° F., combined with moisture for varying periods of time, depending upon the species.

Supplying the required low temperature and moisture is a process known as cold stratification, and the term afterripening describes the complex biochemical or physical changes through which the seed must pass before it can develop normally. Depending upon the seed type, changes in the permeability of the seed coat and adjoining layers, development of immature embryos, dispersal of natural inhibitors, changes in chemical and hormonal balance systems, or combinations of these with other biochemical or physical changes may constitute afterripening. For small lots of seed that require relatively short afterripening or conditioning periods, moist, shredded sphagnum moss is mixed with one-third the volume of seed, placed in a polyethylene bag and stored in a refrigerator at 40° F. Example of seed types requiring a simple type of stratification are afforded by honeysuckle (30–60 days), apple (30–90 days), pear (60–90 days), hemlock (60–120 days) and magnolia (120–180 days).

In contrast to this simple type of stratification are more complicated types requiring an alternation of warm and cold periods coupled with moisture. In these types the afterripening changes take the form of a series of steps, each dependent upon the other, that must take place in sequence before the seed is able to germinate. Dogwood, hawthorn, snowberry and viburnum seed have this peculiarity and for this reason are often referred to as two-year seed. In many leguminous plants, *e.g.*, black locust and clover, the seed is singularly impervious to water, and stratification has little short-term effect; in these cases the seed coat may be made permeable by treatment for a few minutes with concentrated sulfuric acid, followed by thorough washing, or wetting with scalding water. Large seed types having impermeable seed coats may be mechanically scarified, using sandpaper or by filing.

Many plants of the temperate zone have no seed stratification requirement, and it is rare in tropical plants.

Duration of germinative ability in seed varies greatly with the species; elm, magnolia and soft maple seed among the temperate-zone plants, and seed of many tropical plants, are short-lived, in some cases lasting only a few days. Some weed seed, in contrast, have germinated after being stored 25 years. Lettuce seed is usually short-lived, but melon seed frequently germinates well after four years. Retention of viability in seed usually is affected greatly by conditions of storage. In the tropics, for example, without special care, cinchona seed often deteriorates greatly in three or four months; storage in dry atmosphere has prolonged its life, with very little deterioration, for as long as 30 months.

Many seeds are sown in the open ground and, barring extreme wetness or extreme aridity, germinate well enough for practical purposes. Other kinds, however, are so exacting in their requirements that these are best met in a propagating house where humidity and temperature conditions can be more rigidly controlled. Because of their high oxygen requirement, the medium in which they are sown generally should contain more sand than ordinary garden soil does. Greater porosity makes these media more subject to rapid drying, however, and moisture must be carefully watched. Since many soils harbour fungi destructive to sprouting seed and young seedlings, soil that is to be used for germinating seed commonly is sterilized by heat or chemicals. Many diseases of plants are caused by fungi and bacteria carried in or on the seed itself, and treatment of the seed with disinfectants, such as bichloride of mercury, organic mercury compounds, formaldehyde and hot water, is beneficial when it is to be planted in cold soil or soil at normal growing temperatures. So-called clean seed may be treated with protectants, such as zinc oxide, organic mercury compounds and many of the copper compounds, in order to minimize losses from soil-borne pathogens.

For general seeding practices, trays or flats are filled two-thirds full of soil. This is then sterilized and puddled, and a quarter inch of sterilized sand, peat or vermiculite is added. The seed is then sown in shallow rows 1 to 1½ in. apart and in depth usually twice the diameter of the seed being planted. The seed is then covered lightly with a medium such as shredded sphagnum moss,

and the entire tray or flat covered with glass or polyethylene sheeting. At the time the seedlings emerge the glass or polyethylene cover is removed, and the seedlings are watered at regular intervals thereafter.

With more and more cultivated crops, practical advantage has been taken of heterosis, or hybrid vigour; *i.e.*, enhanced vigour and productivity of the first-generation descendants from crosses between two strains previously kept pure by selfing (inbreeding) for several generations. By 1945 hybrid corn constituted a major portion of the U.S. corn crop, and the same procedure has been introduced with the onion, tomato and petunia, as well as many other crop and ornamental plants.

Asexual Propagation.—With crops that produce seed freely and come true closely enough for the purposes in view, growing from seed usually is the cheapest and most satisfactory method of propagation. Some species of plants, in their cultivated forms, do not produce seed; *e.g.*, banana, pineapple and sugar cane. In a great number of cultivated species, seedlings vary so much that the desired traits are found in only a small proportion. Among dioecious plants the natural distribution of sex, approximately 50–50, does not suit the purpose for which they are grown. Female trees of ginkgo and poplar are undesirable for street planting because of the unpleasant smell of the fruits, particularly when trodden underfoot; in date or pistachio orchards or muscadine grape vineyards, one male plant will effectively pollinate several pistillate plants, and since the males produce no fruit, a surplus would be a needless expense. To meet these various requirements asexual propagation, *i.e.*, division or separation and indefinite subdivision of the original plant having the desired traits, is utilized.

Many people have held—and voiced—the opinion that asexual propagation is unnatural and that plants thus derived lack the hardiness or the sturdiness of plants grown from seed. Asexual propagation, however, is not unnatural; some of its forms, *e.g.*, layering and grafting, are rather common in nature. The only justification for the generalization that asexually propagated plants lack hardiness or sturdiness is the fact that virus diseases can be transmitted by asexual propagation and that most such diseases are not transmitted through seed. In severe cases the build-up of a particular virus complex may result in a decline of the productivity of an asexually propagated horticultural crop or in the extinction of the infected clone or variety.

Division.—In some respects, the simplest method of asexual propagation is the form known as division, in which the aggregate of roots is cut roughly through the crown, and the fractional parts are planted out as separate units. In dividing the dahlia, care must be observed to include a bud with each root, but in some plants, *e.g.*, rhubarb, buds are so numerous that any random division is adequate. In bulbous plants new buds form at the base of the old structure; these may be separated and replanted. This process is hastened in the hyacinth by scooping or slitting the base of the bulb and replanting it. Lily bulbs may be divided concentrically into scales, which form new bulbs. In the potato the modified stem or tuber may be divided into as many segments as there are buds or eyes, each of which, when planted, will produce a new plant. In practice larger segments of the potato tuber are used, since a greater food reserve gives the new stem a better start.

Layering.—The great majority of plants can be induced to emit roots on their stems. Many do this naturally, particularly in a moist environment. Black raspberries, dewberries and one form of forsythia, for example, regularly develop roots at the tips of the stems, where these touch the ground. This process, tip layering, may be accelerated by pegging the tips so they will not sway in the wind, or by placing a small amount of soil over the stem, leaving the tip bud protruding (fig. 2B). At the end of the growing season the rooted tips are cut loose from the parent plant and set in plantations or in nursery rows. Some plants may be layered by bending whole shoots so that they can be pegged down or held in place by stones in narrow trenches, which are filled with earth a little at a time as the new lateral shoots grow (fig. 2D). This method is particularly adapted to multiplication of the more vigorous varieties.

A method used frequently with gooseberries and with the less

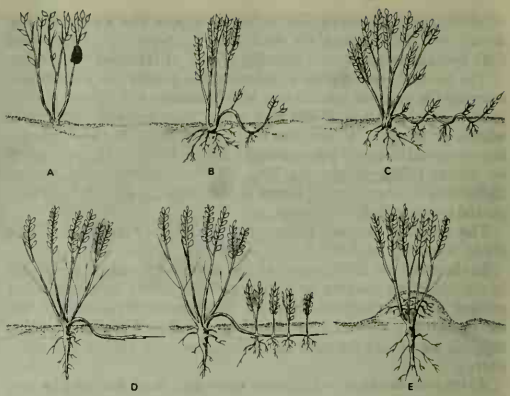


FIG. 2.—PROPAGATION BY LAYERING: (A) AIR LAYER; (B) SIMPLE LAYER; (C) SERPENTINE OR COMPOUND LAYER; (D) TRENCH OR CONTINUOUS LAYER BEFORE AND AFTER SPROUTING AND ROOTING; (E) MOUND OR STOOL LAYER

vigorous clonal apple rootstocks is known as mound layering (fig. 2E); this involves cutting back an established plant close to the ground and progressively erecting a mound around the bases of the new shoots as they develop. Basic principles in handling layering by these methods are: (1) to cover with soil or suitable medium the bases of the new shoots before they have hardened but after they have lost their original softness; (2) to keep the soil around the plants moist but not wet. Production of roots is increased, if necessary, by wire constriction, by ringing, *i.e.*, removing a ring of bark, or by notching the stem just below the point where the roots are desired. With some plants the same effect can be obtained with less labour by twisting the stem.

Aerial or Chinese layering (fig. 2A) brings the rooting medium around the stem at a point above the soil, sometimes high in the air. The procedure is to place a pot of soil or a ball of sphagnum moss or similar rooting material around the stem, which has been wounded or girdled at the desired rooting point. To further facilitate rooting, a proprietary root-promoting growth substance may be dusted on the wounded area. The entire area together with the moist rooting medium is then wrapped in polyethylene plastic film and bound firmly at either end with a waterproof tape. After rooting, the plastic is removed and the rooted layer severed from the parent and potted or placed directly in a nursery row. Layering, in general, is rather expensive in space and time and is not particularly successful in many soils and climates.

Cuttings.—Plants whose stems emit roots readily are generally propagated by cuttings as the preferred vegetative method. To be preferred because of ease in handling are hardwood cuttings of the previous season's growth, taken in the dormant season and comprising 6–12 in., according to the species and amount of wood available for propagation, and planted in the open. Most American and some European grapes, currants and most poplars and willows are grown by this method. Greenwood or semihardwood cuttings using shoots, ordinarily 2–6 in. in length, which are still somewhat succulent, are more suitable with many plants that do not root freely from mature stems. Softwood or herbaceous cuttings (fig. 3, left), as well as the more mature greenwood cuttings, must retain some foliage if they are to root and, therefore, must be protected against loss of excessive moisture; hence they are usually placed in a cold frame, hotbed, greenhouse or out-of-doors in full sunlight under a fine, controlled mist spray. The medium in which they are set should be porous and free of rot-producing organisms; these requirements are generally met by using washed river sand, vermiculite or processed volcanic rock as the rooting medium. In cases where the water is not applied automatically, frequent moistening of the rooting medium and maintenance of high atmospheric humidity are necessary.

Cuttings set for rooting in cold frames generally require cover-

ing with sash and shade for maintenance of humidity. Temperature requirements of evergreen and greenwood cuttings vary widely according to species; conifers in general root better, though slowly, at lower temperatures (60°–65° F.), while roses root better at higher temperatures (65°–70° F.). Important factors in success with cuttings, regardless of type, are selection of time for taking cuttings, degree of maturity of the cutting at the point where it is severed and, in some measure, general condition and physiological age of the mother plant.

With such plants as carnations, usually propagated from softwood cuttings, the guide to proper condition is the type of fracture made when the cutting is broken from the parent plant: if the stem crushes, it is too young; if the fracture is stringy, the cut ends adhering by fibres, it is too mature; when it makes a clean fracture without crushing, the chances for successful propagation are highest.

Use of root-promoting growth substances applied to the basal end of cuttings has greatly facilitated propagation of many species, increasing the amount of rooting and, through speeding the process, in some cases reducing loss from fungus diseases. The principal materials used have been indolebutyric acid, indoleacetic acid, naphthaleneacetic acid and several of the phenoxyacetic acid compounds.

In order to prevent the increase and distribution of systemic diseased cuttings and plants, a technique known as culturing is used to maintain clean propagating stock plants of chrysanthemum and carnation. The general procedure is to place on agar plates surface-sterilized stem sections removed from the basal end of cuttings. The cutting, which is numbered to correspond to the plate number and parent plant, is placed in a sterile test tube for holding. The agar plate and stem sections are then incubated, and if no organisms grow from the sections, the cutting is removed from the test tube and rooted in the usual manner. If any organisms grow from the stem sections, the cutting, together with the stock plant from which it was taken, is discarded.

When cuttings have rooted adequately (fig. 3, right), they are generally potted or planted out in transplant beds or nursery rows. This stage may require some care in protection against sudden exposure to strong sun and drying air currents for a few days until the plants are established in their new environment.

Root cuttings, *i.e.*, pieces of the roots, ordinarily about four inches long, are used in the propagation of a few plants, among them blackberries, clonal strains of black locust and some of the herbaceous perennials. These cuttings should be taken in the dormant season, either autumn, winter or early spring. Root cuttings of blackberry grow well if laid horizontally in rather shallow trenches, but root cuttings of clonal apple rootstocks seem to grow better if placed vertically, with the distal end down and the proximal, or portion closest to the crown, just below the surface of the ground. Obtaining root cuttings of most plants in quantity is expensive, and use of the method is limited.

Leaf cuttings, utilizing leaves only, or portions of them, are used for the propagation of a few plants. Leaves of many plants can be induced to form roots, but only a few will develop shoots in the absence of a pre-existing axillary bud from the stem. Many begonias and sansevieria are frequently propagated by this method.

Grafting.—When vegetative propagation is necessary and layers and cuttings are not easily made, or increased growth rates over own-root material is desired, recourse to grafting is common (*see* GRAFTING [IN PLANTS]).

FIG. 3.—SOFTWOOD CUTTING: (LEFT) UNROOTED PRIVET CUTTING; (RIGHT) ROOTED CUTTING READY FOR TRANSPLANTING

By this process a bud or a twig of the plant whose propagation is desired is transferred to another plant already supplied with a root system or capable of forming one readily.

Budding, as separate from grafting, generally is understood to be a form of lateral grafting that makes use of a scion having only a single bud. Grafting is used, in one form or another, on plants either in the growing or in the dormant stage.

(JN. P. M.)

PLANT QUARANTINE. Plant quarantine is that branch of law enforcement established by a country to prevent the introduction and distribution of foreign plant pests, principally insects and plant diseases, within its boundaries. The objective is to protect a nation's agriculture and horticulture from injury by any type of foreign plant pest that may be introduced. Similar regulatory procedures may also be adopted by a civil division within a country to prevent the internal spread of plant pests that have gained a limited foothold within its borders, or to facilitate eradication of such pests. Governmental agencies enforcing plant quarantine laws are variously designated in different countries as plant quarantine, plant protection, phytopathological and phytosanitary services. Most of these plant regulatory services are under the supervision of the national department or ministry of agriculture. The services usually operate in close co-operation with the customs service.

Plant Quarantine Service Operation.—Plant quarantine prohibitions and restrictions, applying to both the individual and the commercial shipper of such material, affect the importation of plants and plant products into most countries of the world. Plant quarantine regulations usually provide that before restricted plant material may be brought into the country the importer must apply in writing to the department of agriculture or equivalent agency for an import permit authorizing the entry of the desired items. Such a permit is also known as a certificate of introduction or import licence. This application allows the plant quarantine service to determine whether the consignment is prohibited entry, may enter under certain safeguards or is entitled to unrestricted entry. An import permit also informs the importer of any requirements for a phytosanitary or health certificate from the department of agriculture or some authorized official of the country of origin, certifying that the material has been officially inspected. Certification may also be required from the country of origin that the area where the material was grown is free of a particular pest, that the material was inspected in the field during the growing season or was grown beyond a certain distance from an area known to be infested by a specified pest, or that the material has been fumigated, disinfected or otherwise treated. The permit may also specify the port through which the material must be entered and the mode of transportation.

Upon arrival under the terms of the import permit, imported material, in general, is still subject to inspection by the plant quarantine service of the country of destination. If found infested or infected by injurious insects or plant diseases the material may require fumigation or other treatment. If such treatment is ineffective, the material may be destroyed or returned to the country of origin. Plant material for scientific purposes may enter under special provisions.

Examples of internal plant quarantine measures designed to control the spread of plant pests or to eradicate such pests are found in the rigid measures adopted by Great Britain to eradicate all infestations of the Colorado potato beetle and the interstate quarantines imposed by the U.S. to retard the spread of such pests as the Japanese beetle, pink bollworm, white-fringed beetle and black stem rust of grains.

Insect Migration Between Countries.—The cosmopolitan nature of a country's insect population is illustrated by a statement of the U.S. department of agriculture in 1917 that "The majority of the insect pests of the United States which now occasion the greatest damage to orchard, field, and garden crops and to stored products and in homes, etc., are of foreign origin, and were introduced with the host plants or accidentally in the course of commerce." The statement was supported by a list of 110 of the most important insect pest introductions of previous years. Further-

more, the department listed about 1,800 insects which occurred in different parts of the world and were liable to be introduced at any time with nursery stock, in merchandise or as accidental stowaways on ships or in baggage.

The rapid migration of a dangerous insect when allowed to spread freely through articles of commerce is well illustrated by the instance of the pink bollworm of cotton. This insect, a native of India, is the most destructive known pest of cotton. The worm exacts a double toll from the crop: it damages both the lint and the seed, resulting in loss of cotton and reduction in oil content of the seeds. About 1908 this pest was introduced into Egypt in bales of cotton from India. Destined for an Egyptian spinning mill, the ginned cotton contained a very high proportion of infested cottonseed. When the Egyptian infestation was discovered in 1910, the worm was already well established in widely separated localities.

In an attempt to get improved cotton varieties for planting in the Laguna district of Coahuila, Mex., a cotton grower planted imported Egyptian cottonseed in a field near Monterrey, thereby introducing the pink bollworm to a new country. When this infestation was first reported in Nov. 1916, the worm was found to have spread throughout the entire Laguna district. Surveys were begun in the vicinity of 11 cottonseed-crushing mills in Texas that had received seed from the Laguna area. By the end of 1917, infestations had been found in cotton fields adjacent to two of the mills. Further, an extensive infestation was found late in 1917 at Anahuac, Tex., on Trinity bay. The latter spread was attributed to Mexican cottonseed that was washed far inland when the great storm of 1915 wrecked a Mexican steamship en route to Galveston, Tex. Thus in less than a decade a major cotton pest, through a series of intercontinental distributional leaps, was spread through commercial channels from Asia to Africa, and to the North American continent.

Horticultural items of exotic beauty may nevertheless serve as avenues for introducing noxious pests, as illustrated by the Japanese cherry trees around the Tidal basin in Washington, D.C. The first shipment of 2,000 trees received from Japan in 1910 was so heavily infested with insects that it was burned. While much freer of insect pests than the first gift shipment, a second lot of these trees imported from Japan and planted in 1912 was responsible for the introduction of the oriental fruit moth. Now spread throughout the U.S., this moth is one of the most destructive pests of peaches in that country.

Among the hundreds of noxious insects and plant diseases that countries seek to keep out are: the golden nematode of potatoes and tomatoes; pink bollworm of cotton and cotton boll weevil; harmful species of fruit flies, such as the Mediterranean, oriental and Mexican fruit flies and the melon fly; Colorado potato beetle; citrus canker; and various virus diseases.

Functions of a Plant Quarantine Service.—A comprehensive national plant quarantine service provides for the following:

1. Inspection stations at all important maritime, border and air ports of arrival to enforce all plant quarantine prohibitions and restrictions prescribed by the national government.

2. Inspection of surface ships and aircraft and their cargoes, stores and baggage, as well as arriving mail, express shipments and freight, at all ports of entry. In addition, at land ports of arrival, inspections are made of pedestrian, passenger-car and truck traffic, freight cars, passenger trains and dining cars. This inspection is for the purpose of determining whether arriving plant products meet the requirements for entry, or whether they must be treated, destroyed or re-exported.

3. Fumigation or other treatment of any type of carrier, cargo or products, or destruction of infested products or packing materials, when necessary to ensure freedom from injurious pests. The principal fumigants used by plant quarantine services are hydrocyanic acid gas, methyl bromide and ethylene dibromide. Release of an agricultural insecticidal aerosol in foreign aircraft may be required immediately upon landing.

4. Inspection of domestic plants and plant products intended for export and certification of the products to meet the phytosanitary requirements of the country of destination.

Air travel introduced an important additional hazard of pest spread. Insects particularly now have a much better chance of reaching another country alive, since the short elapsed time of air travel permits them to survive without food or water. For example, the oriental fruit fly was discovered in Hawaii in May 1946, presumably having travelled by military air transport from Saipan. In another instance, an overseas flight that originated in Cairo, Egypt, stopping en route at Paris, was found upon arrival in the U.S. on June 26, 1956, to contain 51 live adults of the European chafer beetles. The plant quarantine inspectors who searched the plane were informed by crew members that during their stopover in Paris the chafers were swarming "like bees" around the lights at the airport. The chafers were found in the passengers' compartment as well as in baggage and cargo compartments. This destructive insect already had been unwittingly introduced and established in several scattered areas of northwestern New York.

The benefits of a plant quarantine can be illustrated by California's experience in introducing the eucalyptus tree from Australia in the seed stage. This is the safest stage in which to make introductions, since clean seeds that have been surface treated and fumigated carry few insects or bacteria, fungus or virus organisms. In its native home the eucalyptus has a large number of insect enemies. Not a single Australian insect species was brought to California with the seeds. In contrast, eucalyptus importations, probably in the form of Australian-grown nursery stock, resulted in the introduction into South Africa and New Zealand of several destructive eucalyptus pests. By utilizing a perfectly natural plant quarantine barrier, California protected itself from pests that it might otherwise have received.

History of Plant Quarantine Development.—Prior to 1870 there was little realization by national governments of the dangers inherent in a free exchange of the plants and plant products that are hosts to injurious plant pests. As a result of this indifference, many harmful insects and destructive plant diseases travelled with their hosts to distant lands. In their new environments these pests frequently found hosts more susceptible to their attack. Natural enemies and other controls which often held them in check in their native home were absent. Characteristically, most introduced foreign pests become well established in a new country before their unwelcome presence is discovered.

Also, comparatively pest-free plants introduced into a new environment may be attacked by a previously unimportant pest. The pest may then spread throughout the range of the newly found host. Such was the case with the Colorado potato beetle, a relatively unimportant insect first described in 1824 and thriving on native weeds in the Rocky mountain area of the U.S. When cultivated Irish potatoes were planted nearby it fiercely attacked the new food crop, and in the short span of 16 years, from 1859 to 1874, spread from Nebraska to the Atlantic coast of the U.S., an average annual migration of 85 mi.

Two North American insects that became established in European countries and in Australia were responsible for the inception of national plant quarantine legislation in the decade following 1870. During this decade, many national governments realized that destructive insects and disease-producing organisms are abundant in many parts of the world, ready to be taken to other countries and there attack the native agricultural and horticultural crops.

The Colorado potato beetle incidentally was responsible for the first legislation affecting the international movement of a plant product. This prolific pest was transported in potato exportations to Germany, where a localized infestation was found in 1874. Following eradication of the small infestation, a decree was issued by the German government on Feb. 26, 1875, forbidding the further importation of potatoes and potato sacks. This decree appears to be the pioneer in plant quarantine legislation affecting the international movement of a plant product. France also imposed exclusion measures against this new U.S. pest in 1875. These two exclusion orders antedated by only two years the Destructive Insect act adopted by the United Kingdom in 1877.

About 1859 the grape *Phylloxera* (*see* PHYLLOXERA), a native of

eastern U.S., was introduced into France through the medium of imported grapevine cuttings. During the following 20 years the *Phylloxera* spread until it was established in the entire grape-growing area from Spain through central Europe to the Black sea district of Russia. Within 25 years after it was discovered in France it had destroyed nearly one-third of the French vineyards. Whereas the grape in *Phylloxera*'s native habitat had acquired practical immunity to its attack, European grape varieties proved easy prey. The sight of the small galls on the leaf and the gall-like swellings on the roots formed by this minute, aphidlike insect caused near panic among the growers when outbreaks grew to serious proportions. Similar shipments of vine cuttings from France to Australia about 1872 spread the *Phylloxera* to the latter country. Plant quarantine legislation to suppress this infestation was passed by the Australian legislature in 1877. This act gave power to quarantine and even to eradicate vines and destroy vineyards. In France regulation relating to *Phylloxera* was proclaimed in Oct. 1878.

The first widespread concerted action in Europe in the field of plant quarantine was taken in Nov. 1881, when an international conference held in Bern, Switz., drafted an international agreement known as the Phylloxera convention. The conference also considered means of preventing the introduction of the *Phylloxera* from the U.S. and restrictions and regulations on the movement of grapevines and grape products to prevent its further spread between European countries.

Adoption of the Phylloxera convention of 1881 emphasized to European nations the need for restrictions on the movement of plants and plant products to prevent the accidental introduction of alien insects and plant diseases. Within a few years plant quarantine restrictions affecting a number of U.S. plants and plant products in addition to the grape had been adopted by several European countries.

Most important of the emergent European plant quarantine orders was an embargo placed in 1898 on plant material that might be infested with the San Jose scale. This scale had been introduced into the United States from China with importations of such ornamentals as the flowering peaches that were planted on a large estate at San Jose, Calif., in 1870. The pest was named after the town where it was first observed. In 1880 the scale was recognized as the most pernicious pest of deciduous trees then known. Shipments of nursery stock from the San Jose area spread the scale to an orchard in Virginia and to several nurseries in Missouri, New Jersey and New York, where the infestations came to public notice in 1893. One state after another promulgated quarantines to keep out this pest. These quarantines were followed in a few years by practically world-wide quarantines banning the importation of U.S. plants and placing restrictions on the importation of U.S. apples and other fruits.

Legislation intended to control local infestations of the migratory grasshopper was enacted by the midwestern states of Kansas, Minnesota, Missouri and Nebraska in 1877. These laws made no attempt to control initial invasions by these pests, since this was considered impossible. The laws did provide for the compulsory destruction of migratory grasshoppers in localized areas already invaded. The object was prevention of further spread the following year through migratory flights from invaded areas.

In addition to its instigation of plant quarantine legislation among European nations, the grape *Phylloxera* was also the incentive for the first interstate plant quarantine in its country of origin. This pest was found in a vineyard near the town of Sonoma, Calif., in Aug. 1873. It had been accidentally transported from its native habitat in the eastern U.S. to California vineyards having European-type plantings. Sentiment for control legislation grew so strong among viticultural (vine-growing) and other horticultural interests that on March 4, 1881, the California legislature passed an act "to protect the interests of horticulture and viticulture," the first legislation adopted in the U.S. to prevent the spread of injurious insects. This act, as subsequently modified and strengthened, authorized state officials to require inspection and other measures to prevent the entry of pests from other states or from foreign countries. In 1890 California became, so far as is known, the first area in the world to inaugurate a system of maritime port inspection against insects and plant diseases. For 31 years following the act of 1881, California's was the only existing legislation in the U.S. to protect the country from the entry of injurious foreign plant pests. The U.S. was the last of the major nations of the world to protect itself by law against the importation of plant pests. Its Plant Quarantine act was not passed until Aug. 20, 1912.

Professionally, plant quarantine is recognized by the Entomological Society of America through its section on control, extension and regulatory entomology and by the American Phytopathological society through its committee on regulatory work and foreign plant diseases. Courses in plant quarantine are offered in several colleges and universities in the U.S., including the universities of Florida (Gainesville) and Minnesota (Minneapolis) and Colorado Agricultural and Mechanical college (Fort Collins).

International Plant Quarantine Agreements.—Closer liaison between plant quarantine services of different countries was established as a result of the drafting of an International Plant Protection convention by the Food and Agriculture organization of the United Nations in 1951. This international agreement dealing specifically with plant quarantine matters became effective April 3, 1952. Its purpose is to strengthen co-operation among governments for the protection of plant resources. By May 1957, 38 governments, including signatories which had ratified it and subsequently adhering governments, had become parties to this new convention, which replaced the Phylloxera convention of 1881 as well as the International Convention for the Protection of Plants of 1929.

The 1951 convention provided, in part, for uniform phytosanitary certificates, the establishment of plant protection agencies by each contracting government, the promulgation of national quarantines only as biologically warranted, the creation of regional plant protection organizations, a world reporting agency and a procedure for settling international disputes.

By June 1957 regional plant protection organizations had been created in Europe, southeast Asia and the Pacific, and in Central America and Mexico. Similar regional organizations had been developed independently in that part of Africa south of the Sahara and in the southern half of South America.

A world-wide reporting service on plant diseases and pests was established by the Food and Agriculture organization in 1952 under the provisions of the International Plant Protection convention. The service issues a monthly publication, the *FAO Plant Protection Bulletin*, the first number of which appeared in Oct. 1952. Published in English, French and Spanish, the bulletin disseminates information on plant quarantine of world-wide interest, especially current reports on the occurrence, outbreak and control of insects and plant diseases of economic significance. The service also assembles information on all plant quarantine legislation and regulations in effect throughout the world. A *Digest of Plant Quarantine Regulations* was first published by FAO in 1949, prior to adoption of the convention. A more complete edition was issued in 1952, covering the regulations of 40 countries, and a supplement in 1954 covered 38 additional countries and territories.

BIBLIOGRAPHY.—Publications on the subject are somewhat fragmentary, being mostly scattered, brief references in textbooks, scientific papers and government bulletins. The background and plant disease phases of the subject are well covered in W. A. McCubbin, "The Plant Quarantine Problem," *Ann. Cryptog. Phytop.* (1954). *See* also H. S. Smith *et al.*, "The Efficacy and Economic Effects of Plant Quarantines in California," University of California College of Agriculture *Bulletin 553* (Berkeley, Calif., 1933). (R. W. SH.)

PLANTS AND PLANT SCIENCE. Living things are commonly divided into two general groups—the animal kingdom and the plant kingdom. With higher organisms the difference between plants and animals is quite obvious; it is simple, indeed, to distinguish seaweed, ferns and trees from fish, birds and man. In the case of the lower forms of life—bacteria, fungi, slime molds, protozoa, sponges—the distinction often is not so evident, and, indeed, it is an artificial one since plants and animals probably had common ancestors in evolution (*see* ANIMAL).

The biologist recognizes no definite line separating animals and

plants, or for that matter separating life and nonlife (*see* VIRUSES). But on the basis of certain fundamental differences in (1) mode of nutrition; (2) scheme of growth; (3) cell wall composition; and (4) locomotion, higher organisms may be placed in either the animal kingdom or in the plant kingdom.

1. Plants generally manufacture their own food, a process (see *Photosynthesis* below) directly associated with the presence in plant cells of tiny bodies or plastids containing chlorophyll, a vital green pigment. Animals, on the other hand, generally lack chlorophyll and are unable to manufacture their own food; they depend ultimately upon plants for food.

2. Embryonic tissues remain extremely active in plants and result in what is termed unlimited growth; as tissue dies it remains in place and the young, active tissue grows away from it. Thus each apex of the root or shoot system consists of an aggregation of embryonic cells, an apical meristem, which persists throughout the life of the plant unless it changes into a reproductive cone or flower, or is destroyed by accident or disease; in some higher plants, especially treelike forms, lateral meristems (vascular and cork cambia) produce a growth in girth (see *Tissues* below). A mature animal, however, usually attains a maximum size and a characteristic form, that is, it has a limited growth pattern.

3. Almost all plants have cells whose walls contain cellulose and are, therefore, more or less rigid. Animal cells generally lack cellulose, and their cell walls are usually elastic.

4. Higher plants are anchored to the soil or to some other solid surface from which they cannot move by their own power. Most animals, on the other hand, are capable of considerable movement and make rather rapid changes to new locations when this is necessary.

Of course there exist plantlike animals such as the sessile marine corals, graptolites, anemones, sponges; and there exist also animallike plants such as bacteria, fungi and certain stages of algae and of higher plants. Nevertheless, when all characteristics are considered, it is relatively easy to determine whether an organism should be listed as a plant or as an animal. For the really difficult cases—slime molds, euglenoids, chlamydomonads, etc.—some biologists have advocated a separate kingdom, the protista (*q.v.*).

This article is divided into the following sections:

I. Classification of Plants
II. Morphology of Plants
  1. Alternation of Generations
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    1. The Cell
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    3. Fat Metabolism
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  1. Direct Influence of Plants
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I. CLASSIFICATION OF PLANTS

A census of living things indicates that there exist today more than 300,000 species of plants and more than 1,000,000 species of animals. In the evolutionary sequence of the rise and fall of living things, many more have had their golden ages, and whole groups have either disappeared or exist today only as minor elements of the earth's flora and fauna. Knowledge of these relict or extinct groups of organisms is limited either to studies of the few representatives remaining or to the discovery of fossils.

Man has always been curious about his environment. History points to his efforts at identifying, naming and using the living things around him for his own ends. As man's knowledge grew, he has devised numerous systems of classification. The early systems for classifying plants are now little more than historically important (*see* BOTANY). With the general acceptance of the doctrine of evolution another point of view was added to the classification of organisms, namely, the understanding of relationships and origins of plants and plant groups as well as animals and animal groups. Clearly the evolutionary system is a natural system in that it occurred in nature over geological time.

Man, appearing late in the evolutionary system, has had to rebuild the natural system for himself from available evidence. Certainly an understanding of this system has become a major end of classification for both plants and animals. Here the accumulative evidence from comparative morphology and comparative anatomy; the contributions from embryology; the findings from paleobotany; the results from experimental studies in genetics, cytogenetics and morphogenesis; and the more recent additions from comparative physiology and biochemistry have helped clarify the issues and have pointed up the problems inherent in any attempt to duplicate the natural system. As a result certain areas of evolutionary relationship are now established. Many areas, however, remain conjectural and controversial. The present objective of investigators in diverse fields of botany is to narrow down or fill in these controversial gaps of knowledge.

Efforts at artificial classifications of plants need not concern us in detail here except insofar as terms employed in them have been carried over into present usage. The major divisions of the

plant kingdom in the artificial system set up by Linnaeus (1754) were Cryptogamia and Phanerogamia, terms derived from the Greek meaning hidden marriage and visible marriage.

The phanerogams include what we know as flowering plants, or, as conceived then, seed plants. These have seemingly visible sexual organs in the flower. The cryptogams encompassed the nonflowering plants with inconspicuous sexual cells. It is now known that the plants in each group were misunderstood by Linnaeus and his followers. Actually the cryptogams, though their sexual cells are not advertised by showy flowers and are therefore not immediately evident, have the more obvious sexual reproduction on closer examination; the phanerogams, with their flowers making known the presence of sexual cells within, do by this device conceal them, rendering it difficult to detect and understand the details of sexual reproduction. Even though the Linnaean system has been superseded, the term phanerogam is still sometimes employed to cover all plants which reproduce by seeds, and cryptogam is frequently used for those that do not. The term vascular cryptogam is often used in current writings to indicate those vascular plants that do not bear seeds: the spore-producing club mosses, horsetails and ferns.

After the artificial system of Linnaeus, classification turned in the direction of a natural system, one such system being that largely attributed to Eichler (1886). Under this system, the plant kingdom was considered to consist of four divisions:

1. Thallophyta, the algae and fungi.
2. Bryophyta, the liverworts and mosses.
3. Pteridophyta, the club mosses, horsetails and ferns.
4. Spermatophyta, the seed plants (gymnosperms and angiosperms).

Until recently, the Eichler system had persisted generally; at the present time, however, it is largely replaced by a more natural arrangement (*see* the outline below). The tremendous strides made during the first half of the 20th century in paleobotanical investigations of Devonian and even Silurian fossils have produced a picture of an early, apparently world-wide flora of vascular plants with considerable diversification. While their beginnings are not clear, the different phyletic lines (lines of descent) already established in this flora by the mid-Devonian must have originated at a much earlier geological period.

Available evidence supports the premise of an origin for vascular plants from the green algae (Chlorophyta), but whether they descended from one line of green algae (monophyletic) or from more than one line (polyphyletic) is not clear. In the face of this irresolution, it has seemed wise for the present to hold to the conservative premise of a monophyletic origin for vascular plants. Pending further information, the phylum, or division, Tracheophyta is maintained for all vascular plants, and supersedes the divisions Pteridophyta and Spermatophyta of the Eichler system. This classification of the vascular plants, foretold by E. C. Jeffrey (1899–1910), took firmer form during the period 1917–1930; since 1930 it has slowly replaced the Eichler system.

With regard to Eichler's Thallophyta, students of algae (algologists) and of fungi (mycologists) have demonstrated it to be a cover-all group, including numerous phyletic lines. The number of these lines in the algae is generally agreed upon. By contrast, in the Eumycota, or true fungi, current opinion tends to favour a single origin directly from colourless flagellate organisms rather than multiple origins from algal groups, as advocated earlier.

Another body of opinion deserves mention: that both algae and fungi descended from colourless flagellate ancestors termed Protista initially by Haeckel in 1866. The term has been extended by adherents of this thesis beyond the limits set up by Haeckel until it includes all flagellated groups and their presumed early evolutionary progenitors. Therefore the Protista is presently conceived of as the first kingdom, ancestral to all living beings.

An increasing tendency among mycologists to question the grouping of the fungi with green plants must be considered. These students, who doubt that fungi and green plants were ever related, conclude that fungi may well have arisen directly from the colourless Protista. The whole outlook of these mycologists depends upon an ecological and physiological approach; they base the classification of living beings upon nutritional modes of life. By this viewpoint the Protista are considered as having given origin to (1) a producing group of organisms that live by manufacturing their own food through photosynthesis—the plant kingdom; (2) an ingesting group that live by devouring organisms—the animal kingdom; and (3) an absorbing group that live by absorbing nourishment from either living or dead organisms—the fungal kingdom (R. H. Whittaker, 1959).

The place of the bacteria is as yet unresolved. It may be within the fungal groups or, in close alliance with the blue-green algae, either in the Protista or in a separate phyletic line from the supposed colourless flagellated ancestors. Preponderant opinion among bacteriologists separates the bacteria from the fungi.

The outline provided below attempts to produce an approach to the natural system of classification of plants; certain portions appear sound from the available facts and other portions are tentatively set forth as reasonable evaluations of data in hand. Since each scheme results from the interpretations of evidence by one man, or at most a few men, differences of opinion are to be expected. It is even more to be expected that the system of classification as set forth in this article will be changed as more information becomes available. The present offering is conservative and, with only minor variations, currently in wide use.

KINGDOM PLANTAE

Current System Phylum or Division	Eichler System Class	Phylum or Division
1. Chlorophyta*—green algae *Chlamydomonas, Oedogonium, Ulva, Spirogyra,* etc.	Algae	Thallophyta
2. Euglenophyta—euglenoid algae *Euglena,* etc.		
3. Chrysophyta—yellow-green algae, golden-brown algae and diatoms *Tribonema, Dinobryon, Navicula,* etc.		
4. Pyrrhophyta—dinoflagellates, desmokonts *Peridinium, Ceratium,* etc.		
5. Phaeophyta—brown algae *Ectocarpus, Laminaria, Fucus,* etc.		
6. Cyanophyta—blue-green algae *Anacystis* (= *Chroococcus*), *Oscillatoria, Nostoc,* etc.		
7. Rhodophyta—red algae *Nemalion, Polysiphonia, Corallina,* etc.		
8. Schizomycota—bacteria † *Streptococcus, Bacillus, Spirillum,* etc.		
9. Myxomycota—slime molds *Physarum, Stemonitis, Dictyostelium,* etc.		
10. Eumycota—true fungi Class Phycomycetes—algal fungi *Mucor, Pythium, Phytophthora,* etc. Class Ascomycetes—sac fungi *Saccharomyces, Aspergillus, Neurospora,* etc. Class Basidiomycetes—club fungi *Puccinia, Amanita, Polyporus,* etc. Fungi Imperfecti	Fungi	
11. Bryophyta Class Hepaticae—true liverworts Class Anthocerotae—horned liverworts Class Musci—mosses		Bryophyta
12. Tracheophyta Class Psilopsida Order Psilophytales *Psilophyton, Rhynia, Asteroxylon,* etc. Order Psilotales *Psilotum* and *Tmesipteris* Class Lycopsida Order Lycopodiales—club mosses *Lycopodium* and *Phylloglossum* Order Selaginellales—little club mosses *Selaginella*		Pteridophyta

Order Lepidodendrales—tree club mosses	
Lepidodendron, Sigillaria, Bothrodendron, etc.	
Order Pleuromeiales	
Pleuromeia	
Order Isoetales—quillworts	
Isoetes	
Class Sphenopsida	
Order Hyeniales	
Hyenia, Calamophyton, etc.	
Order Sphenophyllales	Pteridophyta (*Continued*)
Sphenophyllum, etc.	
Order Equisetales—horsetails	
Equisetum, Calamites, etc.	
Class Pteropsida	
Subclass Filicinidae—ferns	
Order Coenopteridales—early fossil ferns	
Botryopteris, etc.	
Order Marattiales	
Marattia, Danaea, Angiopteris, etc.	
Order Ophioglossales	
Ophioglossum, Botrychium, Helminthostachys	
Order Filicales—"true" ferns	
Osmunda, Gleichenia, Dryopteris, Pteris, etc.	
Subclass Gymnospermidae—gymnosperms	
Order Cycadofilicales—pteridosperms, or seed ferns	
Order Bennettitales—fossil cycads	
Williamsoniella, Wielandiella, Cycadeoidea, etc.	
Order Cycadales—cycads	
Cycas, Zamia, Dioon, Bowenia, etc.	
Order Ginkgoales—ginkgo, maidenhair tree	
Ginkgo	
Order Cordaitales	Gymnospermae
Cordaites, etc.	
Order Voltziales—early fossil conifers	
Lebachia, Walchia, Pseudovoltzia, etc.	Spermatophyta
Order Coniferales—conifers	
Pinus, Sequoia, Taxodium, Thuja, Araucaria, etc.	
Order Gnetales‡	
Ephedra, Welwitschia and Gnetum	
Subclass Angiospermidae	
Dicotyledones—44 orders, with over 250 families §	
Ranunculus, Quercus, Rosa, Malus, Taraxacum, etc.	Angiospermae
Monocotyledones—11 orders, with 45 families §	
Triticum, Avena, Lilium, Musa, Cocos, etc.	

*For the first seven phyla some algologists prefer Chlorophycophyta, Euglenophycophyta, Chrysophycophyta, etc.; the addition "phyco" designating alga. At present no universal agreement on the designations of the phyla exists, and the more common usage is followed. †The bacteria are sometimes omitted from the fungi completely. ‡This group of plants may represent more than one order of plants. In the absence of significant fossil evidence, existing information does not yet justify this separation. §Totals of orders and families were taken from Engler and Diel's *Syllabus der Pflanzenfamilien,* 11th ed. (1936).

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(R. H. We.)

II. MORPHOLOGY OF PLANTS

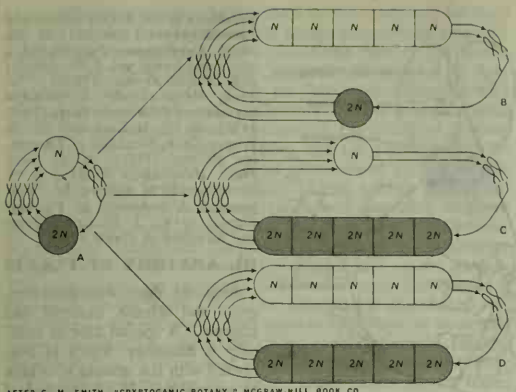
Plant morphology is concerned with the form and structure of plants and of their parts, and with the relation of parts to one another and to the whole. Morphology is thus fundamentally descriptive. A morphological study may be merely the determination of the facts of the history of an organism through all stages of development and reproduction; that is, it may be a purely descriptive life history study. As commonly understood, however, morphology has a broader basis: its object is to trace the underlying similarities in form between various plant groups; it is comparative in its nature, and its comparisons are considered in the light of evolutionary modification and development. Morphology thus conceived aids in the establishment of a natural classification of plants and in the reconstruction of their evolutionary history (phylogeny).

The methods used in morphological studies are: (1) comparison of adult forms of living plants; (2) comparison of living plants with fossils of ancient extinct forms (paleobotany); (3) observations on development of the individual (ontogeny). Morphology is generally subdivided into external morphology which deals with the external form, and anatomy—the study of the external and internal structure of plants. Cytology, study of the cell, arose as a subdivision of morphology concerned with internal structure, but it has become an independent branch of biological science. A morphological study may assume a somewhat specialized aspect. Thus it may deal with the early development of an individual (embryogeny); with the causes that determine form and structure (morphogenesis); or with plant parts considered as organs carrying out certain distinct functions (organography).

1. Alternation of Generations.—The phenomenon of alternation of generations is so prominent and important a feature of the morphology of plants that for many years it has been one of the main objects of morphological studies. The term alternation of generations is used to designate the occurrence of two distinct phases in the life history of the plant, each of which produces the other. One is the sexual phase, the gametophyte, that bears male and female organs (gametangia) and gametes (sperms and eggs) and in which fertilization (syngamy) is effected. The fertilized egg (zygote) develops into a nonsexual phase, the sporophyte, which produces a large number of single-celled spores. The latter develop directly into new gametophytes. The two phases of the life cycle are commonly referred to as generations, though actually they are two phases of one generation if the latter concept is used in the same sense as in zoology.

At fertilization the number of chromosomes is doubled through the union of two gametes. At some other point of the life cycle this number is again halved through reduction divisions (meiosis) (*see* FERTILIZATION; CYTOLOGY). The phase of the life cycle in which all cells have a double complement of chromosomes (diploid) and which begins with the fertilization and ends with the reduction divisions is the sporophyte. The phase characterized by a single complement of chromosomes (haploid), from reduction division to fertilization, is the gametophyte. The character and relative extent of these two phases differ considerably in different groups and show great variability in the lower plants. In many of the thallophytes (algae and fungi) almost the entire life cycle is gametophyte, since the first divisions of the zygote are meiotic; in others it is almost all sporophyte. Still others show varying degrees of relative development of these two phases, and often both are vegetative plants entirely similar in everything except the method of reproduction.

The diagrams give examples of different types of life cycles. The simplest possible life cycle occurs in the unicellular green alga *Chlamydomonas* (phylum Chlorophyta). It consists of an alternation of a one-celled haploid phase with a one-celled diploid



AFTER G. M. SMITH, "CRYPTOGANIC BOTANY," MCGRAW-HILL BOOK CO.

FIG. 1.—VARIOUS TYPES OF LIFE CYCLE AMONG THE CHLOROPHYCEAE (GREEN ALGAE)

(A) chlamydomonad; (B) haplontic; (C) diplontic; (D) diplohaplontic

phase (fig. 1[A]). In the somewhat higher Chlorophyta vegetative cell divisions occur in one or the other or in both phases. In the haplont type, as seen in the green algae *Spirogyra* and *Oedogonium*, a multicellular haploid phase alternates with a unicellular diploid one (fig. 1[B]). In the diplonts, the green alga *Codium*, the life cycle consists of an alternation of a diploid coenocyte (the morphological equivalent of a multicellular diploid generation) with a unicellular haploid phase (fig. 1[C]). Certain other green algae, *e.g.*, *Ulva*, are diplohaplonts and have an alternation of a many-celled haploid generation with a many-celled diploid generation (fig. 1[D]) (*see* ALGAE).

The gametophyte is the dominant phase or "the plant" of the mosses (Bryophyta), whereas the sporophyte is merely a spore-bearing structure that develops from the zygote and remains attached to the gametophyte (fig. 2). In contrast, the vascular plants (Tracheophyta) have a large and conspicuous sporophyte with roots, stems and leaves and predominates in the life history. The fern sporophyte bears the spores on the backs of its leaves. Each spore may develop into a small but independent generation, the gametophyte or prothallus, on which the sex organs are borne (fig. 3). In the conifers and their allies (gymnosperms) and in the flowering plants (angiosperms) the gametophyte generation is extremely reduced. The spore (megaspore) producing the female gametophyte (megagametophyte) remains attached to the sporophyte after germination. Other spores (microspores) germinate to form the male gametophytes (pollen grains), which are liberated and carried (by wind, rain or insects) to or near an ovule containing the female gametophyte. One of the two male gametes (sperms) produced by the male gametophyte fertilizes the egg. The zygote grows at once into the embryo (fig. 4).

Two theories have long existed concerning the nature and origin of the sporophyte of vascular plants: the antithetic theory and the homologous theory. The first assumes that the two phases are distinct, that the sporophyte is a new phase introduced into the life cycle of vascular plants in relation to life in air. It is supposed to have evolved from the zygote of an ancestral algal form through a stage in which it was merely a spore bearer dependent on the gametophyte.

According to the homologous theory (which is supported by modern morphological and paleobotanical studies), the sporophyte and gametophyte are fundamentally alike in nature; they are correlative phases in the life cycle of plants that have arisen by modification of an original single sexual phase. In several interpretations the homologous theory places the differentiation of the gametophyte and sporophyte in ancient algal stocks and assumes the origin of land-living independent sporophytes directly from independent aquatic sporophytes.

2. Plant Body.—In the simplest plants the body consists of a single cell within which all life activities are carried on. According to the evolutionary concept, the simple cells united into colonies forming at first a loose, later a more intimate, union, until a multicellular plant arose. With the advent of "division of labour" between the different parts of the multicellular body, a morphologic differentiation of these subdivisions occurred, so that a very complex plant body appears in the higher plant groups. In the lowest plants any part may perform all functions, whereas in the highest the various functions have organs devoted to their performance, and in these the cells are grouped in definite and very specialized tissues. The lower plants (Thallophyta) show various degrees of complexity of form and structure. Certain groups of red and brown algae somewhat resemble the higher plants in the formation and arrangement of the members of their bodies. The progressive differentiation of the thallus of the liverworts and mosses (Bryophyta) presents an even closer parallel to the organization of the higher plants. Some of these have stemlike and leaflike body parts resembling organs of the most highly organized plants. True roots, stems and leaves, however, do not occur in either thallophytes or bryophytes. These are characteristic organs of the vascular plants (Tracheophyta). According to a modern concept, these organs evolved with the invasion of the dry land by plants that formerly inhabited only the sea.

The nature of the plant body and its parts in vascular plants has long been a basic morphological problem. As was shown in the preceding section, it is the body of the sporophyte that is

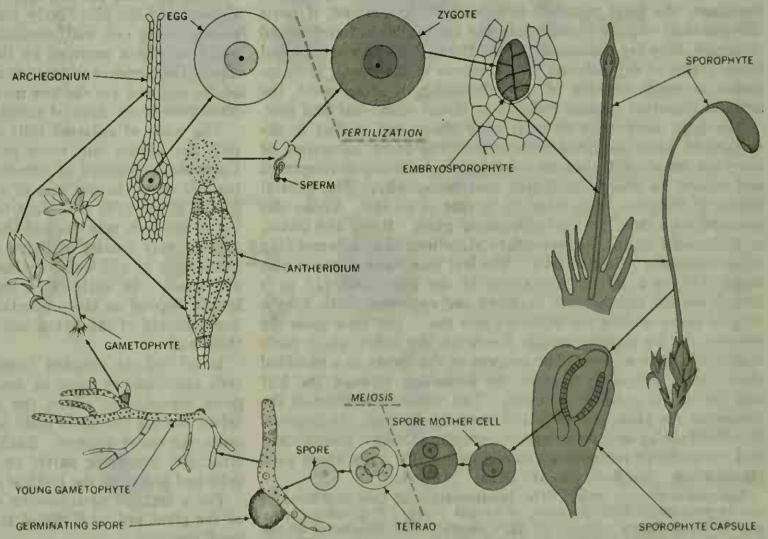


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FIG. 2.—LIFE CYCLE OF A MOSS (FUNARIA)

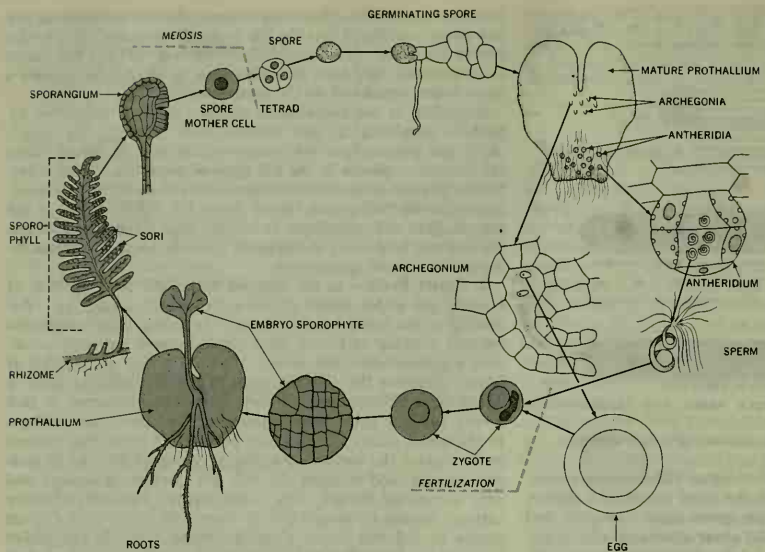

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FIG. 3.—LIFE CYCLE OF A FERN (POLYPODIUM)

so complex in the higher plants. The gametophyte is extremely simple. In early days of morphological study the sporophyte body was looked upon as constituted of organs that were of different fundamental nature. The number of these organs was at first large; for example, stem, root, leaf, ovule, sporangium, sporangiophore, emergence, hair. With the development of the concept of homologies, the interrelation of parts of a plant body began to be recognized. Comparative and developmental studies suggested that differently appearing parts may bear the same relation to the whole plant body, that, in other words, they may be homologous. For example, the flower appeared homologous with the shoot, the floral members with leaves. In contrast, if parts differ in their relation to the whole, but are similar in function and structure, they are analogous. Thus the flattened green stems of many plants of dry habitats are analogous with leaves. With increase in comprehension of the relationship between parts, the units of structure became reduced to three: stem, leaf and root.

The later discoveries of early land plants and studies in development have indicated that even these three categories of parts are not absolute, but are results of evolutionary development and cannot be clearly separated morphologically. The general nature of the plant body seems to be that of an axis. Under this interpretation there are no fundamental parts. Roots and leaves, as elaborated organs, are secondary structures that differentiated on an originally primitive axis. The leaf may have arisen in two ways: (1) as a lateral emergence of the axis; and (2) as a branch system that became flattened and expanded, with a webbing of tissue uniting the branches into one. The view upon the relation of the angiospermous flower to the other plant parts is also in a state of flux. The concept of the flower as a modified shoot, and particularly that of the homology between the leaf and the carpel, is being contested. The complex problem of the nature of the plant organs is still awaiting its final clarification. A judicial use of data on ontogeny, vascular anatomy, paleobotany and comparative morphology should eventually bring about such clarification. *See* ROOT; LEAF; STEM; FLOWER.

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III. ANATOMY OF PLANTS

Anatomy deals with structure, gross and minute, external and internal. A special field of anatomy is histology, which is concerned with the minute structure of organisms. If an anatomical study deals with the structure of cells, particularly with the protoplast, it enters the field of cytology. Thus anatomy merges with cytology and only an arbitrary limit may be set up between the two.

A. MINUTE STRUCTURE

1. The Cell.—An account of the anatomy of plants naturally begins with the cell, which is the smallest physiological unit of organisms. The cell is essentially an integral mass of protoplasm, of small dimensions and containing many specialized structures, chief among which is the nucleus. Other protoplasmic bodies, known as plastids, and inanimate matter, are present. The different living bodies and nonliving inclusions are dispersed within the more or less fluid living substance called cytoplasm. Among the nonliving inclusions are starch grains, crystals of various shapes and compositions, oil globules, tannins and food masses of different sorts. Much of the inanimate matter occurs in a watery solution forming the cell sap. All cells that are permanent tissue elements of the plant body possess a more or less rigid limiting membrane or cell wall, consisting primarily of cellulose or some allied substance excreted by the living cell body. As mentioned above, the presence of plastids in the protoplasm and the existence of the cell wall are the two main characteristics that differentiate plant cells from those of animals.

The walls of adjacent cells are cemented together so that the cells are united into more or less coherent masses or tissues. Upon the characters of constitution, thickness and sculpture of the cell walls, the qualities of a plant tissue largely depend. The life of all the cells in a plant body may be prolonged, or a number of the cells may die and their protoplasm be removed. Thus a tissue may consist of living cells combined with an inanimate framework of cell walls, enclosing in their cavities solely liquids and gases. In such cases the characters of the adult tissue largely depend on the proportion and distribution, the size, form and contents of the living and dead units, and on the nature of their walls.

In all but the simplest forms the plant body is composed of cells associated in more or less definite ways. In the higher or more complicated plants the cells differ greatly among themselves so that the adult body is composed of definite systems of units, the tissue systems. Each system has its own characteristic structure, depending partly on the characters of the component cells and partly on the method of association.

For a detailed consideration of the structure and development of the plant cell with regard to the protoplasm and the nucleus, *see* CYTOLOGY.

Plastids.—The plastids are portions of the protoplasm that have become specialized for the performance of certain func-

tions. They are readily distinguished in the adult cell by their size and definite form, and they are often conspicuously coloured. Leucoplasts are colourless and occur in the cells of the deeper lying tissues where light cannot penetrate—if exposed to light they often become green. They are frequently concerned with the formation of starch grains. Chromoplasts are colour-carrying bodies giving red and yellow colours to the petals of flowers, ripe fruits, etc.; they contain yellow and red pigments such as xanthophyll and carotin. The most important of all the plastids, however, are the green chloroplasts. These contain chlorophyll and are of universal occurrence throughout the plant kingdom with the exception of the important groups of fungi and bacteria. By means of this pigment the plastids are enabled in the presence of light to form carbohydrates from water and carbon dioxide. The chloroplasts are extremely variable in shape, particularly in the algae. In the higher plants the chloroplast is disc-shaped and, according to the prevalent view, consists of a mass of somewhat dense colourless cytoplasm, the stroma, and of granules containing chlorophyll. Chloroplasts frequently contain starch grains.

The differentiated plastids seen in mature tissues may be traced back to plastid primordia, or proplastids, in the youngest tissues (meristems) or embryo. The proplastids appear in the cytoplasm of the young cells as minute bodies grading off to the limit of visibility. At all stages of development from proplastids, and at maturity, the plastids may divide by simple constriction. These divisions are sufficiently numerous to account for the large numbers of plastids in mature cells. It has not been disproved, however, that plastids arise also anew (*de novo*) in the cytoplasm. The problem of individuality of the plastid is mainly one of determining whether they are continuous or not through the critical stages in the life cycle, the gametes and spores. They have been shown to be present in the gametes and spores of some plants and are, in these instances, apparently passed on from one generation to another.

Mitochondria.—In addition to the plastids there are other bodies in the cytoplasm which are very minute and appear as tiny granules, rods or threads and whose nature and function are not well understood. They are called chondriosomes or mitochondria. According to one opinion, mitochondria are the bodies from which plastids develop; according to another, the proplastids and mitochondria are distinct structures. Mitochondria are thought to be concerned with respiration and accumulation of certain substances.

Cell Sap.—All living cells in plants contain variable amounts of nonliving materials that are collectively designated as inclusions or ergastic substances. They include storage products, waste material, or by-products of protoplasmic activity. One of the commonest examples of ergastic substances is the cell sap, which occurs within cavities or vacuoles of the cell. One or more vacuoles may be present in a cell, their number and shape varying from time to time in the same cell. The total vacuolar system of a cell or other protoplasmic mass, whether this system consists of one or more vacuoles, is called the vacuome. The cell sap is water in which are dissolved substances of various kinds, some being food materials, others products of the metabolism of the protoplasm. Its composition is constantly changing, but among the substances of constant occurrence are inorganic salts, carbohydrates such as the sugars and soluble nitrogenous compounds.

Vacuoles appear to be universally present in living plant cells. In the youngest or meristematic cells, which by continual division form the tissues and organs of the plant body, the vacuoles are rather numerous, small, spherical or drawn out into other shapes by the streaming cytoplasm in which they are dispersed. As the meristematic cells multiply, the vacuoles are distributed, with or without division, to the daughter cells. During the enlargement and maturation of the cell the vacuoles increase in size and eventually coalesce to form one large central vacuole, and the cytoplasm thus becomes displaced to a comparatively thin layer closely applied to the cell wall.

Cell Wall.—The cell wall in young, active cells (meristematic cells) is thin and extremely delicate; however, upon completion of the growth of the cell, the cell wall becomes thicker and may undergo considerable modification. It is commonly regarded as a secretion of the protoplasm and is, in living cells, in intimate relation with the protoplasm which may interpenetrate the particles of its substance. This close relation can be readily appreciated when the process by which the wall is first laid down is considered. From the beginning of the plant's existence as a single cell, all new cell formation consists in the division of a pre-existing cell into two halves by the formation of a dividing wall. In this process the cytoplasmic spindle, which functioned in the preceding nuclear division (*see* CYTOLOGY), plays an important part. The new wall begins with the appearance of a cell plate dividing the spindle in two halves. If the spindle does not reach to the

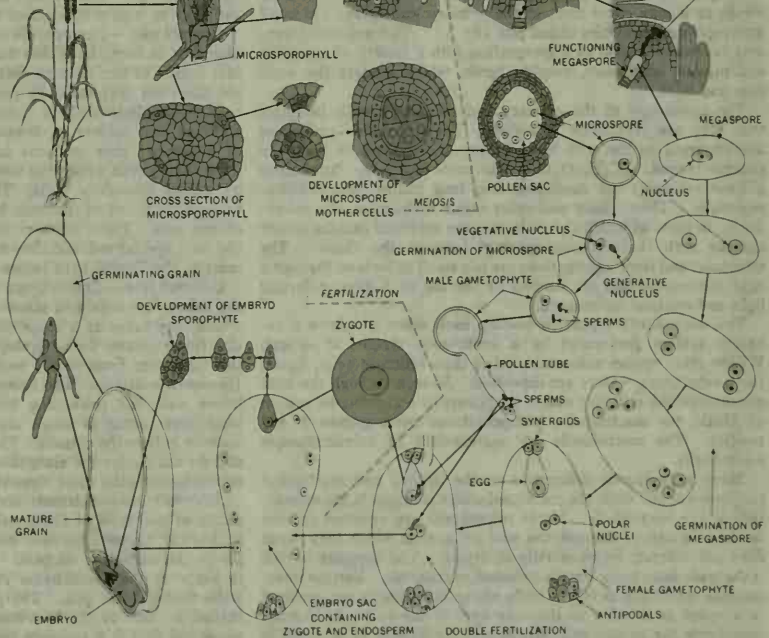

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FIG. 4.—LIFE CYCLE OF WHEAT (TRITICUM)

side walls of the dividing cell, new fibres arise on its periphery and extend the cell plate to the side walls. The cell plate is a fluid layer appearing first as minute droplets that unite to form a continuous layer. Some interpret these small units as droplets of pectic substances. The fluid cell plate apparently soon solidifies and becomes part of the wall. The two daughter protoplasts that resulted from the division of the original cell secrete additional wall substances. These are deposited among the existing particles (intussusception) and also over the inner surface of the new wall (apposition). The amount of wall material deposited varies in different kinds of cells. One extreme is cells with walls that are a little thicker than those of the meristematic cells from which they arose; the other, cells whose interior spaces (lumina) are almost filled with wall material.

Commonly the wall does not appear homogeneous, but shows layering. The layers may differ in origin, in appearance when viewed in polarized light, and in chemical and physical structure. Three main types of layers exist: intercellular substance, primary wall and secondary wall. The intercellular substance is composed of pectic substances and is isotropic (*i.e.*, dark or nonrefringent when viewed under polarized light). This substance acts as a cementing material binding together the walls of adjacent cells. Some regard it as being derived from the cell plate formed during cell division.

The primary wall consists largely of cellulose and pectic substances and is anisotropic (*i.e.*, bright or refringent when viewed under polarized light). It occurs next to the intercellular substance. Many thin-walled tissues contain only primary walls. In other tissues, however, these primary walls may be comparatively thick. They are formed while the cell is still enlarging during differentiation from a meristematic cell.

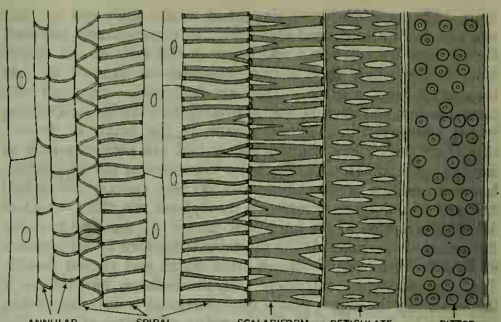
The secondary wall is extremely complex, physically and chemically, and strongly anisotropic. Cellulose is its basic component and it is formed after the cell attains its final size and shape. The secondary wall of plant cells is rarely continuous over the entire surface of the underlying primary wall. It may develop as separate rings, spirals, bars, or as complex network or mesh; or it may cover most of the primary wall except for small interruptions or cavities called pits (fig. 5). All three wall layers may become modified by impregnation with a variety of inorganic and organic substances, notably lignin, which renders the walls firm and hard.

The anisotropy of the primary and secondary walls indicates that they are crystalline in nature. The crystalline properties are imparted to the wall by cellulose, a carbohydrate with the general formula $(C_6H_{10}O_5)n$. The units $C_6H_{10}O_5$ (anhydrous glucose residues) are combined into long chains—the cellulose molecules. These chain molecules occur in bundles, the microfibrils, in parts of which the molecules are arranged parallel to one another with characteristic spacings between the chains. The molecules and their aggregations are too small to be seen through a light microscope and are studied by the use of X-rays, polarized light and electron microscope.

The microfibrils appear to overlap each other and form a coherent system perforated by a continuous system of spaces. Within these spaces substances other than cellulose (*e.g.*, lignin, fatty substances, water) are deposited. As seen through the light microscope the cellulose wall also appears as a continuous system of fibrils, the macrofibrils, interpenetrated by a system of porosities. The macrofibrils are aggregations of submicroscopic microfibrils.

Many conspicuous differences in the optical and mechanical properties of cell walls are correlated with variations in the orientation of the microfibrils. If the microfibrils are oriented parallel to the long axis of the cell, the wall or layer in which they occur does not contract longitudinally in drying. The opposite is true if the walls have transversally oriented microfibrils. Various intermediate conditions occur in walls whose microfibrils are oriented in a spiral in relation to the long axis of the cell. To further complicate the system microfibrils may be differently oriented in the various wall layers of the same cell.

Plasmodesmata.—The living cell in a complex multicellular plant



AFTER E. W. SINNOTT, "BOTANY PRINCIPLES AND PROBLEMS," MCGRAW-HILL BOOK CO.

FIG. 5.—CELL WALL TYPES IN PRIMARY XYLEM SHOWN IN A LONGITUDINAL SECTION OF VASCULAR BUNDLE IN A STEM

body is not a completely independent unit, and its functions are conditioned by, and related to, the activities of the organism as a whole. This must involve a close connection between the living protoplasm of neighbouring cells, and this is effected by delicate connecting strands, the plasmodesmata, which traverse the walls. The connecting strands may be scattered singly throughout a wall or may be aggregated in thinner places of the wall, the pit areas. Plasmodesmata may represent the persistence of the original continuity of the protoplasm of two sister cells, but also are established after growth is completed. These delicate connections seem to occur universally in the higher plants. They play a part in the correlation of the functions of the cells and may also provide the means by which stimuli can be conveyed through long tracts of tissue.

2. Cell Types and Tissues.—As plants increased in complexity the component cells also came to differ greatly among themselves. Plant cells may vary in size, shape, contents and wall structure, and may be highly specialized with regard to function.

Parenchyma.—Parenchyma cells are commonly more or less isodiametric in form, have thin walls and active protoplasts. A certain degree of variation in characteristics occurs with relation to the functions performed by parenchyma. Thus the parenchyma cells of the photosynthetic tissue of a leaf are rich in chloroplasts and may be considerably elongated or lobed; the parenchyma cell of a potato tuber contains leucoplasts that store starch; the parenchyma cells within the water-conducting tissue (xylem) may have thick secondary walls. The retention at maturity of living protoplasts is one of the most important characteristics of parenchyma cells. These cells are regarded as the least differentiated, the least specialized, and they make up the entire plant bodies of most of the Thallophyta (algae and fungi).

Collenchyma.—Collenchyma cells occur in layers or strands in the subsurface region of many stems, petioles and ribs of leaves where they serve as a supporting tissue. Like the parenchyma, this tissue retains living protoplasts at maturity. The shape of the cell varies from nearly isodiametric to very much elongated (prosenchymatous). The principal characteristic is the thick cellulose wall, the thickening being irregular and massive. The thickenings occur in strips along most walls, or the tangential walls or only in the corners. The walls are very strong but plastic, and do not hinder the elongation of the growing organs in which collenchyma is the chief supporting tissue.

Sclerenchyma.—Sclereids and fibres are often treated as elements of one type of tissue called sclerenchyma (mechanical or supporting tissue), because both have thick walls, lack protoplasts and serve for support. Sclereids show similar variations in shape as the parenchyma cells but have very thick lignified walls with tubular pits. The protoplasts are usually lacking at maturity. One of the best-known examples of a sclereid is the stone cell that is a common component of the flesh of the pear fruit. The hard shell of the walnut is made up largely of sclereids. Fibres are elongated cells, sometimes very much so, with

thick pitted secondary walls which may be of cellulose or lignified cellulose. The protoplasts usually die when the cells mature. The two main groups of fibres are those that occur in the wood tissue, the xylem fibres, and those located in various parts of the plant outside the xylem, the bast fibres. The xylem fibres are usually lignified and are chiefly responsible for the rigidity and hardness of the wood. Some bast fibres are lignified, others have unmodified cellulose walls. The latter kinds of fibres are valued commercially and occur in such well-known fibre plants as flax, hemp and ramie.

Conducting Elements.—Tracheary elements are water conductors located in the xylem or wood. The vascular plants are called Tracheophyta because they contain tracheary elements. Two principal types of tracheary elements occur in plants; tracheids (fig. 6[A]) and vessel elements (fig. 6[B], 6[C]). Both of these are commonly prosenchymatous with oblique or transverse end walls. They have secondary walls of lignified cellulose that are deposited as rings, spiral bands, bars, a network, or as pitted layers upon the thin primary wall. At maturity the protoplasts are lacking.

The principal distinction between the two types of tracheary elements is that the tracheid is an imperforate cell with a continuous primary wall, whereas a vessel element has openings or perforations usually located in the end walls of the cell. The vessel elements are combined into longitudinal pipelike units, the vessels, in which water passes freely through perforations from element to element. Water moving through tracheids passes from one cell into the other through places where the secondary wall is discontinuous but the primary wall is present. Often these places are very restricted and are then called pits. The water passes through the exposed part of the primary wall of the pit, the pit membrane.

In the wood of gymnosperms (firs and their allies) the pits show very elaborate structure. The pit membrane has small but numerous perforations and is reinforced by a primary thickening, the torus, in the middle. The secondary wall overhangs the pit cavity as a border (hence bordered pit), leaving a small opening (pit mouth) at the entrance into the pit cavity (fig. 6[D]). The pit membrane is flexible and can bulge one way or the other within the cavity formed by two communicating bordered pits of the adjacent cells. The torus may become appressed to the mouth of one or the other pit, obstructing the entry into the pit cavity. Thus, apparently by changes in the position of the pit membranes of bordered pits, some control is exercised over the passage of fluids in the xylem.

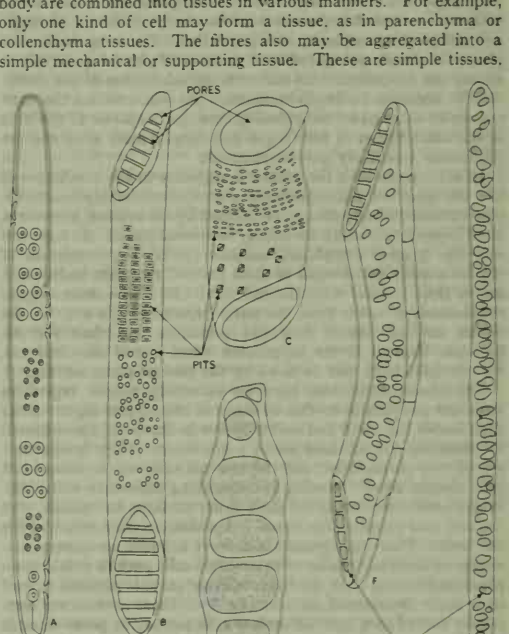
Sieve cells (fig. 6[G]) and sieve-tube elements (fig. 6[F]) are the characteristic components of the phloem, a tissue outside the xylem and concerned with the conduction of food (chiefly sugars and protein) manufactured in the leaves. The sieve-tube elements occur in the angiosperms (plants having their seeds enclosed in an ovary), whereas sieve cells are typical of gymnosperms and ferns. The sieve-tube elements have specially modified walls or portions of walls called sieve plates (fig. 6[E]). The essential feature of a sieve plate is the presence of perforations (sieve-plate pores) in the wall through which the protoplasts of two adjacent or superposed elements are continuous. These connecting strands are comparable with plasmodesmata but tend to be thicker than ordinary plasmodesmata.

In the sieve plate a special kind of carbohydrate, callose, surrounds each strand. In other words, each strand is enclosed in a tube or cylinder of callose, the callose cylinder. As the sieve tube ages, the callose becomes more massive. Since each callose cylinder thickens, the strands are constricted and, furthermore, callose bulges and spreads over the surface of the plate until the latter appears completely buried within the callose. The bulging callose masses on both sides of the sieve plate are referred to as callose plugs, though it is not known whether they actually plug the sieve plate. The appearance of the callose plugs indicates that the sieve-tube element has ceased to function. Therefore, the final callose masses developed at the end of the active period of the conducting element are also called definitive callose.

As it matures the protoplast of the sieve-tube element loses its nucleus, but the cytoplasm is retained until the cell ceases to function. Some studies indicate that this cytoplasm is peculiar: it appears to be very fragile. The contents of the vacuole are often slimy and readily coagulate when the tissue is killed. The so-called slime plugs often seen on sieve plates result from such coagulation. The sieve-tube elements of the angiosperms tend to have their sieve plates on the end walls. The sieve plate may cover the wall uniformly or may be broken up into more or less clearly defined sieve areas. The lateral walls show similar sieve areas, but with thinner strands (fig. 6[F]).

Series of sieve-tube elements are combined into longitudinal series, the sieve tubes. Each sieve-tube element is closely associated with one or more slender parenchyma cells called companion cells (fig. 6[F]). These arise by division from the same mother cell as the sieve-tube element. The sieve cell of the gymnosperms and ferns shows no differences between end and lateral walls. All bear sieve areas of similar nature with rather thin connecting strands. Furthermore, sieve cells are not arranged in vertical superposed series and have no companion cells. Otherwise the sieve cell resembles the sieve-tube element in having callose associated with the connecting strands of the sieve areas and containing no nucleus in the mature protoplast.

Tissues.—The different types of cells characteristic of the plant body are combined into tissues in various manners. For example, only one kind of cell may form a tissue, as in parenchyma or collenchyma tissues. The fibres also may be aggregated into a simple mechanical or supporting tissue. These are simple tissues.



A, AFTER E. C. JEFFREY "THE ANATOMY OF WOODY PLANTS," THE UNIVERSITY OF CHICAGO PRESS. B, C, F, G, AFTER A. J. EAMES AND L. H. MACDANIELS, "AN INTRODUCTION TO PLANT ANATOMY," MCGRAW-HILL BOOK CO., INC. E, FROM K. ESAU, "HILGARDIA"

FIG. 6.—TYPES OF CONDUCTING ELEMENTS IN XYLEM AND PHLOEM

(A) Tracheid of a gymnosperm; (B and C) vessel elements; (D) transverse section of tracheid showing two bordered pits; (E) sieve plate from a sieve-tube element like that shown in (F); the light spots in each sieve area in (E) are callose rings with the cytoplasmic connecting strand in the centre of each. The small cells attached to the right side of the sieve-tube element in (F) are companion cells; (G) sieve cell of a gymnosperm

In other instances many different kinds of cells are combined to make a complex tissue. The best examples of complex tissues are the xylem and phloem, which together constitute the vascular or conducting tissues. The xylem is concerned principally with the conduction of water and inorganic solutes and contains vessels and tracheids (or only tracheids), xylem fibres of different kinds, xylem parenchyma, and ray parenchyma in different proportions and combinations. The phloem translocates various organic solutes and contains sieve tubes and companion cells (or sieve cells), phloem parenchyma, ray parenchyma and bast fibres. The vascular tissues, notably the xylem, function also as supporting tissues because of the presence of fibres. The parenchyma that occurs in these tissues commonly serves for storage of different ergastic substances, particularly starch. The vascular tissues together form an elaborate system, the vascular system. Parenchyma is the principal tissue that surrounds and interpenetrates the vascular system. It may be spoken of as ground tissue.

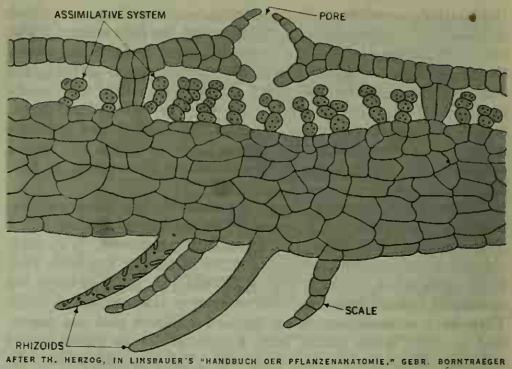
B. Organization of the Plant Body

1. Nonvascular Plants.—The reader is referred to special articles on the anatomy of the lower plants (Thallophyta: Algae and Fungi; and Bryophyta: mosses and liverworts) in which the tissues are rather undifferentiated. Suffice it here to mention that both algae and fungi range from the simplest unicellular forms with no external differentiation of the body to forms of larger size and greater complexity of organization. The progress in complexity is closely associated with division of physiological labour among the component cells and with the adaptation of the multicellular organism to its environment. But whatever are the various states attained by individual genera, the majority of the cells of the adult bodies of both algae and fungi remain alive and the tissues are essentially parenchymatous.

In accordance with the greater complexity in the conditions of life on land for self-supporting plants, considerably more advanced tissue differentiation is exhibited by the mosses, liverworts, etc. (Bryophyta), which are mainly terrestrial plants. In a general way this greater complexity consists (1) in the restriction of regular absorption of water to those parts of the plant body which are in close contact with the soil; and (2) in the more regular evaporation of water from the parts exposed to the air. In the higher vascular plants these two principles find their full expression, whereas in the bryophytes water is still absorbed (as, for example, from rain or dew) by the general plant surface.

The lowest liverworts have an extremely simple vegetative structure comparable to that of many of the simpler algae. Since their bodies are small and normally live in damp air, the demands of terrestrial life on them are at a minimum. Their bodies consist of true parenchyma, and the vast majority of the component cells remain alive. Rooting and absorbing threadlike cells (rhizoids) universally occur on their lower surfaces in contact with the soil, and considerable tissue differentiation may occur within the body. Thus some possess a distinct assimilative system consisting of branched chains of thin-walled cells packed with chloroplasts and arising from the bases of large cavities directed toward their upper illuminated surfaces (fig. 7). These cavities are completely roofed by a layer of surface cells pierced by pores through which aeration and evaporation are freely maintained. In certain forms in which the body consists of thick midribs and delicate lateral leaflike appendages, strands or bundles of long thick-walled fibrelike prosenchymatous cells with pointed ends are arranged longitudinally within the midribs, which are devoid of special assimilative tissue. The walls of these cells are strongly lignified and are irregularly thick and thin so as to be closely studded by simple pits. The latter are usually arranged in spirals and are often elongated in the direction of the spiral. There is much variety of detail in the differentiation of the tissues of the liverworts, but the general plan of construction resembles that characteristic of the leaves of higher plants.

In the mosses the plant body is generally more elaborate. There is a radially organized supporting and conducting axis (stem) bearing laterally through most of its length thin, flat assimilating and transpiring appendages (leaves). Branched rhizoids are attached



AFTER TH. HERZOG, IN LINSBAUER'S "HANDBUCH DER PFLANZENANATOMIE," GEBR. BORNTRAEGER

FIG. 7.—SECTION OF THALLUS OF A LIVERWORT (MARCHANTIA)

to the base of the stem or to parts in contact with the soil. In some instances the stem possesses a special surface or epidermal layer of cells, but usually all the outer layers of the stem (the outer cortex) are composed of brown, thick-walled, lignified, prosenchymatous, fibrelike cells forming a peripheral sclerenchyma (fig. 8). This passes gradually into the thinner walled parenchyma of the inner cortex. The entire cortex is generally alive, and its cells often contain reserve foods in the form of starch. The centre of the stem, in the forms which live on soil, is composed of a strand of narrow, elongated, thin-walled, unlignified, dead cells, which are commonly interpreted as water-conducting elements (hydroids). This hydrom strand has in most cases no connection with the leaves, but forms a straight column in the stem and branches locally below the reproductive organs. In the aquatic and semiaquatic forms, and in those mosses which live under conditions of extreme drought, the entire plant surface absorbs water. In all such forms the hydrom strand is either slightly developed or altogether absent. The leaves of most mosses are flat plates, each consisting of a single layer of square or oblong assimilating cells containing chloroplasts. The marginal cells of the plates are frequently produced as teeth, and their walls are thick. The centre of the leaf is often occupied by a midrib consisting of several layers of parenchymatous cells elongated in the direction of the long axis of the leaf and poor in chloroplasts. This midrib is usually considered a primitive conductive foliar strand or leaf bundle. Hydroids, like those of the central strand of the stem, are frequently associated with this conducting parenchyma, and in some instances are continued into the cortex of the stem as a leaf trace bundle (the anatomically demonstrable trace of the leaf in the stem) (fig. 8). In several forms the leaf trace extends vertically downward for some distance in the outer cortex and ends blindly in a fan-shaped expansion; in others it joins the central hydrom strand so that a connected system is established between stem and leaf.

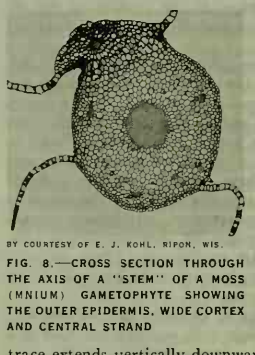

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FIG. 8.—CROSS SECTION THROUGH THE AXIS OF A "STEM" OF A MOSS (MNIUM) GAMETOPHYTE SHOWING THE OUTER EPIDERMIS, WIDE CORTEX AND CENTRAL STRAND

Further differentiation of tissues characterizes the highest family of mosses, the Polytrichaceae. In these, elongated, living, nucleated cells with a thin lining of protoplasm surround the dead central strand and form the phloemlike tissue, commonly called leptom. Between the hydrom and leptom is a cylinder of cell layers that may serve for the temporary storage and distribution of carbohydrates, since they sometimes contain an abundance of starch. The underground portion of the stem (rhizome) bears

rhizoids and simple scales. The aerial parts bear leaves, each with a simple midrib several cells thick and with a strong band of sclerenchyma above, and below a bundle of leptom, hydrom and starch cells, all of which join the central cylinder of the stem. Each midrib bears two wings, one cell thick, while above the midrib is a series of closely set, vertical, longitudinally arranged plates of green assimilative cells.

2. Vascular Plants.—The greatest anatomical complexity occurs in the vascular plants, which comprise the psilopsids, lycopods, horsetails, ferns and seed plants. The vascular plants are not exactly comparable with the bryophytes for while the body of the latter bears the sexual organs and is called a gametophyte, the vascular plant is a sporophyte. Nevertheless the gametophytic bryophyte and the sporophytic vascular plant have similar physiological needs and are both fixed to the soil. The chief new feature in external conformation of the body of a vascular plant compared with that of a bryophyte is the presence of "true" roots, the first formed of which is the downward prolongation of the primary axis of the plant. From this and from various parts of the shoot system, other roots originate. The roots of ferns are structurally simple and uniform compared with those of seed plants, but all manifest a primary plan of construction in direct relation to their normally subterranean life and fixative and absorptive functions; they differ from aerial stems in the characters of their surface tissues, in the absence of the green assimilative pigment chlorophyll, in the arrangement of their vascular systems, and in their mode of apical growth. Great variety in stem and leaf form and structure is shown by the vascular plants.

Evolutionary Trend.—In spite of the many differences of detail between ferns and seed plants, we can trace, alike in root, stem and leaf, a threefold division of tissue systems, already indicated among the bryophytes, and expressive of the fundamental conditions of evolution of the bulky body of a land plant. Thus there is (1) a specialization of a surface layer of cells that regulates the immediate relations of the plant with its surroundings, while varying in expression in the subterranean and aerial parts. In the former the surface layer is pre-eminently absorptive whereas in the latter it is protective and is concerned with the gaseous interchange of oxygen and carbon dioxide involved in respiration, and in such vital functions as assimilation and transpiration. This surface layer is known as the epidermis. Then there is (2) an internal differentiation of conductive tissue, presaged in the bryophytes, and collectively known in the vascular plants as the vascular system. The vascular structures are imbedded in (3) fundamental or ground tissue. The latter may show different distribution and may be combined with other types of tissue. Thus in the axis a cortex appears between the epidermis and the vascular tissues and, in the stem, a pith usually occurs enclosed by the vascular tissues. In the root the pith is usually absent. In leaves the vascular system is imbedded in parenchyma which is called mesophyll. The mesophyll is especially adapted for photosynthesis.

Besides absorption, assimilation, conduction and protection, plant tissues serve for support and the storage of food. Thus locally in the cortex, mesophyll and vascular system, special supporting tissues (sclerenchyma) may be developed, and living cells of both the ground tissue and the vascular system may serve for temporary storage of foods and are specialized accordingly. The functions of aeration, assimilation and transpiration are maintained by an extensive system of intercellular spaces communicating with the external air.

C. Tissues

1. Meristems.—The different types of cells characteristic of the body of higher plants are alike at the beginning of their existence. They arise together from meristems, and only through subsequent differentiation in development become unlike. A meristem is best defined as a specific region in the plant body where cells are engaged chiefly in division and enlargement. Meristems can be conveniently classified according to position as apical and lateral meristems. The apex or growing point of the root or shoot illustrates the former type, the vascular and cork cambia the second. The localization of the regions of cell formation in the plant body distinguishes the plants from the animals, whose parts grow through their whole extent. Also, unlike animals, the higher plants have a continuous formation of new tissues and organs throughout the life of the individual. A meristem is described as undifferentiated embryonic tissue exhibiting juvenile characteristics in contrast with the differentiated or mature tissues that arise from it. Meristems, however, differ morphologically and physiologically from each other and are not sharply separated from those differentiated tissues that retain protoplasts at maturity, particularly the parenchyma tissue. The living mature tissues are potentially meristematic, and resume meristematic activities when appropriately stimulated. Furthermore, cells of a given meristematic region may vary among themselves in many features.

Apical Meristems.—These meristems are usually composed of approximately isodiametric cells with prominent nuclei. The cytoplasm is often dense but may be also conspicuously vacuolated. The dense cells have many small vacuoles dispersed in the cytoplasm. The walls are commonly thin, and the cells are closely packed without intercellular spaces among them. The architecture of the apical meristems varies in different groups of plants. In most ferns, in the horsetails and in some other vascular plants, all tissues of the stem and root are derived from single apical cells located at the apices of these organs. The apical cell, which may be termed also initial cell, is usually tetrahedral in shape. Its base occupies the surface of the apical mound of tissue, and the apex points inward. By definite and regular divisions of such a cell, a mass of still undifferentiated cells is produced immediately below the apex that is continuously occupied by a residual apical cell. From these undifferentiated cells the different tissues sooner or later arise by further growth, divisions and differentiation. In the seed plants a few to many cells at the apex of shoot and root initiate the body tissues, and these cells function in different manners. In angiospermous shoots one or more superficial layers and a central core of the apical mound have independent initials. The peripheral layers (tunica) are characterized by surface growth, that is, anticlinal divisions predominate. The underlying core (corpus) shows divisions in all planes and thus grows in volume. The two zones are interdependent and their extent and behaviour fluctuate. They are not at all specific as to the tissues that originate from them. The peripheral zone may be concerned with the production of the epidermis only, or it may give rise to one or more of the underlying regions. Similarly, the central zone may produce pith only or also the vascular tissues and even the cortex. In the gymnosperms a peripheral and central zone may also be distinguished but here they appear to be more interdependent than in the angiosperms: a superficial group of initials divide anticlinally and periclinally and give rise to both the external and the internal cells of the apical mound.

The root and shoot apices differ from each other in several fundamental features. The shoot apex is concerned with the production of the lateral organs of the stem axis, that is, the leaves; the root apex produces no lateral organs: the lateral roots arise some distance from the apex and not superficially (like the leaves) but in the deeper layers of the axis. Thus the lateral roots have an endogenous origin in contrast to the leaves, whose origin is described as exogenous. The shoot apex is exposed to the outside and cuts off cells only toward the axis. The root apex is covered with a protective tissue, the root cap, produced by cells that are cut off away from the axis of the root. Thus, strictly speaking, the apical meristem of the root is subterminal, whereas that of the shoot is terminal. The initial cells of the root apex of angiosperms are commonly arranged in two or more tiers. One tier may form the root cap, epidermis and cortex, the other the central cylinder containing the vascular tissues. In other species the root cap arises from a separate initial layer (calyptrogen), the cortex and epidermis from another, the central cylinder from a third; or the epidermis and root cap have common origin. Sometimes all four root regions arise from separate sets of initials. In some roots the apical meristem appears generalized and shows no dis-

tinct tiers of initials. The study of a root having separate initials for the various regions of the root axis might give the impression that the regions are predetermined in the apical meristem. Such a view has been actually held and the supposedly independent meristematic regions, the histogens, have received special names: dermatogen, periblem and plerome, the precursors of the epidermis, cortex and central cylinder, respectively. Since in some roots, and apparently in all shoots, the regions of the axis cannot be traced back to separate sets of initials, the deterministic scheme of apical structure cannot be accepted.

2. The Primary Plant Body.—The apical meristem of shoot and root produce a complete plant body with all its vegetative and reproductive organs. This body is spoken of as the primary body, and the tissues composing it as primary tissues in distinction from the secondary body or secondary tissues that are later added to the primary body by the two lateral meristems, the vascular cambium and the cork cambium. The primary tissues result from progressive differentiation of the cell masses produced by the apical meristems, and the latter may be traced back to the embryo and the zygote. As previously stated, the various tissues or regions of the plant body do not appear to be predetermined in the initial regions of the apical meristems. The first certain evidence of tissue differentiation occurs in the subapical regions. There some cell masses show speeded up vacuolation of their protoplasts, others remain dense somewhat longer, but divide largely by longitudinal walls and soon become longer than wide. The more highly vacuolated parts of the subapical meristem later differentiate into the cortex and pith (if the latter is present) and are termed the ground meristem; the meristem part composed of the dense elongated cells is the precursor of the primary vascular system called procambium. It forms the primary xylem and primary phloem. A young plant organ, or part of it, composed of these partly differentiated but still meristematic tissues, is covered on the outside by a discrete meristematic layer, the protoderm, which later matures into the epidermis. These three meristems, the ground meristem, the procambium, and the protoderm, as well as the apical meristems, are the primary meristems whereas the two cambia are secondary meristems.

3. Epidermis.—The epidermis of the aerial stems and leaves is primarily a covering layer which protects against harm from loss of water and against mechanical injury. It usually consists of a single layer of living cells devoid of chloroplasts, and with thickened and waterproofed (cuticularized) outer walls. At intervals the epidermis is interrupted by small pores (stomata or stomates) leading from the outer air to the system of intercellular spaces in the underlying tissues, and serving for gaseous interchange between these tissues and the outer air. Each stoma or stomate is surrounded by a pair of peculiarly modified epidermal cells called guard cells, which possess chlorophyll and open and close the pore in accordance with the changes in water content (turgidity). The stomates of leaves are generally much more numerous in the lower epidermis than in the upper, and even may be absent in the upper epidermis. They are often situated at the bottom of pits in the leaf surface. Thus loss of water (transpiration) is checked by the creation of a still atmosphere in the pit above the pore. Such an arrangement of the stomates is found especially in plants adapted to growth in regions where the supply of available water is deficient. In some angiosperms the epidermis is doubled or trebled by tangential divisions in the original layer, resulting in a multiple epidermis, which functions as a water-storage tissue. In many vascular plants epidermal organs, known as hydathodes, are developed, especially on foliage leaves, and serve for excretion of water in liquid form.

Hairs and Scales.—The epidermis of many species of vascular plants bears hairs or scales of varied form and function. The simplest hairs consist of single elongated cells projecting above the general surface of the epidermis, whereas others consist of simple or branched cell chains. The more complex scales are flat plates of cells commonly inserted on mounds or stalks, and may be placed parallel to the leaf surface or projecting directly from it. In other instances the hairs are glandular and excrete volatile oils, or they may be stinging, as in the common stinging nettle, in which the top of the hair is brittle, and when touched penetrates the skin, breaks and injects a poisonous liquid into the wound thus formed. In many plants both hairs and scales are shed before the stems and leaves are mature; in others they are retained throughout the life of the plant.

Epidermis of Root.—The epidermis of the root is different from that of the stem or the leaf. In relation to its normal function of water absorption its cell walls are not conspicuously cuticularized, and usually remain thin. The absorbing surface is increased because many of the cells expand their outer walls into tortuous, delicate, one-celled tubes (root hairs) which aid in anchoring the root, and readily absorb the surface films of water from the soil particles. A root hair thus corresponds in function with a rhizoid of a moss. The hairs are normally definitely restricted to a more or less definite zone of the root a little removed from the growing root tip. At the lower limit of this zone hairs are constantly being formed as the root advances in the soil, while at the upper limit they have passed maturity, are dying and are being destroyed. Thus beyond the zone which at any moment bears living absorbing hairs the epidermis is extensively or completely destroyed, and its place is taken by the immediately subjacent cortical layer, which is not absorptive, but becomes protective like the epidermis of the stem or leaf.

4. Cortex.—The cortex consists primarily of living parenchyma, but its differentiation may be extremely varied, and in the complex bodies of vascular plants its functions also are varied and may be modified. The cortex of a young stem is usually green—for its cells possess chloroplasts—and a fine system of intercellular spaces communicates with the external air through stomates. With age the inner cortical layers may lose their chlorophyll and become merely storage tissue, and the outer layers may be extensively modified. In many ferns and lower vascular plants the mature outer cortical layers of the stem and root are hard sclerenchyma with thick brown walls, but in flowering plants, while the stems are still slender, the cells of the outer cortical layers elongate and become cylindrical or spindle-shaped and develop localized cellulose thickenings; that is, this part of the cortex differentiates as collenchyma. It provides peripheral support for the growing stem, and as its cells are alive, is open to later modifications with changing conditions in stems that undergo annual increase in girth. On the other hand sclerenchyma is commonly dead, and provides a more rigid but usually unmodifiable supporting tissue. Its adequacy will be evident for stems such as those of modern ferns, which do not increase annually in girth. Less commonly, scattered cells or cell groups which increase little in length may become stone cells, with irregularly but inordinately thickened hard walls. Various secretory cells may occur in the cortex, usually lining cavities or canals which arise through a breakdown of certain cells (oil cavities in a citrus stem or fruit) or through enlargement of intercellular spaces (resin canal in pine stem). The cortex of the stem shows more modifications than that of the root. In the dicotyledons the root cortex commonly remains entirely parenchymatous and is early shed in connection with secondary growth, whereas in the monocotyledons and in the ferns it is more or less sclerified at maturity.

Endodermis.—The innermost layer of the living cortex investing the centrally located vascular system of the axis may be early and peculiarly modified as a continuous cylinder called the endodermis. Throughout its extent the endodermal cells are in close contact, so that the system of intercellular spaces in the cortex is not continued into the central cylinder of conductive tissue. In the absorbing region of angiospermous roots the endodermis shows a very characteristic structure. A band of wall material impregnated with fatty substances and lignin extends completely about the inner surface of the lateral longitudinal and end walls of each cell. These bandlike thickenings of the wall are known as Casparian strips. This kind of endodermis is thought to play a role in the regulation of the transfer of solutes from the cortex into the vascular system: the presence of the fatty substances in the Casparian strip and the firm connection between the strip and the cytoplasm of the cell apparently force the soil solution to move through the cytoplasm and be subjected to the proto-

plasmic control of the endodermal cells. In older roots that cease to absorb the endodermis may develop thick lignified walls; or it is torn and shed because of secondary increase in thickness of the central vascular cylinder.

The stems of seed plants rarely show peculiar morphologic characteristics in the innermost layer of the cortex. In the youngest part of the stem this layer is commonly differentiated as a starch sheath, which may be regarded as an equivalent of the endodermis. It is rich in starch and forms a continuous layer around the vascular system. In the more mature regions of the stem starch is absent. In most ferns the endodermis appears as a morphologically distinct layer throughout the stem and the root. Casparian strips and more generally corky (suberized) endodermal cells have been observed in this group of plants.

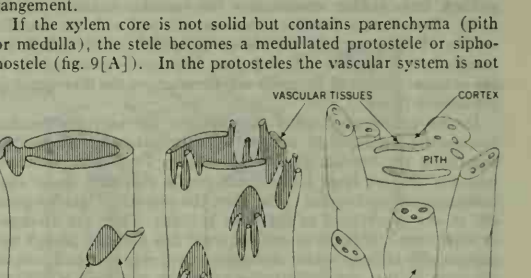
5. Mesophyll.—The mesophyll of the leaf is primarily concerned with the fundamental function of manufacture of carbohydrates (carbon assimilation), and to the active performance of this function the maximum exposure of living parenchymatous tissue containing chloroplasts is necessary. Thus the mesophyll is essentially a green expanse of thin-walled parenchyma and is penetrated by a large and elaborate system of intercellular spaces which serve at one and the same time for the promotion of transpiration and respiration. The pathways for the gases between the mesophyll and the outer air are the stomates which are in direct communication with the ample system of intercellular spaces in the mesophyll. The lower layers of the mesophyll are loosely arranged as spongy tissue with extensive intercellular spaces. This is the main transpiring tissue of the leaf, and in it chloroplasts may be comparatively few. It is protected from direct illumination and is at the same time liable to overevaporation. The main assimilating tissue, on the other hand, is under the upper epidermis and it is well illuminated; its cells are densely packed with chloroplasts, and are commonly oblong, with their long axes perpendicular to the leaf surface. The intercellular spaces in this upper epidermis are narrow, as between sticks in a bundle, and are in open communication with the intercellular spaces in the spongy tissue below. By reason of its resemblance to the boards in a fence, when viewed in a transverse section of the leaf, this portion of the mesophyll is called the palisade tissue. Leaves with blades held in a vertical position commonly possess palisade tissue on both sides or have little or no distinction in the form and arrangement of the cells of the mesophyll, since there is no difference in the illumination or other external conditions, while cylindrical or approximately cylindrical leaves may have palisade tissue all around. The leaves of shade plants have little or no differentiation of the palisade tissue. In fleshy leaves, which contain a great bulk of tissue in relation to their chlorophyll content, the central mesophyll contains little or no chlorophyll and may consist of water-storage tissue, while locally a layer or mass of subepidermal cells may be thick-walled and fibrous.

The cortex of the leaf stalk or petiole is transitional in structure to that of the stem and leaf blade. The petiole is traversed by one or more vascular strands connected below to the central conductive system of the stem, and leading forward in the leaf blade to a complex system of minor strands which ramify in the mesophyll where the spongy and palisade tissues meet. The layer of mesophyll immediately investing each bundle (bundle sheath) usually has the form of a special parenchymatous sheath of elongated cells. In dicotyledons the sheath cells commonly have fewer chloroplasts than the rest of the mesophyll. The bundle sheaths are considered important in the conduction of carbohydrates from the manufacturing (assimilative) cells to the conductive strands and in the supply of water from the latter for transpiration. Their function is thus considered in some measure comparable with that of the endodermis.

6. Vascular System.—Among the most striking characters of vascular plants is the possession of a double (xylem-phloem) conducting system, such as has been presaged in the higher mosses, but with more sharply defined and specialized features. This is the vascular system, and associated with it are other tissues consisting of parenchyma and sclerenchyma. The primary vascular system together with the associated tissues is known as the stelar system (from the way in which in its simpler forms it traverses the whole axis of the plant as a column). When it is remembered that the moss plant is a gametophyte while the vascular plant is a sporophyte, it will be realized that the vascular system of the latter is not the result of elaboration of the conductive system of the former, but that these vascular systems are most readily interpreted as somewhat similar products of differentiation in plants adapted to life on land.

Arrangement of the Vascular System.—In the vascular system the xylem and phloem are nearly always found in close association in strands or bundles, but as is to be expected the arrangement of such bundles is by no means stereotyped either in the given plant group or in the different parts or members of the plant body. A connected vascular system penetrates, however, the entire body. When the vascular system of the axis appears in the form of a solid central rod, with a core of xylem ensheathed by phloem, it is termed protostele. Usually a discrete parenchymatous layer, the so-called pericycle, surrounds the phloem and lies directly beneath the endodermis. The evidence from comparative anatomy and paleobotany indicates that protostele is the primitive type of vascular system. It occurs in both the stem and root of many lower vascular plants, but is restricted to the root of seed plants. In the advanced ferns the vascular system of the juvenile stem is a solid protostele, but that of the more bulky portions of the adult plant shows a somewhat different arrangement.

If the xylem core is not solid but contains parenchyma (pith or medulla), the stele becomes a medullated protostele or siphonostele (fig. 9[A]). In the protosteles the vascular system is not



AFTER Y. OGURA, IN LINSBAUER'S "HANDBUCH DER PFLANZENANATOMIE," GEBR. BORNTRAEGER

FIG. 9.—TYPES OF VASCULAR SYSTEM IN HIGHER PLANTS

(A) Siphonostele; (B) dictyostele; (C) tissues other than the vascular in connection with a dictyostele

interrupted, at least not markedly so, where a vascular bundle, the leaf trace, diverges to a leaf. Siphonosteles usually show breaks in the continuity of the vascular tissues above the departure of a leaf trace, these breaks being called leaf gaps. The gaps are filled with parenchyma, which connects the pith with the cortex. In cross sections of internodes such a stele appears as a continuous circle but shows breaks in the nodal region. If the leaf gaps overlap in their longitudinal extent in a siphonostelic vascular system, the stele is a dictyostele which, in cross section of both nodes and internodes, appears composed of several portions (fig. 9[B]). This kind of dictyostele may be found, for example, among ferns. In a dictyostele breaks other than leaf gaps—the parenchymatous medullary rays—may be present. A stele of this type should be visualized as a tubular network, the meshes representing the vertical leaf gaps and parenchymatous rays. The stems of seed plants usually have similar steles. Thus the vascular system of the axis (root and stem) commonly has the shape of a solid rod or a tube with or without perforations.

The leaves, if small as in the lower Tracheophyta (*e.g., Selaginella, Equisetum*) or the conifers (*e.g.*, firs), have a very simple system which typically consists of one unbranched vein. The large-leaved ferns have complex systems of bundles in the petioles and rachises (extension of petioles to end of leaf) with branches

given off into the leaflets (pinnae). The flowering plants (angiosperms) commonly have rather large leaves with complex vascular systems (*see* below, *Vascular System of Leaf*). The xylem and phloem show two types of arrangement in siphonosteles. If the phloem appears only on the outside of the xylem the stele is ectophloic, if on both sides, amphiphloic. If the ectophloic stele is a much dissected siphonostele the individual strands making up such a stele are collateral bundles, having xylem on one side, phloem on the other. The component parts of an amphiphloic siphonostele are bicollateral bundles having phloem on both sides of the xylem.

The Vascular System in the Stem of Seed Plants.—In this group of plants distinct vascular bundles traverse the axis and connect or anastomose with each other (very much dissected siphonostele). At certain intervals one or more bundles diverge into a leaf, and it appears that all bundles of the stem are directly or indirectly related to the leaf bundles. In other words, the vascular system may be regarded as made up of leaf traces and their fusions. The number of leaf traces to a given leaf varies. Common numbers are one, three and many. If the trace is single only one leaf gap or lacuna is associated with the given leaf and the node is called unilacunar. If there is more than one trace the node may be trilacunar (three gaps) or multilacunar (more than three gaps). The unilacunar node associated with two leaf traces to one leaf is primitive in the angiosperms. The development of axillary buds further complicates the vascular anatomy of the node. The vascular bundles connecting the bud with the vascular system of the main axis are known as branch traces, which are usually two in number. Branch gaps or parenchymatous areas in the vascular system of the main axis occur above the divergence of the branch traces.

In the gymnosperms and dicotyledons the vascular bundles are usually arranged in one circle, with parenchymatous rays separating the bundles from each other. The monocotyledons typically possess large leaves with broad sheathing bases containing numerous bundles. Therefore the number of bundles present at any given level of the stem is high. They are arranged in more than one circle or are scattered in a definite, though not superficially obvious, order throughout the cross sectional area of the stem so that the delimitation of cortex and stele is difficult or impossible. The bundles are surrounded by large-celled ground tissue and around each bundle there is a fibrous investment or sheath.

Vascular System of Root.—The stele of the primary root of a gymnosperm or angiosperm is of radial structure. There are usually two or more xylem strands radially alternating with as many phloem strands, and the first formed xylem groups (protoxylem) are peripheral. Depending on the number of the xylem strands, the root is called diarch, triarch, tetrarch or polyarch. The centre of the stele is either solid xylem or is pithed, and sclerotic cells are in the ground tissue. Thus the vascular system of the root in seed plants is much simpler than in the stem. It forms a protostele, though not of the most primitive kind: the phloem does not completely ensheath the xylem but appears in strands alternating with the protoxylem groups.

Vascular System of Leaf.—In the leaf of the average seed plant the vascular tissue appears as a number of branching or approximately parallel, and usually anastomosing, strands. Above and below the larger strands the leaf parenchyma is raised so as to produce the so-called veins. The vein system is typically very elaborate, and the bundle system is concentrated in the petiole as the tributaries of a river are massed in the main stream. The leaf bundles are usually collateral (the phloem being turned downward and the xylem upward), and the whole bundle may be protected above and below by fibrous cells. As the bundles are followed toward their blind endings in the mesophyll the fibres first disappear, the sieve tubes are replaced by narrow elongated parenchyma cells which disappear before the end of the bundle is reached. The bundles usually end in short or long spiral or reticulate tracheids covered by the bundle sheath.

Ontogeny of the Vascular System.—The primary vascular system in the various organs of the plant is first delimited in the form of a meristem called procambium. The procambium assumes similar aspect as the mature vascular system with its continuities and interruptions, gaps, traces, bundles and other details. But all parts of the procambial system are short. The elongation of these parts is one of the phases in the maturation of the procambium into the vascular system. In a given transverse section of the procambium the vascular elements differentiate not all at once, but gradually. The first primary xylem elements (protoxylem) may appear on the periphery of the xylem system, and the subsequent primary elements (metaxylem) toward the centre. Such order of differentiation is spoken of as centripetal and the xylem of this kind is exarch; or the protoxylem occupies the innermost position in the xylem system and the further xylem differentiates centrifugally. Such primary xylem is endarch.

The first phloem is termed protophloem; then follows the metaphloem. The phloem located on the outside of the xylem differentiates centripetally. The internal phloem, as in an amphiphloic siphonostele, differentiates centrifugally.

A good example of exarch xylem is found in the roots of seed plants. Here the starting points of xylem differentiation, the protoxylem poles, occur on the periphery of the stele and alternate with the protophloem poles. Both metaxylem and metaphloem differentiate toward the centre of the root, but the phloem remains essentially peripheral, whereas the metaxylem frequently reaches the centre. The xylem in the stems of seed plants is typically endarch. The protoxylem occurs on the periphery of the pith in each major subdivision of the dictyostele. Opposite each protoxylem strand on the periphery of the stele is the protophloem bundle. The metaxylem and metaphloem differentiate toward each other, that is, the xylem shows a centrifugal, the phloem a centripetal order of development. The leaf bundles commonly show the same order of differentiation as the stem bundles.

The longitudinal course of differentiation in the root is from the more mature toward the younger parts of the root, that is, the differentiation is acropetal. In the stem, however, xylem and phloem, as far as known, differ from each other in their initial course. The phloem differentiates acropetally from the lower regions of the axis toward the apex and into the leaf primordia, whereas the xylem is initiated at the base of the leaves or in the leaves and then differentiates toward the apex of the elongating leaf and downward (basipetally) into the axis toward the junction with the mature xylem below.

The primary xylem is simpler in structure than the secondary. The protoxylem contains only one or two kinds of tracheids or vessels (commonly with annular and spiral secondary thickenings) and some parenchyma. The metaxylem shows greater variety of elements and often contains fibres. The primary phloem also is simpler than the secondary. The protoxylem and protophloem mature before the organ in which they occur completes its elongation.

Since the water-conducting elements are dead at maturity and the sieve tubes or sieve cells have enucleate protoplasts, these vascular elements cannot respond with growth to the continued division and elongation of the adjacent tissues. For a while the protoxylem and protophloem elements, which have no rigid walls, are passively stretched, then they are torn and more or less completely obliterated while new conducting elements differentiate to take the place of the old ones. Consequently in mature plant organs the protophloem and protoxylem may appear much modified as compared with their original state. This is particularly true of the protophloem in which fibres (bast fibres) or collenchymalike cells often differentiate after the obliteration of the conducting elements. The fibrous or collenchymatous protophloem appears like a region very distinct from the rest of the phloem and has often been called the pericycle. The metaxylem and metaphloem remain longer intact, though they too become functionless when secondary vascular tissues are formed. In plants having no secondary growth, the metaxylem and metaphloem are the main conducting tissues of the mature plant.

7. Laticiferous Tissue.—In certain families of angiosperms there are peculiar tissues that do not occur in the ferns and their

more primitive relatives. Such, for example, is the laticiferous tissue found in many composites (Compositae) and spurges (Euphorbiaceae), which appears in the form of long, usually branched tubes penetrating the other tissues of the plant in a general longitudinal direction. The tubes possess a delicate layer of protoplasm with numerous nuclei lining the walls, whereas the interior of the tube (corresponding with the cell vacuole or cavity) contains a fluid called latex, consisting of an emulsion of fine granules and drops of various substances, suspended in a watery medium, in which other substances (salts, sugars, rubber producers, tannins, alkaloids and various enzymes) are dissolved. Of the suspended substances, grains of caoutchouc, drops of resin and oil, proteid crystals and starch grains may be mentioned. Of this varied mixture of substances some are undoubtedly plastic (*i.e.*, of use in constructing new plant tissue), while others are apparently end-products of metabolism, secreted within the plant body. The latex may be milky in appearance or nearly colourless. The use of certain plants as rubber producers (notably *Hevea brasiliensis*, the Para rubber tree), depends on the property of coagulation of the latex. The trees are regularly tapped and the coagulated latex which exudes is collected and worked up into rubber. Opium is obtained from the latex of the opium poppy (*Papaver somniferum*), which contains the alkaloid morphine.

Laticiferous tissue is of two kinds: (1) laticiferous cells, which branch but do not anastomose, and the apexes of which keep pace in their growth with the other tissues of the plant, as seen in dog bane (Apocynaceae) and in most spurges; (2) laticiferous vessels, which are formed from rows of actively dividing (meristematic) cells. The end walls of these cells break down so that a network of laticiferous tubes arises (Papaveraceae, *Hevea*). In some plants, as in onion (*Allium*) and in morning glories (Convolvulaceae), rows of cells with latexlike contents occur, but the walls separating the individual cells do not break down.

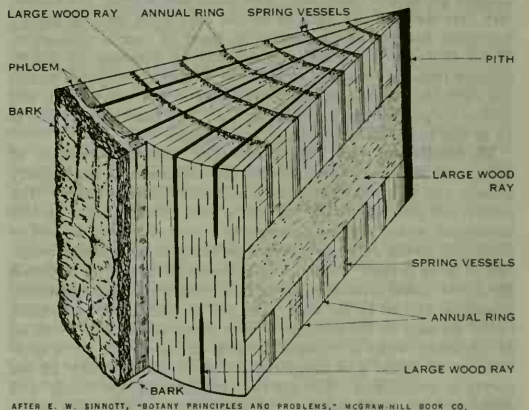
8. Cambium and Secondary Growth.—Most of the modern ferns, horsetails and herbaceous monocotyledons, and many of the annual dicotyledons, are composed of primary tissues only. The gymnosperms and many dicotyledons, particularly the treelike forms (arborescent), have, in roots and stems, large amounts of secondary vascular tissues added to the primary so that the axis becomes many times thicker than it was in the primary state. These tissues are formed by the vascular cambium. In the stems this meristem arises partly from the procambial cells that remain in meristematic state after the primary xylem and phloem of the bundles mature, and partly from the ray and gap parenchyma cells located between the bundles. Because of this double origin it is customary to speak of fascicular cambium, if it arises within the bundle, and interfascicular, if it is formed between the bundles. The two, however, form one continuous meristem, circular in cross section. In the roots, the cambium arises first on the inside of the phloem strands. Then these strips of cambium become connected with each other by cambial cells that arise within the parts of pericycle located outside the protoxylem poles. Thus in both the stem and root a continuous cambial cylinder is formed, which produces secondary xylem toward the centre of the axis, secondary phloem toward the periphery.

It is difficult to indicate precisely when procambium becomes cambium. Generally, one might say that the procambium exists and produces the primary vascular tissues as long as the primary organ is still elongating by continued cell division and cell enlargement. After this growth ceases, the remaining vascular meristem assumes the characteristics of the cambium. The latter thus functions in the part of the body that attained its final length. Therefore, if the elements produced by the cambium elongate, they do so not in harmony with the adjacent tissues but by a kind of sliding growth in which the elongating cell intrudes among other cells.

In a wide range of dicotyledons and gymnosperms the vascular cambium shows certain common characteristics. It is composed of two kinds of initials: (1) the elongated, prosenchymatous, sometimes spindle-shaped, fusiform initials, and (2) the prismatic parenchymatous ray initials. Both kinds of initials are highly vacuolate. The fusiform initials form such elements as tracheids, vessels, fibres, wood parenchyma and sieve tubes, that is, vascular elements that are disposed vertically in the axis of the plant. The ray initials are points of origin and propagation of the radially disposed xylem and phloem rays. There is only one layer of initials around the circumference of the axis but the immediate products of this layer cannot be distinguished anatomically from the initials. The initials and their nearest products (the xylem and phloem mother cells) together form a few layered cylinder of thin-walled vacuolate cells between the xylem and the phloem.

Through secondary growth the primary xylem is buried in the centre of the stem or root, while the primary phloem is pushed outward. The cambial cylinder itself moves outward because of the accumulation of secondary xylem inside of it. As it does so, it also increases in circumference. The divisions that add to the xylem and phloem are tangential, but those that cause the increase in girth of the cambial cylinder are either radial longitudinal (anticlinal) or oblique radial divisions, followed by such elongation of the daughter cells that they appear to slip past each other and eventually lie side by side, at least part of their length.

9. Secondary Vascular Tissues.—The secondary xylem and phloem are highly complex tissues composed of many kinds of cells. As in the cambium, two systems of cells may be distinguished in the secondary tissues, the radial or transverse formed by rays, and the vertical or longitudinal made up of various cells having their long axes parallel with the axis of the organ (fig. 10).



AFTER E. W. SINNOTT, "BOTANY PRINCIPLES AND PROBLEMS," MCGRAW-HILL BOOK CO.

FIG. 10.—SEGMENT OF OAK LOG

(Right) radial cut; (top) transverse cut; (left) surface of log with a portion of the phloem and bark cut away showing a tangential view of the wood underneath

The xylem and phloem rays are usually parenchymatous, but may contain ray tracheids in the xylem of gymnosperms. The longitudinal system of the phloem contains sieve cells, phloem parenchyma and fibres in the gymnosperms; sieve tubes with companion cells, phloem parenchyma and fibres in the dicotyledons. The vertical system of the xylem in gymnosperms may contain only tracheids or also fibres and xylem parenchyma. The dicotyledons have a more complex longitudinal system, the complexity varying in different groups. Vessels, tracheids, several kinds of fibres, and xylem parenchyma are common components. The patterns of distribution of the different elements of the secondary phloem and xylem vary greatly and serve as useful criteria in the recognition of relationships among plants.

The secondary vascular tissues in roots and stems are fundamentally similar, but often the root contains a higher proportion of storage parenchyma. The fascicular and interfascicular cambium portions of stems may produce essentially the same kinds of tissues, as in most trees; or the interfascicular cambium forms only ray parenchyma, as in woody vines. In the former case the secondary xylem and phloem form continuous cylinders; in the

second the vascular system is broken up into blocks or large strands, each associated with a primary xylem strand next to the pith. Similarly in the roots, the cambium arising in the pericycle may form parenchyma only; or the cambium produces a continuous vascular cylinder.

Annual Rings.—In those plants whose annual activity is interrupted by a regular winter or dry season the limit of each year's increase of secondary wood is marked by a more or less distinct line which is produced by the sharp contrast between the elements formed in the late summer of one year and those produced in the spring of the next. Frequently large vessels are produced by the cambium in the spring, while as summer advances the vessels formed are narrower, and then fibres with greatly reduced cavities arise. In gymnosperms containing no vessels the tracheids formed in the spring have much thinner walls and wider interiors (lumina) than those produced during the summer. Thus in a single season of cambial activity a rough outward progression may be traced in the secondary wood of that season from wide vessels or tracheids to narrow fibres, beyond which the transition to the wide vessels or tracheids of the succeeding spring is sudden. Each zone thus recognized in a cross section of the stem is called an annual ring, and the lines of separation of successive rings mark the temporary cessation of cambial activity at the end of successive seasons.

Sapwood and Heartwood.—The older wood of large trees, forming a cylinder in the centre of the trunk, frequently undergoes marked changes in character. The wood parenchyma and medullary rays die, and the walls of all the cells often become greatly hardened, because of the deposit in them of special substances. Wood thus altered is called heartwood or duramen, as distinguished from the younger sapwood or alburnum, which is nearer the cambium, carries on the active function of conduction, and retains its parenchymatous cells in life. The heartwood ceases to be of any use to the tree except as a support.

10. Phellogen and Periderm.—The secondary increase of xylem and phloem involves an outward movement of the primary phloem and of all the elements which surround the latter. The cortex, and particularly the epidermis, must accommodate for this movement, either yielding passively to a limit and being injured or destroyed by the outward pressure, or being to some extent modified so as to persist. Mostly the epidermis is unable to maintain the active radial division of its cells necessary for such expansion, is soon stretched to its limit, dies and is destroyed. Extensive radial division in the cortical cells is progressively less essential as the inner cortex is followed inward, and as a rule, by a combination of radial and tangential divisions, the integrity of the cortex is maintained. Toward the periphery of the cortex, and commonly by modification of its outer layer, a secondary meristem arises and produces external and internal secondary tissues. This meristem is the cork cambium or phellogen, and the whole of the tissue it gives rise to is known as periderm.

Cork and Bark.—The phellogen is simple in structure as compared with the vascular cambium; it is composed of one kind of cell which is rather short and prismatic. The external product of this meristem is the characteristic tissue known as cork. This consists typically of closely fitting layers of cells which quickly die, and when mature, have completely suberized walls. The cork serves to replace the epidermis as an external protective layer when the former is ruptured. The outer layers of the cork are constantly being destroyed, but new layers are in progress of formation within. The internal tissue sometimes formed by the phellogen is known as phelloderm; it augments the cortex, and typically consists of living parenchymatous cells to some extent capable of further division. Indeed, an inward succession of phellogens may arise in the phelloderm and in even more deeply seated living layers. The phellogens arising deeply may cut off parts of cortex and even phloem. These tissue parts then die and together with the cork form the rough bark on the surface of the tree. In certain plants the epidermis becomes the phellogen. To the great activity of the phellogen, and to the power of formation of a series of phellogens in deep layers, the value of the cork oak as a source of cork is due. Certain regions of the periderm show loosely arranged cells whose walls are not suberized. These regions are the lenticels through which gaseous interchange between the stem tissues and the outside air is possible.

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IV. PLANT PHYSIOLOGY

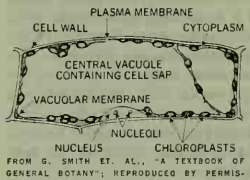
Plant physiology is the division of botanical science which comprises knowledge of the processes occurring in plants and the influence of environmental conditions on those processes. Since experimental analysis of plant processes has invariably shown that each such process can be resolved into a number of relatively simpler physical and chemical processes, it is customary for the plant physiologist to regard a plant as essentially a complex living mechanism. Adoption of this viewpoint has led to notable advances in our knowledge of the material and energy transformations which occur within plants, and no exception has ever been found in which plant processes do not operate in accord with the fundamental principles of the physical sciences. Given a plant of known heredity, and of known previous history, it is possible by applying the principles of plant physiology to predict with considerable certainty the physiological reactions which will be evoked in that plant upon its exposure to a given complex of environmental conditions.

The following discussion is largely restricted to the physiology of seed plants.

A. Physiology of the Plant Cell

Although from one point of view all plant physiology is cellular physiology, most plant processes are considered in relation to larger structural units such as tissues, organs or the entire plant body. Certain topics, however, can most conveniently be discussed under the above heading.

1. Organization of the Plant Cell.—Essential to the discussion that follows is a review of cell structure as given earlier in the *Anatomy* section. The typical mature plant cell is a tiny many-sided compartment enclosed by a cell wall. Lining the inside of the wall is a thin layer of protoplasm, which is the seat of physiological processes. Present as a part of the protoplasm of each cell is a more or less spheroidal body called the nucleus, which appears to exert a controlling influence on the processes of the cell. The remainder of the protoplasmic layer is called the cytoplasm. Within the cytoplasm are present other organized bodies, smaller than the nucleus. The most important of these are the plastids. The great bulk of the cell cavity or lumen is the vacuole, which contains a complex watery (aqueous) solution called the cell sap. Present as solutes in the cell sap are sugars, salts and many other compounds.



FROM G. SMITH ET. AL., "A TEXTBOOK OF GENERAL BOTANY"; REPRODUCED BY PERMISSION OF MACMILLAN CO.

FIG. 11.—A CELL OF ELODEA, GREATLY MAGNIFIED

Plant cells of higher plants vary greatly in size and configuration. Some are essentially spheroid (isodiametric), others are considerably or greatly elongate. They range in size from $\frac{1}{250}$ to $\frac{1}{2,500}$ in. in rough diameter; a cubic centimetre of compact plant tissue may contain 1,000,000 or more cells. The protoplasts of individual cells are not entirely isolated from each other by the imprisoning walls, but are interconnected by minute strands of cytoplasm called plasmodesmata, which extend from protoplast to protoplast through pores in the separating wall.

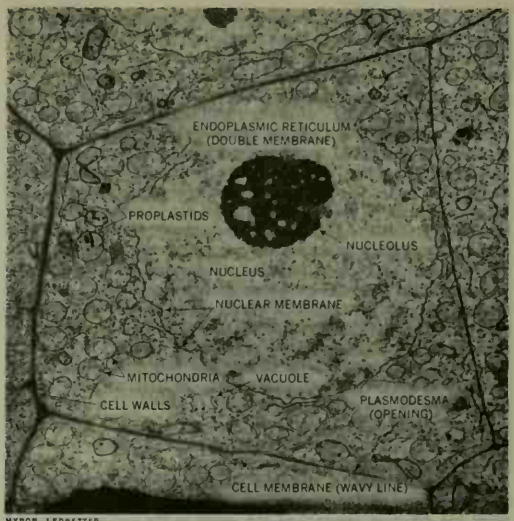
The cell wall between two adjacent cells consists of two or more

layers: (1) the middle lamella; (2) the primary cell wall of each cell; and (3) secondary layers which are not present in all cells. The middle lamella is the first cell wall layer formed in the process of cell division and is bounded on each side by the primary walls of two adjacent cells. This layer is composed of pectic compounds of which calcium pectate is one of the more important. The primary cell wall, which also develops largely during and immediately subsequent to cell division, is composed of cellulose and pectic compounds which are water-saturated. The basic structural framework of such walls is composed of long chainlike cellulose molecules, which, in portions of the wall at least, are bound together into bundles (micelles) of 100 to 170 parallel molecules. The pectic compounds in the primary wall apparently occupy only the irregular spaces between the micelles. In some kinds of cells a secondary wall may be formed on the inner surface of the primary wall. Unlike primary cell walls, secondary walls lack elasticity, and fail to manifest reversible changes in thickness which are characteristic of many primary walls. Secondary cell walls often contain a smaller proportion of pectic compounds to cellulose than primary cell walls. A number of other constituents are also found in plant cell walls. The most important of these are lignin, suberin and cutin. Lignin, the characteristic constituent of the walls of the cells of woody tissues, is a brownish substance whose exact chemical composition is unknown. It occurs in the intermicellular spaces of the cellulose-containing wall. Suberin is a fatlike substance which is the characteristic constituent of cork cells; cutin is another fatlike substance which occurs as a thin "varnish" over the epidermis of most aerial plant organs.

2. Protoplasm.—As observed at high magnification in an ordinary optical microscope protoplasm appears as a clear fluid in which are suspended numerous granules or droplets of insoluble materials. This visible gross structure of the protoplasm does not, however, represent the physical organization which accounts for its unique properties. Portions of the protoplasm which contain no suspended granules exhibit all of its fundamental properties. Hence the ultimate structure with which most of the distinctive properties of protoplasm are associated is beyond the limit of the optical microscope; it is ultramicroscopic and resides in the hyaline, optically empty fluid which is its basic constituent.

Chemical analyses of protoplasm tell us no more of its organization than the analysis of a ground-up watch would tell us of its mechanical construction. The protoplasmic system is destroyed the moment it is subjected to chemical analysis. Nevertheless such analyses do yield the best available information on the proportionate amounts of various ingredients present in protoplasm. Water is the chief component of the protoplasm of all active cells, usually constituting 90% or more of its total weight. Most detailed chemical analyses of protoplasm have been made upon the formless ameboid bodies (plasmodia) of slime molds. These are inconspicuous naked masses of flowing protoplasm often found creeping imperceptibly over rotting logs in damp woods. Because of the absence of cell wall material, and because the protoplasm can be collected in relatively large quantities, such plasmodia have been favourite materials for chemical analyses of protoplasm. Analysis of such a plasmodium shows that proteins and chemically related substances constitute about 67%, lipids about 11%, minerals about 4%, and sugars about 14% of the total dry weight. The sugars, however, appear to be entirely restricted to the vacuoles, as is also true of a part of the minerals and some of the nitrogenous compounds, especially the amino acids.

The properties of protoplasm are clearly as much a function of its ultimate physicochemical organization as of the specific compounds of which it is composed. A number of the properties of protoplasm are similar to those of gelatin, agar and other water-absorbing colloids (hydrophilic colloids). Among these are its elasticity, its variable viscosity, its capacity to absorb water, its capacity for reversible gelation, and the fact that its physical state may be markedly influenced by mechanical disturbances, high or low temperatures, or certain concentrations of various salts (electrolytes). Although protoplasm appears to have the organization of a hydrophilic colloid, its structural and dynamic complexity far transcends that of nonliving hydrophilic systems



MYRON LEDBETTER

FIG. 12.—ELECTRONMICROGRAPH OF A MERISTEMATIC CELL OF THE AFRICAN VIOLET, GREATLY MAGNIFIED

such as agar or gelatin sols or gels. William Seifriz and others postulated that protoplasm has a basically fibrillar structure, the submicroscopic fibrils (composed largely or entirely of complex proteins) overlapping and interlocking through molecular side chains within an aqueous medium. Electrolytes, carbohydrates, lipids and other constituents of the system may be dissolved or dispersed in the aqueous medium, dissolved in water held within the fibrils, or adsorbed at interfaces within the system. For a detailed treatment of the physics and chemistry of protoplasm *see* CYTOLOGY.

Protoplasmic Streaming.—In many plant cells the protoplasm is in active motion, the exact mechanism of which is unknown. In the simplest cases this movement consists of a rotation around the inner surface of the cell wall. Rates of streaming may range up to at least 19 in. per hour. Cyclosis is accelerated by increases in temperature up to the point at which injury occurs, and is retarded at lower temperatures, ceasing just above freezing. Protoplasmic streaming also ceases in the absence of oxygen.

3. Permeability.—Unlike the cell walls, which in most living cells are quite freely permeable to water and solutes, the cytoplasmic layer is more permeable to some substances than to others. In other words, cytoplasm is differentially permeable. This property of differential permeability resides largely in the surface layer of the cytoplasm in contact with the cell wall (plasmalemma), and the surface layer in contact with the vacuole (tonoplast). The cytoplasmic layers are usually relatively permeable to water and to certain solutes such as dissolved gases, and to some types of organic compounds. On the other hand, they are usually much less permeable to sugars and mineral salts. The permeability of the cytoplasmic membranes is a variable property, however, and under certain conditions solutes which ordinarily penetrate through these membranes slowly or not at all may enter or leave cells very rapidly.

4. Osmotic Relations.—If a flabby or flaccid plant cell (*i.e.*, one in which the cell sap exerts no pressure against the encompassing protoplasmic layer and cell wall), is immersed in pure water, inward diffusion of water (osmosis) occurs into the cell sap. Diffusion of the water takes place because the diffusion pressure of the water in the cell sap is less than that of the surrounding pure water by the amount of its osmotic pressure. If the osmotic pressure of the cell sap is 12 atm. (atmospheres, each of which is equivalent to a pressure of 14.7 lb. per square inch or 14.7 lb./inch^2) the diffusion pressure of the water in the cell sap is

12 atm. less than that of pure water at the same temperature and under the same pressure. The lower diffusion pressure of the water in the cell sap results from the presence of solutes. As water enters the cell it exerts a turgor pressure against the protoplasm and cell wall, a pressure which also prevails throughout the mass of water within the cell. If the cell wall is elastic, as it usually is, some expansion will occur in the volume of the cell. As diffusion of water into the cell continues, turgor pressure gradually increases until eventually it is equal to the final osmotic pressure of the cell sap. At this point of dynamic equilibrium the diffusion pressures of the water in the cell sap and the surrounding water are equal, and the number of molecules entering the cell exactly equals the number passing out of the cell per unit of time. Subjection of water to an imposed pressure increases its diffusion pressure by the amount of the imposed pressure. In this example, disregarding the usually small effect of sap dilution as the cell expands, the diffusion pressure of the water in the cell sap is reduced 12 atm. because of the presence of solutes (the osmotic pressure is the index of this effect) and raised 12 atm. by the turgor pressure; hence its equilibrium diffusion pressure is the same as that of the pure water bathing the cell. If the same cell in a flaccid condition is immersed in a solution with an osmotic pressure of 5 atm., inward diffusion of water occurs but does not continue as long as in the preceding example.

Disregarding dilution, dynamic equilibrium is attained when a turgor pressure of 7 atm. prevails within the cell, because at that point the diffusion pressure of the water in the cell sap and that of the water in the solution are equal. As exemplified in the preceding examples, the effective physical quantity determining the direction of osmotic movement of water from cell to cell in plants or between a cell and an external solution is the diffusion pressure deficit of the water. This value is equal to the osmotic pressure of the contained water (which tends to hold the water in) less the turgor pressure to which it is subjected (tending to push the water out). In an unconfined solution (no membranes) the diffusion pressure deficit is equal to its osmotic pressure, since there is no turgor pressure. In a fully swollen or turgid cell the diffusion pressure deficit is zero, and the turgor pressure equals the osmotic pressure, and as much water leaves the cell as enters it; in a fully flaccid cell the turgor pressure is zero, and the diffusion pressure deficit is equal to the osmotic pressure; therefore much more water diffuses into the cell than goes out.

The osmotic pressures of plant cell saps mostly lie within a range of 5–40 atm. Much higher values occur in some halophytes, the maximum on record being 202.5 atm. in the leaf cells of saltbush (*Atriplex confertifolia*). The osmotic pressures of the cells of a given plant tissue may vary considerably with environmental conditions and the metabolic status of the cells; more or less regular diurnal or seasonal variations in osmotic pressure occur in the cells of many tissues.

In some kinds of cells water may, under certain conditions, pass into a state of tension (negative pressure). In such cells the diffusion pressure deficit is equal to the osmotic pressure plus the tension imposed on the water, and sometimes far exceeds the osmotic pressure of the cell sap. Osmotic movement of water always occurs from the cell of lower to the cell of greater diffusion pressure deficit unless some interfering or offsetting condition or mechanism prevents or counteracts such movement. Movement of water in plant tissues commonly occurs from cell to cell along diffusion pressure deficit gradients. The osmotic pressure, diffusion pressure deficit and turgor pressure are called the osmotic quantities of plant cells; all three of these physical quantities are necessary in any critical evaluation of the water relations of cells.

5. Plasmolysis.—If a partially turgid plant cell is immersed in a solution with a higher osmotic pressure than the cell sap, a slow shrinkage in the total volume of the cell ensues; *i.e.*, water moves from the cell sap to the surrounding solution. When the lower limit of elasticity of the rigid cell wall is reached the protoplasmic layer begins to recede from the wall because of continued loss of water from the cell sap. This recession often continues until the protoplasm has shrunk to a more or less rounded sack in the centre of the cell, the space between the wall and the protoplasm becoming filled with the external solution. This phenomenon is called plasmolysis. Since immersion of a cell in a solution with an osmotic pressure just barely exceeding that of the cell sap should just initiate withdrawal of the protoplasm from the cell wall, this phenomenon is the basis for one of the methods of measuring the osmotic pressure of plant cells.

FROM K. ESAU, "PLANT ANATOMY" (1960); REPRODUCED BY PERMISSION OF JOHN WILEY & SONS, INC.

FIG. 13.—PLASMOLYZED CELLS OF RED ONION BULB SCALE

6. Enzymes.—Numerous kinds of chemical transformations are constantly occurring in physiologically active plant cells. Many of these chemical reactions can be accomplished artificially, if at all, only by subjecting the reactants to drastic conditions such as high temperatures or extreme degrees of acidity or alkalinity. Yet these reactions occur efficiently and rapidly at ordinary temperatures in a protoplasmic medium which is neither strongly acid nor strongly alkaline. This is possible because of the accelerating effect of certain organic catalysts called enzymes, which are synthetic products of the protoplasm.

Two principal groups of enzymes occur in plants. Hydrolytic enzymes catalyze certain hydrolytic decomposition reactions such as digestive processes and also condensation reactions in certain synthetic processes. Desmolyzing enzymes catalyze various kinds of reactions such as those that involve breaking the bonds between carbon atoms, adding or removing atoms or atomic groups, and shifting atoms or groups of atoms from one part of a molecule to another. The enzymes participating in the various chemical steps of respiration are of the desmolyzing type (*see* below, *Respiration*). A very small amount of an enzyme can catalyze the transformation of an enormous quantity of substrate. The enzyme sucrase, for example, can catalyze the hydrolysis of 1,000,000 times its own weight of sucrose into glucose and fructose and still retain its catalytic properties.

Many enzymes catalyze the same reaction in both directions, but this is not true of all of them. Most enzymes are thermolabile and in a liquid medium are chemically destroyed at temperatures between 140° and 158° F. Some enzymes appear to consist solely of protein molecules; others of protein molecules to which some nonprotein (prosthetic) group is attached. The prosthetic groups of some enzymes appear to exist in the protoplasm apart from the protein fraction, in which case they are called coenzymes. Some coenzymes are related chemically to the vitamins. *See* also ENZYMES.

B. Transpiration

In spite of the indispensability of water for their growth and metabolism, most kinds of land plants—excepting only certain species native to arid habitats—are extremely inefficient in their utilization of water. An overwhelmingly large proportion of the water absorbed from the soil is not retained within the plant or used in metabolic processes but escapes in the process of transpiration, essentially a modified kind of evaporation. Although loss of water vapour, at least in limited amounts, can occur from any part of the plant exposed to the atmosphere, in general most transpiration occurs from the leaves. Leaf transpiration is of two types: (1) stomatal transpiration, in which water vapour loss occurs through the stomates; and (2) cuticular transpiration, in which evaporation of water takes place directly from the surface of epidermal cells through the cuticular layer which, although relatively impervious to water, does permit the passage of limited quantities. In most species stomatal transpiration accounts for 90% or more of the water vapour loss from leaves. Through the investigations of Stephen Hales, in 1727, transpiration was the

first major plant process studied from essentially a modern experimental viewpoint.

1. Physiology of Stomates.—The stomates are minute, elliptical pores which occur in the epidermis of plants, being most abundant in leaves. Every stomate is surrounded by two distinctive epidermal cells called guard cells. Open stomates are the principal pathways through which gaseous exchanges occur between a leaf and the atmosphere.

The principal gases which diffuse into or out of a leaf through the stomates are water vapour, carbon dioxide and oxygen. When the stomates are closed all gaseous exchanges between a leaf and its environment are greatly retarded. The size of a fully open stomate varies greatly according to species. Among the largest known stomates are those of *Zebrina pendula* whose axial dimensions average $31 \times 12\mu$ ($1\mu = \frac{1}{25,000}$ in.). The number of stomates may range from a few thousand per square centimetre of leaf surface in some species to over a hundred thousand per square centimetre in others. In many kinds of plants stomates occur in both the upper and lower epidermis, usually being more abundant in the lower. In numerous other species, especially trees and shrubs, they are present only in the lower epidermis. In aquatic plants with floating leaves stomates occur only in the upper epidermis.

The total combined area of the fully open stomates is only 1%–3% of the total leaf area. Despite this fact, rates of stomatal transpiration are often 50%, and sometimes more, of the evaporation from a free water surface under comparable conditions. Much more important is the fact that the rate of diffusion of carbon dioxide, essential in photosynthesis (*see* below), into the leaf through the stomates is much greater than through an equivalent portion of the area of a fully exposed carbon dioxide absorbing surface. H. T. Brown and F. Escombe in 1900 showed that the high diffusive capacity of stomates in proportion to their area is in accord with the principles of the diffusion of gases through multiperforate septa. Diffusion rates through small openings vary as the perimeter, not the area; therefore, the smaller the aperture the greater its diffusive capacity relative to its area. As a result a gas may diffuse nearly as rapidly through a septum pierced with a number of small apertures, whose combined area represents only a small proportion of the septum area, as through an open surface equal in area to the septum. Since diffusion of gases through stomates is proportional to the perimeter of the pore, diffusion rates through a partially open stomate are almost as great as when the stomate is fully open.

Increase in the turgidity of the guard cells results in opening of the stomates; decrease in their turgidity results in their closure. In general stomates are open in the daytime and closed at night, although there are many exceptions. The mechanism whereby stomates open in the light and close in its absence seems to be principally an osmotic one. Upon illumination the hydrogen ion concentration of the guard cells decreases. This favours the conversion of insoluble starch in the guard cells into soluble glucose-1-phosphate by the enzyme phosphorylase. The resulting increase in the osmotic pressure of the guard cells causes an increase in their diffusion pressure deficit. Osmotic movement of water from adjacent epidermal cells, in which there is no appreciable daily variation in osmotic pressure, takes place in the guard cells. A thicker ridge of cell wall occurs on the stomate side of the guard cells, and as the turgor of the guard cells increases the cells "buckle" and part, thus opening the stomate. With the advent of darkness or even of a markedly reduced light intensity, the reverse train of processes is induced in the guard cells, leading to stomatal closure. Since light of low intensity is relatively less effective in inducing stomatal opening, stomates usually do not open as wide on cloudy as on clear days and often do not remain open for as much of the daylight period. Deficiency of water within the plant induces partial to complete closure of the stomates. During periods of drought stomates therefore remain closed much or all of the time regardless of the light intensity to which the plant is exposed. Stomatal opening does not occur in most species at temperatures approaching 32° F. Therefore in cold or even cool weather stomates may remain closed even when other environmental conditions favour their opening. Nocturnal opening occurs at times in some species, but the conditions resulting in such stomatal behaviour have not been adequately investigated.

Dynamics of Stomatal Transpiration.—In most kinds of plants the cells of the mesophyll do not fit together tightly and the intercellular spaces between them are occupied by air. A labyrinth of these air-filled spaces is thus present in a leaf, bounded by the water-saturated cell walls of the mesophyll. Evaporation of water takes place from the wet cell walls into the intercellular spaces. If the stomates are closed the only effect of this evaporation is the saturation of the intercellular spaces with water vapour. When the stomates are open, however, diffusion of water vapour may occur through them into the outside atmosphere. Such diffusion always takes place unless the atmosphere has a vapour pressure equal to or greater than that within the intercellular spaces, an uncommon condition during the daylight hours of clear days. The physical processes of evaporation of water from wet mesophyll cell walls and its subsequent diffusion from the intercellular spaces through the stomates into the atmosphere are, therefore, the two main steps in stomatal transpiration.

2. Environmental Influences on Transpiration.—Because of its usually controlling influence on the opening and closing of stomates, light is a factor of prime importance in influencing the rate of transpiration. Stomatal transpiration is largely restricted to the daylight hours; hence daytime transpiration is usually many times greater than nighttime transpiration, which is largely or entirely cuticular. Light also has a secondary effect on transpiration through its influence on leaf temperatures, since leaves in direct sunlight usually have temperatures one to several degrees higher than that of the surrounding atmosphere.

The rate of diffusion of water vapour through open stomates depends upon the steepness of the vapour pressure gradient between the intercellular spaces and the atmosphere. Assuming open stomates, therefore, the greater the atmospheric humidity (vapour pressure) for any given vapour pressure just below the stomatal pores in the intercellular spaces, the less the rate of transpiration. Temperature affects the rate of transpiration principally because of its differential effect upon the vapour pressures in the intercellular spaces and the atmosphere.

Although leaf temperatures do not follow atmospheric temperatures exactly, in general, increase of atmospheric temperature results in a rise of leaf temperature. Assuming a warm, clear day and an adequate soil water supply, increase in temperature results in an increase in the vapour pressure in the intercellular

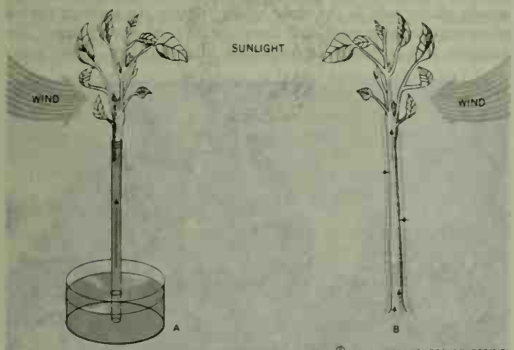


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FIG. 14.—THE TRANSPIRATION-COHESION-TENSION THEORY OF WATER RISE

(A) Under conditions of rapid transpiration a twig can be shown to cause the rise of water over considerable heights, greater than those attributable to atmospheric pressure alone. If properly free of gas, the column of water will rise as a unit, due to cohesion of water molecules to each other. (B) Where water loss exceeds water absorption, the conducting tubes are under tension, and shrink

spaces. Such a rise in vapour pressure occurs because the vapour pressure necessary to saturate air increases with rise in temperature, and the extensive evaporating surfaces of the cell walls bounding the intercellular spaces make it possible for the intercellular spaces to be maintained in an approximately saturated condition most of the time. Rise in temperature ordinarily has little or no effect on the vapour pressure of the atmosphere. Consequently the vapour pressure gradient through the stomates is steepened and the rate of outward diffusion of water vapour increases.

Transpiration rates on windy days are usually greater than on otherwise comparable but quiet days. A gentle breeze is relatively more effective in increasing the transpiration rate than winds of greater velocity. In very quiet air local regions of relatively high humidity may build up in the vicinity of transpiring leaf surfaces. Such localized zones of relatively high vapour pressure retard transpiration unless the air movement is adequate to prevent such an accumulation of water vapour molecules. The bending, twisting and fluttering of leaf blades, and the swaying of branches in a wind also contribute to increasing the transpiration rate.

Soil water conditions also influence the rate of transpiration. Whenever soil conditions are such that the rate of absorption of water is retarded, a corresponding diminution in transpiration rate soon follows.

3. Significance of Transpiration.—Transpiration rates of temperate zone plants may range up to values of about 5 g. per square decimeter (about 15½ sq.in.) of leaf area per hour. Considerable interest also attaches to the quantities of water transpired per acre of crops, grassland or forest. An acre of corn, for example, transpires water equivalent to 15 acre-inches in a growing season. Tremendous variations occur in such values from season to season, however, depending upon climatic conditions. The quantities of water vapour transpired by vegetation-covered areas of the earth's surface are often of sufficient magnitude to have important effects on meteorological conditions.

Much fruitless discussion has raged over the question of whether transpiration is detrimental or beneficial to plants. The extreme viewpoints are (1) that the process is an unavoidable evil; and (2) that it is a physiological necessity. Some of the incidental effects of transpiration are advantageous to the plant, but none is indispensable for its survival or even for its normal physiological operation. Likewise, some of the incidental effects of transpiration are detrimental to the plant, but plants have transpired and survived for untold centuries.

Transpiration is a necessary consequence of the relation of water to plant structure. Terrestrial green plants cannot survive unless they obtain carbon dioxide from the atmosphere. Whatever course the evolution of green plants might follow, their structure must always remain such that carbon dioxide can reach interior cells of the leaf. The principal carbon dioxide absorbing surfaces of terrestrial vascular plants are the moist mesophyll cell walls bounding the intercellular spaces of the leaves. Ingress of carbon dioxide to these spaces occurs almost entirely through open stomates.

When the stomates are open, outward diffusion of water vapour is unavoidable, and this process of stomatal transpiration accounts for most of the loss of water by plants. Transpiration is, therefore, in itself an incidental phenomenon. Despite this fact it often has marked indirect effects on other physiological processes occurring in the plant, especially photosynthesis and growth, because of its influence on the internal water relations of the plant.

4. Guttation.—The exudation of drops of water at the tips or margins of the leaves of many species of herbaceous plants can often be observed, especially in the early morning on a spring day. This phenomenon, called guttation, also occurs in some woody plants. The exuded water is not pure but contains traces of sugars and other solutes. Guttation occurs from special glands called hydathodes, which resemble enlarged stomates. In most species water loss by guttation is negligible compared with water loss by transpiration.

C. Translocation of Water

In land plants the water absorbed from the soil moves to all living parts of the plant. The most striking examples of upward translocation of water occur in trees. One of the tallest known living trees is a specimen of coast redwood (*Sequoia sempervirens*) which has attained a height of 364 ft. In this tree water ascends to an elevation of nearly 400 ft., since the roots extend for at least several feet into the soil. Many other individual trees of this species and of several others exceed 300 ft. in height. The mechanism of the ascent of sap in plants, and especially in tall trees, has long been one of the classical problems of plant physiology.

1. Mechanics of Water Movement.—The upward movement of water in plants occurs in the xylem, which in the stems of trees and shrubs is identical with the wood. In the trunks and larger branches of a tree, however, sap movement is restricted to a few of the outermost annual layers of wood. For this reason hollow trees, in which most of the central core of heartwood has disintegrated, can remain alive indefinitely. The xylem of any plant constitutes a unit system which extends from just back of every root tip through all the intervening root and stem branches to the mesophyll of the leaves. In angiosperms most translocation of water occurs through vessels, which are elongated tubelike structures in which cross walls are of relatively infrequent occurrence. In gymnosperms movement of water occurs solely through spindle-shaped cells called tracheids, which may be as much as five millimetres in length. Small, often rounded, thin areas occur in the walls of vessels and tracheids which are contiguous with other vessels or cells; these pits are structurally of several types but all of them appear to facilitate passage of water from one xylem element to adjacent ones.

Root Pressure.—If the stem of an herbaceous plant is cut off, a slow exudation of sap often occurs from the xylem tissues at the cut surface of the stump. A similar phenomenon occurs in many woody plants, such as the maple, birch, currant and grape, especially in the spring. A vigorous grapevine often loses a quart or more of sap per day after spring pruning. The exudation of sap results from a pressure originating in the roots, called root pressure. There are several reasons, however, why root pressure cannot be the principal mechanism operating in the upward transport of water in plants: (1) there are many species in which this phenomenon—the exudation of sap—does not occur; (2) the magnitude of measured root pressures seldom exceeds 2 atm. (about 30 lb. per square inch), which could not motivate a rise of water for more than about 60 ft.; (3) known rates of flow under the influence of root pressure are inadequate to compensate for known rates of transpiration; (4) root pressures are usually present in woody plants only in the early spring; during the summer period when transpiration rates, and therefore rates of sap transport, are greatest, root pressures are negligible or nonexistent. Root pres-

J. ARTHUR HERRICK

FIG. 15.—GUTTATION OF STRAWBERRY LEAVES

sure does account for some upward movement of water in certain species of plants at some seasons, but it represents only a secondary mechanism of water transport.

Ascent of Sap.—Molecules of water, although ceaselessly in motion, are also strongly attracted to each other. This property of a liquid is called cohesion. The cohesion of water is the cornerstone of an important theory of the ascent of sap in plants. The postulated mechanism is relatively simple. Evaporation of water from the walls of the mesophyll cells of leaves results in an increase in the diffusion pressure deficit of the mesophyll cells. Resulting intercellular movements of water cause an increase in the diffusion pressure deficit even of those mesophyll cells not directly exposed to the intercellular spaces. The increased diffusion pressure deficit of the cells abutting directly upon xylem elements in the veinlets of the leaf induces movement of water from the vessels or tracheids into the adjacent cells. Whenever transpiration is occurring at appreciable rates, water does not enter the lower ends of the xylem conduits in the roots as rapidly as it passes out of the xylem vessels or tracheids into mesophyll cells at the upper end of the water-conductive system, consequently the water in the xylem ducts is stretched into taut threads; *i.e.*, passes into a state of tension. Each column of water behaves like a tiny steel wire which is stretched. Because of their saturated condition, cross walls in the xylem do not interfere with the continuity of the water. The tension is propagated along the entire length of the water columns to their terminations just back of the root tips, causing entry of water from adjacent root cells (*see* below, *Absorption of Water*). The tension can be sustained by the water threads because of the cohesion between the water molecules, operating in conjunction with adhesion of the boundary layers of water molecules to the walls of the xylem ducts. The existence of water under tension in vessels and tracheids has been confirmed by direct microscopic observation and in other ways. Conservative calculations indicate that a cohesion of 30 to 50 atm. would be adequate to allow conduction of water to the topmost leaf of the tallest known tree. However, under conditions of internal water deficiency, tensions considerably in excess of 50 atm. probably prevail in the water columns of many plants. Actual measurements of the cohesion of water in physical systems indicate with a high degree of probability that tensions of this magnitude can develop in the water columns of plants.

2. Absorption of Water.—*Soil Water Conditions.*—Since soil particles never fit together tightly, there is a certain amount of space between them. This pore space varies from about 30% of the soil volume in sandy soils to about 50% in clay soils. The pore space may be occupied entirely by air, as in dried soils, or entirely by water, as in saturated soils, but is commonly occupied partly by air and partly by water. In a soil in which the water table lies relatively close to the surface, considerable quantities of water may rise into its upper layers and become available to plants. In many soils, especially in arid regions, there is no water table, and in many others, even in humid regions, the water table is continuously or intermittently too far below the soil surface to be an appreciable source of water for most plants. In such soils the only water available to plants comes through natural precipitation or artificial irrigation.

If rain falls on a dry, homogeneous soil the water will become rapidly distributed to a depth which will depend on the amount of water which falls per unit area and the type of soil. After several days, further deepening of the moist blanket of soil extending down from the ground surface will virtually cease because downward capillary movement of water has become extremely slow or negligible. The boundary between the moist layer of soil and the drier zone underneath will be quite sharp. At this equilibrium condition the water content of the moist soil layer is essentially uniform throughout. The water content of a soil in this condition is termed the field capacity. A soil at its field capacity, although relatively moist, is also well aerated; hence soil water contents in the vicinity of the field capacity are the most favourable for the development of most kinds of plants.

A considerable proportion of the water in any soil is unavailable to plants. The permanent wilting percentage, an index of the soil water unavailable in growth, is measured by allowing a plant to develop with its roots in soil enclosed in a waterproof pot until the plant passes into a state of permanent wilting. The water content of the soil at this point is its permanent wilting percentage. The range of permanent wilting percentages is from less than 5% in very sandy soils to about 20% in clay loams. Therefore, sandy soil gives up a greater portion of its moisture; only about 5% of its total moisture content is unavailable to plants. The permanent wilting percentage of a given soil is about the same, regardless of the kind of test plant used.

The diffusion pressure deficit of the water in soils varies with the soil water content. In most soils it is virtually zero at saturation, less than 1 atm. at the field capacity, and about 15 atm. at the permanent wilting percentage. As the water content of a soil drops below its permanent wilting percentage, its diffusion pressure deficit increases at an accelerating rate, soon attaining a value of hundreds of atmospheres; it is for this reason that the permanent wilting percentage is an index of the soil water which is unavailable in plant growth.

Relation of Root Growth to Water Absorption.—The successively smaller branches of the root system of a plant ultimately terminate in the root tips, of which there may be thousands or millions on a single plant. The term root tip refers to the region extending back from the actual termination of the root for a distance of several to many centimetres. The terminal zone of a root tip is the dome-shaped root cap, just back of which are the regions of cell division and elongation (*see* below, *Growth*). Just back of these regions, in most species, is the root hair zone. Each root hair is a projection from an epidermal cell of which it remains an integral part. A single root tip may bear thousands of root hairs, each of which may be from a few millimetres to a centimetre or more in length. A root hair is generally a short-lived structure, but new ones are constantly developing as the root advances through the soil.

Most absorption of water occurs at the root tips, especially in the root hair zone, since the older portions of roots become covered with cutinized or suberized layers which are virtually impermeable to water. Whenever the diffusion pressure deficit of root hairs and other peripheral cells of the root tip exceeds that of the soil water, movement of water into the root cells occurs. If the soil is above the field capacity, water may move from more remote portions of the soil by capillarity toward the region of absorption; the supply of water to root tips is largely or entirely maintained in this way. Elongation of the root tips, although slower in most species in relatively wet soils, also helps maintain their contact with untapped portions of the soil water. Many plants grow for a great part of the time in soils with a water content between the field capacity and the permanent wilting percentage. In this range of soil water contents, capillary movement of water is too slow to maintain an adequate supply of water to rapidly absorbing root tips, and after most of the water on the soil particles in contact with a root tip is absorbed, it cannot be replaced in significant quantities. In such soils it is the continued elongation of the root tips which maintains their contact with available soil water. The numerous root tips may be pictured as slowly progressing through the soil, absorbing water from the particles with which they come in contact. The aggregate increase in length of the root system of a rye plant averages 3.1 mi. per day. Calculations show that daily root growth of this plant would permit sufficient absorption of water from soils at the field capacity to compensate for daily transpirational water loss.

Mechanism of Water Absorption.—The tension generated in the water columns of a plant as an indirect result of transpiration is propagated to the terminations of the xylem ducts in the root tips. As soon as the tension in the water columns exceeds the diffusion pressure deficit of adjacent cells in the root tip, water passes from those cells into the xylem. This engenders further cell to cell movement of water in a lateral direction across the root tip with the presumable result that a gradient of diffusion pressure deficits, consistently increasing from the epidermal cells to the root xylem, is established. As soon as the diffusion pres-

sure deficit of the peripheral cells of the root exceeds that of the soil water, entrance of water from the soil begins. Essentially, the long chain of water molecules is "drawn" upward by transpiration in the leaves, and water from the soil is "taken in" through the root hairs.

The process just described accounts for most of the absorption of water by plants. The phenomenon of root pressure, previously described, involves an absorption mechanism which is localized in the roots. Absorption of this type occurs only when transpiration is low and the soil is relatively moist. Although xylem sap is relatively dilute, its osmotic pressure is often greater than the diffusion pressure deficit of the soil water. This leads to the establishment of a gradient of diffusion pressure deficits across the cortex and other tissues of the root tip along which water moves from the soil to the xylem.

Environmental Factors Influencing Water Absorption.—Because of their reciprocal relation any factor which influences the rate of transpiration influences the rate of absorption; the converse is also true. In addition the rate of absorption is also influenced by certain soil conditions. Within limits the greater the available soil water supply the greater the possible rate of absorption. Extremely high soil water contents decrease absorption rates in many species because of deficient soil aeration. Low soil temperatures retard the rate of absorption of water by many species. The rate of water absorption by sunflower plants, for example, is rapidly reduced as the soil temperature drops below 55° F. Deficient aeration, characteristic of wet soils, retards water absorption in many species. In such soils the oxygen concentration is lower and the carbon dioxide concentration is higher than in the atmosphere. This retarding effect on water absorption is correlated with a retardation in the rate of root respiration. The presence of solutes in appreciable concentrations in the soil solution also retards or checks water absorption by roots. In most soils the solute concentration is too low to have any appreciable effect on water absorption, but in saline or alkaline soils the influence of this factor may be so pronounced that only a few species of plants are able to survive.

Relative Rates of Water Absorption and Transpiration.—On a clear, warm day, when transpiration rates are high, the rate of water absorption usually lags behind the rate of transpiration, largely because of the resistance of the root cells to the passage of water. As a result there is a gradual increase in the tension in the water columns and a gradual diminution in the water content of the plant, especially of the leaves, during the day. This leads to the partial loss of turgor pressure by the leaf cells, a condition called incipient wilting. Sometimes, especially on clear, hot summer afternoons, the decrease in water content of the leaves is sufficient to induce visible wilting. If the soil water supply is adequate, absorption of water during the night exceeds nocturnal transpiration loss, and the leaf cells gradually regain their turgor. Visible wilting caused by a temporary excess of transpiration over absorption is called temporary wilting, which is distinguished from permanent wilting, caused by a soil water deficiency. Plants automatically recover from temporary wilting during the night, but will not recover from permanent wilting unless the soil water supply is replenished.

D. Metabolism

1. Carbohydrate Metabolism.—The dry matter content of a plant tissue can be determined by drying it at 212° F. The dry residue remaining after the evaporation of water can be further separated into two fractions by incinerating it at about 1,100° F. The bulk of the dry matter, representing combustible organic constituents, disappears, leaving only a small mineral residue called the ash, which is derived from mineral salts absorbed from the soil.

An adequate explanation of the origin of the bulk of the dry matter of plants long eluded students of plant life. As a result of the investigations of Joseph Priestley, Jean Senebier, Jan Ingenhousz, N. T. de Saussure and others in the late 18th and early 19th centuries, the gaseous exchanges between green plants and the atmosphere were first clearly envisaged. Green parts of plants, exposed to light, were found to utilize carbon dioxide and release oxygen. Nongreen parts, whether in light or dark, and green parts in the dark were found, like animals, to release carbon dioxide and consume oxygen. These gaseous exchanges are the external manifestations of the processes now known as photosynthesis and respiration, respectively. Photosynthesis occurs only in green plant organs exposed to light. Respiration occurs in all living plant tissues, green or nongreen, in light or dark. The fact that green plants usually lose oxygen and use carbon dioxide in the light does not mean that no respiration occurs in such organs in the light, but merely that the rate of photosynthesis exceeds the rate of respiration. Although De Saussure in 1804 recognized that utilization of carbon dioxide by plants contributed to their increase in dry weight, it was not until Julius von Sachs, in 1862, discovered the appearance of starch in the chloroplasts of leaf cells as an accompaniment of the consumption of carbon dioxide that the relation of the gaseous exchanges of plants to their carbohydrate metabolism began to be adequately realized.

2. Photosynthesis.—In the process of photosynthesis certain carbohydrates are synthesized from carbon dioxide and water in the chloroplasts of living plant cells, oxygen also being a product, and light the source of energy. The summary chemical equation for the process is:

$$6CO_2 + 6H_2O + 673 \text{ kg.cal. of radiant energy} \longrightarrow C_6H_{12}O_6 + 6O_2$$

A hexose sugar is conventionally considered to be the basic carbohydrate product of photosynthesis, although in actuality the situation is much more complex. Most of the carbon dioxide used diffuses into the leaf through the stomates and dissolves in wet cell walls bordering the intercellular spaces, from where it diffuses in solution to the chloroplasts. In most species less than 1% of the water absorbed is used in photosynthesis. Most of the oxygen liberated passes out of solution into the intercellular spaces, from where it diffuses through the stomates into the atmosphere. For details of the synthesis of carbohydrates *see* Photosynthesis.

Plant Pigments.—In the higher plants photosynthesis occurs only in the chloroplasts, which are green ellipsoidal bodies about 5 μ in diameter. A single mesophyll cell may contain hundreds of chloroplasts. The green colour of chloroplasts and of leaves is because of the presence in the plastids of chlorophyll, of which there are two kinds: chlorophyll *a* ($C_{55}H_{72}O_5N_4Mg$) and chlorophyll *b* ($C_{55}H_{70}O_6N_4Mg$). Most leaves contain from two to three times as much chlorophyll *a* as chlorophyll *b*. Both chlorophylls have been extracted in pure form from the leaves of over 200 species. The structural formulas of the chlorophylls were determined in 1936 by H. Fischer and S. Breitner. In the angiosperms chlorophyll is, with rare exceptions, synthesized only in the light; in plants of all other groups it can be made either in light or dark. Among the substances which must be present in the cells for normal chlorophyll synthesis are oxygen, carbohydrates, nitrogen, magnesium, iron and water.

The role of chlorophyll seems to be a twofold one: it absorbs light of certain wave lengths, principally in the blue-violet and short red regions of the spectrum, which is used as a source of energy in photosynthesis, and it is a transitory participant in some step of the reaction, presumably acting as a catalyst (*see* also Chlorophyll, Chemistry of).

The chloroplasts also contain the yellow pigments carotene ($C_{40}H_{56}$) and xanthophylls (mostly $C_{40}H_{56}O_2$). The leaves of any angiosperm which have developed in the dark are yellow as a result of the presence of these pigments. Carotene is the precursor of vitamin A, one molecule of carotene being split into two molecules of vitamin A by a simple hydrolysis reaction. Carotene, the xanthophylls and certain other chemically related red and yellow pigments are collectively called the carotinoids. In some plant organs, such as carrot roots, carotinoid pigments occur in the amorphous or crystalline state. The cell sap anthocyanins constitute the other principal group of plant pigments; they are responsible for most of the red, blue and purple colorations of flowers, fruits and other plant parts. Both the carotinoids

and anthocyanins play a prominent part in the autumnal coloration of leaves (*see* ANTHOCYANINS AND ANTHOXANTHINS; PLANT COLORATION).

Factors Influencing the Rate of Photosynthesis.—F. F. Blackman's (1905) "principle of limiting factors" has assisted materially in the interpretation of the effects of various factors on the rate of photosynthesis. This principle was stated by its author as follows: "When a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the 'slowest' factor." This principle, which also holds for other physiological processes, does not admit of too rigorous an application, but in general the concept is valid that the rate of a physiological process is largely controlled by the factor present in relative minimum, the so-called "limiting factor."

Carbon dioxide constitutes only 0.03% by volume of the atmosphere, marked deviations from this value seldom occurring. In the air stratum just above the surface of rich forest or agricultural soils, however, concentrations several times the usual one sometimes occur, as a result of the upward diffusion of carbon dioxide released in the respiration of soil organisms. With increase in the carbon dioxide concentration of the atmosphere, the rate of photosynthesis increases until some other factor becomes limiting. If the natural concentration of carbon dioxide in the atmosphere were higher than 0.03%, most plants, much of the time, would photosynthesize at a more rapid rate than they do. Very high concentrations of carbon dioxide (15% or more), however, cause a retardation in photosynthesis.

Photosynthesis can occur in visible light from any source, provided its intensity is sufficiently great. The minimum light intensity at which sufficient photosynthesis occurs during an average day's length to be in excess of the consumption of carbohydrates in respiration during 24 hours—no plant can long survive at intensities less than this—differs according to species. In tree seedlings this minimum light intensity ranges from about 1% of full sunlight intensity in some shade species to about 5% in some sun species; in larger plants the minima are probably greater. For measurements made on a leaf or group of leaves, all of which are well exposed to light, the rate of photosynthesis rises with increase in light intensity until some other factor becomes limiting. At the atmospheric concentration of carbon dioxide, maximum rates of photosynthesis in single leaves are attained in many species at one-fourth to one-third of full sunlight intensity, and in some shade species at still lower values. Very high light intensities cause a retardation in photosynthesis, a phenomenon termed solarization.

The rate of photosynthesis for an entire tree, or for a plot of vegetation, increases consistently with increase in light up to the maximum sunlight intensity, which at noon on a clear summer's day in mid-temperate latitudes approximates 1.3 g.cal. per square centimeter per minute (equivalent to about 9,000 foot-candles). Even in full sunlight many interior leaves of an apple tree, for example, cannot photosynthesize at their maximum capacities because they are shaded by peripheral leaves. The lower the light intensity, the greater the proportion of the leaves of which this will be true. Hence the greater the intensity of the light, the greater the average photosynthesis per unit of leaf area and the greater the total photosynthesis per tree up to the limits of sunlight intensity. All wave lengths of light are not equally effective in photosynthesis. For equal intensities of light incident on the leaf, maximum photosynthesis occurs in the orange—short red region, with a secondary maximum in the blue. Rates in the green and yellow regions are lower, but still very appreciable.

The daily rate of photosynthesis is also influenced by the daily duration of the light period (photoperiod). One reason certain crops can develop to maturity during the short growing seasons of high latitudes is that more sugar can be synthesized during the long photoperiods than during the shorter photoperiods of lower latitudes (*see* below, *Photoperiodism*).

Photosynthesis occurs over a wide range of temperatures, but in temperate zone plants this process takes place at relatively rapid rates in the temperature range 50°–95° F. Increase in temperature, in general, results in an increase in the rate of photosynthesis, if no other factors are limiting the process. In nature, however, the effect of an increase in temperature on the rate of photosynthesis is often not fully realized because of the limiting effect of some other factor. Very commonly the factor which prevents a temperature rise from being fully effective in increasing the rate of photosynthesis is the carbon dioxide concentration of the atmosphere, but low light intensity and low water supply also often act as limiting factors.

Reduction in the water content of a plant causes a retardation in the rate of photosynthesis. This effect is not primarily a result of a deficiency of water as a raw material used in photosynthesis, but of certain indirect effects such as a reduction in the diffusive capacity of the stomates, and a decrease in the hydration of the protoplasm. In young apple trees marked diminution in the rate of photosynthesis occurs long before wilting is apparent, although even in wilted leaves some photosynthesis continues. When water is applied to the soil, wilted apple leaves recover their turgidity in a few hours, but the original rate of photosynthesis is not regained for several days (G. W. Schneider and N. F. Childers, 1941).

Conditions within the plant also affect the rate of photosynthesis. Among the internal factors which may influence photosynthesis are peculiarities of leaf anatomy, chlorophyll content of the cells, hydration of protoplasm, other "protoplasmic factors," and the accumulation of carbohydrates within the cells.

Mechanism of Photosynthesis.—From the standpoint of fundamental chemistry photosynthesis is, in essence, an oxidation-reduction reaction between carbon dioxide and water. The carbon dioxide is reduced and the water is oxidized, largely as a result of the transfer of hydrogen atoms from water to carbon dioxide. Because the energy content of the products (carbohydrates and oxygen) is greater than that of the reactants (carbon dioxide and water), energy must be supplied from an outside source. In actuality the energy source is light, and the process is thus a photochemical one. As is true of many metabolic processes, photosynthesis is a complex process, embracing numerous sub-reactions, and is by no means entirely understood. Three major sub-reactions which are generally recognized are: (1) photolysis (splitting by light) of water; (2) photosynthetic phosphorylation; and (3) carbon dioxide fixation. All three of these reactions occur in the chloroplasts (D. I. Arnon, 1958).

Substantial evidence exists that the light energy is used in splitting the water molecules and that chlorophylls play a role in this stage of photosynthesis. R. Hill (1937) showed that illumination of a suspension of chloroplasts in water in the presence of certain hydrogen acceptors results in the evolution of oxygen. This phenomenon, now generally called the Hill reaction, can be represented chemically as follows, *A* representing a hydrogen acceptor:

$$2H_2O + 2A \xrightarrow[\text{chloroplasts}]{\text{light}} 2AH_2 + O_2$$

The Hill reaction has also been shown to occur in suspensions of grana from disintegrated chloroplasts, as well as in suspensions of intact chloroplasts. It has been shown experimentally that the oxygen released in this reaction comes from the water molecules. The Hill reaction appears to represent, in essence, the photolysis of water stage of photosynthesis.

Photosynthetic phosphorylation is a process in which adenosine diphosphate is converted into adenosine triphosphate in the chloroplasts. This compound and triphosphopyridine nucleotide, which is reduced simultaneously with the synthesis of adenosine triphosphate, provide the necessary "assimilatory power" used in the final step in photosynthesis, which is the fixation of carbon dioxide. M. Calvin and A. A. Benson (1949) and others consider that the compound phosphoglyceric acid is a key intermediate compound in the fixation of carbon dioxide stage of photosynthesis. (*See* PHOTOSYNTHESIS.)

Biological Significance of Photosynthesis.—World-wide cessation of photosynthesis would soon result in the disappearance of all plants and animals, including man, with the negligible exception

of a few species of autotrophic bacteria, because this process provides both the energy and organic substance capital of the biological world. Directly or indirectly, all plants and animals, with the minor exception just noted, obtain from green plants oxidizable carbon compounds ("food"), which alone can be used as a source of energy (*see* below, *Respiration*) by living organisms in growth, movement and the accomplishment of metabolic processes. All such oxidizable carbon compounds are the direct or derivative products of photosynthesis. Carbohydrates, fats and proteins all are synthesized by chains of chemical transformation from the hexose sugars produced in photosynthesis, and retain within their molecules chemical energy primarily incorporated in hexose molecules by the transformation of radiant energy from the sun. In some food chains carnivorous animals prey upon smaller or weaker carnivorous animals, which in turn prey upon smaller or weaker animals, but ultimately all such chains always lead to animals which obtain their food from green plants. Photosynthesis not only supplies the energy upon which living organisms operate, but all of the organic substance out of which bodies of plants and animals are constructed consists of the direct or derivative products of photosynthesis.

Magnitude and Efficiency of Photosynthesis.—Under favourable conditions rates of photosynthesis often approximate 10–15 mg. of hexose per square decimeter of leaf surface per hour. Corn plants yielding 100 bu. to the acre synthesize about 8,700 kg. (nearly 10 tons) of sugar in a growing season. This represents the transformation of about 33,000,000 kg.cal. of radiant energy into chemical energy. Nearly one-fourth of this is oxidized in respiration and most of the rest has been transformed into starch, cellulose and other compounds before the plants are mature. The world production of sugar by land plants has been estimated by H. Schroeder (1919) at 4×10^{13} kg. annually which represents the transformation of 1.6×10^{17} kg.cal. of radiant energy into chemical energy.

Despite the utter dependence of the entire organic world upon photosynthesis, only a relatively small percentage of the light incident on plants is used in the process. Of the radiant energy falling on the acre of corn mentioned above only 1.6% is utilized in photosynthesis. Under certain conditions, particularly when the light intensity is low, the efficiency of the process in utilizing incident light may be as high as 5%, but rarely, if ever, is greater than that under natural conditions. From a theoretical standpoint the quantum yield of photosynthesis is of considerable significance, but this question has not been settled with finality. Results of various investigators are not in agreement on the magnitude of this quantity, values ranging from 0.1 to 0.25 molecule of carbon dioxide reduced per quantum of light absorbed having been recorded.

Synthesis of Other Carbohydrates.—Sucrose is universally present in plants, and is the most abundant of plant sugars. In some plant tissues (sugar cane, sugar beet) it may constitute as much as 20% of the fresh weight, but its concentration is usually lower. Upon hydrolysis sucrose yields an equal number of glucose and fructose molecules, both hexose sugars. In rapidly photosynthesizing leaves the sucrose content usually increases during the daytime; during the night hours the concentration decreases because of its continued translocation out of leaves to other parts of the plant.

Starch is a complex, insoluble carbohydrate which is synthesized in many, but not all, species of plants. In green leaves starch synthesis occurs in the chloroplasts and apparently is initiated whenever the concentration of hexoses exceeds a certain critical value. Starch is a long chainlike carbohydrate molecule composed of hundreds of α D-glucose residues. It is synthesized in plant cells from glucose-1-phosphate by a specific enzyme. Considerable quantities of starch accumulate in green leaves during the occurrence of photosynthesis, but most of it is converted into soluble carbohydrates and translocated out of the leaves at night. Starch is also synthesized in many other organs of plants, as for example in potato tubers, from soluble carbohydrates translocated from the leaves. In the nongreen organs of plants, starch synthesis occurs in the colorless leucoplasts. Starch usually occurs in plant cells as microscopically visible starch grains.

Cellulose, the importance of which as a cell wall constituent has already been mentioned, is also synthesized from glucose. Cellulose molecules are long chainlike molecules built up from hundreds of β D-glucose molecules. Cellulose is the most abundant organic compound present on the earth. Among the other more important carbohydrates synthesized in plants are pentosans, dextrins, inulin, hemicelluloses, pectic compounds, gums, mucilages, glycosides and tannins.

3. Fat Metabolism.—Fats and fatlike substances, collectively called lipids, are universal constituents of plant cells. All lipids contain the elements carbon, hydrogen and oxygen; some of the more complex ones, the phosphatides, also contain phosphorus and nitrogen. Phosphatides and perhaps other lipids are essential ingredients of the protoplasm. Fats (called oils in the liquid state) accumulate in various organs of plants, especially in seeds and fruits, in which they constitute a reserve supply of food. Upon germination of fatty seeds the oils are digested and used in the processes of respiration and assimilation. Many vegetable oils are important items of commerce; among these are castor bean, rape, sunflower, linseed, peanut, corn, cotton, coconut, palm and olive oils. Lipids apparently can be synthesized in any living plant cell.

Only the synthesis of the fats is well enough understood to warrant discussion. There are three main steps in this process: (1) synthesis of glycerol from carbohydrates; (2) synthesis of fatty acids from carbohydrates; and (3) condensation of glycerol and fatty acid molecules. The detailed chemistry of the first two steps is not known, except that in both there is a chemical reduction with the result that both glycerol and fatty acids contain more energy than the carbohydrates from which they are made. This energy is derived from respiration. The condensation of fatty acids and glycerol to form a fat, using palmitic acid as an example, proceeds as follows under the influence of the enzyme lipase:

$$\underset{\text{palmitic acid}}{3C_{15}H_{31}COOH} + \underset{\text{glycerol}}{C_3H_5(OH)_3} \longrightarrow \underset{\text{palmitin}}{(C_{15}H_{31}COO)_3C_3H_5} + 3H_2O.$$

In this condensation reaction there is very little energy change, but because of the endothermic nature of the reactions by which fatty acids and glycerol are made, a fat contains about $2\frac{1}{4}$ times as much energy as an equal weight of carbohydrate.

4. Mineral Metabolism.—Although many other chemical elements are constituents of plants, only 15 are definitely known to be necessary in chemically detectable quantities for most kinds of plants. These are: carbon, oxygen, hydrogen, nitrogen, magnesium, potassium, calcium, phosphorus, sulfur, iron, boron, manganese, zinc, copper and molybdenum. The first three of these elements are obtained by plants from atmospheric gases or soil water. The remainder are obtained from mineral salts which are absorbed from the soil. The last six of the elements listed above are often called micrometabolic (or trace) elements because they constitute only a very small proportion of the necessary mineral ration of plants. In agricultural soils the elements most likely to be deficient are nitrogen, phosphorus and potassium; hence most commercial fertilizers consist of mixtures of compounds of these three elements. There are many soils, however, to which one or more of the other essential elements, including some of the micrometabolic ones, must be added if satisfactory growth of plants is to be obtained.

Absorption of Mineral Salts.—A part of the mineral salts used by plants is absorbed from the soil solution. Another and, at least for cations, more important source of mineral elements is the clay fraction of the soil. The clay particles are largely of colloidal dimensions and bear negative charges, having associated with them certain cations in large numbers, the commonest of which are hydrogen, calcium, magnesium, potassium and sodium ions. Of all these cations the hydrogen ion is held most tenaciously by the clay particles. As a result of respiration, carbon dioxide is continuously being generated in root cells. Part of this carbon dioxide reacts with water, forming carbonic acid, which in turn dissociates, forming hydrogen ions. If a root hair or root epi-

dermal cell is in intimate contact with a clay particle, hydrogen ions from the cell exchange places with cations associated with the clay particles. This process of cation exchange is one of the mechanisms of absorption of ions by the roots of plants. Similar cation exchanges often occur following the addition of a fertilizer to a soil, the displaced cations passing into the soil solution.

Some of the absorption of mineral salts from the soil solution undoubtedly occurs by a simple diffusion, but a larger proportion of the absorption results from the operation of a more complex mechanism, called accumulation of salts. Many of the kinds of ions in the cell sap of large-celled species of submersed water plants such as *Nitella*, *Chara* and *Valonia* are present in a much greater concentration than in the water in which the plants live. A similar situation appears to exist in cells of root tips, which contain various kinds of ions—apparently in a freely dissolved state—each in a concentration much greater than in the medium from which they have been absorbed. Many kinds of plant cells, including those of root tips, appear to possess such a capacity of accumulating salts, *i.e.*, in causing their net movement from a medium of their lesser concentration to one of their greater concentration, which is directly opposite to the direction in which they would move if simple diffusion were the mechanism of movement. Furthermore, such cells possess the capacity of retaining accumulated salts in the cell sap in a higher concentration than in the surrounding medium. In this process, unlike the cation exchange process, both the anions and cations of a salt usually pass into a cell in electrostatically equivalent quantities. The accumulation of salts and their retention in the cell in a higher concentration than in the surrounding medium is correlated with an adequate rate of aerobic respiration within the cells. Presumably energy released in respiration is utilized in the process. Absorption of water and absorption of mineral salts both occur principally through the root tips although the mechanisms of the two processes are entirely different. Continued growth of the root tips through the soil is an important factor in the absorption of mineral salts, particularly in soils at water contents below the field capacity.

Roles of Mineral Elements in Plants.—Plants absorb many kinds of ions which are not necessary for their development, and commonly absorb necessary ions in quantities greater than are utilized in the metabolism of the plant. Absorption of ions, therefore, is not necessarily followed by their utilization. Generally speaking, however, most of the ions of essential elements which are absorbed are utilized in one manner or another in metabolic processes, or else have important influences upon physiological conditions within the plant. Many of the mineral elements are important constituents of protoplasm, cell walls or accumulated foods within the plant. The osmotic pressure, hydrogen ion concentration, buffer action and permeability of plant cells are all influenced by mineral salts or their constituent ions. Some mineral elements act as catalysts in the plant. Others have, in certain concentrations, toxic effects which often may be offset by the presence of other ions, a phenomenon known as antagonism. Examples of specific roles of most of the essential mineral elements are given at other places in this article.

Absence or deficiency of any of the essential mineral elements sooner or later becomes apparent in the plant as aberrations in growth or pigmentation. Characteristic visible symptoms of the deficiency of each of the essential elements have been recognized for a number of kinds of plants. Ability to identify such symptoms is of value in diagnosing developmental disorders in plants under natural or cultural conditions.

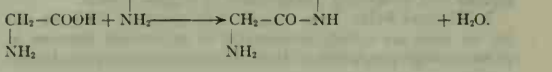
Hydroponics.—J. von Sachs in 1860 and W. Knop in 1865 were the first to use the method of water culture (solution culture) for studying the mineral salt relations of plants. In this method the plants are grown with their roots immersed in dilute solutions containing dissolved salts (so-called nutrient solutions). An alternative procedure is to grow plants with their roots in pure quartz sand or gravel which is kept moist with the solutions. By comparing the development of plants in solutions containing different kinds and proportions of ions, or the growth reactions of plants in a solution markedly deficient in one of the necessary elements with its growth in a complete solution (one containing all necessary elements) many important facts concerning the mineral nutrition and metabolism of plants have been discovered.

Solution and sand cultures have been used by plant physiologists as a laboratory technique for many years, but it was not until about 1936 that the extension of these methods to the commercial culture of plants in large tanks was attempted, a procedure for which the name hydroponics has been proposed. In one such method plants are supported in a matrix of peat, excelsior or some similar material on a wire screen with their roots projecting into a tank of solution below. Provision for adequate aeration of the solution is necessary if suitable development of the plants is to be insured. In another method the plants are rooted in a medium of coarse sand, gravel or haydite (fused shale) contained in large shallow tanks into which the solution is automatically pumped at intervals from a reservoir, to which it drains back after each cycle of pumping. Considerable success in the culture of certain greenhouse crops by these methods has been reported by commercial growers. The principal salts used in preparing solutions suitable for use in soilless plant culture are potassium dihydrogen phosphate, calcium nitrate, potassium nitrate, magnesium sulfate, ammonium sulfate and iron tartrate. (*See* HYDROPONICS.)

5. Nitrogen Metabolism.—Proteins, as already noted, are, next to water, the most abundant constituent of protoplasm. Proteins also accumulate in certain plant organs in considerable quantities, especially in the seeds of legumes. Upon germination of such seeds the proteins present are digested and utilized in the processes of assimilation and respiration. All molecules of plant proteins contain the elements carbon, hydrogen, oxygen and nitrogen. Sulfur also appears always to be a constituent, although present in relatively small quantities. Phosphorus is also a component of certain plant proteins.

In spite of the fact that nitrogen gas constitutes about 79% of the atmosphere, green plants are not able to utilize nitrogen from this source. Leguminous plants, an apparent exception to this statement, obtain atmospheric nitrogen indirectly through metabolic activities of symbiotic bacteria living in nodules on their roots. The well-known influence of legumes in enhancing the nitrogen content of soils is dependent upon the action of these bacteria. Most green plants obtain their nitrogen as a constituent of the nitrates or ammonium compounds which they absorb from the soil.

Protein molecules are synthesized by the condensation of large numbers of molecules of amino acids. More than 15 different amino acids occur in plants. The simplest amino acid is glycine: $CH_2(NH_2).COOH$. Most amino acids have a more complex molecular structure; at least one plant amino acid (cystine) also contains sulfur. Amino acids are apparently synthesized from organic acids derived from carbohydrates and from the nitrogen absorbed as nitrates or ammonium compounds. The sulfur present in cystine and possibly other amino acids is absorbed by the plant as sulfates. In some species of plants (apple, asparagus, certain grasses) synthesis of amino acids occurs principally in the roots, while in others (pea, soybean, tomato) it occurs principally in the aerial parts. The principal regions of protein synthesis do not necessarily correspond with the principal regions of amino acid synthesis. Amino acids may be made in one part of a plant, translocated to other parts, and used there in protein synthesis. Condensation of amino acids resulting in the formation of proteins occurs chiefly in the meristems and in certain storage tissues, especially in seeds. The condensation of amino acid molecules occurs mainly by their union through the peptide linkage. Using two glycine molecules for illustration, this process occurs as follows:



By the linking together of at least several hundred amino acid residues in this fashion the long, complex molecular chains characteristic of proteins are built up. A number of different kinds of amino acids enter into the constitution of each protein molecule; these are not arranged in a haphazard manner, but according to definite linear sequences, which are different and characteristic in each kind of protein. Many of the proteins found in the nuclei of plant cells contain phosphorus. Such proteins are complex compounds formed by the combination of proteins and the phosphorus-containing nucleic acids. Among the compounds important in the protein metabolism of plants are asparagine and glutamine, chemically very closely related to aspartic acid and glutamic acid, respectively, both of which are important plant amino acids. Organic nitrogen is often translocated from one part of the plant to another as asparagine, and this compound also commonly occurs as a temporary storage food. Alkaloids, complex nitrogen-containing compounds, very different in chemical constitution from the proteins, occur in some species of plants. Examples are nicotine, quinine, strychnine and morphine. These compounds are apparently only incidental products of plant metabolism; many of them, however, are important in therapeutics.

E. Translocation of Solutes

1. Organic Solutes.—*Downward Translocation.*—Organic solutes, principally carbohydrates synthesized in the leaves, are translocated in a downward direction in plants to the tissues of stems and roots through the phloem. In the stems of woody plants downward translocation occurs only in the youngest layers of phloem, corresponding roughly to the inner bark adjacent to the cambium. In tall trees the carbohydrates entering the root tips may have moved hundreds of feet through the continuous phloem from the leaf cells in which they were made. Most of the translocation of solutes through the phloem occurs in the sieve tubes, which consist of linear series of elongate cells joined together end to end. The exact mechanism of the downward translocation of solutes through the phloem is not known. One theory is that it is accomplished by cyclical streaming of the cytoplasm in the sieve tube cells, the solutes passing from one cell to the next by diffusion. Another theory is that there is a mass flow of solution in a downward direction through the phloem, movement from cell to cell being assumed to occur through the interconnecting cytoplasmic strands. There are a number of objections to both of these theories, one of the most serious being that neither of them can account for the rapidity with which translocation occurs in some plants. There are indications that the movement of solute molecules is in some manner greatly accelerated by the metabolic activity of the phloem cells through which translocation occurs, and that energy is actually expended in the accomplishment of solute movement (H. F. Clements, 1940).

Upward Translocation.—Under certain conditions considerable quantities of carbohydrates and other soluble foods are translocated in an upward direction through plants. This occurs, for example, in the stems of woody species when the buds resume growth in the spring. The tissues of the shoots formed shortly after initiation of growth are constructed largely from foods which move in an upward direction from storage tissues of the older stems. Translocation of foods in an upward direction also occurs toward developing flowers or fruits located in a terminal position, in seedlings as food moves from the endosperm or cotyledons toward the apical growing regions, and during the earlier stages in the development of leaves or shoots from bulbs, corms, rhizomes and tubers. Upward translocation of organic solutes occurs largely in the phloem. It is not certain whether solutes can move simultaneously in the phloem in both directions or can only move in an upward direction under certain conditions and in a downward direction under others. The comments previously made regarding lack of knowledge of the mechanism of downward translocation apply equally well to upward translocation of organic solutes.

2. Mineral Salts.—The mineral salts absorbed from the soil by the roots are mostly translocated in an upward direction in plants, a large proportion of them ultimately reaching the leaves. Considerable controversy has flourished over whether upward movement of the mineral salts occurs principally in the xylem or principally in the phloem, but the preponderance of the evidence at present indicates that the xylem is the chief tissue through which mineral salt transport occurs (P. R. Stout and D. R. Hoagland, 1939). The dissolved mineral salts, generally in very low concentration, are passively carried in an upward direction through the ascending streamlets of water in the xylem ducts. The possibility of some upward movement of certain mineral elements in the phloem, particularly if in organic combination, cannot, however, be entirely excluded. Not all of the mineral salts translocated into a leaf or other lateral organ of a plant necessarily remain in that organ permanently. Re-translocation of certain mineral elements either as ions or as constituents of organic compounds out of the leaf and their subsequent distribution to other organs, often younger leaves, is of frequent occurrence in plants. Just prior to the abscission of leaves or floral parts a considerable proportion of the nitrogen, phosphorus, potassium, sulfur and magnesium present is translocated back into the stems. Such movements of minerals out of leaves occur through the phloem. There are also indications of a periodic daily "circulation" of at least certain of the minerals in the plant. Mobile phosphorus compounds, for example, apparently can move from root to leaf through the xylem, and from leaf to root through the phloem within a 24-hour period (O. Biddulph, 1941).

F. Respiration

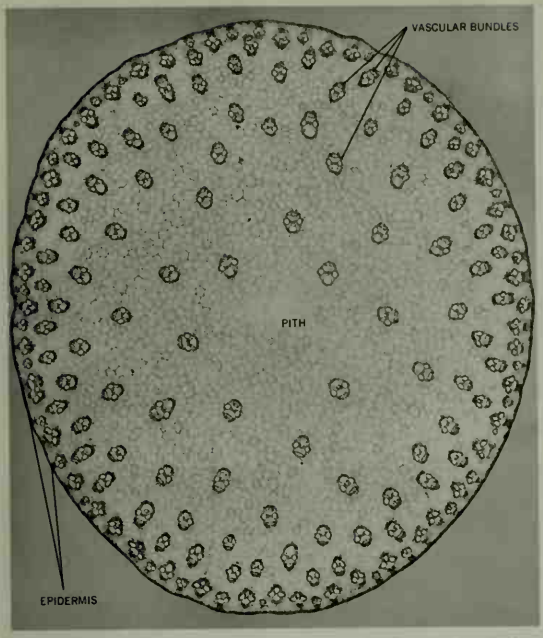
The gaseous exchanges—consumption of oxygen and release of carbon dioxide—accompanying respiration are only external manifestations of this process.

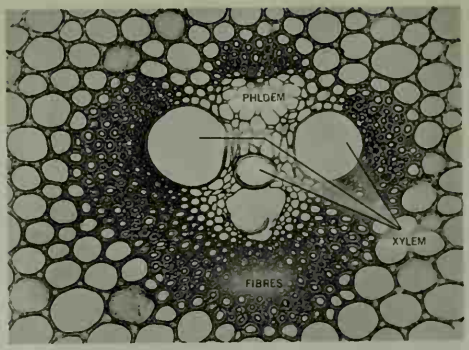
1. Aerobic Respiration.—The essential and only invariable feature of respiration in green plants is that this process results in the oxidation of foods in living cells. The summary equation for the most usual course of respiration is:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 673 \text{ kg.cal.}$$

This process is often termed aerobic respiration because it proceeds only in the presence of atmospheric oxygen. Hexose sugars are most commonly the substrate of respiration and the equation given above, representing their complete oxidation, is the exact opposite of the photosynthetic equation. Fats and proteins can also be oxidized in plant cells after conversion into soluble hydrolytic products. Oxidation of fats usually is not initiated until the soluble carbohydrates in the cell are exhausted. Oxidation of proteins apparently seldom occurs until the cells have been depleted of both carbohydrates and fats. The respiratory ratio (ratio of volume of carbon dioxide released to volume of oxygen consumed) of a plant tissue depends upon the type of substrate being oxidized. Oxidation of carbohydrates results in a respiratory ratio of approximately 1, of fats a ratio of about 0.8, of proteins about 0.9, and of certain organic acids, such as oxalic and malic acids, a ratio of more than 1. The occurrence of anaerobic respiration in a tissue also results in a respiratory ratio greater than 1. That heat energy is released in respiration can be demonstrated by placing a mass of germinating seeds in a calorimeter and measuring the rise in temperature with a thermometer. The energy which escapes as heat is entirely lost to the plant. An important fraction of the energy released is not transformed into heat, but is used in endothermic synthetic processes, in various translocation phenomena, in protoplasmic streaming, in the accumulation of ions or molecules by plant cells, in various stages of growth and in other ways. All of the energy made available by respiration represents radiant energy previously entrapped in the process of photosynthesis.

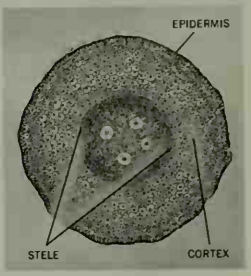
Factors Influencing the Rate of Respiration.—In general, young meristematic tissues, relatively rich in protoplasm, have higher rates of respiration than older tissues in which the proportion of cell walls and dead cells is greater. Opening leaf or flower buds, growing root tips and germinating seeds all have relatively high rates of respiration. Germinating poppy seeds at 61° F. may lose 122 cc. of CO_2 per gram of dry weight in 24 hours. The respiration rates of meristematic plant tissues are of the same order of





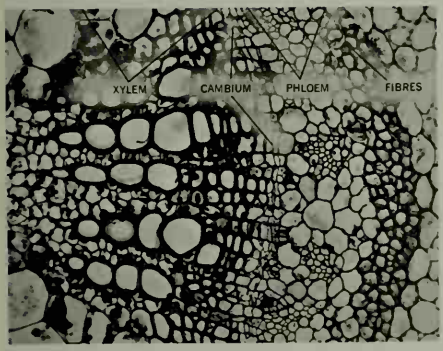
MONOCOT

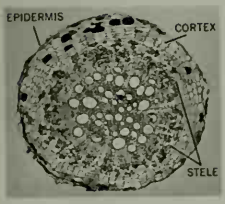
Cross section of (left) corn stem with vascular bundles scattered throughout the cortex; (above) close-up of a vascular bundle of corn; (right) corn root



SOME ASPECTS OF MONOCOTS AND DICOTS

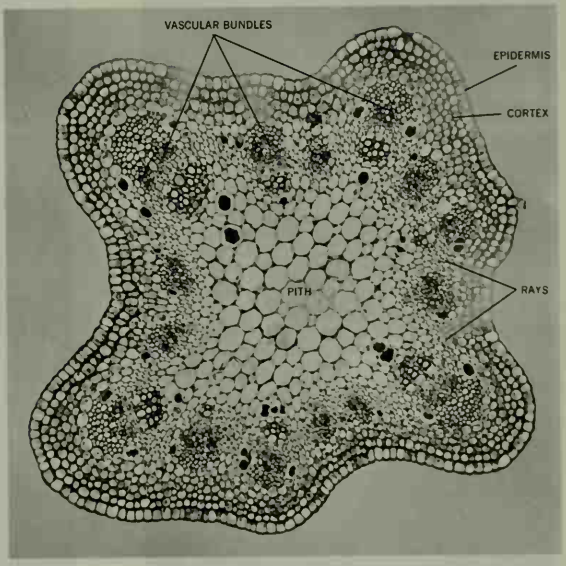
The angiosperms or flowering plants are divided into two groups, monocots and dicots, each of which follow strikingly different growth patterns. The photomicrographs on this plate show some of these differences as seen in the stems and roots of a member of each group





DICOT

Cross section of (right) trefoil stem, showing marginal arrangement of vascular bundles; (above) close-up of a vascular bundle of trefoil; (left) trefoil root

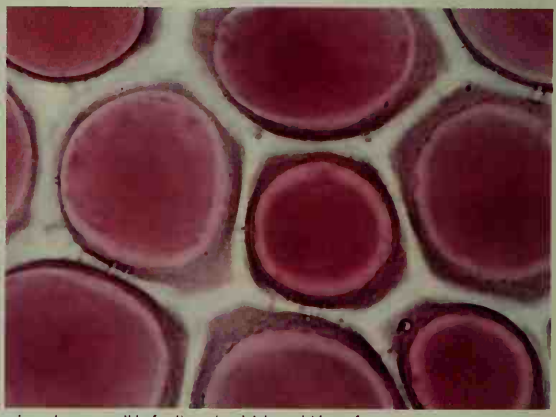


BY COURTESY OF (TOP RIGHT, CENTRE RIGHT, CENTRE LEFT, BOTTOM RIGHT) J. E. SASS, IOWA STATE COLLEGE JOURNAL OF SCIENCE, (BOTTOM LEFT) H. W. HANSEN, ST. OLAF COLLEGE; PHOTOGRAPH. (TOP LEFT) PHILIP A. FEINBERG, FELLOW OF THE NEW YORK MICROSCOPICAL SOCIETY

PLANTS AND PLANT SCIENCE

Plants produce their brilliant colours chiefly with three classes of pigment. The chlorophylls, which are the photosynthesizing pigments of green leaves and stems, predominate. (Right) A microscopic section of a tulip leaf reveals hundreds of chlorophyll-containing ellipsoid bodies called chloroplasts

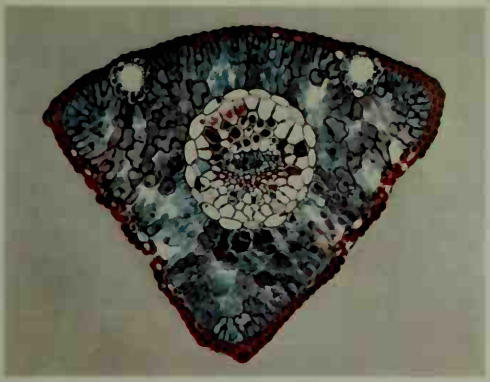
Daffodil flowers are coloured by the carotenoids—the same group of pigments that give colour to carrots, tomatoes, and autumnal leaves of birches and aspens. (Right) Under the light microscope, a thin slice of daffodil petal shows yellow carotenoid-containing bodies called chromoplasts



African violet blossoms are coloured by anthocyanin pigments—responsible for the reds, violets, and blues of many flowers and fruits. (Right) A magnified, thin slice of an African violet blossom; unlike plastid-borne chlorophyll and carotenoid, anthocyanin is dissolved throughout the cell sap

PLANT COLORATION

PHOTOGRAPHS, (CENTRE LEFT) JANE KINNE—PHOTO RESEARCHERS, INC., (OTHERS) RUSS KINNE—PHOTO RESEARCHERS, INC.



Cross section (stained) of a conifer needle. A single vascular bundle, bordered by endodermis, is surrounded by mesophyll cells. The entire leaf is bounded by a thick, waterproof epidermis. Note the two large resin canals (top); sunken stomates (right and left); diffuse intercellular spaces; and transfusion parenchyma cells in the vascular bundle (surrounding vessels)

Starch grains of potato, viewed through a polarized light microscope. Starch, a complex carbohydrate food, is stored in grains of different size and shape depending on the plant species

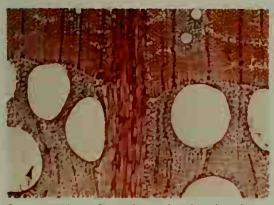
Crystals formed during metabolism glow pink and yellow in cells of onion skin, viewed under polarized light

A pair of summerwood vessels of hickory. Greatly magnified cross section was stained in Congo red, photographed in polarized light

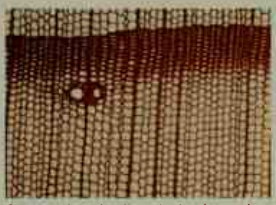
Photomicrographs of wood. (Left) Tangential section of a hardwood (scarlet oak) showing cut ends of two large and many small rays

(Right) Tangential section of a softwood (white pine), viewed under polarized light, showing cut ends of rays and longitudinal views of tracheids

Cross section of carrot, under polarized light, reveals fibrous and other tissues scattered among parenchyma cells



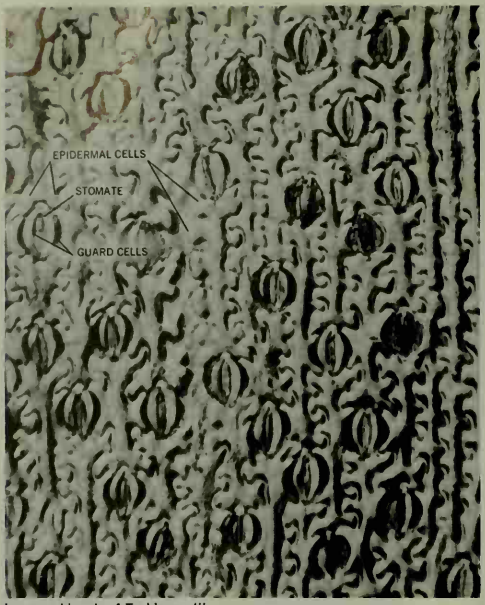
Cross section of scarlet oak, showing large xylem vessels and a pith ray (reddish lines in centre)



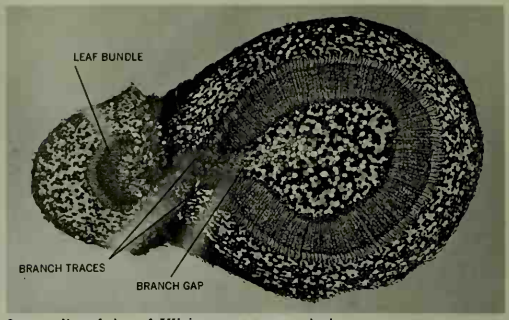
Cross section of softwood, showing springwood and summerwood (with two resin canals)

BY COURTESY OF (CENTRE RIGHT, BOTTOM LEFT GROUP OF FOUR PHOTOGRAPHS) THE MEAD CORPORATION, CENTRAL RESEARCH LABORATORIES; PHOTOGRAPHS, (TOP LEFT) PHILIP A. FEINBERG, FELLOW OF THE NEW YORK MICROSCOPICAL SOCIETY, (OTHERS) ERIC GRAVÉ—PHOTO RESEARCHERS, INC

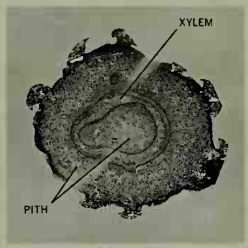
PLANTS AND PLANT SCIENCE



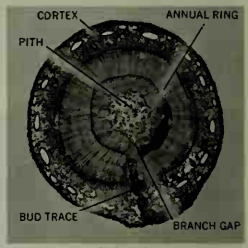
Lower epidermis of Turk's-cap lily



Cross section of stem of *Illicium*, an evergreen shrub

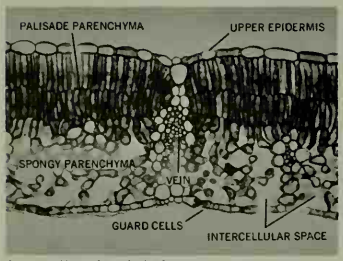


Cross section of fern stem

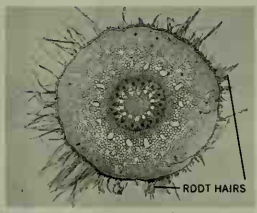


Cross section of pine stem

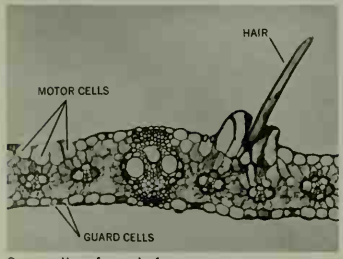
MICROSCOPIC VIEWS OF PLANT STRUCTURES



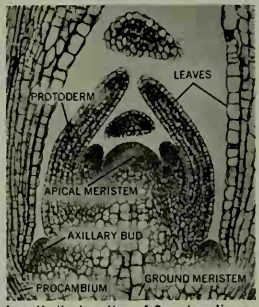
Cross section of apple leaf



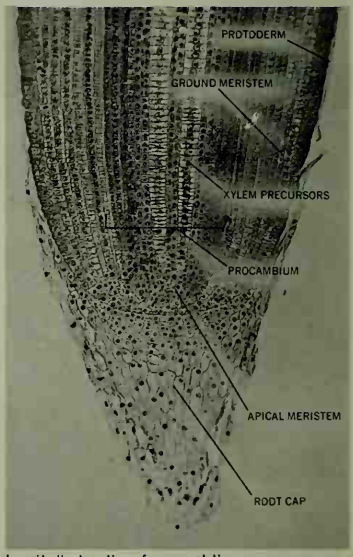
Cross section of vanilla root



Cross section of corn leaf



Longitudinal section of flax stem tip



Longitudinal section of corn root tip

BY COURTESY OF (TOP RIGHT) I. W. BAILEY, (TOP CENTRE) R. H. WETMORE, (TOP CENTRE RIGHT) G. H. CONANT, (CENTRE LEFT, CENTRE, BOTTOM RIGHT, BOTTOM LEFT, BOTTOM CENTRE) J. E. SASS, IOWA STATE COLLEGE JOURNAL OF SCIENCE; PHOTOGRAPH, (TOP LEFT) VINCENT J. SCHAEFER

magnitude as the rates in warm-blooded animals. Rates in dormant seeds or other dormant organs, and mature or senescent leaves, fruits or other organs are much lower. Within a temperature range of about 32°–113° F., increase in temperature usually causes an increase in respiration rate (an approximate doubling for each 18° F. rise in temperature), although at the higher temperatures the increased rate often diminishes with time. Starved plant cells respire relatively slowly, and in general, with increase in the soluble carbohydrate content of the cells there is an increase in the rate of respiration up to the point at which some other factor becomes limiting. Very high oxygen contents of the atmosphere result in increased rates of respiration, very low ones result in decreased rates. The oxygen content of the atmosphere can, however, deviate considerably from the usual atmospheric concentration without any pronounced effect on the rate of respiration. An increased carbon dioxide content of the atmosphere results in a decrease in the rate of respiration of some plant tissues and an increase in others. The effect of a shift in the hydration of the tissues on the rate of respiration is exhibited most clearly in seeds. The respiration rate of dry seeds is often vanishingly small, but immediately upon the imbibition of water, the first step in germination, it increases markedly.

Influence of Respiration Rate on Net Rate of Photosynthesis.—The average quantity of hexose produced in photosynthesis by a corn plant during its life history is about 9 g. per photoperiod, while the average amount of hexose consumed in respiration during its life history by the entire plant is about 2 g. per 24-hour day. The difference between these two quantities is the net daily rate of photosynthesis and represents the amount of hexose which can be utilized by the plant in assimilation or which may accumulate as unused food. The average net daily rate of photosynthesis is an important consideration in evaluating the survival and development of plants, as, in general, the greater this quantity the larger the plant can grow and the more food that can accumulate. Temperature has an important effect on net daily photosynthesis because of its differential influence on the rates of respiration and photosynthesis.

In many and perhaps all species the temperature optimum for respiration is higher than the optimum for photosynthesis. In the potato, for example, the temperature optimum for photosynthesis, under otherwise favourable conditions, is about 68° F., while the optimum for respiration, at least of the leaves, is about 95° F. Hence, the higher the temperature above the photosynthetic optimum, the greater the proportion of the photosynthate which is consumed in respiration in one part of the plant or another, and the smaller the daily net photosynthesis. At relatively high temperatures, therefore, there is relatively less food which can be used in the construction of new tissues and which can accumulate in the tubers or other organs. This is the explanation of the well-known fact that the potato is a cool climate crop. The same principle also applies to other species, although the temperature which results in maximum daily rates of net photosynthesis varies with other environmental factors and with the species, being in general higher in species indigenous to warm climates than to those indigenous to cool climates. Analysis of this effect of temperature on plants is complicated by the fact that plants in nature are exposed to a daily cycle of temperature variations, the general pattern of which varies from season to season and habitat to habitat.

2. Fermentation.—When a dilute sugar solution becomes inoculated with yeast cells the process of alcoholic fermentation ensues:

$$\underset{\text{hexose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{ethanol}}{2C_2H_5OH} + 25 \text{ kg.cal.}$$

This process proceeds as a series of sub-reactions, each catalyzed by a specific enzyme. The over-all series of reactions in which the compound pyruvic acid is formed from a phosphorylated hexose sugar is called glycolysis. Although an oxidation reaction, glycolysis can occur in the complete absence of atmospheric oxygen; *i.e.*, it is anaerobic. The further steps in the conversion of pyruvic acid to ethanol are also anaerobic. Even when oxygen is present yeast cells carry on very little aerobic respiration, still obtaining most of their energy from the relatively less efficient process of fermentation.

A process identical with or at least very similar to alcoholic fermentation occurs in the tissues of green plants under certain conditions. If kept in an atmosphere devoid of oxygen many plant tissues continue to release carbon dioxide while ethanol or other chemically related compounds accumulate in them. In some plant organs such anaerobic respiration occurs even in the presence of oxygen. This is true in the earlier stages in the germination of some kinds of seeds and grains (pea, oat, sunflower) because of the virtual impermeability of the coats to oxygen. The skin of the grape and some other fruits is also highly impermeable to oxygen, and considerable anaerobic respiration undoubtedly occurs in such organs. Many tissues of higher plants are soon injured by prolonged anaerobiosis. Within a day signs of injury appear in corn seedlings which have been deprived of oxygen. The injurious effect of anaerobic respiration on many plant tissues is undoubtedly in part a result of the low-energy output of this process and in part a result of the accumulation of ethanol or other toxic products within the cells. Some aging (senescent) plant tissues, on the other hand, such as apple and pear fruits, continue to release carbon dioxide and remain uninjured for months when stored in pure nitrogen or hydrogen.

Mechanism of Respiration.—Like fermentation, the process of aerobic respiration proceeds as a complex series of sub-reactions. The earlier steps in fermentation and respiration appear to be identical. By means of the glycolytic series of reactions pyruvic acid is formed in the cells of plants. Glycolysis may occur either in the presence or absence of oxygen. In the presence of oxygen fermentation is usually inhibited and the further aerobic oxidation of the pyruvic acid to water and carbon dioxide takes place through another complex series of reactions known as the Krebs cycle. Most of these reactions in this cycle are catalyzed by specific enzymes. Energy transfers from molecule to molecule during respiration are accomplished through the intermediation of certain complex molecules of which adenosine triphosphate is the best known. Compounds formed during the intermediate steps of respiration are the starting points for many metabolically important chains of reactions. The biochemical pathway along which respiration proceeds appears to be the same or very similar in most kinds of plant and animal cells.

G. Growth

The co-ordinated development of plant organs and tissues is just as clearly a type of physiological activity as relatively simpler processes such as photosynthesis and respiration. The tissues and their constituent cells resulting from the complex of physiological processes referred to as growth in turn become factors influencing subsequently occurring physiological processes in those tissues. Growth of plants occurs primarily in meristems, which are tissues in which the cells retain a capacity for cell division. The principal meristems of a vascular plant are the apical stem meristems, the apical root meristems and the cambium (not present in ferns or monocots). An embryo plant has only one apical stem meristem, but with the development of the branching stem system there comes to be such a meristem at every growing stem tip and in every bud. Hence there may be thousands of apical stem meristems on any plant with an extensive system of branching. Likewise there is only one apical root meristem on an embryo plant, but with the branching of the root system the number of such meristems on a single plant may exceed many thousands or even millions, since one is present at every root tip.

Growth of any meristem proceeds by successive microscopically visible stages of cell division, cell enlargement and cell maturation, which are the three principal morphological phases of growth. The terms for the first two stages of growth are self-explanatory. Cell maturation refers to the final stage in growth during which most of the distinctive structural and chemical differences in the walls of the various kinds of cells develop. It is also the stage in which the protoplasm disappears from many kinds of cells as, for example, most cells of the xylem. An ac-

tively growing meristem is a centre of intense assimilatory activity, assimilation being the term used to refer to the construction of new cell walls and protoplasm from foods. Protoplasmic proteins are made by the condensation of amino acids, principally during the cell division stage of growth. Cellulose, pectic compounds and other cell wall constituents are synthesized by the condensation of soluble carbohydrates, principally during the cell division and cell enlargement phases of growth. Water is incorporated into the cells in considerable quantities during both cell division and cell enlargement, some entering into the hydration of newly formed cell walls and protoplasm, and larger quantities entering into the expanding vacuoles, particularly during cell enlargement. Translocation of water and soluble foods is, therefore, constantly in progress toward growing meristems. Translocation of essential minerals, as soluble compounds of one kind or another, is also continually occurring toward growing meristems. Certain growth substances must also be present if growth is to occur. Regions of cell division and cell enlargement are also centres of intense respiratory activity, considerable quantities of carbohydrates being oxidized in such cells, much of the resulting energy being utilized in various dynamic and metabolic processes which are integral phases of growth. Respiration rates during the maturation phase are distinctly lower than during the two preceding stages of the growth process.

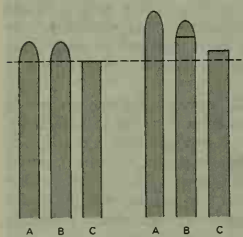


FIG. 16.—EFFECT ON ELONGATION OF OAT COLEOPTILE AS A RESULT OF DETIPPING

Left: (A) intact coleoptile; (B) tip severed and replaced; (C) tip removed. Right: differences in subsequent elongation

Growth from primary meristems is called primary growth and results in all increase in the length of stems and roots, in the development of their branching system, in the development of the primary tissues of such organs, and in the production of all lateral appendages, such as leaves, floral parts and root hairs. Primary growth of plants is not a continuous but a periodic phenomenon, periods of growth having in general a correlation with favourable seasons, but varying greatly from one species of plant to another. The periodicity of root growth in a given species is usually different from the periodicity of stem growth, often beginning earlier in the season than stem growth and continuing after the latter has ceased. Most of the secondary growth of plants is initiated in the cambium, which is a uniseriate layer of cells located between the xylem and phloem. In most plants in which it occurs the cambium is present as an almost continuous layer of cells extending from just back of every root tip to just below every stem apex. As a result of secondary growth in a lateral direction xylem cells (secondary xylem) are formed on the inner side of the cambium and phloem cells (secondary phloem) on its outer side (the first layers of these two tissues, primary xylem and primary phloem develop during primary growth). In woody perennials secondary tissues may develop from the cambium for hundreds of years, cambial activity being resumed periodically with the advent of each growing season. The diameter of the woody cylinder is thus increased from growing season to growing season, and commonly each season's layer of xylem (wood) can be distinguished in cross sections of the wood as a definite annual ring. As new layers of phloem form adjacent to the cambium, the older phloem is displaced outward and, in most woody species, becomes part of the bark, which eventually sloughs off.

Leaves develop from the leaf primordia, small protuberances of meristematic cells which originate laterally in apical meristems. The zone of attachment of a leaf to a stem is called a node; in most kinds of plants the leaves become more or less regularly spaced along the stem axis by elongation of the internodes. In the axil of each leaf an offshoot of the terminal meristem develops which in turn becomes a terminal meristem. Such meristems are essentially rudimentary side branches and are called lateral buds, usually being covered with bud scales in woody species. The branching stem system of the plant is a result of the development of the lateral buds into side branches. Branch roots, on the other hand, develop from meristems which originate in interior pericycle tissue. In many woody plants scale-enclosed terminal buds form annually at the tip of each stem axis. In the woody plants of temperate regions resumption of growth from the terminal buds and from some of the lateral buds occurs each spring, continuing for a few weeks to several months, depending upon the species of plant and the environmental conditions. In most species of plants some of the apical stem meristems sooner or later become differentiated into flower primordia from which develop flowers and, ultimately, fruits and seeds.

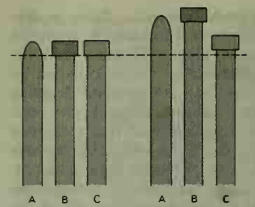


FIG. 17.—EFFECT OF AUXIN ON ELONGATION OF OAT COLEOPTILE

Left: (A) check or control; (B) agar block containing auxin placed on detipped coleoptile; (C) block of pure agar placed on detipped coleoptile. Right: differences in elongation

1. Hormones.—Hormones are substances synthesized within an organism which, in very minute concentrations, exert profound effects on its metabolism or growth, often after translocation to parts or organs remote from their centre of production. Although the existence of such substances in plants had been suspected for many years, the first convincingly clear demonstration of the presence of growth hormones (growth substances) in plants was not made until the investigations of F. W. Went in 1928.

The auxins have been the most thoroughly studied of the plant hormones. Their action has been investigated mostly in the coleoptile of the oat, which is the first part of the plant that emerges above the ground in germination. This is a cylindrical structure several centimetres in height, which encloses the first leaf. If the tip of an oat coleoptile is removed, elongation of the stump is greatly retarded as compared with an intact coleoptile. If the cut off tip is replaced on the coleoptile, nearly the original rate of elongation may be regained (fig. 16). Furthermore, if the cut off tip be placed with its cut surface in contact with a small block of agar gel for about an hour, and the agar block then be affixed on the cut surface of a detipped coleoptile, that coleoptile will elongate at nearly its usual rate. No such effect will be obtained if a block of pure agar is used (fig. 17). Cell divisions cease very early in the development of a coleoptile and the cell elongation which results in its increase in length is restricted to the basal portion. The facts just cited indicate that the tip exerts a controlling influence on the elongation of basal cells of the coleoptile and, furthermore, as shown by the agar block experiment, this controlling influence must be ascribed to some diffusible substance or substances which move from the tip toward the base through the coleoptile. These substances are called auxins. If an agar block containing auxins from one source or another is affixed one-sidedly on a detipped coleoptile, cell elongation is found to be more rapid on a side of the coleoptile below the portion of the tip on which the block is located, resulting in curvature of the coleoptile (fig. 18). Translocation of the auxin is almost strictly longitudinal, the elongating cells on the side of the coleoptile below the block receiving much more than cells on the opposite side, with a corresponding differential effect on growth. Within limits of 0° to 20°, curvature resulting from the eccentric attachment of agar blocks containing auxin to detipped coleoptiles is proportional to the concentration of auxin in the blocks. This

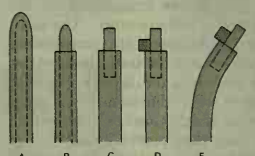


FIG. 18.—QUANTITATIVE TEST FOR AUXINS BASED ON DEGREE OF BENDING OF AN OAT COLEOPTILE

(A) Intact coleoptile enclosing primary leaf; (B) tip of coleoptile removed; (C) primary leaf pulled loose and its tip cut off; (D) agar block containing auxin affixed to one side of prepared coleoptile; (E) curvature resulting from action of auxin on left side of coleoptile below block

proportionality between auxin concentration and coleoptile curvature has made it possible to use the bending of oat coleoptiles as the basis for a quantitative and extremely sensitive biological test for auxins. Auxins are essential for the occurrence of cell elongation in all plant cells. In their absence elongation ceases; in their presence elongation occurs if no other factors are limiting, and within limits, elongation is proportional to auxin concentration. Relatively high concentrations of auxins inhibit cell elongation, and the concentration most favourable for elongation is different in different tissues, being, for example, much higher in stems and coleoptiles than in roots. The only auxin definitely known to occur in the tissues of higher plants is the compound indole-3-acetic acid, although the presence of others, probably chemically similar, is suspected. A number of synthetic compounds, not known to occur in plants, have been discovered to have many of the same effects on plants as the naturally occurring auxins.

More roots form on cuttings of many kinds of plants if they are

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FIG. 19.—LEMON CUTTINGS, DEMONSTRATING THE IMPORTANCE OF LEAVES IN PROVIDING AUXIN NECESSARY FOR ROOT PRODUCTION. (LEFT) TWO SLIPS WITHOUT LEAVES HAVE NO ROOTS; (RIGHT) TWO SLIPS WITH LEAVES HAVE FULLY DEVELOPED ROOT SYSTEMS

first treated with an auxin. Some of the synthetic auxins, notably indole-butyric acid and α-naphthalene acetic acid, are especially effective in inducing root formation. The hormone may be applied in solution, in a paste, as a vapour or in a powder. Information on the rooting of cuttings of many species by treatment with auxins is given by G. S. Avery, *et al.* (see *Bibliography*, below).

The detachment of leaves, fruits and certain other parts of plants from stems usually occurs by the process of abscission. The first step in the abscission of leaves or fruits is the formation of an absciss layer across the base of the petiole of the leaf or the peduncle of the fruit. The absciss layer is a transverse zone consisting of several layers of parenchymatous cells. It may form weeks or months before detachment of the leaf or fruit occurs. Abscission proper, which in the leaves of deciduous trees of temperate regions occurs principally in the autumn, takes place as a result of dissolution of the middle lamella between layers of cells in the absciss layer. Artificial introduction of auxin into leaf petioles at a time when they would ordinarily abscise within a short period materially delays the time of abscission. A practical application of this discovery is to spray apples with a solution of α-naphthaleneacetic acid shortly before harvest in the fall. Application of such a spray delays abscission of the fruits and makes it more likely that they can be picked before they fall to the ground and deteriorate in quality.

Usually fruit development ensues only after pollination and subsequent fertilization have occurred. If, however, pollination is prevented and any one of several of the auxins is introduced into the pistil by a suitable technique, development of the fruit will occur (F. G. Gustafson, 1936). Such parthenocarpic fruits are seedless.

One of the seemingly paradoxical developments from the study of auxins which, in general, are growth hormones par excellence, is that some of them also exert such toxic effects on plants that they are widely used as weed killers. The best known of such auxins is 2,4-dichlorophenoxy-acetic acid (2,4-D). Such auxins exert their toxic effects only when employed at considerably higher concentrations than those at which they exert growth-promoting effects.

Other growth reactions of plants which are influenced by auxins include cambial activity, abscission, initiation of flowers, growth correlations and tropisms.

The auxins are by no means the only hormones which occur in plants. Many vitamins of the so-called B-complex appear to operate as hormones in plants. Thiamin, for example, is synthesized principally in the leaves, whence it is translocated to other parts of the plant (J. Bonner, 1942). The same situation appears to prevail with respect to some of the other B vitamins.

The kinins constitute another group of plant hormones. These compounds are purine derivatives, the most thoroughly investigated of which is 6-furfurylaminopurine (C. O. Miller, *et al.*, 1956). The kinins were originally considered to be primarily cell division promoting hormones, but have also been found to favour certain other growth reactions of plants such as expansion of leaf blades.

The gibberellins constitute still another group of plant hormones, the best known of which is gibberellic acid. This compound has the molecular formula of $C_{19}H_{22}O_{11}$ and has the basic ring structure of the compound fluorene. One of the principal effects of the gibberellins is that of promoting elongation of various plant organs. In this respect they resemble the auxins, but they are not to be classed with the auxins because their effects on many plant growth reactions are quite different from those of the auxins. Among other growth reactions of plants influenced by gibberellins are induction of flowering in certain species, shifting the growth cycle of some biennials to annuals, induction of parthenocarpy, enhancing cambial activity, and overcoming the dwarf habit of growth in some species (B. B. Stowe and T. Yamaki, 1957).

2. Factors Influencing Growth.—The process of growth is so complex that it is impossible to characterize it by any single index. Quantitative measurements may readily be made of such aspects as increase in lengths of stems or roots, increase in diameter of a stem, increase in volume of a fruit, or increase in dry or fresh weight of a plant organ. However, qualitative differences in growth are often of greater significance than quantitative differences. The relative development of vegetative and reproductive growth, for example, or whether the vegetative growth is soft and succulent or hard and woody are often of greater import from a physiological or practical standpoint than the absolute development of any plant organ or organs, measured as length or weight. Such developmental differences must be characterized largely in descriptive terms rather than in quantitative measurements.

The growth and reactions of a plant are the result of the coordinated interplay of its hereditary factors and the environmental conditions to which it is exposed upon its internal physiological processes. Genetic factors have as much influence on the development of a plant as environmental factors, but a detailed consideration of their effects cannot come within the scope of this article. The environment of plants is too complex to be subjected to any completely logical analysis, but the following are the principal factors of the physical environment which have effects upon the rate and type of growth of plants: radiant energy (intensity, quality, duration), temperature of air and soil, atmospheric humidity, soil water supply, soil aeration, supply of available minerals in the soil, concentration of gases in the atmos-

phere, gravity and atmospheric pressure. Since an individual factor can vary in more than one way, since various interrelations exist among the different factors, and since each factor can induce various chains of reactions in a plant, interpretation of the effects of an individual environmental factor on the growth of plants is usually a complex problem. The principle of limiting factors can be applied in the approximate analysis of many growth phenomena. In this epitomized discussion the influence of only a few of these environmental conditions can be considered in detail.

Photoperiodism.—The reaction of plants to the length of the daily period of illumination is called photoperiodism. The daily length of the photoperiod varies from latitude to latitude and from season to season in the same latitude. In the tropics, seasonal variations in the photoperiod are small, day lengths approximating 12 hours the year round. In mid-temperate regions, photoperiods vary in length from 8 or 9 hours in December to 15 or 16 hours in June. In arctic regions the photoperiod drops to a zero value in December, and is of a 24-hour duration in June. Although the length of the photoperiod has certain effects on the vegetative development of plants, its most noteworthy influence is upon reproductive development. The foundations of our knowledge of photoperiodism in plants were laid by W. W. Garner and H. A. Allard, beginning in 1920. Originally four categories of plants, in terms of their photoperiodic reaction, were recognized: short-day plants, long-day plants, indeterminate plants and intermediate plants. Further investigations have shown that all plants belong basically to the two categories of long-day plants and short-day plants. Long-day plants require a certain minimum length of photoperiod (which varies considerably from one species or even variety of plant to another) out of each 24-hour day for the induction of flowering, but flower under any longer photoperiod, up to and including continuous light. Short-day plants, on the other hand, require an alternation between a dark period and a light period during each 24-hour day if flowers are to be induced. The dark period must be of a certain minimum length (which varies considerably from one species or even variety of plant to another) but flowering also occurs under dark periods which are considerably longer than the minimum. In the Biloxi soybean, for example, a dark period at least 11 hours (but which may be considerably longer) must alternate with photoperiods which may be from 4 to 18, but optionally from 10 to 12 hours in length if flowers are to be initiated (K. C. Hamner, 1940).

Examples of short-day plants include: cocklebur, salvia, aster, dahlia, poinsettia, chrysanthemum and violet; examples of long-day plants include spinach, radish, dill, lettuce, grains, timothy and hibiscus. Spring-flowering plants of temperate zones are mostly of the short-day type, the flower primordia having been formed during the shortening days of the preceding late summer and autumn. Temperate zone autumn flowering plants mostly fall into the same category, except that flowers are initiated during the current instead of the preceding season. Most summer-blooming plants are of the long-day type.

The daily length of the photoperiod is an important factor influencing the distribution of crop plants and of plants in nature. Species of the pronounced long-day type cannot survive in nature in the tropics. Similarly species of the pronounced short-day type cannot survive under natural conditions in more northern latitudes, excepting only those which are maintained by vegetative propagation. Short-day Biloxi soybeans, for example, fruit readily in the gulf states of the United States, but not in the latitude of Washington, D.C. In the latter region days short enough to induce flowering come so late in the season that fruits are killed by frost before they can ripen. Long-day species with a short critical photoperiod (indeterminate plants) can complete their life cycle over such a wide range of day lengths that their ecological distribution and season of blooming are controlled by factors other than length of the photoperiod.

When the leaves of short-day Biloxi soybean are exposed to short photoperiods while the apical growing regions are kept under long photoperiods or in total darkness, initiation of flower primordia occurs. If the growing tip of the plant is exposed to short photoperiods and the leaves to long photoperiods, no such initiation occurs (H. A. Borthwick and M. W. Parker, 1938). Similar results have been obtained with other short-day species and also with long-day species. These facts indicate that the leaves are the loci of the reactions which lead to the flowering of plants, and that the effects of processes which occur in the leaves are transmitted to the apical meristems, causing them to differentiate into flower primordia. Under the influence of photoperiods of the proper duration it seems likely that a substance (or substances) is made in the leaves, whence it is translocated to the terminal meristems, inducing flower formation. The name florigen has been proposed for this postulated flower-inducing hormone.

It is not necessary for plants to be exposed continuously to photoperiods of the proper length for the initiation of flowers to occur. Short-day Biloxi soybeans, which have been growing under long days, will initiate flower primordia after exposure to only two short-day cycles and a return to long days. Similarly four long-day cycles are sufficient to initiate flowering in long-day dill plants which are kept under short days before and after exposure to long days. The existence of this phenomenon of photoperiodic induction has also been demonstrated in a number of other species of both long-day and short-day types.

When a typical short-day plant is kept under a distinctly short-day cycle, such as 8 hours of light alternating with 16 hours of dark, initiation of flowers soon ensues. If, however, the dark period is interrupted at somewhere near its mid-point by a short period of relatively low-intensity light flowering is inhibited. When a long-day plant is kept under such a short-day cycle flowering does not occur. If, however, the dark period to which such a plant is exposed is interrupted at approximately its mid-point by a short period of relatively low-intensity light, flowering is induced. In both short-day and long-day plants the usual photoperiodic reaction is reversed by such a treatment. The same effect can be achieved by following the 8-hour photoperiod, which must be of relatively high light intensity, with a 6- to 8-hour exposure to low-intensity light.

This low-intensity light reaction of photoperiodism (which must be distinguished from the "high intensity" reaction of the photoperiod proper) has been investigated from the standpoint of the relative effectiveness of different spectral bands of light. A narrow band in the red vicinity of 6500 Å (1 Å or Ångstrom unit = $\frac{1}{10,000,000}$ mm.) wave length has been found to operate most effectively in the low-intensity light reaction. Furthermore, a closely adjacent band in the far red, at about 7,300 Å wave length reverses the effect of the red band. This reversible far red reaction affects a number of other growth phenomena in plants in addition to the photoperiodic reaction. These include germination of seeds, elongation of stems, expansion of leaves, germination of fern spores and the formation of certain pigments. Many of these growth reactions apparently can be reversed an indefinite number of times by alternately exposing the plant first to the effective red band, then to the effective far red band of light.

Temperature Effects on Growth.—Within limits a rise in temperature favours increased rates of elongation or enlargement of plant organs. The range of temperatures within which this occurs is usually higher in tropical than in temperate zone species, and higher in plants of the latter group than in subarctic species. In temperate zone species, the temperature range over which such an effect occurs approximates 40°–95° F. With further rise in temperature above the optimum, elongation or enlargement rates decrease, falling to zero at about 105°–115° F. The temperature most favourable for one stage of development of a plant is often not the most favourable for another stage.

Relatively low temperatures favour initiation of flowers in some species, relatively high temperatures favour flower initiation in other species, and flowers are initiated in still other species over a wide range of temperatures (H. C. Thompson, 1939). Celery plants which have been exposed to a temperature range of 40°–50° F. or 50°–60° F. for 10–15 days will develop flowers, fruits and seeds if subsequently grown at 60°–70° F., a range of temperatures too high for the initiation of flowering. On the other hand, lettuce plants (White Boston) develop flowers, fruits and seeds without forming heads if grown at 70°–80° F. Similar

plants grown at 60°–70° F. first form heads and subsequently go to seed. Other species for which exposure to a relatively low temperature seems essential to induction of flowering include rutabaga, onion, cosmos and stock; other species for which exposure to a relatively high temperature seems essential to induction of flowering include pepper, phlox and cleome.

Growth Correlations.—The influence of one part of a plant upon the development of another part of the same plant is called a growth correlation. The harmonious development of the plant body as a whole is controlled by correlative influences operating reciprocally from organ to organ, tissue to tissue, and cell to cell. Innumerable examples of growth correlations can be cited. A familiar one is the phenomenon of apical dominance. As long as the terminal bud on a woody stem remains intact or continues to grow, development of lateral buds, at least on the current season's shoots, fails to occur. If the terminal bud is injured or destroyed, however, development of the lateral buds usually ensues. Obviously the terminal bud has some sort of an influence on the lateral buds which prevents their development. Apical dominance also occurs in the growing shoots of herbaceous plants. When the terminal bud is removed from a broad bean and replaced with a block of agar gel containing auxin *b* or heteroauxin, inhibition of lateral bud development continues just as if the terminal bud remains intact. If the terminal bud is replaced with a block of plain agar, however, lateral buds begin to develop immediately. It is obvious that auxins play a role in apical dominance, but the exact mechanism of their action has not been worked out. Many, but not all correlative influences of one plant organ on another result from the action of growth substances. One part of a plant often has an influence on the relative quantities of certain foods, of mineral compounds, or of water which reach other parts of the plant, and correlative influences on growth often result from such effects. For example, if the nitrate supply is low, the root system of a plant is large in proportion to its top. Under such conditions absorbed nitrates are largely used in the synthesis of amino acids in the roots and these amino acids are used in protein synthesis accompanying root growth. Only small quantities of nitrogenous compounds escape utilization in the roots and are translocated to the tops. Hence the growth of the tops is checked by a deficiency of nitrates or amino acids, even though they may contain an abundance of carbohydrates, some of which are translocated downward and used in amino acid synthesis and other processes in the roots. If the supply of nitrates is more abundant, however, more nitrogenous compounds are translocated to the tops, where most of them are used in the synthesis of protoplasmic proteins. The resulting enhanced vegetative growth of the tops results in a greater proportionate development of the aerial portions of the plant as compared with the roots than occurs when the nitrogen supply is deficient.

Dormancy.—Many kinds of seeds, apparently mature, fail to sprout even when brought under environmental conditions favourable for germination. This state of internally inhibited growth of seeds or other plant organs is called dormancy. The following are the main causes of dormancy in seeds: (1) seed coats impermeable to water; (2) seed coats mechanically so strong that they cannot be ruptured by swelling of the embryo; (3) seed coats impermeable to oxygen; (4) seed coats containing a specific chemical inhibitor of germination; (5) embryos in a rudimentary state at the time seeds are shed; (6) embryos fully formed at seed maturity but in such a physiological condition that they will not develop further until they have passed through a period of "after-ripening." More than one of these conditions is present in some kinds of seeds. Methods of "breaking" the dormancy, or at least shortening the period of dormancy, have been devised for a number of kinds of seeds and are of considerable practical utility. The method used with a given kind of seed depends upon the cause of dormancy in that particular seed.

The phenomenon of dormancy is also exhibited by buds. The buds on stems of woody temperate zone species ordinarily do not develop during the summer in which they are formed, even under favourable environmental conditions. This condition of dormancy is maintained in most such species until the following autumn or winter. Exposing stems to vapours of ether, ethylene chlorohydrin or ethylene dichlorid is an effective method of breaking bud dormancy in many woody species. The buds of many kinds of tubers, rhizomes, corms and bulbs likewise may remain dormant for a considerable period. Freshly harvested potato tubers, for example, ordinarily do not sprout at once because of bud dormancy. The duration of dormancy in potato tubers can be greatly curtailed by treatment with certain chemicals.

Vernalization.—This term refers to a low-temperature treatment given seeds before sowing which results in shortening the time until flowering of plants that develop from them. Less commonly, it is also applied to treatment of seeds at relatively high temperatures, or to temperature treatments of plant organs other than seeds (H. H. McKinney, 1940). Although seeds of a number of kinds of plants can be vernalized, this technique is employed principally with cereals, and especially with winter wheats. Vernalization of the grains of a winter wheat so speeds up the completion of its life cycle that it can be grown as a spring wheat. Grains of the Turkey Red variety of winter wheat, for example, are vernalized by soaking to a moisture content of about 60%, which just permits initiation of germination, holding them at approximately that water content, and exposing them to a temperature of 33°–37° F. for 9–10 weeks before sowing. The plants developing from these seeds reach the heading stage in 110–120 days from the beginning of the cold treatment. Unvernalized seeds of the same variety require 150 days from sowing to attain the same stage of development in the same environment. This effect of low temperature treatments on pre-germinated seed, now called vernalization, has been known for many years, but gained new prominence beginning about 1930 because of its advocacy as a practical measure by Russian agriculturalists. Because of the particular climatic conditions prevailing over large portions of the U.S.S.R., the vernalization of winter wheats has proved an advantageous agricultural procedure in some parts of that country. In other parts of the world, however, vernalization has not proved to be a practice of commercial value.

H. Plant Movements

The existence of autonomous movements in plants usually escapes notice because most of them occur too slowly to permit their detection by casual observation. That movements of plant organs actually do occur can be readily confirmed by a series of observations of certain plant organs under suitable conditions. The reality and vigour of plant movements can also be demonstrated strikingly by time lapse motion-picture technique in which pictures of the moving plant organs are taken at relatively long intervals and the resulting film projected at such a speed that the movements are greatly accelerated. Most movements in the vascular plants may be classified into growth movements or turgor movements.

BY COURTESY OF SMITHSONIAN INSTITUTION; PHOTOGRAPH, O. DENNISON

FIG. 20.—PHOTOTROPISM IN THE FRUITING BODY OF A FUNGUS

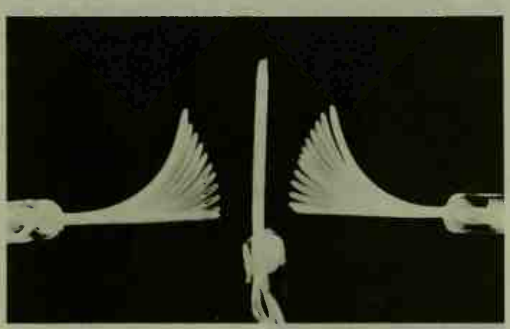
Multiple exposure, taken at a rate of one exposure every four minutes, shows the sporangiophore oscillating between two light sources

Growth movements, many of them curvatures of plant organs, result from differential rates of growth. Growth movements may be classed as tropic movements, nastic movements and nutations.

1. Tropisms.—Tropic movements such as phototropism and geotropism occur under the influence of an environmental factor acting with greater intensity from one direction than another.

Phototropism.—When a plant, such as a potted plant on a window sill, is illuminated more strongly on one side than on others, the stems usually bend toward the brighter light. Two mechanisms of this phenomenon of phototropism have been recognized. One is a retarding effect of light on the elongation of the cells. Hence the cells on the more brightly illuminated side of the stem elongate less than cells on the opposite side, and the stem bends toward the light. The other mechanism of phototropism has been studied principally in the coleoptiles of grasses. Charles Darwin showed many years ago that, although bending occurs in the basal portions of a coleoptile, shading its tip with a tin-foil cap prevents curvature of the coleoptile when unilaterally illuminated. Detipped coleoptiles likewise evince little or no phototropic reaction. Bending of the basal portions of the coleoptile is, therefore, subject to a controlling influence of the tip. Subsequently it was shown that auxin in the tip of an oat coleoptile migrates laterally across the tip from the more strongly illuminated to the shaded side. Some inactivation of auxin on the illuminated side may also occur. Since downward translocation of the auxin is almost strictly longitudinal, the cells on the shaded side of the coleoptile receive more auxin than those on the lighted side. The cells on the shaded side therefore elongate more than those on the illuminated side, and the coleoptile bends toward the light.

Geotropism.—If a potted plant be placed in a horizontal position, the stem bends upward away from, and the root bends downward toward, the force of gravity. These are examples of



"LIFE," © 1963, TIME INC.

FIG. 21.—MULTIPLE EXPOSURE OF OAT COLEOPTILES ILLUSTRATING GEOTROPISM. GRAVITATIONAL REDISTRIBUTION OF HORMONES CAUSES THE TWO SEEDLINGS SET HORIZONTALLY TO GROW UPRIGHT LIKE THE CENTRAL VERTICAL SEEDLING

negative and positive geotropism, respectively. In a horizontally oriented oat coleoptile, auxin migrates from the upper to the lower side of the tip and thence longitudinally in the usual manner. The greater concentration of auxin on the lower than on the upper side induces greater elongation of cells on the former, and the coleoptile bends upward. In a horizontally oriented root tip, auxin also migrates from its upper to its lower side. Elongation of root cells is favoured by much lower concentrations of auxins than favour elongation of coleoptile cells, and root cell elongation is retarded at all higher concentration. A relatively high auxin concentration on the lower side of the root therefore results in a smaller elongation rate of the cells on the lower as compared with the upper side, and a downward bending of the root results.

2. Nastic Movements and Nutations.—Nastic movements are those in which the direction of the movement is limited by the structural symmetry of the plant organ. The more rapid growth of the upper side of a plant organ such as a leaf or flower part is called epinasty; the more rapid growth of its lower side hyponasty. Opening of flowers is caused by epinastic movements of the sepals and petals; closing of flowers, such as occurs in some species at night or at low temperatures, results from hyponastic movements of the floral parts. Careful observation of a growing stem tip reveals that it does not grow straight ahead through space, but moves in an irregular spiral pathway as it elongates. Such growth movements are called nutations.

3. Turgor Movements.—Turgor movements are those caused by reversible changes in cell volume. Many such movements result from turgor changes in structures called pulvini, located at the base of the blade or petiole, or both in some kinds of plants. The well-known and spectacular reactions of the sensitive plant result from turgor changes in cells of pulvini located at the base of the petiole and the base of each leaflet.

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V. PLANT ECOLOGY

Plant ecology is the science which deals with the interrelationships between plant life and environment. It is a segment of general ecology, the empirical basis of which lies in the common observation that living organisms vary with environment, and whose deeper foundations rest upon the fact that life and environment are inseparable parts of a greater whole. Other aspects of general ecology are animal ecology, human ecology and bioecology, which is defined provisionally as the ecology of plant and animal interrelations. Actually, plants, animals and men are so intimately associated that it is seldom possible for the ecologist to confine his attention to any one of them, although each special field has its own core of knowledge and technique.

This last statement can be emphasized by noting the following subdivisions or facets of plant ecology: (1) autecology, the relation of the individual species or plant to its environment; (2) floristics, the distribution in time and space of the various kinds (*i.e.*, species, genera, etc.) of plants; (3) ecological plant geography, the distribution of plant communities; (4) plant sociology, or synecology, the characteristics of plant communities; (5) ecological measurement or habitat analysis, the analysis of the nonliving environment; (6) applied plant ecology.

Throughout the following discussion of these phases of ecology

it should be kept in mind that earth, atmosphere, individual organism and communities of organisms all represent dynamic systems, or processes, whose mutual interplay is the concern of the ecologist.

A. Environment and Species (Autecology)

This subject deals with the types of plant structure and behaviour characteristic of different habitats, and the capacity of plants to adjust themselves to various conditions. These are problems of structure and behaviour as well as of ecology, hence they involve the techniques of morphology and physiology. Genetics is also involved, since the attributes in question depend upon the inherited make-up of the individual.

1. Habitat and Structure.—It is a matter of common observation that plants of arid regions are gray, thick-leaved or leafless, succulent and often thorny, in contrast to those of humid regions which have delicate, bright green, abundant foliage. Every gardener is familiar with the fine texture of lettuce or tobacco leaves grown in moderate light, as against the woody, coarse leaves produced in strong sunlight. Travelers have also noted the rapid decrease in height of wheat and corn in passing from Iowa to Colorado. In a given field of alfalfa, some plants will be killed by winter temperatures which leave others unharmed, partly through local differences in soil moisture, etc., but also in part through inherited differences in different individuals. A field of cabbage or flax may be swept by disease which kills some plants, leaves others unharmed. Such are a few of the countless problems with which autecology must deal.

Every species of plant inherits certain potentialities of adjustment to external conditions. The range of tolerance may be wide or narrow, and differs as regards different factors. The dandelion, which occurs under a wide range of temperature and moisture conditions, has been observed to bloom during ten months of the year at Lincoln, Neb. But along the shore of Lake Michigan it thrives only on clay or where lime-bearing clays are mixed with beach sand.

Within the species are to be found varieties with special limits of tolerance. Upon these, as upon the species, environment may act selectively, eliminating in one place, sustaining in another.

A given factor, such as temperature or moisture, does not always act in absolute fashion. The reaction of a plant with respect to it may vary with other conditions. Thus by regulating water supply, etc., a plant may be hardened to resist cold.

2. Plant Adjustments.—Autecology also considers the numerous specialized adjustments of behaviour between different species of plants, or between plant and animal species. Into this category fall such problems as insect pollination, parasitism and mutual relations between legumes and nitrogen-fixing bacteria.

The course of organic evolution has led not merely to increased specialization of animals and plants, but to increasingly specialized relations between and among species of both. Thus the class of insects, although older than flowering plants, has developed to its present amazing complexity (over 500,000 species) along with the flowering plants, with which insects sustain a wide variety of intimate, often mutual relationships. Unquestionably the development of the flowering plants has been, in its turn, profoundly affected by the activities of these invertebrates. Similarly, the rise of hoofed grazing animals was conditioned by the evolution of grasses and the consequent origin of great continental steppes. The grasses, in turn, have become adjusted to grazing as a factor in their normal environment.

Among the interrelations of plants none is more important than competition. The consequences of competition are evident in all plant communities, but the source and means of competition are a part of the subject matter of autecology. The general principle involved is that the intensity of competition increases as requirements become more nearly alike. This implies that competition should be most intense between individuals of the same species, which have practically identical requirements. Especially is this true of plants, since mutual benefit within the species does not appear so clearly among plants as among animals. Some measure of the intensity of competition can be seen in any normal woodland by comparing the density of seedlings, saplings and mature trees of any species. A single mature tree is likely to be the sole survivor of many thousand seedlings. Since the most critical competition is for light, water and soil nutrients, the ultimate adjustment among individual plants is attained through spacing, both of roots and tops. Secondary species commonly root at shallower depths and branch at lower levels than dominant forms.

The absence of mutual aid within the plant species is compensated for in part by the usually prodigious output of reproductive bodies, *e.g.*, seeds, and by the development of often highly specialized means of dissemination, whose study is an important phase of autecology. Seed transport by wind, water and animals is a phenomenon familiar to anyone with the slightest knowledge of plants, and often attains great effectiveness. Hard seeds of edible fruits not only pass through the digestive tract of animals without injury, but may actually germinate better for doing so. The eccentrically weighted fruit of maple acquires in falling a spin which may project it to a considerable distance from the parent tree. The coconut, although it cannot germinate after prolonged immersion in salt water, appears to have been transported, by ocean currents, to every oceanic isle capable of growing it.

The term adaptation is frequently used with respect to autecological adjustments. It should be employed, however, in such a way as not to confuse (1) the fitness of plants which have become adjusted by selection to a given environment; and (2) the plastic adjustments which a given species can make to variations within an environment to which it has long since been generally fitted by selection.

Autecology has numerous practical applications; *e.g.*, in the selection of drought-, frost-, and disease-resistant varieties of economic plants. It is also of value in diagnosing the character of a habitat under conditions where instrumental studies are not available. Commercial use has been made of it in selecting sweet corn strains with very tight husks through which the larvae of the European corn borer cannot penetrate to the tender grains within.

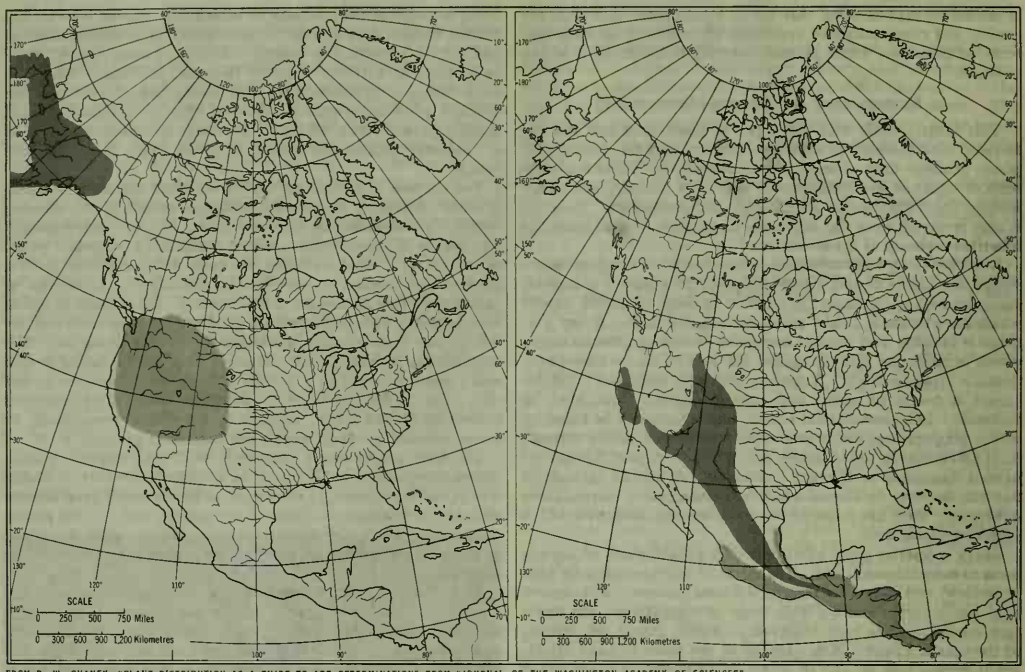
B. Regional Floras (Floristics)

With the possible exception of certain microscopic plants, every species has a limited and characteristic range, although there is wide variation among species in extent and continuity of their range. The same statement may be made of larger groups, the genera and, to a considerable degree, of families. Groups with greatly restricted range, such as the genus *Sequoia* which is confined to California, are known as endemic. The opposite extreme is represented by cosmopolitan forms such as the common dandelion.

1. Pattern of Distribution.—The pattern of distribution of plant families and their subdivisions finds its explanation in terms of organic evolution and subsequent migration. This migration, in turn, has been subject to changing conditions of earth, climate and biological influence. Theoretically, the older a group, the more extensive should be its distribution; but this principle is subject to so many modifications that every instance has to be investigated on its merits. For example, the present genus *Sequoia* referred to above was once widespread.

Thus a study of floristic patterns must take account of the past as well as the present. It draws upon geology and climatology for explanations, and in turn is a source of valuable clues to students of these subjects by suggesting the position, in time and space, of pathways and barriers. These latter are dependent upon changes of land and water area, changes in land elevation, and shifts in climatic centres.

The term continental pairing is sometimes employed to describe the rather frequent appearance of a genus, or even a species, on two continents. Thus closely related forms are to be found in eastern Asia and in North America—a fact correlated with the existence of a land bridge in the Bering region and a uniform, favourable circumpolar climate. Similar relationships exist between the floras of Europe and North America and those of Asia and Africa.



FROM R. W. CHANEY, "PLANT DISTRIBUTION AS A GUIDE TO AGE DETERMINATION" FROM "JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES"

FIG. 22.—DISTRIBUTION OF SUBTROPICAL AND TEMPERATE FOREST UNITS DURING THE CENOZOIC ERA OF WESTERN AMERICA (BEGINNING ABOUT 70,000,000 YEARS AGO)

(Left) Eocene epoch; (right) recent epoch. In both maps, the lighter area indicates a subtropical, and the darker area a temperate forest

On the other hand, members of families common to Africa and South America, or to Australia and other continents of the southern hemisphere, exhibit more distant relationship and hence point to more remote opportunities for migration and to barriers of greater antiquity. These facts are parallel with data obtained from animal distribution—for example, the relatively ancient separation of old and new world marsupials and primates.

2. Factors Influencing Distribution.—The most obvious climatic influence on plant distribution is that of temperature. Few species of seaweeds, if any, have a zone of distribution exceeding a difference of ten degrees in mean annual isotherm. Land species are subject to similar limitations, plus those caused by differences in supply of available moisture. Hence continental desert areas may form barriers as effective as mountain ranges or seas.

Numerous biological factors also influence migration of plant species. Apparently the *Yucca* (*q.v.*) will tolerate a wider range of conditions than the *Pronuba* moth which is essential to its pollination and seed formation. Thus its natural range is limited to that of the symbiotic insect. Again, the evolutionary development of more efficient species will drive older, less efficient species from areas to which they are well adjusted, and hinder their return. This is exemplified in the relation between conifers and deciduous trees in the humid temperate parts of the northern hemisphere. The former, though quite capable of growing in such regions, have been relegated to the less productive margins. Also, the presence of lethal parasites may exterminate a particular species throughout a portion of its natural range especially favourable to the parasite, and thus establish a lacuna or barrier.

The reciprocal relation between human cultures and plant species is of extreme importance. The three great centres of primitive agriculture—eastern Asia, Asia Minor and Central America—are correlated with the original location of three grasses—rice, wheat and maize, respectively. In the subsequent migrations of these and other economic plants, and of numerous ruderals, is to be found much of the record of the shifting of human cultures.

While the subject of floristics deals with the distribution of all species of the plant realm, the greatest interest attaches to seed plants, which are the dominant forms of modern plant life. Considerably more than half the known families are represented within the tropics, which have afforded more or less continuous refuge during periods of climatic stress in more temperate regions. Flowering plants, well established during the Cretaceous, evolved into a wealth of species during the ensuing Tertiary and became widely distributed during that period of comparatively widespread favourable climate. Present patterns of distribution of this great group and the somewhat older conifers are largely the result of the impact of glacial Pleistocene conditions upon this Tertiary pattern.

Pleistocene glaciation involved at least four major advances of continental ice sheets, with three more or less prolonged interglacial periods. The comparatively brief time since the last retreat (about 15,000 years), although usually referred to as postglacial, has exhibited some of the qualities of an interglacial period, and at no time since the Tertiary have the mild conditions of that period been attained.

During the Tertiary a remarkably rich temperate flora had become diffused to high latitudes in both hemispheres and may properly be described as circumpolar. This flora was compelled to retreat toward the tropics by the advance of Pleistocene ice. With each glacial recession some of the lost territory was reoccupied, to be lost again with successive advances of the ice. The effect of this upon the Tertiary flora was less disastrous in North America than in Europe, where southerly retreat encountered obstacles, and where now the deciduous forest flora is relatively poor in species.

Glaciated portions of the northern hemisphere exhibit three

groups of disjunct species of great interest: (1) boreal species in now temperate southerly regions; (2) southern plants occurring in isolated stations north of their present main range; and (3) continental steppe or grassland species in more humid or oceanic regions than they normally occupy. The boreal species, notably bog plants, are now usually regarded as true relicts left behind following the last glacial retreat. The northern outliers of southern plants are still a subject of controversy. One school holds that they represent vegetation which persisted in place on non-glaciated elevations or nunataks throughout glaciation. Critics of this belief hold that this was impossible, questioning the nunatak nature of the areas in question and also the ability of southern plants to survive the glacial climate. Both botanists and geologists are divided in opinion.

In view of this problem, the third group of disjunct species takes on considerable interest. There is a growing belief that they represent relicts from a postglacial time that was warmer and drier than the present—a so-called xerothermic period or periods. Given such climatic conditions and a suitable pathway for migration—for example, the formerly elevated but now submerged Atlantic coastal shelf—southern plants may well have moved northward, leaving relicts behind them during the subsequent cooling and subsidence. At any rate evidence is accumulating from a variety of sources, including modern glaciers and microfossils in peat deposits, to substantiate the existence of postglacial xerothermic conditions.

While the chief contributions to floristics are made by students of plant classification (taxonomy), the knowledge itself is an essential segment of ecology. For example, composite maps of the ranges of characteristic plants of great formations reveal with clarity the dynamic centres of climate and plant distribution in such regions as the eastern deciduous forests and tall-grass prairies of North America and the Mediterranean zone of Europe.

Moreover the Danish botanist C. Raunkiaer has developed a method of climatic analysis through floristic lists of any region. He has classified plants according to the depth of burial or height of exposure of their delicate perennial growing points. Each species falls into a definite category according to the degree of exposure or protection, and the percentage of species in each category constitutes what he calls the "biological spectrum" of a given regional flora. By comparison with a standard spectrum which he devised, inferences may be drawn concerning the climatic characteristics of a region whose flora has been thus analyzed.

C. Ecological Plant Geography

Much that has been said concerning the distribution in space and time of species will apply to communities of plants as well. For a discussion of the nature of communities, see *Plant Sociology* (*Synecology*) below.

Major Communities.—The major communities of the earth can be grouped roughly as follows: (1) tundra, or treeless, largely moss and lichen vegetation found in the arctic and above timberline on mountains; (2) taiga, or coniferous evergreen forest, ranging from sparse and stunted to dense and thrifty, characteristic of cool regions bordering the tundra; (3) forests of other types, including temperate-deciduous and evergreen forests, tropical rain forest and tropical monsoon (deciduous) forest; (4) grassland, including subhumid and dry steppe or prairie and shortgrass; (5) scrub, or woody, semiarid shrub vegetation; (6) desert. Transitions of course are common—for example, savanna between forest and prairie.

The major communities are known as formations. They are regarded, with reason, as expressions of major climatic types. Allowance must be made, however, for variations caused by physiographic conditions which modify the impact of the general climate, thus producing microclimatic differences, and for soil (edaphic) conditions which modify the availability of water and nutrients or impose unusual chemical limitations.

For such reasons, the actual boundaries between formations are seldom smooth and unbroken. Rather they are lobed and interdigitated, resembling peninsulas and chains of islands. As Asa Gray put it, there must be debatable borders between regions where slight incidents will throw the balance either way. Climates fluctuate in the intensity of their expression from year to year, and consequently in their marginal effects.

Rapid increases in elevation result in a telescoping of climates within comparatively small areas. Thus in ascending a mountain one may pass through plant communities expressing climates which on level terrain might encompass many hundreds of miles.

Any map of world formations must be generalized to a high degree, yet inspection of such a map reveals the transitions from extreme oceanic to extreme continental climates except in circumpolar regions where temperature becomes the limiting factor. The failure of such maps, in temperate and tropical regions, to correlate more exactly with conventional rainfall maps is caused by evaporation, a quantity not generally measured by the meteorologist, but one of critical importance to vegetation.

Ecological plant geography is a subject of the highest utility in its bearing upon world resources and industries and in its indication of proper types of land use and management. It is likewise a factor in military strategy.

D. Plant Sociology (Synecology)

In its broad sense this term is equivalent to synecology, or the study of vegetation rather than the individual plant, or the physical factors of the environment. It is sometimes employed to indicate particular techniques of statistical study. Whereas flora represents the sum total of plant species, vegetation refers to the aggregate of plant life in terms of the communities into which it is organized. Beginning with the great formations already referred to, vegetation may be subdivided into communities of descending rank and of distinctive character at each level.

Difficult problems of nomenclature and classification are involved here, including the old Aristotelian problem of the specific thing and the form which it represents. The deciduous forest of eastern North America may be designated as the oak-beech formation, which in turn includes the maple-beech, oak-hickory, and oak-chestnut associations. These associations again may be divided into faciations (white oak–black oak), consociations (bur oak), and these latter into societies of subordinate species. More formal systems, involving Latinized terms, are also employed. In general the more refined a subdivision, the more homogeneous its character.

1. Community Structure and Evolution.—The attributes of a plant community are structure (the growth forms present—*e.g.*, trees, shrubs, grasses—and their relative arrangement), composition (the species present), and development (life history or succession). Thus a forest is dominated by trees of one or more species, the individuals exhibiting definite spatial relations to each other. In the environment thus controlled, characteristic undershrubs, seedlings, vines and herbs occupy suitable niches. Equally essential, although less conspicuous, are the fungi and bacteria which utilize the materials formed by the dominant vegetation and by decay return these materials for re-use by green plants. Characteristic parasites and symbionts are also part of the community structure, and so are its animals as well. Such a structure may vary greatly in floristic composition, depending upon the species present in the region. The deserts of Asia and North America are similar in structure, but composed of different plant families.

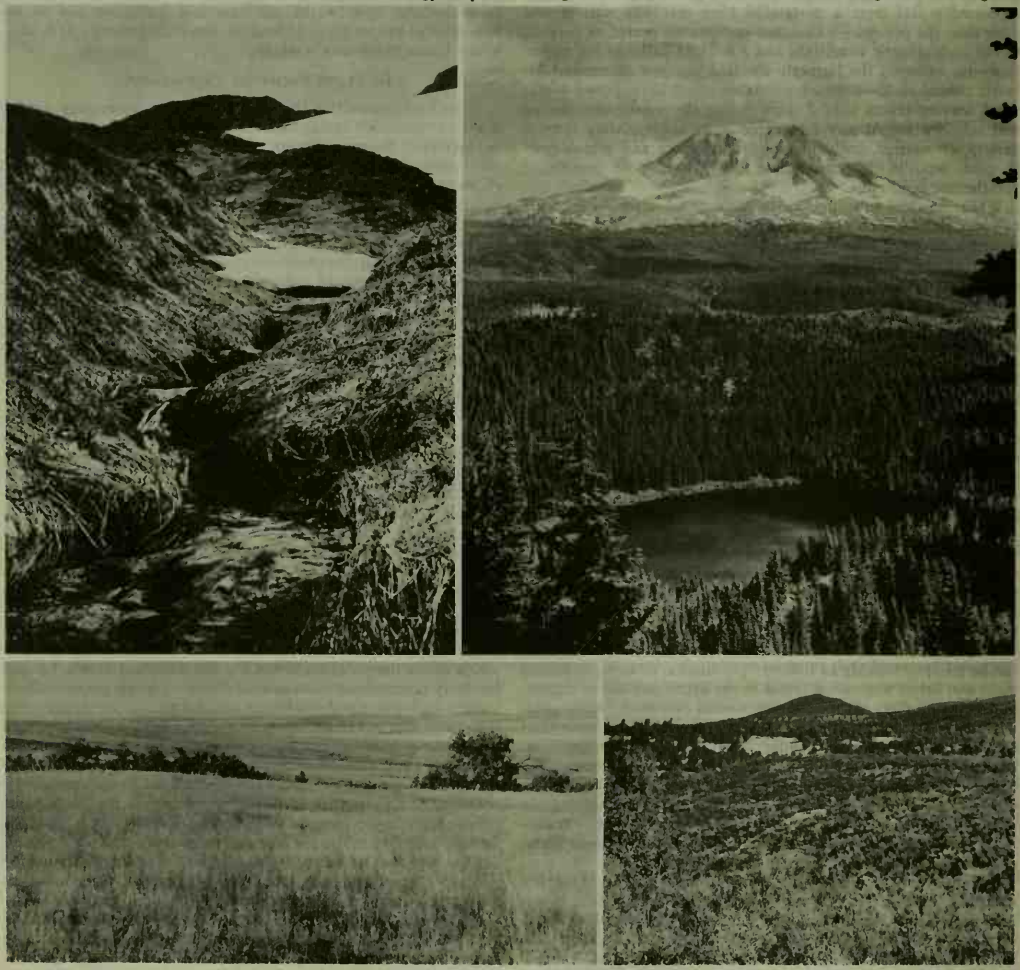
One of the most fruitful discoveries in connection with plant communities is the fact of succession or development. This can be simply illustrated by the changes which occur on an abandoned field, a bare rock surface, or a sand dune from the first invading pioneers to the final stabilized forest or prairie. Succession involves change in both structure and composition and moves toward a condition of relative equilibrium characterized by little change in either respect, and known as a climax community. The test of a climax community lies in the ability of the species composing it to reproduce themselves under the conditions which they so largely determine. Pioneer and subclimax species do not have this power. In principle a climax community, once established, maintains itself unless disturbed by physiographic, climatic, or biological (biotic) change. Such disturbance for example would result from serious erosion, uplift or depression, shift in available

moisture or temperature patterns, evolution or immigration of new species, fire, clearing, drainage, disease, etc.

Succession represents a process of increasing integration between life and environment. It apparently tends to follow the principle of Le Chatelier as developed by Bancroft; *i.e.*, heterogeneous systems tend progressively toward a condition of minimum disturbance by external forces and internal stresses. So far as the somewhat limited evidence goes, succession also tends toward a progressively more efficient use of energy. The climax community is a close-knit and delicately balanced system which stores and uses solar energy. So intimately adjusted are the nutrient and reproductive cycles of its constituent organisms that the minimum of useful energy is wasted in the chain of metabolic relationships. Thus the climax community represents the maximum in organic economy, as contrasted with the extreme of energy waste in a bare area which receives solar energy only to dissipate it into space without benefit to living organisms.

Representing thus the maximum capacity of a landscape for sustained production, the climax community affords a scientific norm of great value to man in the planning of land use and management and, by analogy at least, in the organization of his own communities. For this reason, quite as much as for sentimental and aesthetic considerations, it is important that in civilized and heavily populated areas substantial remnants of natural vegetation should be set aside, preserved and permanently protected from disturbance. Such reserves or nature sanctuaries are to be distinguished from parks set aside for recreation, and from public forests managed for economic yield.

There is, unfortunately, some difficulty among ecologists in arriving at an agreement regarding the exact meaning of the word climax. For practical purposes the climax plant community might be regarded as the limit toward which the vegetation of a given



(TOP RIGHT) BY COURTESY OF THE U.S. FOREST SERVICE; (TOP LEFT, BOTTOM LEFT AND BOTTOM RIGHT) FROM LYMAN BENSON, "PLANT CLASSIFICATION," © 1957; REPRODUCED BY PERMISSION OF D. C. HEATH AND COMPANY

FIG. 23.—FOUR MAJOR ECOLOGICAL COMMUNITIES

(Top left) Western American alpine tundra at 2,000 ft. in the mountains of Kodiak Island, Alaska. In mid-July snow-fed rivulets support rapid-growing, low perennials during short season after thaw. (Top right) Taiga: Sierran subalpine forest in the Cascade mountains, Wash. Close to the tree line, shown clearly here against Mt. Adams, pine, spruce and fir predominate. (Bottom left) Plains grasslands in northeastern Wyoming. (Bottom right) In the foreground is semiarid scrub vegetation of the California chaparral including chamise shrubs; associatad California oak woodland is seen in the upper middle ground of this photograph

climatic area and a given evolutionary composition tends. This definition is chiefly convenient because the changes in climate and evolution are slow in terms of human experience. Against them as a background, succession involves the operation of three other dynamic processes: (1) changes in the landscape; (2) soil development; and (3) biological interaction.

2. Changes in the Landscape.—The youthful landscape is typically marked by strong contrasts of elevation, which for a time are increased by the rapid downcutting of narrow stream valleys. This tends to diversify the effect of climatic conditions, producing extremes of shelter in ravines and depressions, of exposure on uplands, and marked differences in available soil moisture throughout. As topography matures, valleys widen, depressions fill and uplands are lowered, thus lessening the initial contrasts. The limit of this process is represented by the peneplain, a generally uniform physiographic system over which local modifications of climate are at a minimum. Until this mature stage of topography is reached, the stability of any community within the landscape is provisional, and its climax character is relative, subject to completion of the erosion cycle.

Actually the peneplain condition is not often attained. Tilting, warping and uplift often interrupt the orderly progress of the erosion cycle, rejuvenating the landscape and interrupting the course of plant succession. Morever, the rate of erosion and deposition is significantly modified by the presence of vegetation. This can be observed by comparing the sharp and rugged topography of a thinly clad desert or semiarid terrain with the gently rounded hills of a heavily vegetated humid region. By removing natural vegetation and substituting clean-tilled fields, man has become a prime agent of geological change, inducing as much erosion in a few decades as might occur in a millennium under natural conditions.

3. Soil Development.—Soil represents not merely the finely divided rock of the earth's surface, but the underground extension of community action and influence. This activity results in a physical, chemical and biological organization of the soil of which the structural expression is the soil profile. The soil profile is studied by means of trenches, or along road and stream cuts, and accurately records the character of the particular climate and vegetation. Thus a forest soil profile is characterized by a thin, very rich and acid surface layer of black humus formed by the fungus decay of fallen leaves and other organic debris. Beneath is a light layer from which the acids have leached soluble mineral material, and below that the layer occupied by tree roots, from which they draw mineral nutrients that are subsequently dropped on the surface by falling leaves, branches, fruits, etc. By comparison, a grassland soil profile exhibits a dark humus layer often 36 in. or more in thickness, measuring the depth of penetration of the abundant fibrous roots and the accompanying microorganisms and fauna. In consequence of these differences cleared woodland soil quickly loses its shallow, rich surface layer with careless handling, while prairie soil can endure longer periods of exploitation. The latter, on every continent, is particularly suited to cereal production, and from it comes the bulk of such staple foodstuffs.

Thus the soil profile is an expression of the energy which activates the living community, and the organization of the profile indicates the capacity of the area to sustain life under current conditions. It should be noted that this organization represents an accumulation of solar energy, manifesting itself in the accumulation and mobilization of materials, and facilitating the work of living organisms. The accumulated energy in soil is analogous not so much to the power which runs a factory, as to the energy used in its construction and equipment. Soil development is clearly a most important phase of community succession. And in the same way that physiographic processes tend to minimize the initial differences of a given climatic area, soil development tends toward uniformity throughout such an area.

4. Biological Interaction.—The influences of vegetation and habitat are mutual and continuous. Yet it may be said that the influence of the physical environment is at a maximum under pioneer conditions, while that of vegetation is greatest at climax. The pioneers in a new or raw habitat usually encounter extremes of physical and chemical conditions, and frequently violent fluctuations in those conditions. For example, successful pioneer plants must be adapted to withstand high intensities of light usually characteristic of such habitats. But these plants produce shade, which is unfavourable to their own seedlings, and they are replaced by species more tolerant of shading.

Pioneer habitats likewise often present extremes of moisture or dryness. The growth of pioneer plants, adjusted to such extremes, increases humus and modifies the local water balance, a circumstance which operates in favour of plants which, while less hardy than the pioneers, are much more efficient than their predecessors under the new conditions which those predecessors have brought about.

An exceedingly important aspect of this process is the role played by animals and microorganisms, through competition and through the mutual adjustments between dominant and secondary species belonging to the same stage of succession. Like the processes of physiographic change and soil development, biological interaction is convergent in character, leading from initial heterogeneity to ultimate homogeneity. Thus, in the north central states, such varied habitats as dunes, ponds, bare rock and clay ridges have their distinctive pioneer vegetation. Each passes through a characteristic sequence beyond this stage, approaching in structure and composition the beech-sugar maple forest—a relatively stable and self-perpetuating community. Numerous instances are on record of beech-maple climax forests which have developed on each of these types of initial areas; on the other hand a lag in physiographic change or soil development may arrest the sequence for a long period at some subclimax level. Thus the moist shaded northern face of a steep hill may reach the climax condition while the hot dry southern exposure remains covered with the subclimax oak and hickory.

Problems of technique in the field of plant sociology have been quite as troublesome as those of nomenclature. Mapping, both topographic and two-dimensional, is of course essential. Aerial photography has been an invaluable aid.

Within the community itself the problem of expressing quantitatively the relationships which exist is extremely complicated. In addition to relative abundance of various species, their cubic magnitude, both above and below ground, may be significant. Typical concepts used are frequency, coverage, constancy, presence. Since the end of quantitative study is always a qualitative judgment, the choice of particular techniques of counting and measuring varies widely with workers and with the nature of the communities studied. Thus in grassland and herbaceous communities the use of standard quadrats, or squares of uniform size for sampling and comparison, has been extensively developed. In forest regions quadrats of larger size are necessary to give adequate sampling.

Since plant succession is at best a slow process, it must ordinarily be demonstrated by a combination of more or less indirect and inferential methods. Prevalence of vigorous juveniles of species different from the existing dominants is strong evidence of the direction of succession. The zonal distribution of plants, as, for example, about a senescent lake, often indicates the sequence of advance of land vegetation into the lake bed. Comparison of numerous related communities in different stages of development is also a fruitful method. Records, whether paleobotanical, archaeological, or historical, often afford valuable clues. Direct proof is increasingly afforded by the growing length of scientific records.

E. Nonliving Factors of the Environment

1. Ecological Measurement, or Habitat Analysis.—These terms are employed in the absence of better ones to designate evaluation of the nonliving factors of the environment. The ecologist here depends upon techniques borrowed from sciences which deal with earth and atmosphere. Not infrequently he contributes to these sciences in return, as is evidenced by the growing attention given to evaporation by meteorologists.

It is an axiom that the living community is the most perfect

expression of integration of the physical environment. This has led to considerable use of plant communities as indicators of conditions which cannot conveniently be measured otherwise, as for instance, depth of water table. Individual species are also used as indicators.

It is essential, however, that the physical environment be understood as accurately and completely as possible. This is well exemplified by the problem of the North American prairie. For a century able scientific men had propounded explanations as to the absence of trees on the prairie. More than a score of theories were advanced, including such suggestions as fire and soil. It was not until after 1910, and then as a result of patient instrumental studies, that proof was obtained that the lack of available moisture is the limiting factor for tree growth in the main body of the grassland. This had been frequently surmised, but never before established.

For the greatest value, ecological measurements should be continuous and inclusive. Light, humidity, precipitation, temperature, evaporation, wind movement and direction are the atmospheric factors most important. Moisture, temperature, texture and chemical composition are the corresponding soil properties. Automatic recording instruments, such as the hygrothermograph, must be employed, supplemented by frequent determinations for such factors as are not adapted to automatic measurements.

The earlier ecological methods of studying light only measured the intensity of actinic rays. Improved means are now available which measure both intensity and quality for a wide range of the effective spectrum. Also important is the photoperiod, or relative length of day and night. Measurements for evaporation have until recently given only relative figures, which could not be integrated with rainfall data. Improvements under way promise to give means for direct and absolute determination of the evaporating power of the air.

2. Limiting Factors.—In the study of environment the principle of limiting factors must constantly be borne in mind. It is empirically expressed in the proverb "a chain is no stronger than its weakest link," and was recognized by Baron Justus von Liebig in his study of soil fertility by his "law of the minimum." In 1905 it was placed upon precise experimental basis for plant metabolism by F. F. Blackman, who stated that the rate of photosynthesis was conditional upon the least favourable of the several factors necessary. Depending upon local conditions, moisture, acidity, nutrients, temperature, light, etc., may be the controlling or limiting factor in a given habitat for given plants. The object of much ecological measurement is to determine limiting factors.

Ecological measurement has been sufficiently perfected to give material aid in predicting the hazards to be encountered in critical areas under various types of land use and management. This technique can be of the greatest economic importance in semi-arid regions, such as the high plains of North America.

F. Applied Plant Ecology

Illustrations of the economic uses of ecology have been given in the preceding sections. With few exceptions, however, such applications have been sporadic. At the first Imperial Botanical conference, held in London in 1924, systematic plans were laid for the employment of ecology in developing new parts of the empire. With the encouragement of Gen. Jan Smuts, this conference has borne fruit in Africa. The Russians have made intelligent use of ecology, although there is reason to believe that parts of the steppe area have suffered unduly from exploitation. The United States department of agriculture, including the soil conservation service organized in 1935, is making increasing use of ecology.

Yet it is probably fair to say that among public men, and among the general population, there is yet little realization of the basic importance of this subject in establishing permanent and healthful relations between landscape and population.

In the problems of land use and management, ecology occupies a role analogous to that of physics and chemistry in modern industry. Such problems must increasingly be solved by the rigorous application of the principles of ecological science.

Man is the beneficiary not only of a prolonged process of organic evolution which has provided him a great variety of useful plants and animals, but of prolonged and continuous activity by plant and animal communities. This has resulted in the development of fertile soil, as well as in forests and grasslands whose products are no less essential to man than those of his cultivated fields. Moreover, natural vegetation maintains a cover which stabilizes the earth beneath him and retards the violent action of erosion.

Natural communities are characterized by a positive or favourable energy budget. Many, perhaps most, areas controlled by man are exploited, resulting in a negative energy budget, the final mark of which is unproductiveness and abandonment. The fundamental problem of applied ecology therefore is to assay various landscapes occupied by man and determine whether they are registering a net loss or gain in efficiency. The simple criterion of cash returns cannot be applied here. The next problem of the ecologist is to assist in devising methods of land use suited to the character of the locality so that a favourable energy budget may be maintained or restored.

Because of the character of our political system and our long habit of using science chiefly where immediate problems of health or profit are involved, the fundamental application of ecology cannot be hastily achieved. In practice, however, growing numbers of civil servants—foresters, county agents, agricultural engineers, entomologists, etc.—are acquiring some understanding of ecology. The same thing is true to a lesser extent of farmers and farm owners. As this knowledge becomes more general, it will materially affect practice and planning, and has in fact already done so in favoured localities.

In the field of land management, or actual operation, ecology also has important functions, some of which have been suggested in preceding sections.

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VI. IMPORTANCE OF PLANTS TO MAN

Man and other animals exist ultimately because plants exist. Plants are the basic food manufacturers: they gather up water, minerals, and gases, trap the energy of sunlight, and produce organic matter that serves as sustenance for animals. Man's organic evolution is closely associated with the evolution of flowering plants, or angiosperms: as seed bearers angiosperms readily invaded the drier land where man lived and provided him with a source of easily obtainable food. His social evolution is also related to angiosperms: their annual habit and, in the cereal plants, their great yield in proportion to the work invested allowed for the development of relatively stable agriculturally based communities and more complex civilizations.

Man has indeed become dependent upon plants, especially cultivated plants, but he has so adapted them to his use and environment that they in turn are dependent upon him and many could not survive without his care.

1. Direct Influence of Plants.—Plants directly affecting man

include those providing necessities (food, fibres, shelter materials); ameliorants (essential oils, caffeine, poisons, narcotics, medicines); raw materials of industry (wood, cork, fatty oils, waxes, rubbers, gums, resins, dyes, tannins); and ornamentals.

Food.—Man has employed as food approximately 3,000 plant species but only about 150 have become significant in cultivation. The chief crop plants today are: rice, wheat, corn, sugar cane, sugar beet, potato, cassava, common bean, soybean, peanut, coconut and banana. All major civilizations have been built on cereal production (Egyptian, Greco-Roman, Middle Eastern: wheat; Far Eastern: rice; Inca, Aztec, Maya: corn). Rice, by far man's most widely used food, nourishes 60% of the world's population. Historically and currently, corn is, directly and indirectly, the basic carbohydrate food of the Americas, wheat being second in importance. Other starch sources are many: lesser cereals (barley, rye, oats); roots or tubers (oca, taro, yam); fruits or seeds (breadfruit, jackfruit, plantain); stem (sago). Starch is not only man's main food but is of considerable industrial use. Leguminous seeds are the chief source of vegetal protein (beans, peanut, lentil, etc.) and nuts of diverse sources. Other plant parts provide numerous fruits and vegetables. (*See* Food Supply of the World; Fruit Farming; Vegetable.)

Fibres and Essential Oils.—Fibres, serving mainly for textiles, are botanically of three types: surface (cotton, kapok); bast (flax, hemp, jute); foliar (abacá, sisal, henequen). Long known in both hemispheres, cotton, man's most important plant fibre, goes back to 3000 B.C. in India, 2500 B.C. in Peru. Flax dates from the Swiss lake dwellings (2000 B.C.) in Europe; hemp from 1500 B.C. (*See* Fibre; Fibre Plants.)

Thousands of flowering plants yield essential oils used in perfumes, spices, medicine, and industry. Camphor is industrially one of the most important essential oils. Modern man employs in perfumery over 300 species but principally bergamot; orange; geranium; lemon-grass; rose; hyacinth; jasmine; lavender; violet; sandalwood; and ylang-ylang. The French Riviera annually produces 5,000,000 lb. of orange blossoms; 4,000,000 lb. of roses; and 450,000 lb. of jasmine. (*See* Essential Oil; Perfume; Scented Plants.) Oils like wintergreen and peppermint find use in medicine and confectionery. Spices, employed in cookery, medicine and food preservation since early times, have often altered the course of history: the search for new spice routes provided the stimulus to exploration. (*See* also Food Preparation: *Herbs and Spices.*)

Drugs.—Primitive societies discovered caffeine independently in many parts of the world, and from different sources: seeds (coffee, cocoa, cola); leaves (tea, mate, yaupon); bark (yoco). Tea (*q.v.*), at first a medicine in China, is now drunk by more people than any other caffeine beverage, although coffee (*q.v.*), spread from Ethiopia by Arabs only 500 years ago, is commercially more important. Cocoa (*q.v.*), used by the Aztecs before the Spanish Conquest, slowly gained popularity in Europe after its introduction in 1502. Cola, from Africa, is consumed locally and is exported for use mainly in carbonated drinks. Mate (*q.v.*), from the leaves of a holly, is drunk universally in southern South America. Another holly, yaupon (southeastern United States), employed ceremonially by the Indians as an emetic, was later used by white settlers as a stimulant. High in caffeine (5%), guarana (Amazon) is prepared from the pulverized seeds of a cultivated vine, while the bark of the related wild yoco provides western Amazon Indians with a highly stimulating decoction. In Arabia khat leaves, with a caffeine-like alkaloid, are chewed for their stimulant effects. The betel nut, from a palm, is chewed in southeast Asia with betel pepper leaves and spices, a use described by Herodotus as early as 340 B.C. (*see* Betel Nut).

Alcohol, from the fermentation of sugars by yeasts (one of the primitive plants) has been known since earliest times. Prepared from hundreds of fruits and starchy grains or roots, alcoholic beverages play a major cultural role in most societies. They are either fermented (wines, beers) or distilled (whiskey, rum, gin, etc.). (*See* Alcoholic Beverages, Distilled.)

Early in his history man learned that some plants had unusual effects on the mind and body; man considered these drugs sacred and associated them with magic and religion. Nonalcoholic narcotics include excitants (tobacco), hypnotics (kava), hallucinogens (peyote, agaric, marijuana), and euphorics (coca, opium). Only the euphorics, both the blessing and the bane of humanity, are of major medical importance. Opium, native to Asia Minor, has many alkaloids, the principal ones being morphine and codeine. Coca (*q.v.*) leaves, rich in cocaine, are chewed by millions of South American Indians. The pistillate buds of the hemp plant, which yield marijuana (*q.v.*), bhang, ganja, hashish—different forms of the same narcotic—are still widely employed from North Africa to India and spreading elsewhere; in the New World, it is usually smoked. The hallucinogens, as their name implies, induce fanciful and brilliantly coloured visions; their physiological and psychological effects make them interesting as possible medicines for mental treatment (*see* Neuropharmacology and Psychopharmacology; Tranquilizing Drugs). The peyote cactus, important in a growing religious cult among Mexican and American Indians (*see* Peyotism), has shown promise as a tool in experimental psychiatry. Recent studies of hallucinogenic effects of certain mushrooms (teonanacatl) and the morning glory (ololiuqui), employed in religious rites in Mexico, hold similar promise. Sundry narcotic snuffs from tropical America warrant further investigation. Primitive societies in the new world have made extensive use of narcotic plants; the two centres of greatest aboriginal use of narcotic plants are Mexico and Colombia.

Tobacco, man's most widely used narcotic, was smoked ceremonially by the American aborigines. Introduced to Europe as a medicine in 1556, its use as a stimulant spread rapidly in spite of strong public opposition. Tobacco is smoked, chewed, snuffed, and, among some Indians, licked and, as a decoction, drunk. The production and processing of tobacco is at present one of the world's foremost occupations (*see* Tobacco).

Plants have been the source of nearly all medicines. Synthetics are generally modeled on the chemical structure of the natural drug. Discovery of the "wonder drugs" sparked a renascence of medical interest in the plant kingdom. Among the later plant derivative drugs are: muscle relaxants from the curares; hypertensive agents from snake root; cortisone from strophanthus; penicillin, streptomycin, aureomycin and many other antibiotics from molds, actinomycetes and bacteria. Among the older drugs still of major importance are: aloes, belladonna, cascara, castor oil, coca, digitalis, ephedrine, eucalyptus, guaiacum, ergot, ipecac, licorice, nux vomica, opium, psyllium, cinchona, rhubarb, senna and wormseed. It is expected that current research into the medicinal potentialities of plants may uncover still more significant therapeutic agents.

Toxic plants have exerted strong cultural and historical influence. Primitive societies used them in tribal ceremony, warfare, hunting, fishing, euthanasia, determining guilt, and inducing abortion; modern society finds them useful medicines as insecticides and rodenticides. The United States perhaps has 400 toxic species; the tropics are infinitely richer. Alkaloids, glycosides, saponins, resins, phytotoxins, essential oils, tannins and inorganic substances are, when the toxic principle in a plant, classified according to their physiological activity.

The most spectacular use of toxic plants is for arrow poisons, invented independently on nearly every continent (with different plants) but particularly developed in tropical southeast Asia and South America. Similarly, fish poisons are of world wide use, although best developed in South America, where about 100 species are employed. One of these, rotenone, has become an important agricultural insecticide. Another valuable insecticide is pyrethrum from certain species of *Chrysanthemum.* Ordeal poisons, mostly from tropical lianas of the pea family, were administered in primitive African societies to determine guilt (death) or innocence (survival); from one of these poisons, physostigmine, important in ophthalmology, was isolated. Many weeds and ornamental plants are poisonous, as are some edible plants (*e.g.*, tapioca), which have toxic principles that must be removed. (*See* Poisonous Plants.)

Fats, Oils, and Waxes.—It is hard to exaggerate the importance of plants yielding fats and oils. They are employed as foods, in

soap-making, for lubricating and in countless industrial applications. Derived mostly from seeds, oils are classified as: drying oils (linseed, tung, soybean); semidrying (cottonseed, corn, sesame, sunflower); nondrying (olive, peanut, castor). Fats, which are solid or semisolid at room temperature, are derived from the coconut, cocoa and other tropical trees; the palms are particularly rich in members providing fatty oils.

Waxes, closely allied chemically to the fatty oils, are derived from fewer species. Waxes have industrial applications, especially in varnishes and polishes. Most wax plants occur in desert or near-desert areas. Carnaúba, from a Brazilian palm, is preferred for polishes because of its hardness. Other industrial waxes are produced by shrubs or bushes: candelilla, from Mexico; myrtle, from eastern North America); jojoba, from southwestern United States; and cauassú, from the Amazon basin. (*See* Oils, Fats and Waxes; Oil Plants.)

Latex, Gums, and Resins.—Although the milky latex of many species (about 7,000) yield rubber, only about 50 have ever been commercially significant; more than 90% of the world's natural rubber comes from one species, the Pará rubber tree, native to the Amazon but cultivated mainly in southeast Asia. One of the most recently domesticated plants, rubber has been greatly improved from the wild tree (producing 450 lb. per acre) to clones yielding 1,800 lb. per acre. In spite of its short time on the world market, rubber has altered the entire course of civilization; almost 2,000,000 tons are produced annually for a wide variety of industrial uses (*see* Rubber). Other sources of rubber are mainly of historic interest, except the Russian dandelion, from Siberia, and the guayule shrub, from Mexico, which may be utilized in emergencies. Many lacticiferous trees yield nonelastic substances of diverse industrial applications: balata, gutta-percha, jelutong, and chicle.

Gums and resins, occurring widely in plants, result from disintegration of cellulose tissues (gums) or oxidation of essential oils (resins). Common in plants of dry regions, gums are employed in the adhesive, paint, and printing industries and in medicine. Resins are employed in the varnish, soap, incense, perfume and pharmaceutical industries. Hard resins include the copals, dammars, and lacquers; oleoresins, which have more essential oil than hard resins, include the turpentines and balsams. Copals, produced by trees of the pea and pine families in Africa, New Zealand, southeast Asia, and South America, usually are semifossilized but may be relatively soft. Dammars, chemically unlike coniferous resins, come mainly from dipterocarpaceous trees of southeastern Asia and are used chiefly in spirit varnishes and nitrocellulose lacquers. Amber, a fossilized resin from Miocene trees, is especially abundant in the Baltic area. Lacquer, a natural varnish from an Asiatic species of sumac, is the basis of the decorative lacquerware industry of China.

Commercially, turpentine from several pines of the southeastern United States is perhaps the most important oleoresin, being the basis of the "naval stores" industry. Minor turpentines are Canada balsam, spruce gum, Venetian turpentine. The balsams—including Peru balsam, Tolu balsam, benzoin, storax—are mainly medicinal. The gum resins are mixtures of true gums and resins. Historically and commercially the most important are asafetida, myrrh, and frankincense. Produced mostly in desert areas of western Asia and North Africa, they are useful in incenses, perfumes, face powders, toiletries, and medicine. (*See* Gums, Plant; Resins.)

Dyes, once largely vegetal, are now almost wholly synthetic. All parts of plants have yielded dyes: wood (logwood, brazilwood, fustic, osage orange, cutch); leaves (indigo, henna, weld, woad); roots and tubers (madder, turmeric); bark (quercitron); stigmas (saffron); gum resin (gamboge). Archil, cudbear and litmus are derived from lichens. (*See* also Dyes and Dyeing: *History.*)

Tannins and Paper.—Tannins occur widely but commercial sources are few and usually are not cultivated. The bark of hemlock, oak, mangrove, and wattle; the wood of chestnut and quebracho; the leaves of sumac and gambir; and the fruit of myrobalan are prime sources. Tannins unite with proteins in animal skins to form leather. Tannin inks are made by combining a tannin-high extract of oak galls with iron (ferrous) sulfate, gum arabic, and a dye. (*See* Tannin.)

One of the world's most important products—paper—can be made from several different natural fibres. The use of wood fibres dates from about 1850. Currently, spruce furnishes about 30% of all paper; pine, hemlock, birch and poplar are secondary sources of wood pulp. Writing materials manufactured from the papyrus sedge, used in Egypt in ancient times, sparked a remarkable intellectual period. The Chinese, however, actually first made true paper. (*See* Paper Manufacture.)

Wood and Cork.—Wood is man's most valuable forest commodity. Its advantages are: easy and cheap availability; easy tooling; lightness; great strength for its weight; and nonconductivity of heat. The modern lumber industry supplies wood for boxes, construction, furniture, cooperage, railway ties, etc. Veneers and plywoods are increasingly important in many applications. Wood alloys—wood impregnated with resins under pressure—have more and more use in industry. (*See* Wood.)

Cork, known to the ancient Greeks, is a many-purpose substance derived from the bark of oaks. It is used either alone or in composition (finely ground and molded with adhesives). The Mediterranean countries are the chief producers of cork. (*See* Cork.)

2. Indirect Influence of Plants.—Man is indirectly affected by disease-causing plants and weeds. Plant diseases attacking man's cultivated species cause millions of dollars' loss annually in agriculture and forestry. Resistant strains or clones of some crop plants have been developed through selection and breeding, but the main defense is control, costing many millions of dollars yearly. (*See* Plant Diseases.)

Weeds—plants growing where they destroy or impede the growth of cultivated species—likewise are costly to man in terms of their control and the damage they do. Fast-growing annual weeds are often introduced plants which, without the natural enemies of their native regions, become aggressive. Most weeds can thrive under adverse conditions, mature great numbers of seeds (often of long viability), propagate vegetatively or, if perennials, regenerate lost parts. Weeds are not entirely devoid of utility to man—they add humus and nutrients to soil on which little else will grow; some are edible and a few are medicinal. (*See* Weed.)

The extent and importance of range plants basic to the meat industry are so obvious that they need only passing reference here. The number of species thus indirectly affecting man is extremely great. Forests, besides supplying many of man's directly utilitarian plants, affect his life in many indirect ways. They have a part in controlling climate and temperature. They are a major factor in flood control and in water conservation, which is each year more and more important in the United States and elsewhere (*see* Forests and Forestry).

The value of plants as ornamentals is well known. Horticulture is one of our major industries. Ornamentals, while not of immediate utilitarian value, are extensively grown for the pleasure they provide. *See* Horticulture.

See also references under "Plants and Plant Science" in the Index.

Bibliography.—O. Ames, *Economic Annuals and Human Cultures* (1939); A. F. Hill, *Economic Botany* (1952); J. Hutchinson and R. Melville, *The Story of Plants and Their Uses to Man* (1948); R. W. Schery, *Plants for Man* (1952). (R. E. S.)

PLANUDES, MAXIMUS (in the world Manuel) (*c.* 1260–*c.* 1310), Byzantine classical scholar who compiled the Planudean anthology (*see* Anthology: *The "Greek Anthology"*). Born in Nicomedia, he spent most of his life in Constantinople, where he became a monk. His achievement, unique in the Greek east, as a translator of Latin literature (*e.g.*, works by Ovid, Augustine, and Boethius) was probably due in part to results of the Latin occupation of the city (1204–61), and enabled him to be a member of a mission to Venice in 1296. His original attempts in prose and poetry (including an idyll in 270 hexameters) are of much less importance than his anthology, which is valuable chiefly because it contains certain epigrams missing from the Palatine manuscript. In the case of poems occurring in both anthologies, only a few

of the Planudean's individual readings are derived from genuine transmission (*e.g.*, 7,440, 10–11; 7.703, 5–6), the greater number being conjectures by Planudes. Many of these are correct, but obvious to any thinking and linguistically capable copyist, others are clearly hasty attempts to camouflage stylistic difficulties or more fundamental corruptions in the text, while others are due to prudery. Arbitrary alterations of this kind have not been found in the rest of Planudes' work as scribe and collector.

See C. Wendel in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, vol. 20, col. 2202–53 (1950). (P. MA.)

PLASKETT, JOHN STANLEY (1865–1941), Canadian astronomer, discoverer of the dual star known as "Plaskett's twins," was born Nov. 17, 1865, near Woodstock, Ont. He graduated from the University of Toronto in 1899. In 1905 he was made astronomer of the Dominion Observatory at Ottawa, and remained in that position until 1917, when he was placed in charge of the Dominion Astrophysical Observatory in Victoria, B.C. After his retirement in 1935, he supervised the grinding and polishing of the 82-in. mirror for the telescope of the McDonald Observatory of the University of Texas.

Plaskett was one of the most noted astronomers of his time. Of his many important discoveries, one of the first came in 1922 when he found that what had for years been considered a large single star was actually two stars. The stars, although clearly visible to the naked eye, had not been identified as twins until Plaskett studied them through the Dominion Observatory's 72-in. telescope, which he had been instrumental in persuading the government to install. The stars were subsequently given his name and are known as "Plaskett's twins." He also made valuable studies on the motions of stars, on the Milky Way and its movements, and on the rotation of the galaxy.

Of his numerous papers, the most important include *Star Image in Spectroscopic Work; Design of Spectroscopes; The Rotation of the Galaxy; Diffuse Matter in Interstellar Space;* and several on the O-type stars. He was the recipient of a number of honorary degrees and awards for his distinguished services to astronomy. He died at Esquimault, B.C., Oct. 17, 1941.

PLASMA PHYSICS: *see* ELECTRICITY, CONDUCTION OF: *Conduction in Gases;* MAGNETOHYDRODYNAMICS.

PLASSEY, BATTLE OF. Robert Clive's victory over the nawab of Bengal, Siraj-ud-Daula, took place just north of Plassey, a village in Bengal, India, on June 23, 1757. Clive, with a force of about 3,000 men and 8 field pieces, took the field against 60,000 men, 53 heavy guns, and some French artillery under Saint Frais. Despite the adverse decision of a council of war (June 21), Clive on the following day crossed the flooding Bhagirathi River and marched to Plassey to force an engagement. He had confidence in purposefully led Europeans and hoped for the defection of much of the nawab's army under Mir Jafar, whom Clive was plotting to make nawab.

Clive's force, sheltered in a mango grove with its back against the river, awaited the attack from an imposing enemy drawn up in a semicircle with the French artillery on its right, anchoring it to the river. An artillery duel developed during which Clive's carefully protected men and guns worked well against the exposed enemy. During an attack, Mir Mudin, the only loyal general of the nawab, was killed. An attack on Saint Frais's position proved successful, and when Clive was sure that Mir Jafar was not taking part in the battle he pressed his advance. Siraj-ud-Daula fled as his vast, untrustworthy force disintegrated.

The battle, won at the cost of about 65 British casualties, owed its success to Clive's outstanding political and military qualities. The results, as Clive foresaw, were momentous. Bengal fell to the East India Company, and Britain was launched on a territorial expansion that embraced all of India. *See* also BENGAL: *History: The British in Bengal;* CLIVE, ROBERT.

See M. Edwardes, *The Battle of Plassey and the Conquest of Bengal* (1963). (D. M. Sc.)

PLASTERING is one of the most ancient building techniques. Evidence indicates that primitive peoples plastered their reed or sapling shelters with mud, thus developing more durable structures and more effective screens against vermin and inclement weather. More lasting and sightly materials in time replaced mud. Some of the earliest extant plastering is of a quality that compares to that used in modern times. The pyramids of Egypt contain plasterwork executed at least 4,000 years ago which is still hard and durable. The principal tools of the plasterer of that time were in design and purpose like those used today. For their finest work the Egyptians used a plaster made from calcined gypsum which is identical with plaster of paris. In other respects also the materials and the procedures used by the Egyptians 4,000 years ago were identical with those of today.

Very early in the history of Greek architecture (*e.g.*, at Mycenae) plaster of a fine white lime stucco was used. The art of plastering reached a high degree of perfection in Greece more than five centuries before Christ, and plaster was frequently used to cover temples externally (stucco) and internally, in some cases even when the building was made of marble. The stucco and the plaster of the interior provided an excellent ground for decorative painting. The temple of Apollo at Bassae, built of yellow limestone about 450–420 B.C., is an excellent example of Grecian skill and artistry in the use of decoration on stucco and plaster. The ornamental plaster ceilings of England during the reigns of Henry VIII, Elizabeth I, and James I still are admired. Earlier extant specimens of the plasterers' skill in England are the pargeted and ornamented fronts of half-timber houses. Plaster as a medium of artistic expression waned by the 19th century, when imitation and mechanical reproduction all but displaced this creative art. As a surface material for interior walls and ceilings and to a lesser degree for exterior walls, plaster has become common. It facilitates cleanliness and sanitation in building and is a retardant to the spread of fire.

Interior plasterwork is designed according to the type of lathing to which it is applied and the number of applications that are necessary. The first coat, or scratch coat (not over ¼ in. thick), is applied to a wood or metal lath, but not to a gypsum lath. This coat, rich in cementing material and binder, is laid on with a steel trowel, working upward with overlapping diagonal applications of mortar. The second coat, called the brown coat in the U.S. and the floating coat in England, is less rich in cementing material and should not be less than ¼ in. thick. The third coat, or white coat, consists of a lime paste into which plaster of paris is mixed at the time of application. This final coat is applied in three operations: a thin application with a steel trowel; a second application to bring the finish surface to its final true plane; and a third operation in which a steel trowel and a damp brush are used to produce a smooth polished surface.

Ornamental plaster for ceilings and cornices is usually applied with a metal molding tool that has the reverse of the desired profile. Some elements may be formed by hand, while others are precast and stuck in place with plaster of paris. Plaster coating of exterior walls, commonly known as stucco, may be applied directly to concrete, brick, tile, or a supporting metal lath base. Various types of finish, including colours and textures, may be incorporated in the finish coat. Splatter dash and pebble dash are textured surfaces resulting from throwing mortar or pebble with some force on the finish coat while it is still soft. One of the oldest techniques for both interior and exterior embellishment is sgraffito, in which colour coats are applied to a surface finished with a skim coat of fine cement. The outer coat or coats are scraped away, exposing the various coloured layers.

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